ERASMUS+
European Commission

ASTONRAIL – REPORT – Intellectual Output 3 –

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1 Introduction and summary

Intellectual output 3 (IO3) maps out current rail higher education provision against industry expectations, and as a result will identify apparent gaps and mismatches.

This work will be based on the outputs from both WG1 and WG2, and it is a core milestone of the project. Based on the input from IO1 and IO2, a more in-depth and subject-specific study has been conducted to develop a better understanding of particular areas which are ill equipped with the required skills. This is a very important step to clearly showcase current gaps and mismatches between rail industry expectations and current higher education provision.

The results from the questionnaire in IO2 have been further used to classify and map different academic expertise according to the usability towards filling the knowledge gaps that the railway sector currently needs to address.

To learn from other sectors, educational setups from other specialities have also been studied, including what implementations were done to improve the current subject- specific higher education teaching and learning practices.

2 Task 3.1 Systems perspective

Task coordinator: DICEA; Support: KTH, UNIZG, UNIZA, EURNEX, AU, UMA, TH WILDAU.

This section, building on the outputs of IO1, studies how different higher education institutions in Europe split the railway systems knowledge in different subsystems by identifying clear study paths and how they eventually link to the different professional levels. This will allow a sensible approach to understanding the position and perspective of different stakeholders when it comes to graduates as employees. The rail careers matrix is used as a default output of the “railway study paths”, but a deeper discussion is needed on the usefulness of the RCM coupled to the combination of educational paths and job experience.

2.1 Methodology

The methodology employed in this task includes a combination of the representation of the study path through a matrix and a scheme for each partner university.

The matrix used to highlight the study paths (Figure 2) consists of the available bachelor programmes (columns) and the available master programmes (rows). A “1” in a cell indicates that this bachelor program allows for unrestricted access to the respective master program. If there is no direct access form bachelor’s to master’s the cell is left blank. The study paths are then highlighted in accordance with the “railway overview picture” previously used in WP 1.4 (Figure 1) to give a comprehensible visualisation.

The schemes produced in this section are a more synthetic representation of the various study paths at the different partner universities that is combined with the RCM. The scheme allows a visualisation of the connections between levels of study and the resulting cells in the RCM (

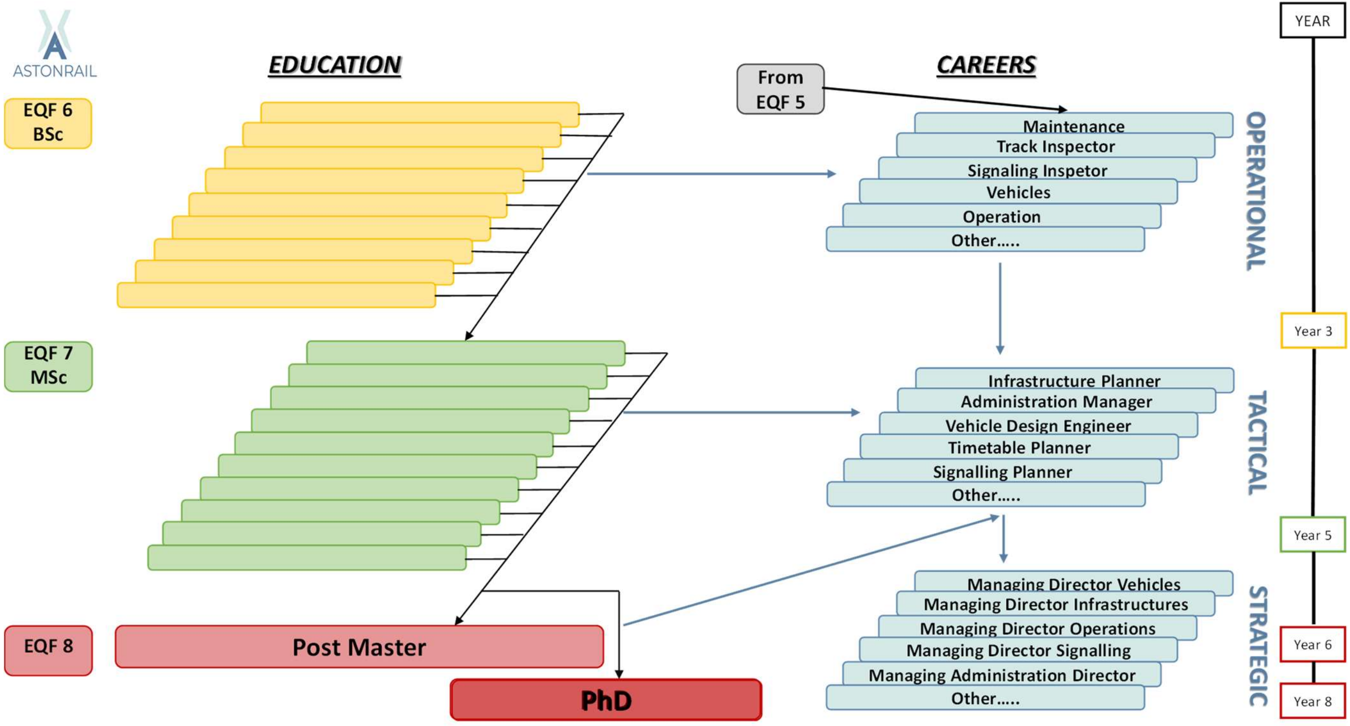


Figure 3).

In general, a bachelor's course can be either used as a preparation for a master's or as direct access to the industry. If the student decided to pursue a master's this allows them to either continue their studies with postmaster courses and PhDs respectively or to enter the industry right after. PhDs have different requirements in different countries: some do not require engineering related master’s degrees, but in Germany or Sweden there are specific requirements for starting a PhD directly related to the area of study, e.g. one can only start a PhD in engineering with an engineering degree.

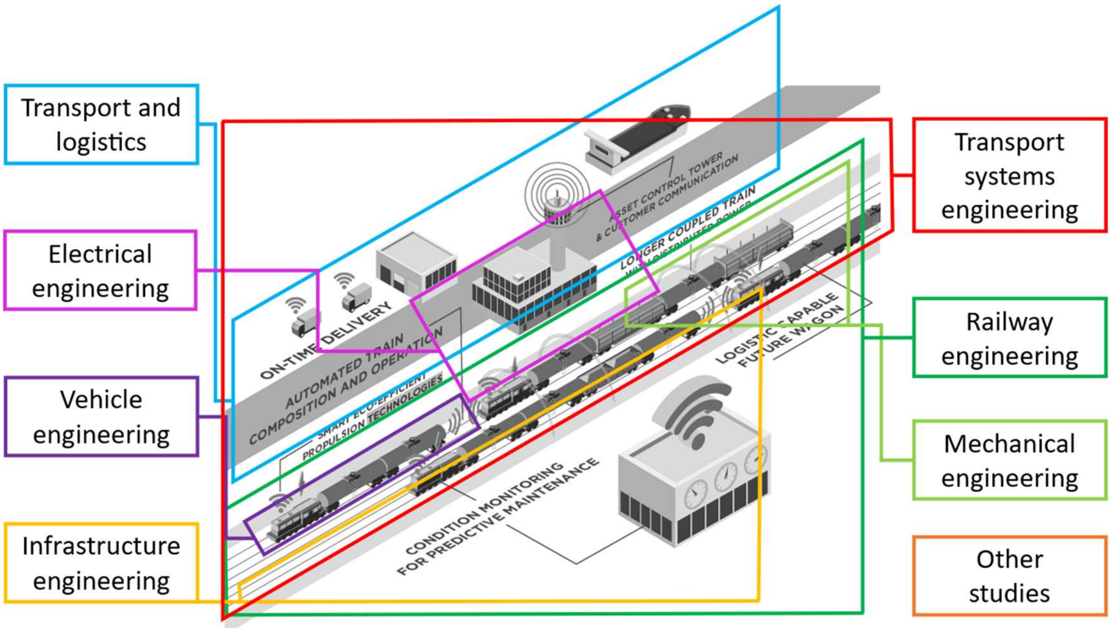
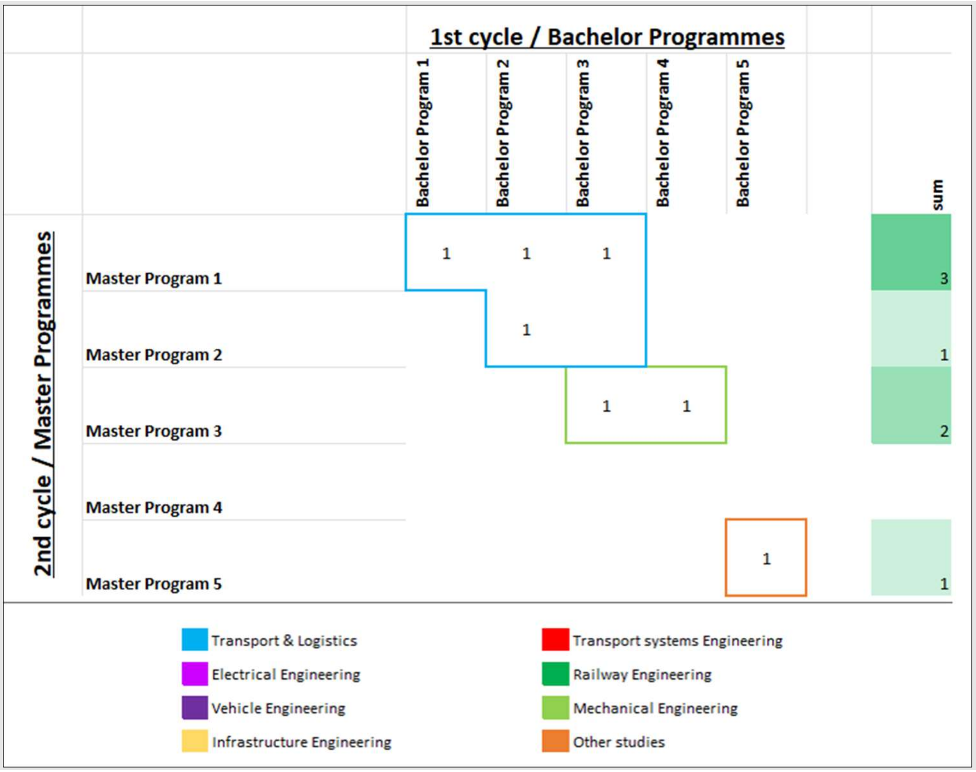


Figure 1 - The railway overview picture



		1st cycle / Bachelor Programmes					
		Bachelor Program 1	Bachelor Program 2	Bachelor Program 3	Bachelor Program 4	Bachelor Program 5	sum
2nd cycle / Master Programmes	Master Program 1	1	1	1			3
	Master Program 2		1				1
	Master Program 3			1	1		2
	Master Program 4						
	Master Program 5					1	1

🟦 Transport & Logistics	🟥 Transport systems Engineering
🟪 Electrical Engineering	🟩 Railway Engineering
🟪 Vehicle Engineering	🟩 Mechanical Engineering
🟨 Infrastructure Engineering	🟧 Other studies

Figure 2 - Matrix Study Path

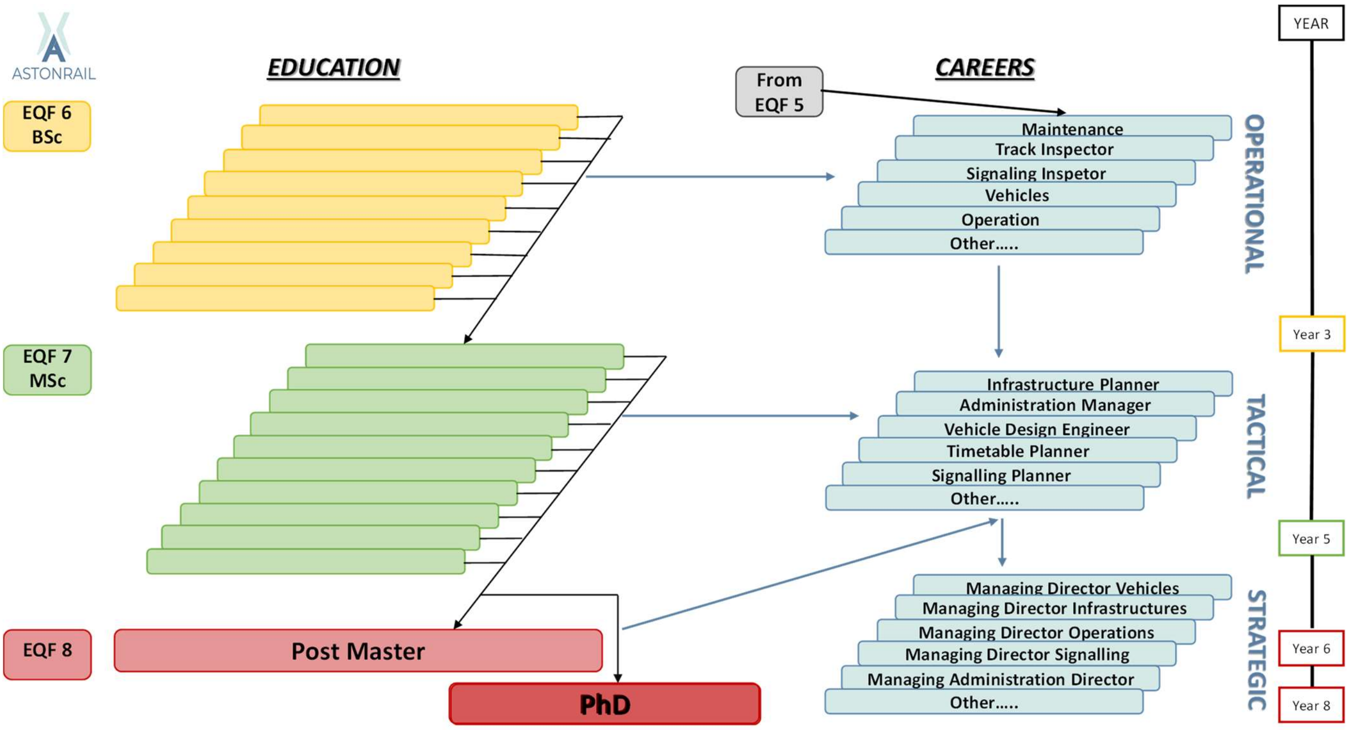


Figure 3 - Scheme Career Map

All the partners have sent the study path of their university, as are shown below:

2.2 Study paths at the different institutions

2.2.1 University of Rome La Sapienza

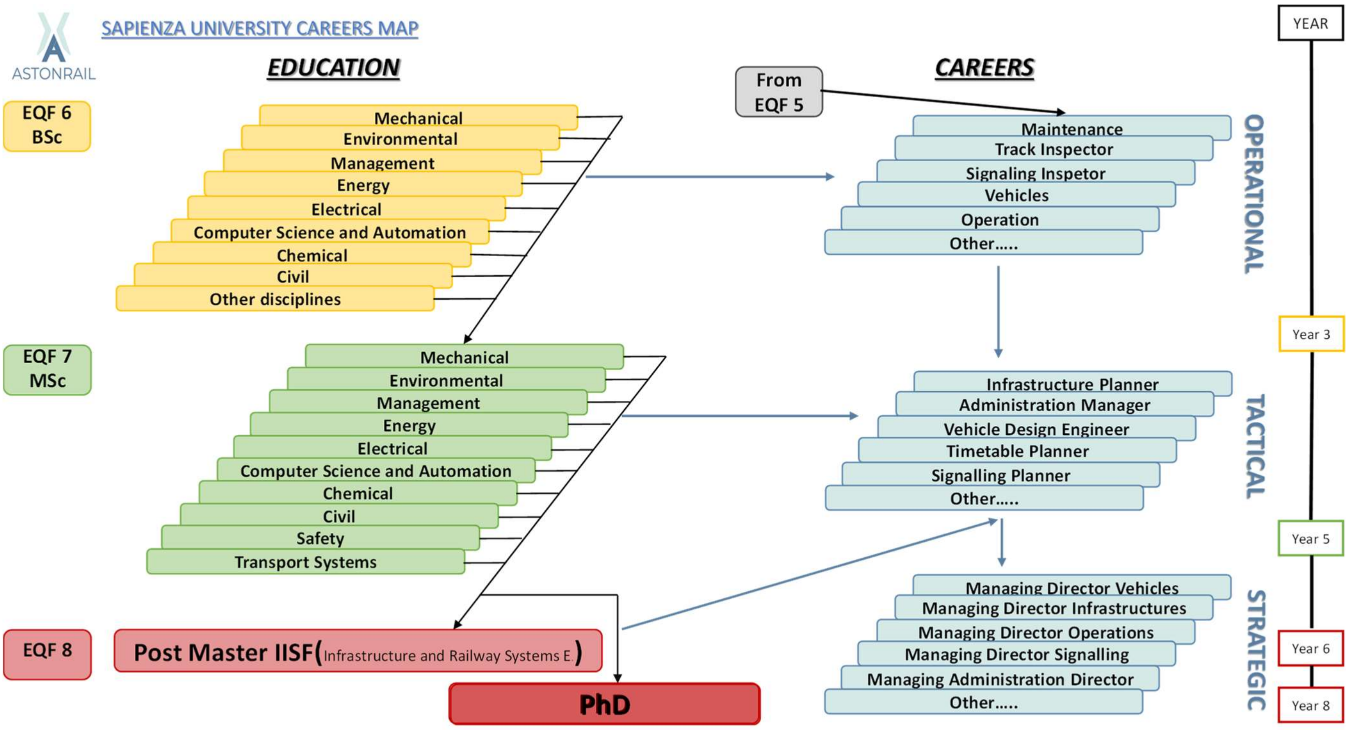
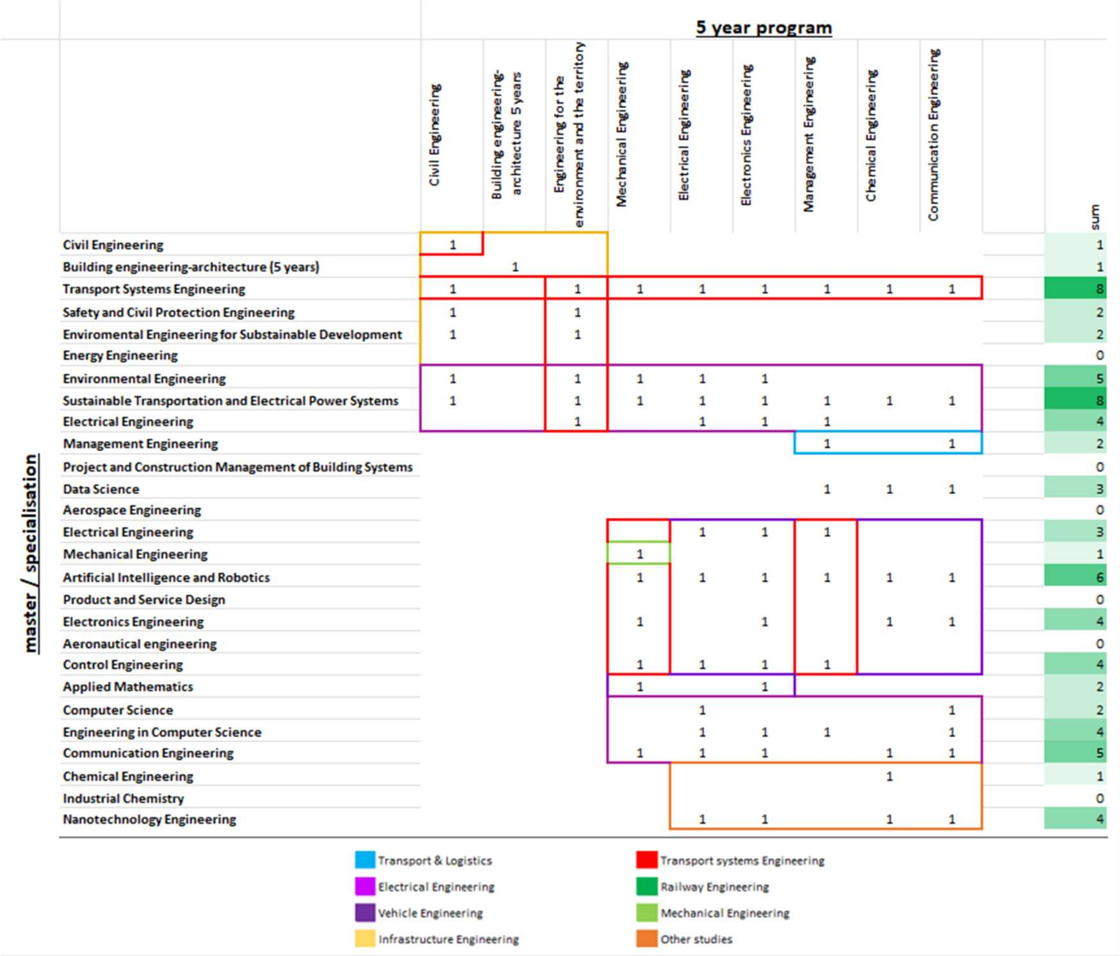


Figure 4 - La Sapienza Scheme Career Map



	5 year program										
master / specialisation	Civil Engineering	Building engineering-architecture 5 years	Engineering for the environment and the territory	Mechanical Engineering	Electrical Engineering	Electronics Engineering	Management Engineering	Chemical Engineering	Communication Engineering		sum
Civil Engineering	1										1
Building engineering-architecture (5 years)		1									1
Transport Systems Engineering	1		1	1	1	1	1	1	1		8
Safety and Civil Protection Engineering	1		1								2
Enviromental Engineering for Substainable Development	1		1								2
Energy Engineering											0
Environmental Engineering	1		1	1	1	1					5
Sustainable Transportation and Electrical Power Systems	1		1	1	1	1	1	1	1		8
Electrical Engineering			1		1	1	1				4
Management Engineering							1		1		2
Project and Construction Management of Building Systems											0
Data Science							1	1	1		3
Aerospace Engineering											0
Electrical Engineering					1	1	1				3
Mechanical Engineering				1							1
Artificial Intelligence and Robotics				1	1	1	1	1	1		6
Product and Service Design											0
Electronics Engineering				1		1		1	1		4
Aeronautical engineering											0
Control Engineering				1	1	1	1				4
Applied Mathematics				1		1					2
Computer Science					1				1		2
Engineering in Computer Science					1	1	1		1		4
Communication Engineering				1	1	1		1	1		5
Chemical Engineering								1			1
Industrial Chemistry											0
Nanotechnology Engineering					1	1		1	1		4

🟦 Transport & Logistics	🟥 Transport systems Engineering
🟪 Electrical Engineering	🟩 Railway Engineering
🟪 Vehicle Engineering	🟩 Mechanical Engineering
🟨 Infrastructure Engineering	🟧 Other studies

Figure 5 - La Sapienza Matrix Study Path

As the matrix (FIGURE) shows, there are two master programs at La Sapienza with unconditional accessibility. Other courses, however, have a higher correlation with the bachelor programmes. It can be furthermore noted that La Sapienza covers almost all rail related fields, the only one missing being "Railway Engineering".

2.2.2 KTH Royal Institute of Technology in Stockholm

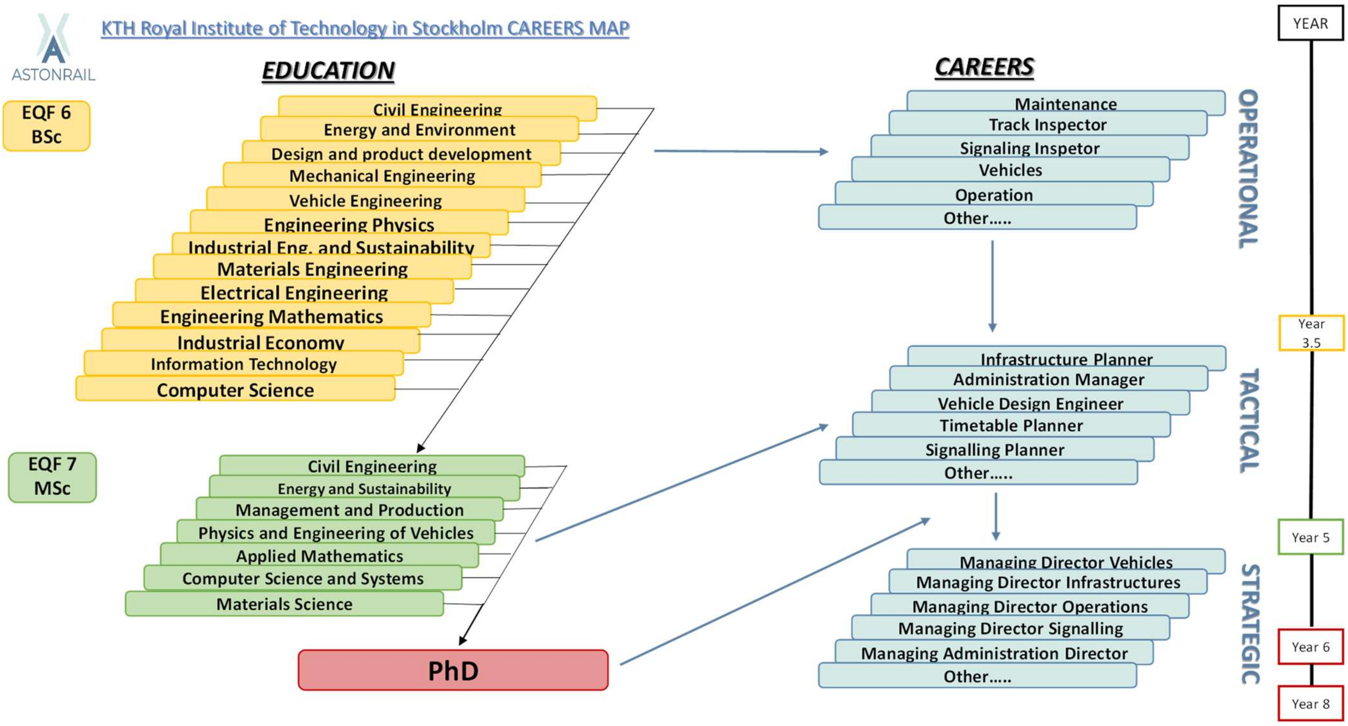
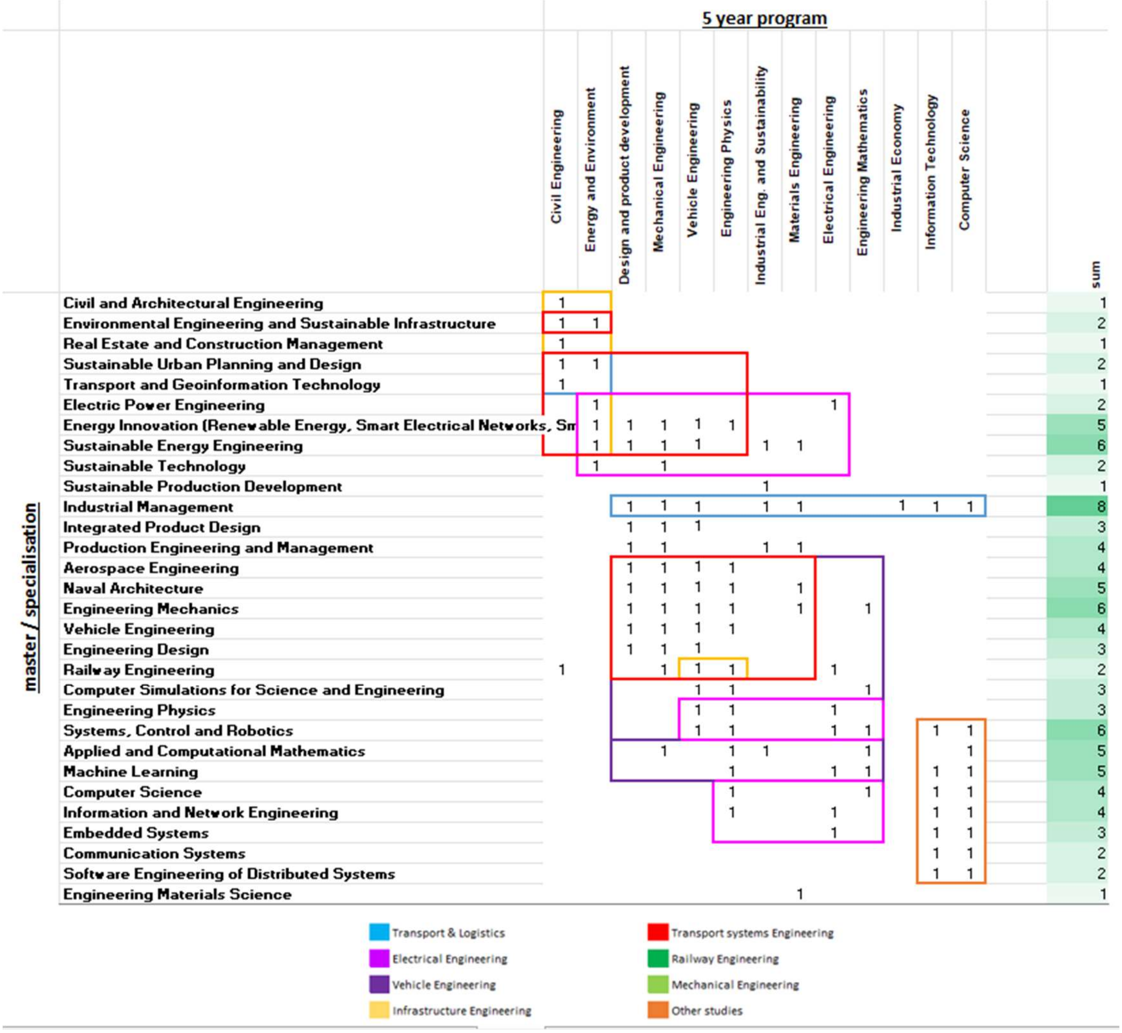


Figure 6 - KTH Scheme Career Map



5 year program

master / specialisation

	Civil Engineering	Energy and Environment	Design and product development	Mechanical Engineering	Vehicle Engineering	Engineering Physics	Industrial Eng. and Sustainability	Materials Engineering	Electrical Engineering	Engineering Mathematics	Industrial Economy	Information Technology	Computer Science	sum
Civil and Architectural Engineering	1													1
Environmental Engineering and Sustainable Infrastructure	1	1												2
Real Estate and Construction Management	1													1
Sustainable Urban Planning and Design	1	1												2
Transport and Geoinformation Technology	1													1
Electric Power Engineering		1							1					2
Energy Innovation (Renewable Energy, Smart Electrical Networks, Sm		1	1	1	1	1								5
Sustainable Energy Engineering		1	1	1	1		1	1						6
Sustainable Technology		1		1										2
Sustainable Production Development							1							1
Industrial Management			1	1	1		1	1			1	1	1	8
Integrated Product Design			1	1	1									3
Production Engineering and Management			1	1			1	1						4
Aerospace Engineering			1	1	1	1								4
Naval Architecture			1	1	1	1		1						5
Engineering Mechanics			1	1	1	1		1		1				6
Vehicle Engineering			1	1	1	1								4
Engineering Design			1	1	1									3
Railway Engineering	1			1	1	1			1					2
Computer Simulations for Science and Engineering					1	1				1				3
Engineering Physics					1	1			1					3
Systems, Control and Robotics					1	1			1	1		1	1	6
Applied and Computational Mathematics				1		1	1			1			1	5
Machine Learning						1			1	1		1	1	5
Computer Science						1				1		1	1	4
Information and Network Engineering						1			1			1	1	4
Embedded Systems									1			1	1	3
Communication Systems												1	1	2
Software Engineering of Distributed Systems												1	1	2
Engineering Materials Science								1						1

🟦 Transport & Logistics
🟪 Electrical Engineering
🟪 Vehicle Engineering
🟨 Infrastructure Engineering
🟥 Transport systems Engineering
🟩 Railway Engineering
🟩 Mechanical Engineering
🟧 Other studies

Figure 7 - KTH Matrix Study Path

The scheme shows that the study paths at KTH consist of bachelor and master programmes. There are, however, PhDs available at KTH, but not displayed in the scheme. The matrix suggests a high correlation between master's and bachelor's, meaning only certain bachelor programmes allow to access a certain master program. Furthermore, KTH offers programs in all fields indicated in the railway overview picture

Aston University

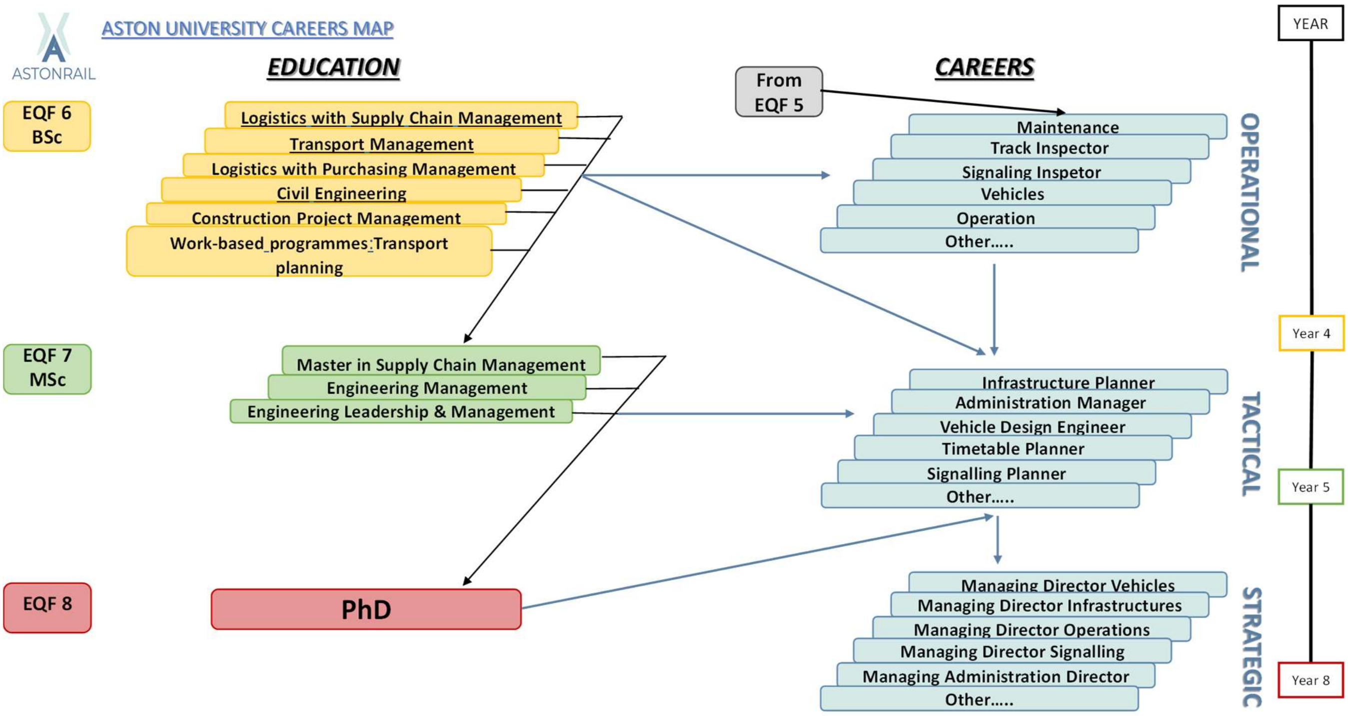
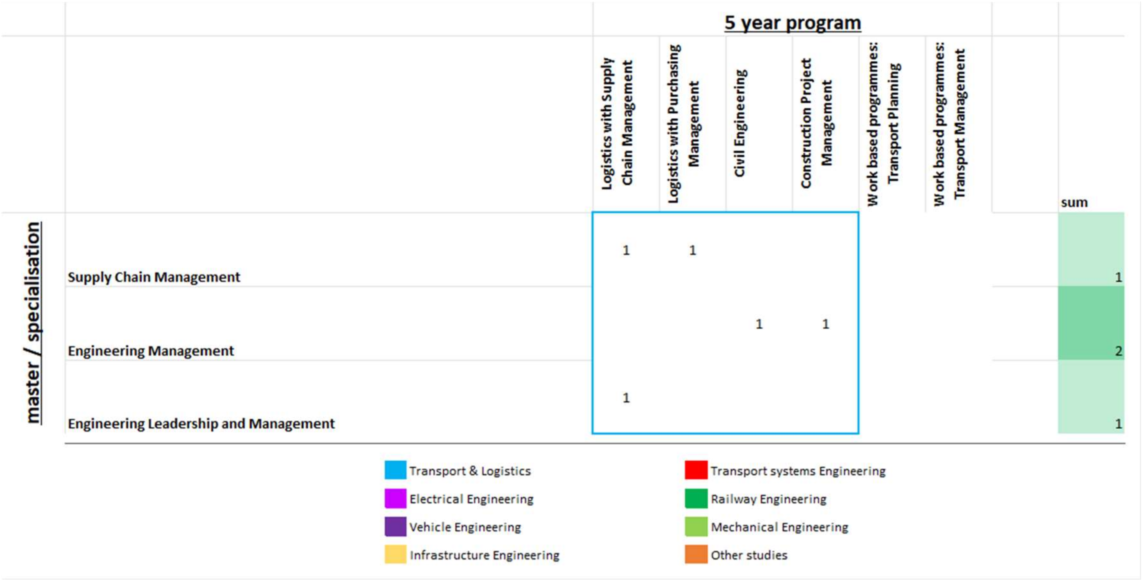


Figure 8 - Aston Scheme Career Map



	Logistics with Supply Chain Management	Logistics with Purchasing Management	Civil Engineering	Construction Project Management	Work based programmes: Transport Planning	Work based programmes: Transport Management	sum
Supply Chain Management	1	1					1
Engineering Management			1	1			2
Engineering Leadership and Management	1						1

🟦 Transport & Logistics
🟪 Electrical Engineering
🟪 Vehicle Engineering
🟨 Infrastructure Engineering
🟥 Transport systems Engineering
🟩 Railway Engineering
🟩 Mechanical Engineering
🟧 Other studies

Figure 9 - Aston Matrix Study Path

The study paths at Aston University include bachelor, master, and PhD programs. As the matrix reveals, Aston exclusively offers courses in “Transport and logistics”.

2.2.3 Technical University of Applied Sciences Wildau

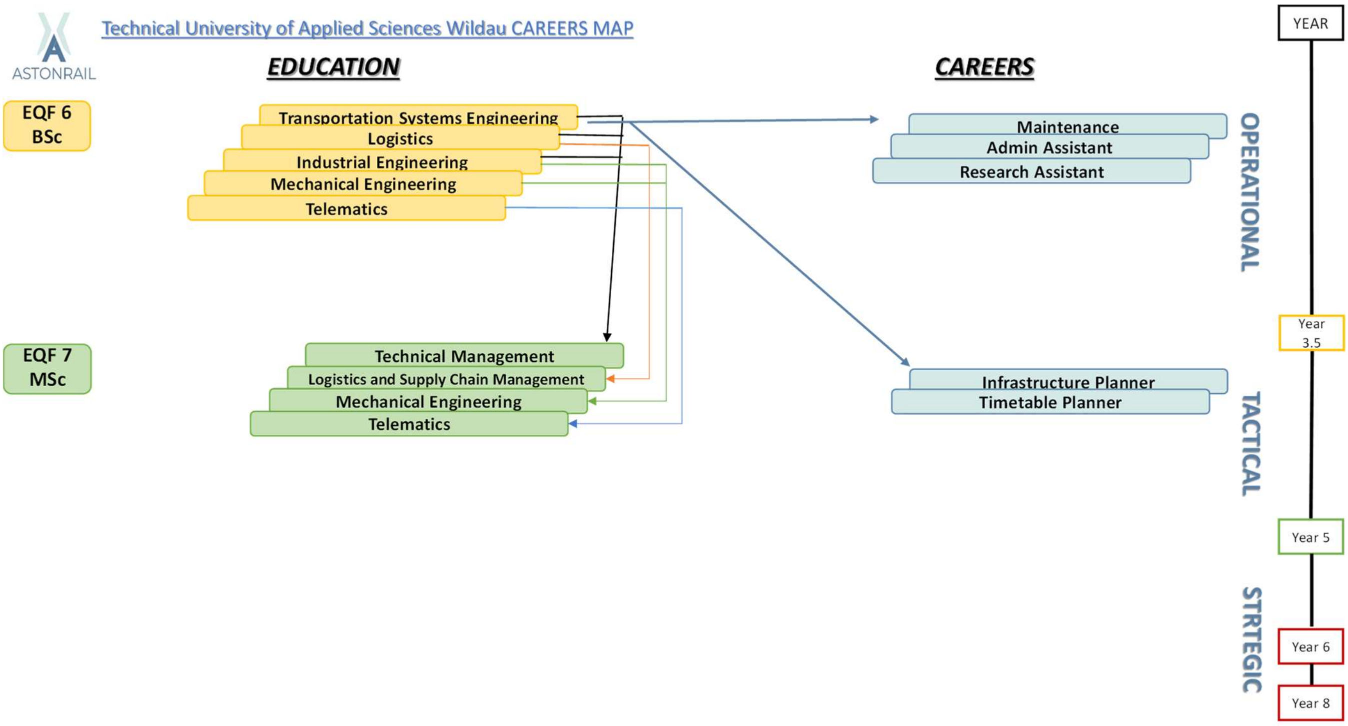
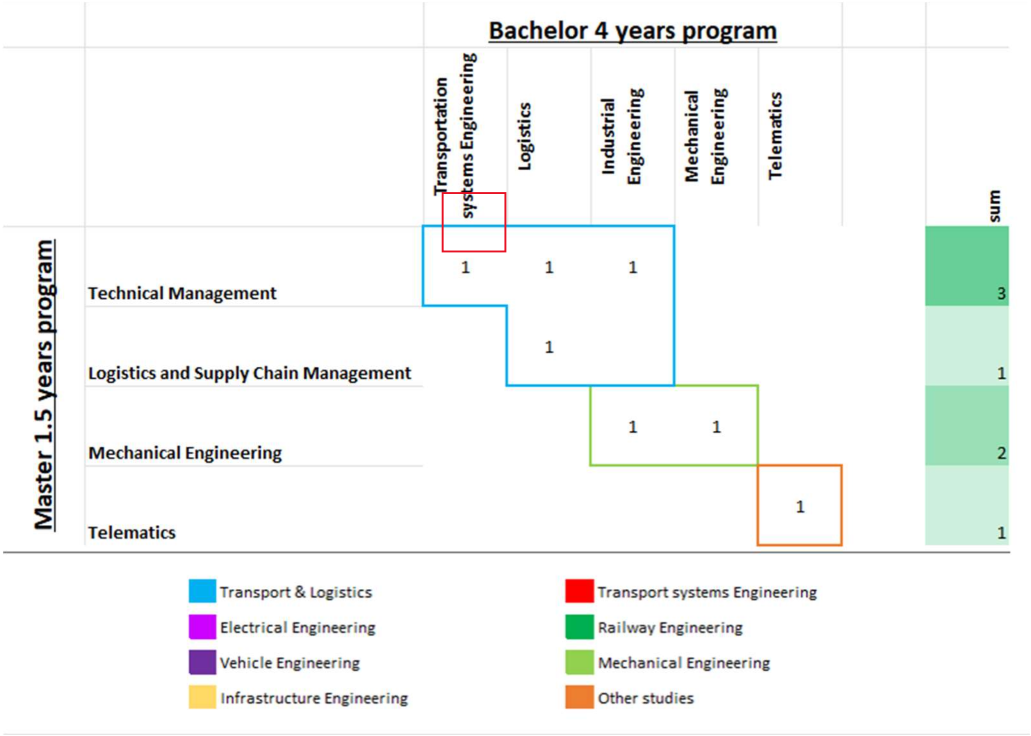


Figure 10 - Wildau Scheme Career Map



Master 1.5 years program	Bachelor 4 years program: Transportation systems Engineering	Logistics	Industrial Engineering	Mechanical Engineering	Telematics		sum
Technical Management	1	1	1				3
Logistics and Supply Chain Management		1					1
Mechanical Engineering			1	1			2
Telematics					1		1

🟦 Transport & Logistics	🟥 Transport systems Engineering
🟪 Electrical Engineering	🟩 Railway Engineering
🟪 Vehicle Engineering	🟩 Mechanical Engineering
🟨 Infrastructure Engineering	🟧 Other studies

Figure 11 - Wildau Matrix Study Path

Technical University of Applied Sciences Wildau's matrix shows that their study paths consist of bachelor and master programmes. The resulting opportunities for graduates can be found on the operational and tactical levels of the RCM exclusively, which of these levels can be reached does not clearly depend on the level of degree obtained. The allocation to the rail careers matrix refers to the Transportation Systems Engineering Bachelor program and the Technical Management Master program. Those are the ones at TH Wildau most relevant for the rail sector. Further transport related study courses (like logistics) are not in the focus of this investigation regarding the rail careers matrix. Bachelor and master programmes are highly correlated as can be observed in the matrix. TH Wildau covers four rail related fields.

2.2.4 Zilinska Univerziate v Ziline

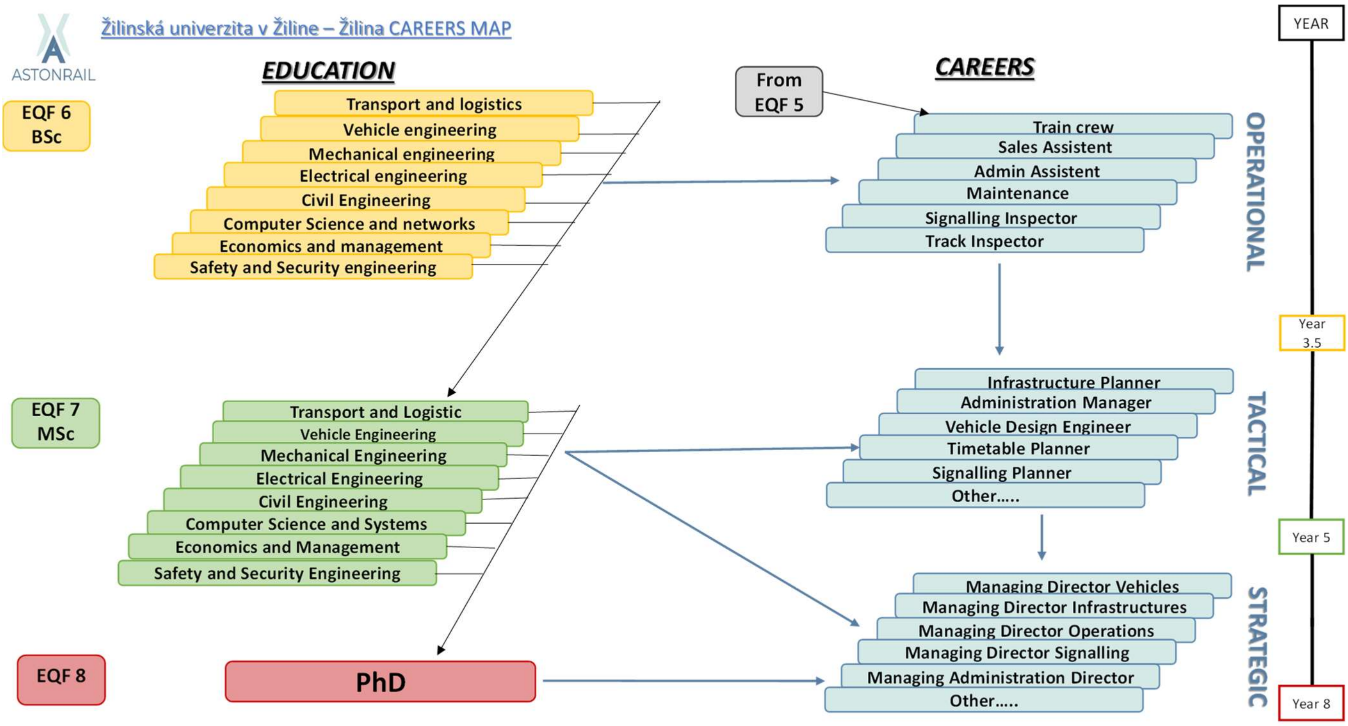
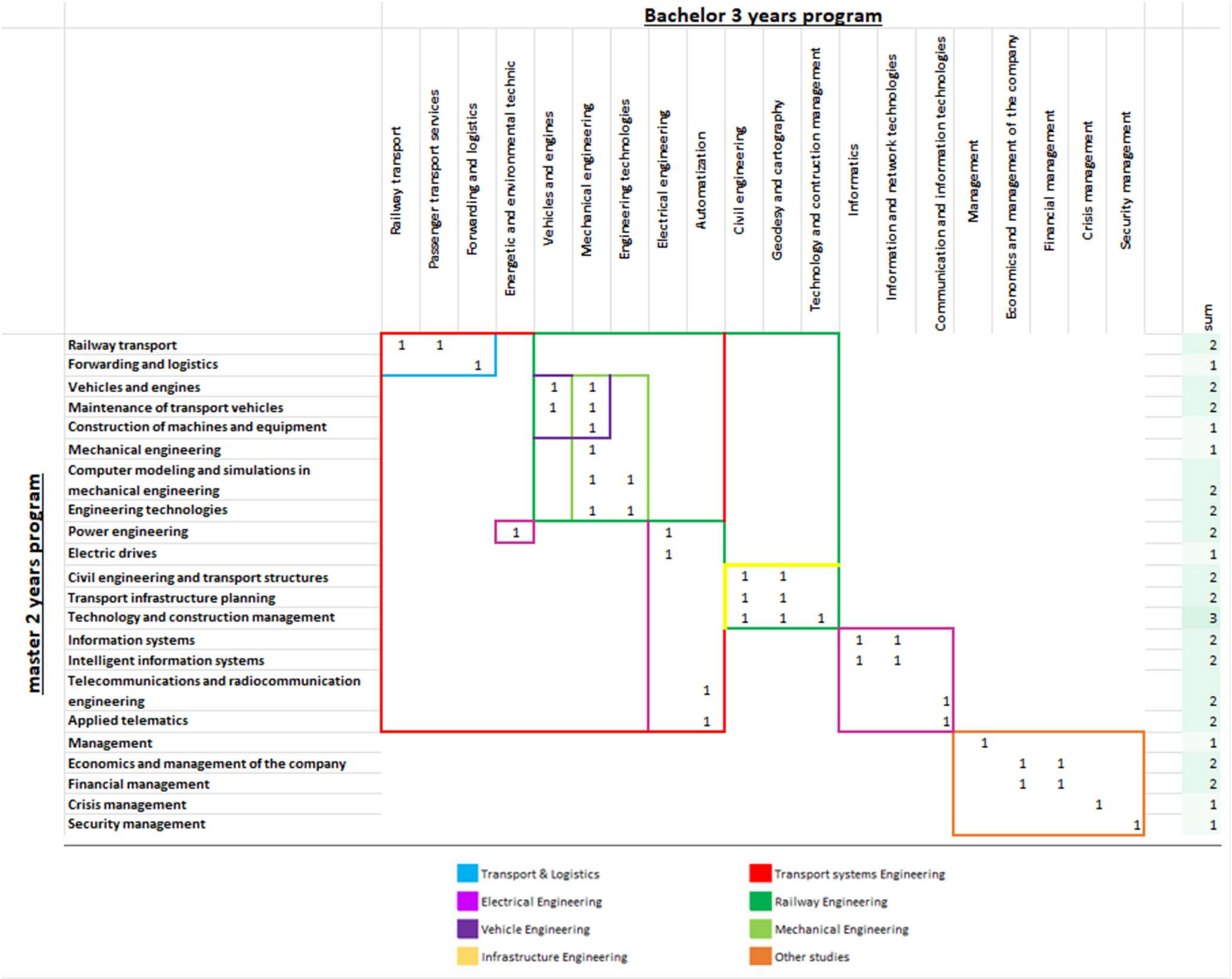


Figure 12 - Zilina Scheme Career Map



		Bachelor 3 years program																				
		Railway transport	Passenger transport services	Forwarding and logistics	Energetic and environmental technic	Vehicles and engines	Mechanical engineering	Engineering technologies	Electrical engineering	Automatization	Civil engineering	Geodesy and cartography	Technology and contruction management	Informatics	Information and network technologies	Communication and information technologies	Management	Economics and management of the company	Financial management	Crisis management	Security management	sum
master 2 years program	Railway transport	1	1																			2
	Forwarding and logistics			1																		1
	Vehicles and engines					1	1															2
	Maintenance of transport vehicles					1	1															2
	Construction of machines and equipment						1															1
	Mechanical engineering						1															1
	Computer modeling and simulations in mechanical engineering						1	1														2
	Engineering technologies						1	1														2
	Power engineering				1				1													2
	Electric drives								1													1
	Civil engineering and transport structures										1	1										2
	Transport infrastructure planning										1	1										2
	Technology and construction management										1	1	1									3
	Information systems													1	1							2
	Intelligent information systems													1	1							2
	Telecommunications and radiocommunication engineering									1						1						2
	Applied telematics									1						1						2
	Management																1					1
	Economics and management of the company																	1	1			2
	Financial management																	1	1			2
	Crisis management																			1		1
	Security management																				1	1

🟦 Transport & Logistics
🟪 Electrical Engineering
🟪 Vehicle Engineering
🟨 Infrastructure Engineering
🟥 Transport systems Engineering
🟩 Railway Engineering
🟩 Mechanical Engineering
🟧 Other studies

Figure 13 - Zilina Matrix Study Path

From the scheme it is possible to notice to study path is formed by: Bachelor's degree, master's degree and PHD. From the matrix it is possible to observe the high correlation between bachelor and master courses. Also, it is possible to notice that all the railway field are covered.

2.2.5 University of Malaga

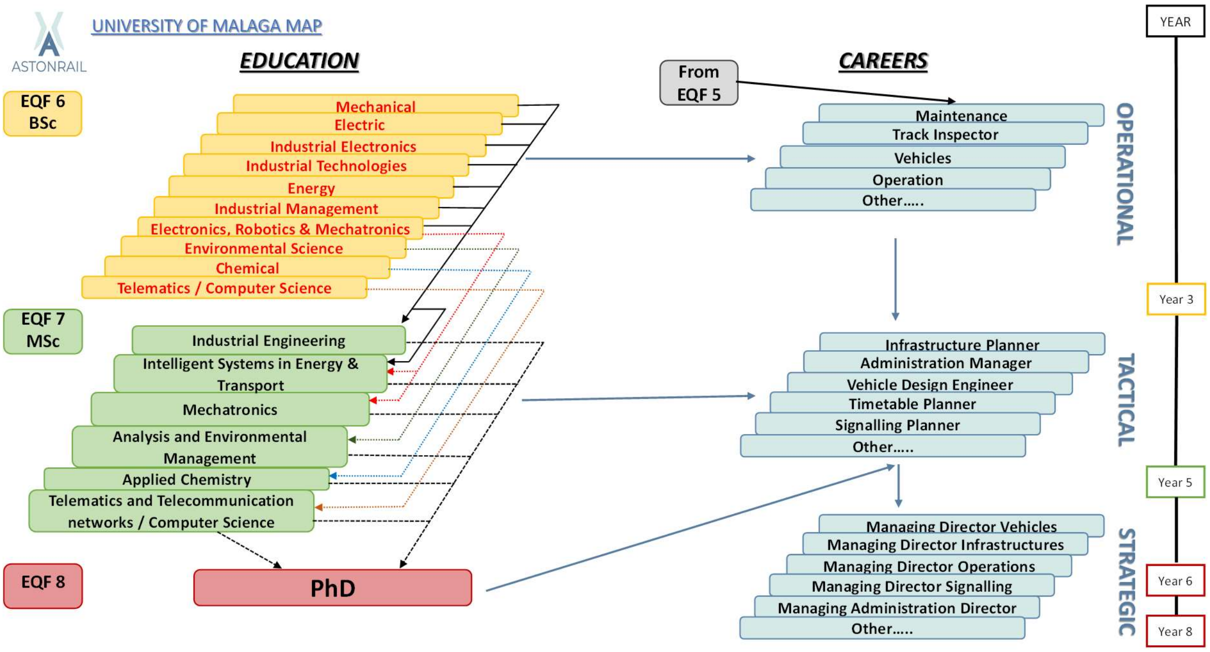
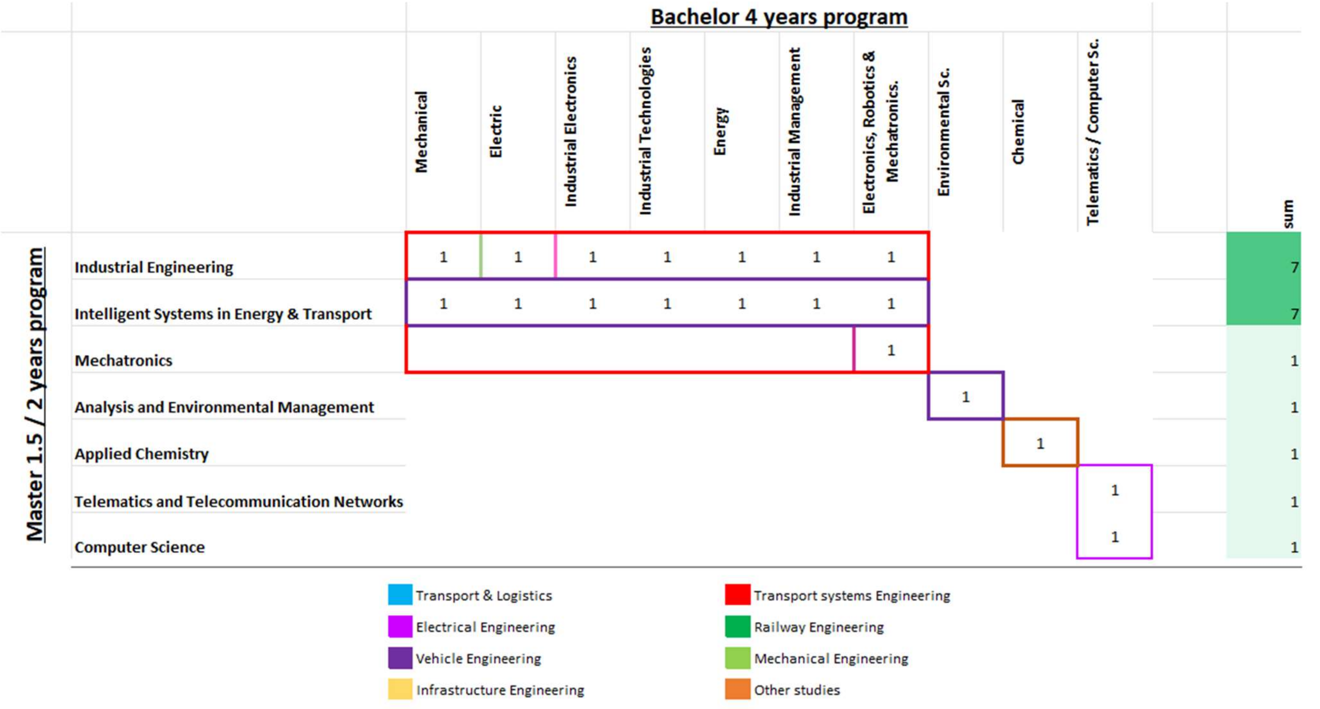


Figure 14 - Malaga Scheme Career Map



Bachelor 4 years program

Master 1.5 / 2 years program	Mechanical	Electric	Industrial Electronics	Industrial Technologies	Energy	Industrial Management	Electronics, Robotics & Mechatronics.	Environmental Sc.	Chemical	Telematics / Computer Sc.	sum
Industrial Engineering	1	1	1	1	1	1	1				7
Intelligent Systems in Energy & Transport	1	1	1	1	1	1	1				7
Mechatronics							1				1
Analysis and Environmental Management								1			1
Applied Chemistry									1		1
Telematics and Telecommunication Networks										1	1
Computer Science										1	1

🟦 Transport & Logistics	🟥 Transport systems Engineering
🟪 Electrical Engineering	🟩 Railway Engineering
🟪 Vehicle Engineering	🟩 Mechanical Engineering
🟨 Infrastructure Engineering	🟧 Other studies

Figure 15 - Malaga Matrix Study Path

The study paths at the University of Malaga are formed by bachelor's, master's, and PhDs. Two master programmes can be studies with several bachelor programmes as preconditions, the other master's, however, show higher correlation to the bachelor programmes. The University of Malaga covers five rail related fields.

2.2.6 University of Zagreb

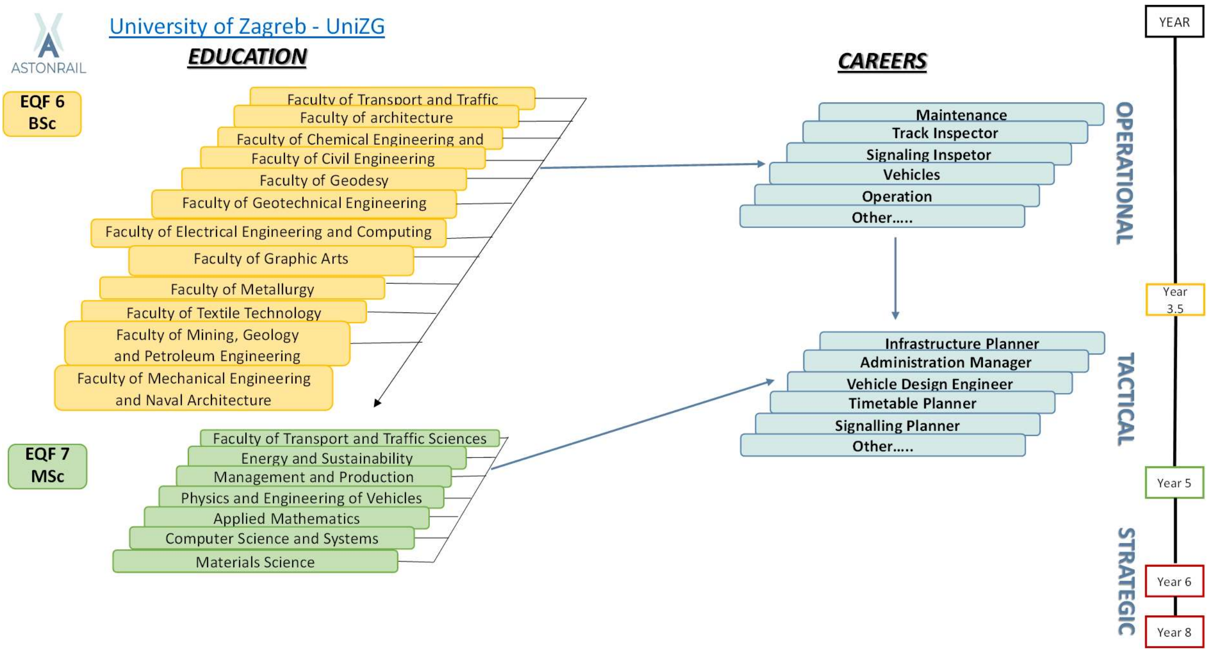


Figure 16 - Zagreb Scheme Career Map

		Bachelor 3 years program													
		Faculty of Transport and Traffic Sciences	Faculty of Architecture	Faculty of Chemical Engineering and	Faculty of Civil Engineering	Faculty of Electrical Engineering and	Faculty of Geodesy	Faculty of Geotechnical Engineering	Faculty of Graphic Arts	Faculty of Mechanical Engineering and Naval	Faculty of Metallurgy	Faculty of Mining, Geology and Petroleum Engineering	Faculty of Textile Technology		sum
master 2 years program	Traffic and Transport	1	1	1	1	1	1	1	1		1	1	1		11
	Intelligent Transport Systems and	1	1	1	1	1	1	1	1		1	1	1		11
	Aeronautics	1	1	1	1	1	1	1	1		1	1	1		11
	Architecture and Urban Planning	1	1	1	1	1	1	1	1		1	1	1		11
	Industrial Design	1	1	1	1	1	1	1	1		1	1	1		11
	Visual Communication Design	1	1	1	1	1	1	1	1		1	1	1		11
	Chemical Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Applied Chemistry	1	1	1	1	1	1	1	1		1	1	1		11
	Environmental Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Material Science and Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Chemical and Environmental	1	1	1	1	1	1	1	1		1	1	1		11
	Geotechnical Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Hydraulic Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Structural Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Construction Materials	1	1	1	1	1	1	1	1		1	1	1		11
	Construction Management	1	1	1	1	1	1	1	1		1	1	1		11
	Transportation Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Theory and Modelling of Structures	1	1	1	1	1	1	1	1		1	1	1		11
	Electrical Engineering and Information	1	1	1	1	1	1	1	1		1	1	1		11
	Information and Communication	1	1	1	1	1	1	1	1		1	1	1		11
	Computing	1	1	1	1	1	1	1	1		1	1	1		11
	Geodesy and Geoinformatics	1	1	1	1	1	1	1	1		1	1	1		11
	Enviornmental Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Printing Technology – Technical	1	1	1	1	1	1	1	1		1	1	1		11
	Mechanical Engineering	1	1	1	1	1	1	1	1	1	1	1	1		12
	Naval Architecture	1	1	1	1	1	1	1	1	1	1	1	1		12
	Aeronautical Engineering	1	1	1	1	1	1	1	1	1	1	1	1		12
	Metallurgy	1	1	1	1	1	1	1	1		1	1	1		11
	Mining Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Geology	1	1	1	1	1	1	1	1		1	1	1		11
	Geological Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Petroleum Engineering	1	1	1	1	1	1	1	1		1	1	1		11
	Textile Technology and Engineering	1	1	1	1	1	1	1	1		1	1	1		11

🟦 Transport & Logistics
🟥 Transport systems Engineering
🟪 Electrical Engineering
🟩 Railway Engineering
🟪 Vehicle Engineering
🟩 Mechanical Engineering
🟨 Infrastructure Engineering
🟧 Other studies

Figure 17 - Zagreb Matrix Study Path

The study path of “University of Zagreb” is formed by: Bachelor’s degree, master’s degree and PHD. From the matrix it is possible to notice that all the master courses can accept all bachelor courses without any condition.

2.3 Discussion

The matrixes and schemas of the partner universities above revealed rather substantial differences among the available study paths at the different institutions. These differences concern the number and spectrum of programmes, the accessibility of master programmes, the availability of postmaster and PhD programmes, as well as the resulting job opportunities.

This variety of paths with their different possibilities to reorientate during the studies makes it impossible to draw a complete picture of all the available study paths at the partners at once. What can be said though, that when starting in one of the generic fields outlined in the railway overview picture it is always possible to continue studying in this field up to the highest level (PhD).

This, however, is neither a big surprise, nor does it very accurately describe the situation at the different partner universities. Thus, we decided to have a closer look on what makes a study path and what characterises it, to obtain more accurate and meaningful results.

A study path is arguably most significantly defined by its end. For students who end their studies after a bachelor's degree, a simple look at a university's list of bachelor programs gives the answer to the available study paths. For master studies, it is not only the area of the master program itself, but also its accessibility from bachelor's level. Or in other words, how easy is it to enter a certain master program with a different bachelor's degree. We may call this criterion "permeability".

We defined an integer scale from 0 to 3 to assess the permeability of the various master programs:

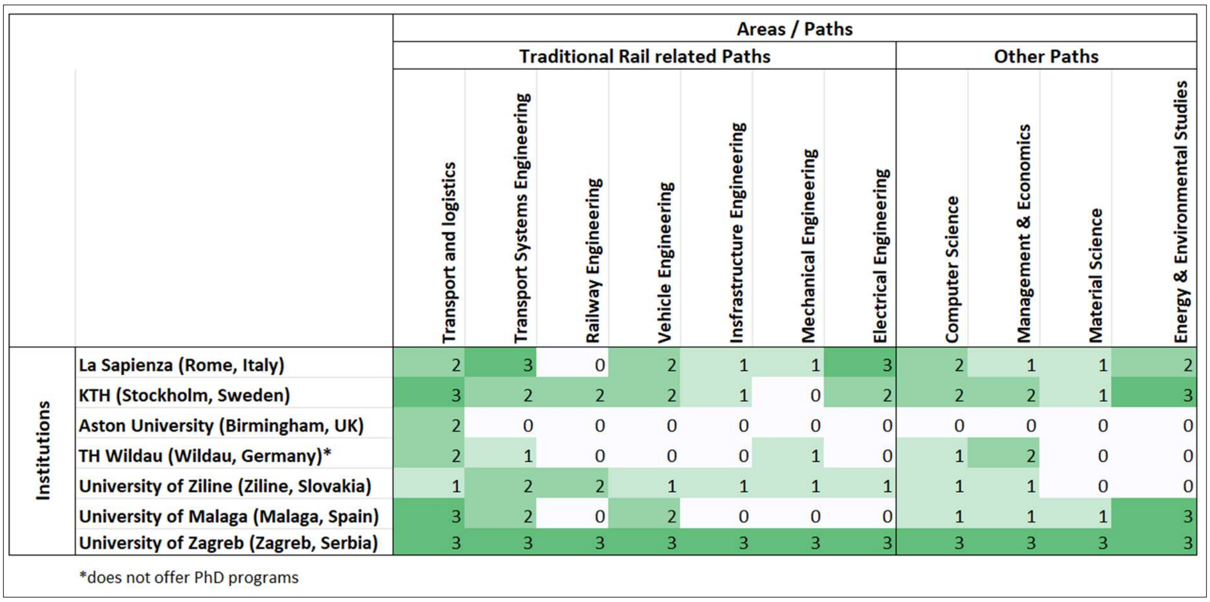
0 Master program(s) of this path not available

1 Master program(s) of this path are only accessible with a bachelors form the same path

2 Master program(s) of this path allow some permeability / are accessible with Bachelor's degrees from certain other paths

3 Master program(s) of this path are accessible with bachelor's from nearly all other paths offered by the university

Using this scale, we were able to draw a more complete picture of the actual availability of study paths at the institutions investigated (Figure 18). Some study paths are rather narrow, meaning that it is not possible to end one's studies in this path when not already starting one's bachelors in the respective field. These are Mechanical Engineering, Infrastructure Engineering as well as Material Science. Others, are highly permeable, given they are available. These are Transport and Logistics, Energy & Environmental Studies and up to a certain degree also Transport Systems Engineering. The permeability of the remaining paths mostly depends on each institution. University of Zagreb stands out, as all paths are highly permeable.



		Areas / Paths										
		Traditional Rail related Paths							Other Paths			
		Transport and logistics	Transport Systems Engineering	Railway Engineering	Vehicle Engineering	Insfrastructure Engineering	Mechanical Engineering	Electrical Engineering	Computer Science	Management & Economics	Material Science	Energy & Environmental Studies
Institutions	La Sapienza (Rome, Italy)	2	3	0	2	1	1	3	2	1	1	2
	KTH (Stockholm, Sweden)	3	2	2	2	1	0	2	2	2	1	3
	Aston University (Birmingham, UK)	2	0	0	0	0	0	0	0	0	0	0
	TH Wildau (Wildau, Germany)*	2	1	0	0	0	1	0	1	2	0	0
	University of Ziline (Ziline, Slovakia)	1	2	2	1	1	1	1	1	1	0	0
	University of Malaga (Malaga, Spain)	3	2	0	2	0	0	0	1	1	1	3
	University of Zagreb (Zagreb, Serbia)	3	3	3	3	3	3	3	3	3	3	3

*does not offer PhD programs

Figure 18 - Study paths at the different universities including the permeability criterion

The conclusions above raise the question of the borders and definitions of the fields from the railways overview picture themselves. Here we want to draw special attention to the field "others" as its definition is particularly blurry and not having a concrete name does indicate a lack of knowledge.

At various times during the preparation of this report, we were confronted with our own traditional perception of the railway industry. The fields apart from "other” indicate this. There are no fields called "Data Science", "IT", “Environmental Studies", "Project & Quality Management", "Security & Risk Management" and many others remain unnamed parts of “others". The findings from WP 3.2 (below), however, outline these skills as important for the industry. We must thus clearly admit that we did not capture all relevant rail related fields in the railway overview picture and thus in the present study paths. We did however try to include some “others” when building Figure 18.

Nevertheless, the railway overview picture and the present research remain important and useful as in many cases the missing fields listed above are considered as necessary additions to more traditional studies. Engineers and logisticians are expected to not only fulfil the traditional requirements, but to have versatile complementary knowledge beyond.

3 Task 3.2 Railway sector needs and expectations

Task coordinator: KTH;

This section analyses the needs and expectations of the railway industry regarding the skills and education of the future workforce. The objective of this report is to determine a number of groups of skills that require special attention, i.e. where improvement in the education is needed.

3.1 Methodology

In the two industry surveys (WP 2.2), companies from the railway sector were asked to state particular skills future employees are supposed to have. This data serves as the basis for the present analysis.

To confirm the *stated* preference data from the industry surveys, it is compared to the revealed preferences from the investigated job offers (WP 2.3). Since the data from the job offers is way less specific than in the surveys, we grouped the single skills in "skill groups" to facilitate the comparison.

Finally for each Rail Careers Matrix (RCM) level (European surveys) and for the German survey the five most demanded skills are selected.

3.2 Survey data - stated preferences

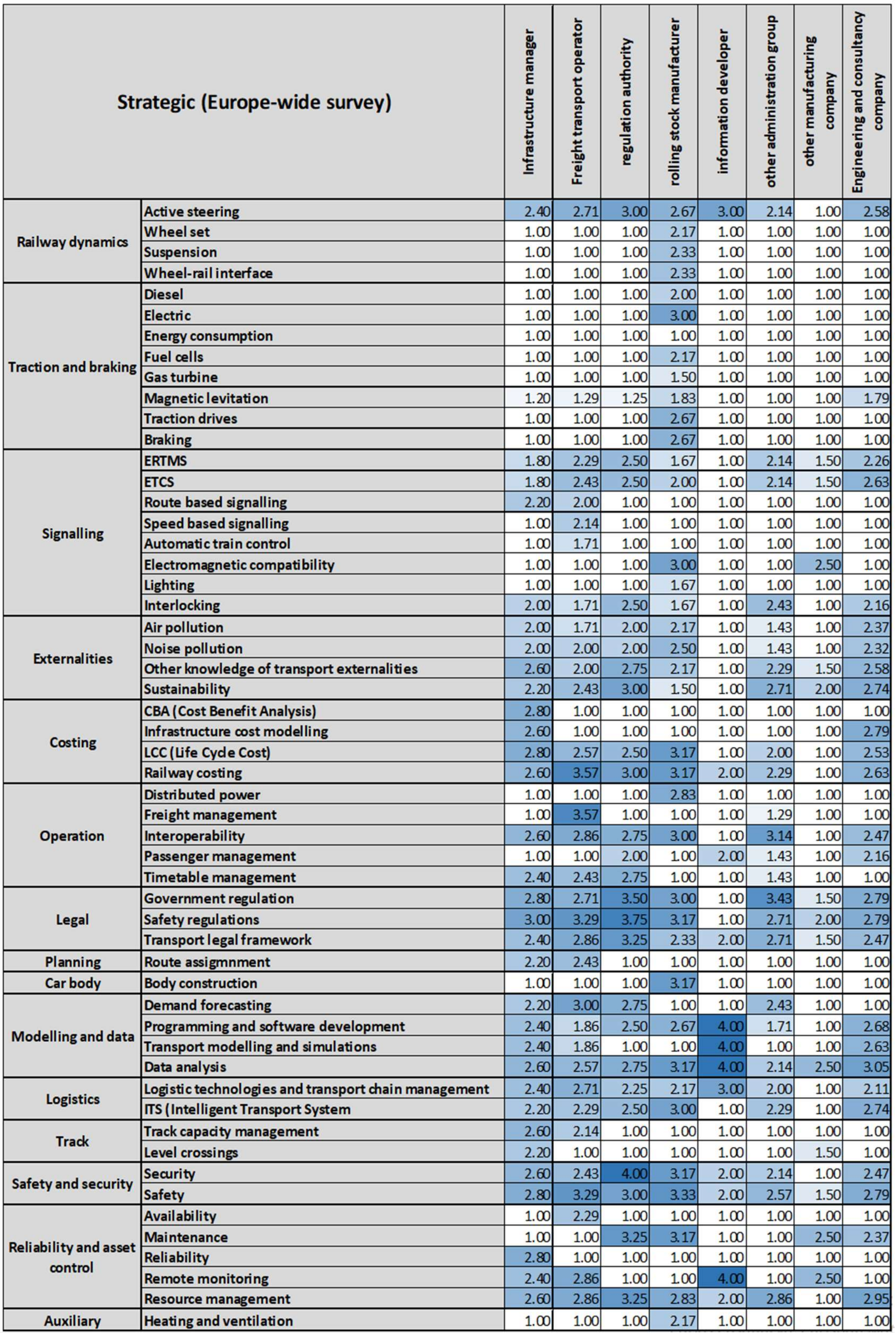
The data from the surveys has been split in four parts. There is one part for each of the three Rail Careers Matrix (RCM) levels operational, tactical and strategic from the Europe-wide survey. The fourth part contains information from the German survey, here no distinction by RCM level has been made. As part of the evaluation of these four different data sets, a score from 1 to 4 (low to high demand) was associated for all different types of companies and all skills. Table *1* shows an example of these scores.

3.3 Comparison with job offers data - revealed preferences

As already mentioned above, the data from the surveys is to be compared with data drawn from the investigation of job offers. This is to confirm the validity of the data obtained from the surveys.

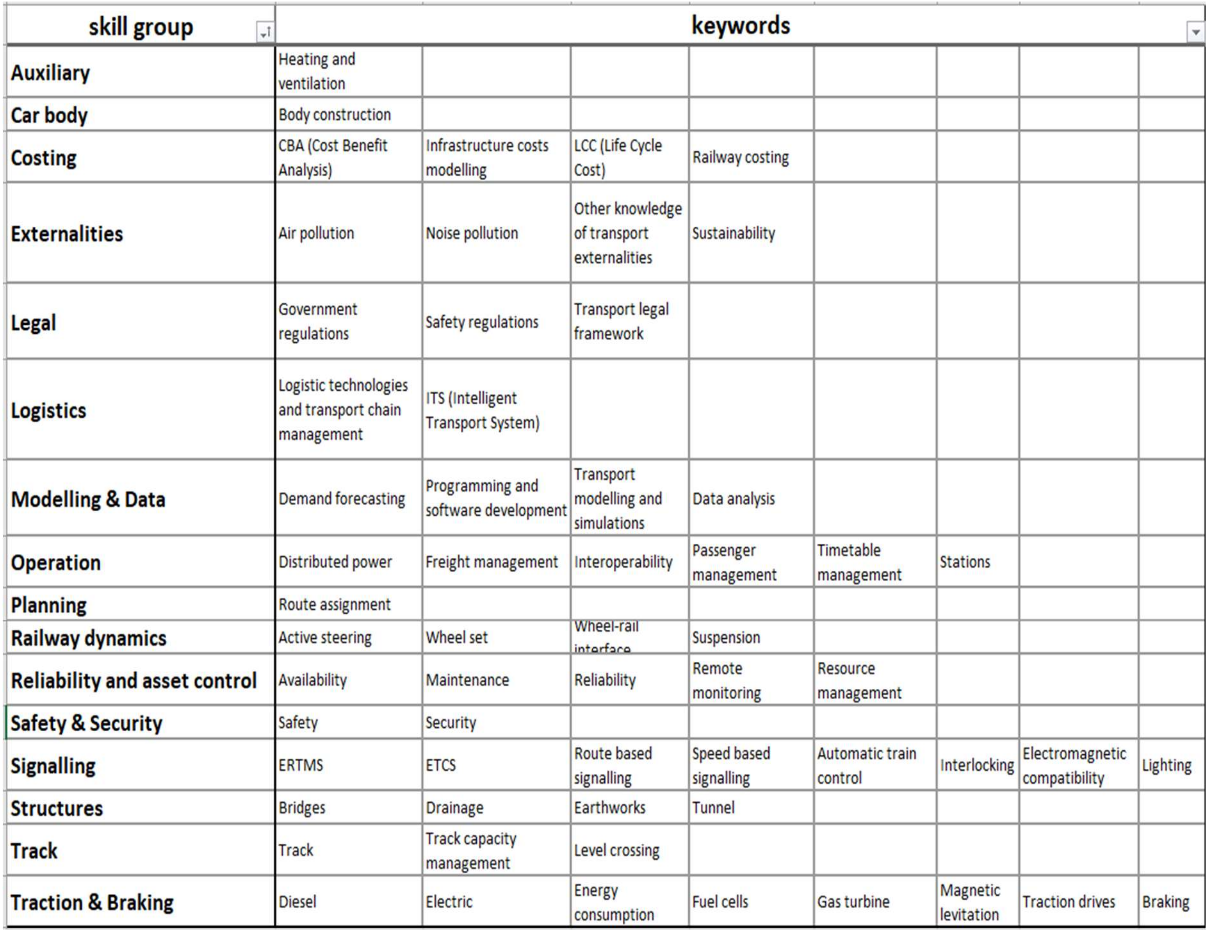
Since the data from the job offers is not as detailed it does not allow for a "skill by skill" comparison. Thus we introduced skill groups as demonstrated in Table *2*. As shown in Table *1*, the different skills have been grouped into these, to facilitate the comparison with the data from the investigated job offers.

Table 1: Example for survey evaluation results (Strategic - Europe-wide survey)



Strategic (Europe-wide survey)		Infrastructure manager	Freight transport operator	regulation authority	rolling stock manufacturer	information developer	other administration group	other manufacturing company	Engineering and consultancy company
Railway dynamics	Active steering	2.40	2.71	3.00	2.67	3.00	2.14	1.00	2.58
	Wheel set	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00
	Suspension	1.00	1.00	1.00	2.33	1.00	1.00	1.00	1.00
	Wheel-rail interface	1.00	1.00	1.00	2.33	1.00	1.00	1.00	1.00
Traction and braking	Diesel	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00
	Electric	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00
	Energy consumption	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fuel cells	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00
	Gas turbine	1.00	1.00	1.00	1.50	1.00	1.00	1.00	1.00
	Magnetic levitation	1.20	1.29	1.25	1.83	1.00	1.00	1.00	1.79
	Traction drives	1.00	1.00	1.00	2.67	1.00	1.00	1.00	1.00
	Braking	1.00	1.00	1.00	2.67	1.00	1.00	1.00	1.00
Signalling	ERTMS	1.80	2.29	2.50	1.67	1.00	2.14	1.50	2.26
	ETCS	1.80	2.43	2.50	2.00	1.00	2.14	1.50	2.63
	Route based signalling	2.20	2.00	1.00	1.00	1.00	1.00	1.00	1.00
	Speed based signalling	1.00	2.14	1.00	1.00	1.00	1.00	1.00	1.00
	Automatic train control	1.00	1.71	1.00	1.00	1.00	1.00	1.00	1.00
	Electromagnetic compatibility	1.00	1.00	1.00	3.00	1.00	1.00	2.50	1.00
	Lighting	1.00	1.00	1.00	1.67	1.00	1.00	1.00	1.00
	Interlocking	2.00	1.71	2.50	1.67	1.00	2.43	1.00	2.16
Externalities	Air pollution	2.00	1.71	2.00	2.17	1.00	1.43	1.00	2.37
	Noise pollution	2.00	2.00	2.00	2.50	1.00	1.43	1.00	2.32
	Other knowledge of transport externalities	2.60	2.00	2.75	2.17	1.00	2.29	1.50	2.58
	Sustainability	2.20	2.43	3.00	1.50	1.00	2.71	2.00	2.74
Costing	CBA (Cost Benefit Analysis)	2.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Infrastructure cost modelling	2.60	1.00	1.00	1.00	1.00	1.00	1.00	2.79
	LCC (Life Cycle Cost)	2.80	2.57	2.50	3.17	1.00	2.00	1.00	2.53
	Railway costing	2.60	3.57	3.00	3.17	2.00	2.29	1.00	2.63
Operation	Distributed power	1.00	1.00	1.00	2.83	1.00	1.00	1.00	1.00
	Freight management	1.00	3.57	1.00	1.00	1.00	1.29	1.00	1.00
	Interoperability	2.60	2.86	2.75	3.00	1.00	3.14	1.00	2.47
	Passenger management	1.00	1.00	2.00	1.00	2.00	1.43	1.00	2.16
	Timetable management	2.40	2.43	2.75	1.00	1.00	1.43	1.00	1.00
Legal	Government regulation	2.80	2.71	3.50	3.00	1.00	3.43	1.50	2.79
	Safety regulations	3.00	3.29	3.75	3.17	1.00	2.71	2.00	2.79
	Transport legal framework	2.40	2.86	3.25	2.33	2.00	2.71	1.50	2.47
Planning	Route assigmnment	2.20	2.43	1.00	1.00	1.00	1.00	1.00	1.00
Car body	Body construction	1.00	1.00	1.00	3.17	1.00	1.00	1.00	1.00
Modelling and data	Demand forecasting	2.20	3.00	2.75	1.00	1.00	2.43	1.00	1.00
	Programming and software development	2.40	1.86	2.50	2.67	4.00	1.71	1.00	2.68
	Transport modelling and simulations	2.40	1.86	1.00	1.00	4.00	1.00	1.00	2.63
	Data analysis	2.60	2.57	2.75	3.17	4.00	2.14	2.50	3.05
Logistics	Logistic technologies and transport chain management	2.40	2.71	2.25	2.17	3.00	2.00	1.00	2.11
	ITS (Intelligent Transport System	2.20	2.29	2.50	3.00	1.00	2.29	1.00	2.74
Track	Track capacity management	2.60	2.14	1.00	1.00	1.00	1.00	1.00	1.00
	Level crossings	2.20	1.00	1.00	1.00	1.00	1.00	1.50	1.00
Safety and security	Security	2.60	2.43	4.00	3.17	2.00	2.14	1.00	2.47
	Safety	2.80	3.29	3.00	3.33	2.00	2.57	1.50	2.79
Reliability and asset control	Availability	1.00	2.29	1.00	1.00	1.00	1.00	1.00	1.00
	Maintenance	1.00	1.00	3.25	3.17	1.00	1.00	2.50	2.37
	Reliability	2.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Remote monitoring	2.40	2.86	1.00	1.00	4.00	1.00	2.50	1.00
	Resource management	2.60	2.86	3.25	2.83	2.00	2.86	1.00	2.95
Auxiliary	Heating and ventilation	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00

Table 2: Skill groups



skill group	keywords							
Auxiliary	Heating and ventilation							
Car body	Body construction							
Costing	CBA (Cost Benefit Analysis)	Infrastructure costs modelling	LCC (Life Cycle Cost)	Railway costing				
Externalities	Air pollution	Noise pollution	Other knowledge of transport externalities	Sustainability				
Legal	Government regulations	Safety regulations	Transport legal framework					
Logistics	Logistic technologies and transport chain management	ITS (Intelligent Transport System)						
Modelling & Data	Demand forecasting	Programming and software development	Transport modelling and simulations	Data analysis				
Operation	Distributed power	Freight management	Interoperability	Passenger management	Timetable management	Stations		
Planning	Route assignment							
Railway dynamics	Active steering	Wheel set	Wheel-rail interface	Suspension				
Reliability and asset control	Availability	Maintenance	Reliability	Remote monitoring	Resource management			
Safety & Security	Safety	Security						
Signalling	ERTMS	ETCS	Route based signalling	Speed based signalling	Automatic train control	Interlocking	Electromagnetic compatibility	Lighting
Structures	Bridges	Drainage	Earthworks	Tunnel				
Track	Track	Track capacity management	Level crossing					
Traction & Braking	Diesel	Electric	Energy consumption	Fuel cells	Gas turbine	Magnetic levitation	Traction drives	Braking

To determine the most demanded skills among the investigated job offers, each job offer was manually assigned one of the skill groups. In some cases it was not possible to assign the individual offers to a skill group. This was either due to a lack of information in the present data or to the fact that the offers required skills that were not among those investigated in the surveys. Unfortunately, the original information was not accessible anymore, as the job offers had been collected several months prior to the time of the present analysis.

In the "European job offers" (all job offers except from GER and AUT) (n=172) 37% of job offer could not be assigned to one of the skill groups above (Table *2*). These 37% consisted of 15% requiring Management related skills, 3% requiring System Engineering skills and 2% requiring Business skills. The remaining 18% simply did not offer enough information.

In the "German job offers" (job offers from GER and AUT) (n=60) 25% of job offer could not be assigned to one of the skill groups. These 25% consisted of 8% requiring Management related skills, 3% requiring System Engineering skills and 5% requiring Business skills. The remaining 8% did not offer enough information.

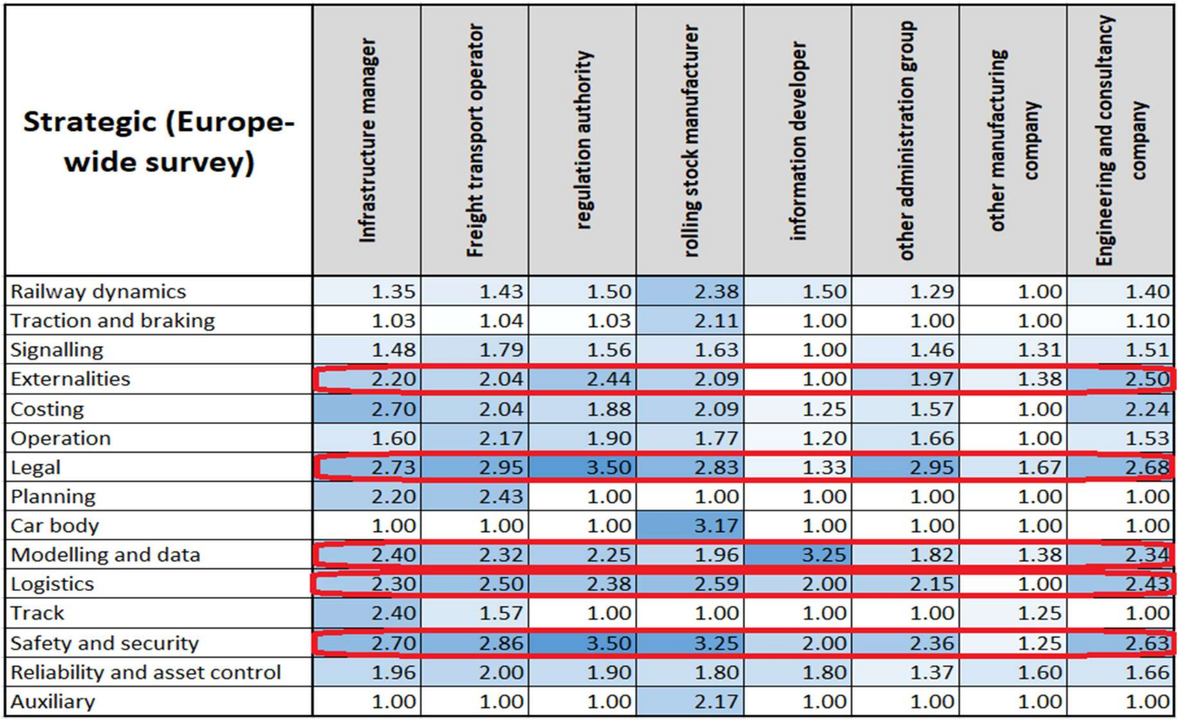
The 63%/75% (Europe/GER+AUT) could be assigned one of the skill groups were used for the comparison with the data from the survey. To facilitate this, the number of job offers from one company category requiring a certain skill group was divided by the total number of job offers from this company category, resulting in a score between zero and one. This was done for all above mentioned sub datasets (operational, tactical, strategic and German). Table *3* shows an example.

Table 3: Example of Skill group specific evaluation obtained from job offers

Strategic	Developer/manufacturer of control and safety technology in rail transport	Development/ supply of information in rail transport	Economics company	Engineering/ consulting company	Freight transport company	Infrastructure manager	Manufacturer of rail vehicles or rail vehicle equipment	Other manufacturing company of the railway industry	Passenger transport company	Regulation authority
Auxiliary	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Car body	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000
Costing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Externalities	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Legal	0.0000	0.0000	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000
Logistics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Modelling & Data	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000
Operation	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Planning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Railway dynamics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Reliability & Asset management	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000
Safety & Security	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Signalling	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Structures	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Track	0.0000	0.0000	0.0000	0.2857	0.0000	0.1667	0.0000	0.0000	0.2500	0.0000
Traction & Braking	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The skill specific data from the surveys had to be generalised per skill group. For this matter a mean value for each skill group was used. Table *4* shows an example.

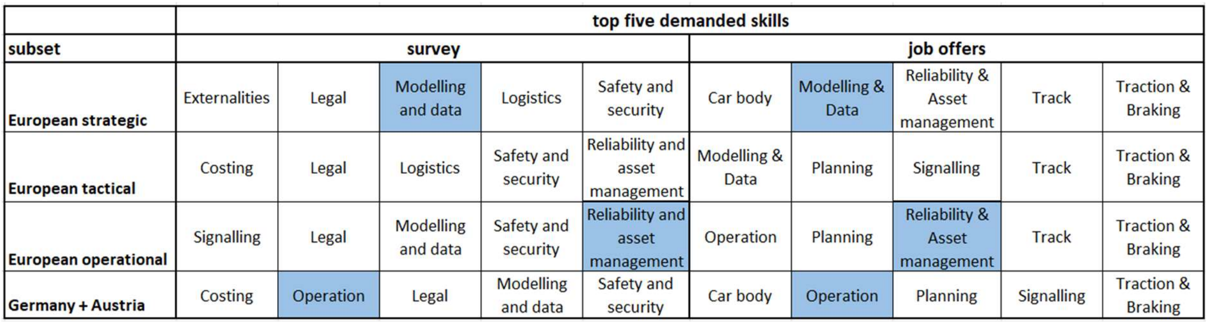
Table 4: Example of Skill group specific evaluation obtained from surveys



Strategic (Europe-wide survey)	Infrastructure manager	Freight transport operator	regulation authority	rolling stock manufacturer	information developer	other administration group	other manufacturing company	Engineering and consultancy company
Railway dynamics	1.35	1.43	1.50	2.38	1.50	1.29	1.00	1.40
Traction and braking	1.03	1.04	1.03	2.11	1.00	1.00	1.00	1.10
Signalling	1.48	1.79	1.56	1.63	1.00	1.46	1.31	1.51
Externalities	2.20	2.04	2.44	2.09	1.00	1.97	1.38	2.50
Costing	2.70	2.04	1.88	2.09	1.25	1.57	1.00	2.24
Operation	1.60	2.17	1.90	1.77	1.20	1.66	1.00	1.53
Legal	2.73	2.95	3.50	2.83	1.33	2.95	1.67	2.68
Planning	2.20	2.43	1.00	1.00	1.00	1.00	1.00	1.00
Car body	1.00	1.00	1.00	3.17	1.00	1.00	1.00	1.00
Modelling and data	2.40	2.32	2.25	1.96	3.25	1.82	1.38	2.34
Logistics	2.30	2.50	2.38	2.59	2.00	2.15	1.00	2.43
Track	2.40	1.57	1.00	1.00	1.00	1.00	1.25	1.00
Safety and security	2.70	2.86	3.50	3.25	2.00	2.36	1.25	2.63
Reliability and asset control	1.96	2.00	1.90	1.80	1.80	1.37	1.60	1.66
Auxiliary	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00

The red borders Table *3* and Table *4* signify the most demanded skills. In the subset *strategic* of the European survey the most demanded skills according to the survey are *car body, modelling and data, reliability & asset management, track* and *traction and braking.* According to the investigated job offers the most demanded skills in the same subset are *externalities, legal, modelling and data, logistics and safety* and *security*. Since the most demanded skills obtained from the survey overlap in just one case (*modelling and data*) with the ones obtained from the job offers, we must conclude that the revealed preference do not confirm the data from the gathered from the surveys. As Table *5* shows, this is also not the case for the other subsets (the overlaps are marked in blue).

Table 5: Overlap of top 5 skills between surveys and job offers



	top five demanded skills									
subset	**survey**					**job offers**				
European strategic	Externalities	Legal	Modelling and data	Logistics	Safety and security	Car body	Modelling & Data	Reliability & Asset management	Track	Traction & Braking
European tactical	Costing	Legal	Logistics	Safety and security	Reliability and asset management	Modelling & Data	Planning	Signalling	Track	Traction & Braking
European operational	Signalling	Legal	Modelling and data	Safety and security	Reliability and asset management	Operation	Planning	Reliability & Asset management	Track	Traction & Braking
Germany + Austria	Costing	Operation	Legal	Modelling and data	Safety and security	Car body	Operation	Planning	Signalling	Traction & Braking

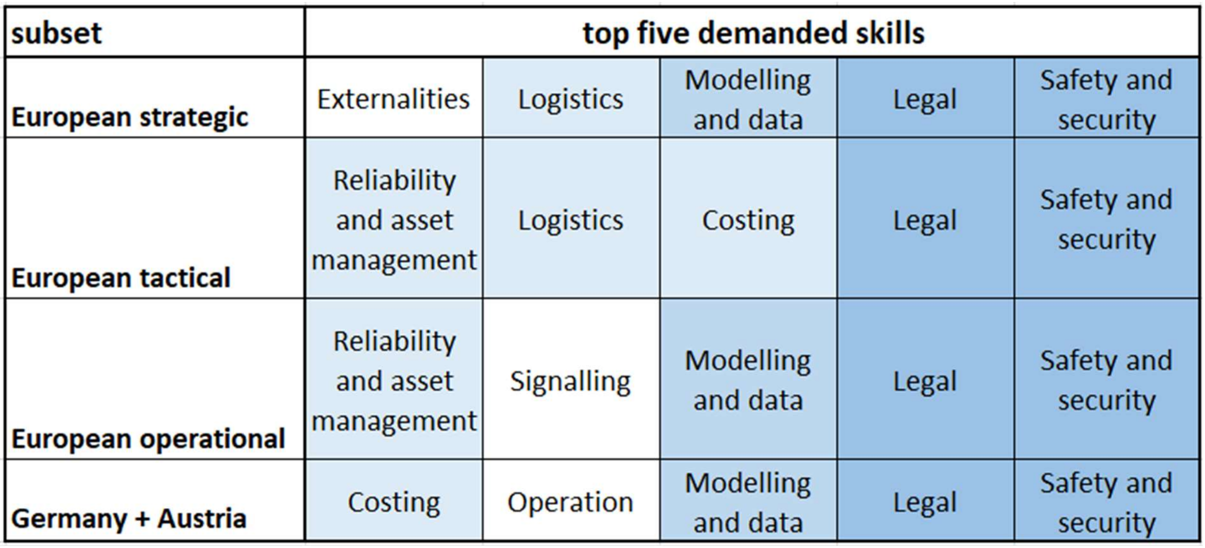
The job market analysis has some limitations though. It does not necessarily include the bigger gaps or needs in the railway market, but the jobs that have a higher density (i.e. there are lots of that specific category employed in the sector) or have bigger turnover (people change jobs more often in that sector). Additionally, the sampling has been done with a specific keyword in mind, “railway”, which might also limit the results obtained from the job offers, e.g. won’t cover consultant companies working in broader infrastructure related projects, or component suppliers that provide a specific component in the railway system. Furthermore, each job offer (n=170+60) covers only one position, while for the surveys with a much smaller n, each one answers for all the possible job categories thy have been asked for directly targeting skill and knowledge gaps.

Because of this, we believe that the data from the surveys is a more reliable source, as it is directly targeting the explicit gaps in the industry. The conclusion is that the relevant top demanded skill groups can be obtained from the survey-based top 5 evaluation.

3.4 Results

The relevant top five skill groups for each of the subsets can be found in Table *6*. The colours signify how many times the particular skill is mentioned among the subsets. the data are essentially identical with the data presented on the left-hand side of Table *5*.

Table 6: Most demanded skill groups for each subset



subset	**top five demanded skills**				
European strategic	Externalities	Logistics	Modelling and data	Legal	Safety and security
European tactical	Reliability and asset management	Logistics	Costing	Legal	Safety and security
European operational	Reliability and asset management	Signalling	Modelling and data	Legal	Safety and security
Germany + Austria	Costing	Operation	Modelling and data	Legal	Safety and security

3.5 Discussion

Dealing with data from surveys always implies some uncertainty about whether the responses given are actually true and valid. In order to deal with the stated preferences we tried to confirm the findings from the survey by using the job offers investigated in WP 2.3. Unfortunately this was not possible. The rather low number of job offers, the non-systematic approach in their acquirement as well as the manual classification into skill groups introduced a lot of uncertainty concerning the job offers.

4 Task 3.3 Parallel experiences

4.1 Benchmarking of parallel experiences

There are many definitions of Benchmarking; we can say that leading authors make their own definition. Etymologically the word originates from two English words (1) bench and (2) mark. The bench can be explained as a workbench or working table and the mark can be explained as a goal (sign) or measure, so benchmark means a point of reference – standard – model. In today's sciences, benchmarking is defined as a method (process, tool) of continuous and systematic comparison of own solutions with the best practices in a given sector (usually of competitors'), using the experience of others, and improvement through learning from others. Improvements may concern services, processes, management methods, organisational structures or their elements. [1]

In our research, we shall investigate parallel experiences using the benchmarking approach. Parallel experiences mean analysing other study programs in the same institution. So, in each institution, we find out the best practice study program that is non-railway.
That benchmarking can be efficient, and we need to establish a methodology. The first step is collecting data. Collecting data at this stage is desktop research. But of course, some short free form interviews with colleagues from this study can better understand the study form. In this step, the necessary data that needs to be collected is a complete curriculum. From the curriculum, we need to detailed analysis following parameters:

1. List of courses with ECTS,
2. Teaching hours divided by type (lecture, field, …),
3. Dividing courses by obligation type (obligatory or elective),
4. Determine the ratio of general and specific courses (non-engineering vs engineering),
5. Dividing courses by focus (for example: mathematical, economy, law, …),
6. Determine the ratio of "home base" lectures and invited lecturers, and
7. Interesting facts about parallel experiences.

In the second step, we made a light statistical analysis of the gathered data. In the third step, we are making a comparative analysis between two programs. At step forth, we can conclude best and worst practices. In the last, respectively, step five, we concluded with lessons learned. For a better understanding of the methodology on Figure 19 - Block diagram of the methodology is shown a block diagram.

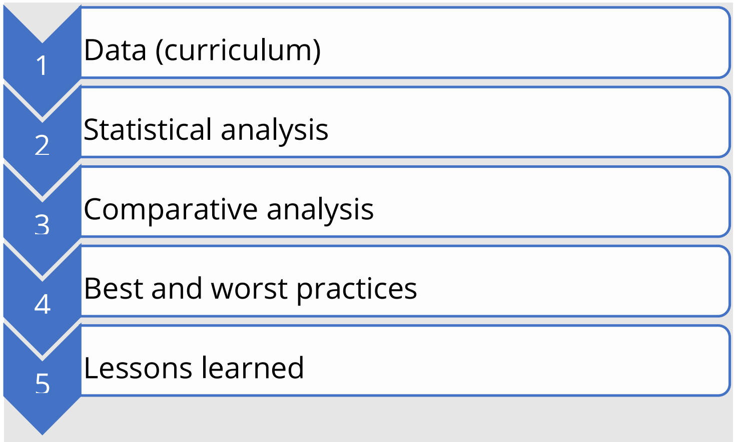


Figure 19 - Block diagram of the methodology

4.1.1 UNIZG

Brief overview of the University of Zagreb

The beginnings of the university date back to 23 September 1669, when the Emperor and King Leopold I Habsburg issued a decree granting the establishment of the Jesuit Academy of the Royal Free City of Zagreb. According to that document, the study of philosophy in Zagreb acquired a formal and legal status as Neoacademia Zagrabiensis and officially became a public institution of higher education.

In 1776, Empress and Queen Maria Theresa issued a decree founding the Royal Academy of Science (Latin: Regia Scientiarum Academia). It consisted of three studies, or faculties: philosophy, theology, and law. The former political-cameral studies became part of the newly established faculty of law, and thus were integrated into the academy. Each of the faculties of the Royal Academy of Sciences had several chairs teaching one or several courses.

In 1861, Bishop Josip Juraj Strossmayer proposed the founding of a University at Zagreb to the Croatian Parliament. During a visit in 1869, the Emperor Franz Joseph signed the decree establishing the University of Zagreb. Five years later, the Parliament passed the Act of Founding, which was ratified by the Emperor on 5 January 1874. On 19 October 1874, a ceremony was held marking the foundation of the Royal University of Franz Joseph I in Zagreb, making it the third university in the Hungarian realm of the Austro-Hungarian Empire. In 1874, the university had four faculties: Law, Theology, Philosophy, and Medicine.

In 1919, of the School of Technology was founded, and it became a faculty at the university in 1926. This was the core of the development of technical studies at the University of Zagreb. In 1926, the university was composed of seven faculties and one of them was Technology, which had the following departments: Construction, Engineering (concentrating on mechanical engineering), and Chemical engineering.

After the Second World War there were several restructurings and reorganisations of the University.

The University is research oriented, contributing over 50% to the total research output of the country.
The University is organised in six main fields: Arts, Biomedicine, Biotechnology, Engineering, Humanities, Natural, and Social Sciences. It has 29 faculties and 3 art academies.

The Engineering field is covered by the following Faculties: Faculty of Architecture; Faculty of Chemical Engineering and Technology; Faculty of Civil Engineering; Faculty of Electrical Engineering and Computing; Faculty of Geodesy; Faculty of Geotechnics; Faculty of Graphic Arts; Faculty of Mechanical Engineering and Naval Architecture; Faculty of Metallurgy; Faculty of Mining, Geology and Petroleum Engineering; Faculty of Textile Technology and the Faculty of Transport and Traffic Sciences.

Today the University has fully implemented the European Credit Transfer System (ECTS) (since 1999) and introduced the Bologna System (from AY 2005/2006).

Currently, the University of Zagreb has around 70,000 students and around 8,000 academic staff. [2]

Overview of the Faculty of Transport and Traffic Sciences
The Faculty of Transport and Traffic Sciences (FTTS) at the University of Zagreb is the leading higher education as well as scientific and research institution in the field of traffic and transport engineering in the Republic of Croatia. The FTTS has 182 employees, of which 121 are members of the teaching staff and 61 work in administration and other areas. There are 2,162 students enrolled.

The mission of the FTTS is to provide quality undergraduate, graduate and postgraduate education, research, and professional work for successful participation in the development of effective, efficient and sustainable transport systems. The FTTS offers programmes in Traffic and Transport, Intelligent Transport Systems and Logistics, and Aeronautics. The Traffic and Transport curriculum of includes courses in Road, Railway, Urban, Air, Waterway, Postal, and Information and Communication Transport and Traffic. All programmes are taught at the three-year undergraduate (180 ECTS) and two-year graduate (120 ECTS) levels. Postgraduate studies provide three-year Doctoral Studies in the field of Transport and Traffic Engineering, as well as one-year Specialist Studies in Urban Transport and Traffic, Inter-modal Transport and Traffic, and Transport Logistics and Management.

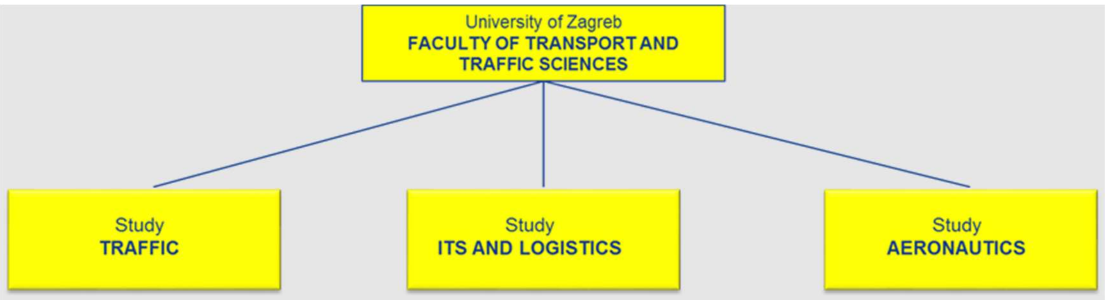


Figure 20 - Organisation of studies at FTTSSource: Presentation of FTTS for AY 2016/2017 (Erasmus+ program)

The FTTS conducts scientific, developmental and professional research in accordance with high international standards and participates in national, regional and international scientific, research and development projects of strategic importance for Croatia. It is funded by the national Ministry of Science, Education and Sports, the European Commission and international institutions. The FTTS also participates in public and commercial projects which resolve transport and traffic problems in Croatia. The FTTS is systematically developing a nationally and internationally recognisable standard of excellence in education and research in all branches of transport and the synergistic effects of their interaction and development. This is done with the aim of establishing a system of transfer and application of knowledge for the benefit and prosperity of the entire society.

Key research activities include research activities into transport and traffic technologies, logistics, intelligent transport systems (ITS), aeronautics and related fields, as well as the application of research results in the teaching process and education required for solving practical transport problems.

The key actors at the FTTS are the undergraduate, graduate and postgraduate students as well as the young scientists employed there. The FTTS provides them with research and training facilities, laboratories, computer workshops and simulators at the Borongaj University Campus, Lučko Airport, and the 93rd Air Base at Zemunik near Zadar. The FTTS publishes the scientific journal PROMET – Traffic & Transportation, cited in SCIE, and also offers mentoring to postgraduate students while supporting and encouraging student and teacher mobility through EU programmes such as Erasmus+.

FTTS is organised into departments and chairs that which follow the organisation of the study programmes: independent departments and chairs, departments of division of transport and traffic, departments of division of intelligent transport systems and logistics and departments of division of aeronautics. The independent departments are the Department of Traffic Accident Expertise, Department of Traffic Signalling, and the Department of Transport Planning. The independents chairs are the Chair of Transport Environmental Impact, Chair of Transport Law and Economics, Chair of Transport Infrastructure, Chair of Fundamental Courses, Chair of Applied Mathematics and Statistics, and the Chair of Foreign Languages. Departments of the division of transport and traffic included the Department of Air Transport, Department of Information and Communications Traffic, Department of Postal Transport, Department of Road Transport, Department of Urban Transport, and the Department of Water Transport. Each of these departments has one chair each for transport technology and one chair for transport engineering.

FTTS has the following laboratories: the Aerodynamics Laboratory, the Department of Traffic Signalling Testing Laboratory, the Flight Simulation Laboratory, the Intelligent Transportation Systems Laboratory, the Laboratory for Aircraft Emissions, the Laboratory for Applied Ergonomics in Traffic and Transport, the Laboratory for Control of Air Navigation, the Laboratory for Geo referential Video System, the Laboratory for Modelling and Optimising

Information and Communication Networks and Services, the Laboratory for Modelling and Simulation in Aviation / Air Traffic Management, the Laboratory for Planning and Modelling in Road and Urban Traffic, the Laboratory for Security and Forensic Analysis of Information Communication Systems, and the Laboratory for Traffic Accidents Expertise. Each of the laboratories falls under the appropriate department.

The FTTS is a part of the Erasmus+ programme and, in addition to Croatian, 70% of the railway curriculum is taught in English. [3]

Railway department

The Department of Railway Transport is organised slightly differently. There are four chairs: (1) Chair of Railway Transport Engineering, (2) Chair of Railway Transport Technology, (3) Chair of Railway Transport Safety, and (4) Chair of Railway Transport Management. The department manages two laboratories: the Laboratory for Modelling and Simulation of Railway Systems, and the Laboratory for Rail Traffic Safety. The department currently employs 6 professors, 1 senior assistant and 2 assistants. The railway master study curriculum is shown in Table 7.

Table 7: The curriculum of the railway study program [4]

Courses	Type	ECTS	L	E	L	S
Semester I						
Integral and Intermodal Transport	O	4	45	5		10
Railway Freight Transport	O	7	45	20		10
Railway Infrastructure II	O	7	30	10		20
Railway Traffic Technology I	O	7	45	30		
Operational Research	I	5	30	30		
Traffic Simulation	I	5	30	15	15	
Transport Optimization	I	5	30	15		
Semester II						
Organizing Railway Passenger Transport	O	7	30	20		10
Railway Telecommunications	O	6	30	25		5
Railway Traffic Technology II	O	7	30	20		10
Railway Intelligent Transportation Systems	I	5	30	5	5	20
Railway Projects Assessment	I	5	30		20	10
Railway Transport Computer Modelling	I	5	30	10		5
Transport Geoinformation Systems	I	4	30		15	
Virtual Reality Systems in Transport	I	4	30	10	5	
Semester III						
Railway Automation	O	6	30	5	5	20
Railway Transport Management	O	6	30	20		10
Railway Vehicles Maintenance	O	5	30	30		
Development and Investment Management	I	4	30	15		

Railway Traffic Control	I	3	30			15
Ropeway Transport Technology	I	3	30			15
Urban Rail Systems	I	4	30			15
Simulations of Railway Operations	I	3	30			15
Transport Ergonomics	I	5	30	20	10	
Transport Safety	I	4	30	5	10	
Semester IV						
Graduation Thesis	O	30				60

Legend: L – lectures, E - exercises, LAB - laboratories, S - seminars, O – obligatory, I - elective

Aeronautics department

The Department of Aeronautics is organised in the following chairs: (1) Chair for Aeronautical Engineering, (2) Chair for Avionics and Navigations, (3) Chair for Air Traffic Control, (4) Chair of Military Aeronautics, and (5) Chair for Aviation English. The department manages the following laboratories: (1) Aerodynamics Laboratory, (2) Flight Simulation Laboratory, (3) Laboratory for Aircraft Emissions, (4) Laboratory for Control of Air Navigation, and (5) Laboratory for Testing in Aeronautical Engineering. The department currently employs 8 professors, 1 senior assistant, 2 assistants, and 3 lecturers. The aeronautics master study curriculum is shown in Table 8.

Table 8: The curriculum of the aeronautics study program [4]

Courses	Type	ECTS	L	E	L	S
Semester I						
Air Traffic Technology	O	5	30	15		
The Helicopter Theory of Flight	O	4	30	15		
Aircraft Emissions	I	5	30	12	3	
Airport Operations	I	5	30	10		5
Aviation English VI	I	3	15		30	
Avionics and IFR Flying	I	5	30	10	3	2
Dynamics and Aircraft Ageing	I	5	30	12	3	
Semester II						
Aircraft Operations and Maintenance	O	5	30	10	2	3
Aerial Reconnaissance and Surveillance	I	6	30	30		
Aviation English VII	I	4	15		30	
Operational Procedures of Air Carriers	I	4	30	15		
Aviation Safety	I	5	30	15		
Transport Geoinformation Systems	I	4	30	15		
Semester III						
Theory of Flight III	O	5	30	15		
Unmanned Aerial Vehicle Operations	I	5	30	15		

Aerial Vehicles Guidance and Control	I	5	30	15		
Quality Management in Aviation	I	5	30	15		
Air Traffic Flow Management	I	5	30		15	
Human Factors in Aviation	I	4	30	15		
Transport Optimization	I	4	30		15	
Operational Research	I	4	30	30		
Dynamics of Transport Vehicles	I	5	30	15		
Semester IV						
Graduation Thesis	O	30				60

Legend: L - lectures, E - exercises, LAB - laboratories, S - seminars, O - obligatory, I - elective

One semester at University of Zagreb is 15 weeks long. Per semester student must have a minimum of 30 ECTS, so that mean that master study of 4 semester student must have a minimum of 120 ECTS.

Statistical and comparative analysis

Both study programmes are on master study level, have 4 semesters, and students gain a minimum of 120 ECTS. The railway study programme (RSP) offers 25 courses, of which 10 are obligatory and 15 are elective. The aeronautics study programme (ASP) offers 22 courses, of which 4 are obligatory and 18 are elective. Comparing these two programs, we can conclude that RSP has 40% of obligatory courses and that ASP have 18% of obligatory courses. We can conclude that students have more elective courses at ASP, and they can follow their own (personal) wishes at the master study level.

Compering the ECTS, on the RSP is 62 ECTS for obligatory courses or 51,7%, and on ASP is 19 ECTS for obligatory courses or 15,8%. This means that the ECTS level of obligatory courses at the RSP is very high compared to ASP.

It is interesting to calculate a ratio between different teaching types and overall teaching hours. So, RSP has 54.8% of lecturers, 29.4% of exercises, 0.8% of laboratory and 15.1% of seminars. ASP has 66.7% of lecturers, 30.6% of exercises, 1.1% of laboratory and 1.7% of seminars. We can conclude that ASP is more concentrated on the theoretical approach than the RSP. And then it is interesting that RSP concentrated quite a lot on seminars, so in obligatory courses, they connect theoretical and practical parts. Comparisons between the structure of teaching hours for RSP and ASP is shown in Table 9.

Table 9. Structure of lectures hours

	L	E	LAB	S
RSP	345	185	5	95
ASP	120	55	2	3

Legend: L - lectures, E - exercises, LAB - laboratories, S – seminars

Both study programs have standard transport and traffic courses, and interesting some are offered in both studies. Comparative analysis is shown in Table 10.

Table 10. Standard transport and traffic courses

RSP + ASP	RSP	ASP
Operational Research	Transport Ergonomics	Dynamics of Transport Vehicles
Transport Optimization	Integral and Intermodal Transport	
Transport Geoinformation Systems	Traffic Simulation	
	Virtual Reality Systems in Transport	
	Transport Safety	

In questions of "home base" lecturers and invited lecturers, the picture is not so good. So, on RSP, they do not have invited lectures, and on ASP, they have 60 lectures hours and 25 exercises hours on two courses. But this is the official counting of lecture hours. Because of legal obstacles, official hours at the university level can have only elected staff (from assistant to full professor level). But praxis is completely different in a positive way. So, both RSP and ASP have invited lecturers from other universities in a frame of ERASMUS+ programme and CEEPUS programme and also from selected lecturers from praxis.

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[1] Marciszewska, E.; Pieriegud, J.: Benchmarking and Best Practices in Transport Sector, Warsaw School of Economics, Warsaw, 2009

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4.1.2 KTH

Brief overview of the Royal Institute of Technology (KTH)

KTH's earliest predecessor is the *Laboratorium Mechanicum* established in 1697 by Christopher Polhem who is seen as a major figure in Sweden's technical development at that time [1]. In 1798 Mekaniska skolan, the School of Mechanics was founded. It was turned into Kungliga *Teknologiska Institutet*, the Royal Institute of Technology in 1827 which is the direct predecessor of *Kungliga Tekniska Högskolan*, the name by which KTH is known today. 50 years later in 1877 the university moved to its current campus in the north of Stockholm [2]

Currently, KTH consists of 5 different schools, namely the school of Architecture and the Built Environment, the school of Electrical Engineering and Computer Science, the school of

Industrial Engineering and Management, the school of Engineering Sciences and the school of Engineering Sciences in Chemistry, Biotechnology and Health. Each school is divided in different departments that offer educational programs. All three programs under investigation are offered by the school of engineering sciences and the department of Engineering Mechanics.

There are two MSc programs offered at KTH that focus on railways: vehicle engineering (railway track) and railway engineering. In the following they are compared with the MSc program in aerospace engineering (aeronautics track). All programs are taught in English exclusively.

To gain a deeper understanding on teaching methods, industry connections and research, two interviews with teachers in the railway engineering and the aeronautics program were conducted. The findings are incorporated in the present report. A description of the interviews and their approach can be found in Appendix A.

MSc. Railway Engineering

The railway engineering program at KTH lasts for two years and consists of 120 ECTS, including an obligatory exchange semester. It covers all aspects of railways from a systems perspective, integrating elements from mechanical, civil, and electrical engineering as well as urban and regional planning. Students learn how to design vehicles, infrastructure and control systems that perform optimally together. It is offered by KTH in collaboration with the University of Illinois at Urbana-Champaign (UIUC) where students spend one semester.

About half of the courses (~45 ECTS) are taught by UIUC. About 15 ECTS are to be taken remotely in the first year, whereas the remaining 30 ECTS are to be taken during the exchange in the fall semester of the second year.

During the first semester students gain basic knowledge on the railways as a system in both obligatory and conditionally elective courses. In semesters two (KTH) and three (UIUC) they dig deeper in specific topics. The courses at KTH focus on rail vehicles whereas UIUC's courses focus on infrastructure. Both universities offer courses in urban planning and other disciplines beyond the obligatory courses. The last semester is designated to a degree project that students perform individually either at KTH or in the industry. [3]

Although centred at the department of Vehicle Technology and Solid Mechanics, the program in railway engineering as well as the affiliated KTH railway group are of a truly multidisciplinary nature. Railway-related research and education is carried out at four of KTH's schools: Engineering Sciences, Architecture and Built Environment, Industrial Engineering and Management, and Electrical Engineering and Computer Science. Nevertheless, program director Carlos Casanueva Perez as well as head of KTH railway group Mats Berg are part of the Vehicle Technology and Solid Mechanics department in the school of engineering sciences. This constellation is a major difference to many other railway engineering programmes which are usually located in civil engineering.

Table 11 Curriculum of the railway engineering program[1] [4]

Courses	Type	ECTS	L	E	LAB	S
1st year						
Railway Track Engineering (UIUC)	O	8	200			
Railroad Transportation Engineering (UIUC)	I	8	162.5			37.5
Structural Dynamics I (UIUC)	I	8				
Railway Signalling and Control (UIUC)	I	7.5	150			37.5
Theory and Methodology of Science with Applications	O	7.5	75	75	0	37.5
Electric Traction	O	6	150	0	0	0
Rail Vehicle Technology	O	7.5	112.5	75	0	0
Rail Vehicle Dynamics	O	8	100	50	50	0
Bridge Design	I	7.5	75	112.5	0	0
Public Transport	I	7.5	87.5	100	0	0
Transport Policy and Evaluation	I	7.5	0	87.5	100	0
Applied Vehicle Dynamics Control	I	7.5	0	0	188	0
Challenge-based Railway Systems Design	I	7.5	0	0	188	0
Vehicle Aerodynamics	I	6	55	75	20	0
2nd year						
High-Speed Rail Engineering (UIUC)	O	7.5	100	87.5	0	0
High-Speed Rail Planning (UIUC)	I	7.5				
Transportation Soils (UIUC)	I	8				
Decision and Risk Analysis (UIUC)	I	7.5				
Logistics (UIUC)	I	10				
Railway Terminal Design and Operations (UIUC)	I	10				
Concrete Materials (UIUC)	I	10				
Degree project	O	30				

Legend: L – lectures, E - exercises, LAB - laboratories, S - seminars, O – obligatory, I - elective

MSc. Vehicle Engineering – Railway track

The MSc programme in Vehicle Engineering lasts for 2 years and consists of 120 ECTS. It covers all aspects from vehicle design, functions, and dynamic properties to systems for safety and comfort, and vehicles as part of the transport systems. Students can specialise in Automotive or Railway Engineering.

In the Rail Vehicle specialisation, the system aspect is very important, as the different parts of a railway system – vehicle, track, electrification and signalling – all strongly influence each other.

The first year of the programme focus on providing a common base in vehicle engineering, which includes some common compulsory courses for all students as well as compulsory

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[1] Unfortunately, detailed information on most courses given by UIUC was not available.

courses for each specialisation. In addition to the compulsory courses, students can choose several conditionally elective courses to create their own profile, for example related to vehicle design, functional design, structural design, control theory as well as transport systems.

The second year consists mainly of elective courses, a common project course and the final master's degree project which can either be undertaken at a university or, more commonly, a company.[5]

Table 12 Curriculum of the vehicle engineering program – railway track [6]

Courses	**Type**	**ECTS**	**L**	**E**	**LAB**	**S**
Electric Traction	O	6	150	0	0	0
Rail Vehicle Technology	O	7.5	113	75	0	0
Rail Vehicle Dynamics	O	8	100	50	50	0
Vehicle System Technology	O	8	100	100	0	0
Road- and Railway Track Engineering	I	7.5	113	75	0	0
Transport Data collection and Analysis	I	7.5	125	62.5	0	0
Traffic Engineering and Management	I	7.5	87.5	100	0	0
Traffic Simulation Modelling and Applications	I	7.5	100	87.5	0	0
Vehicle Aerodynamics	I	6	55	75	20	0
Urban Modelling and Decision Support	I	7.5	75	113	0	0
Control Theory and Practice, Advanced Course	I	7.5	113	75	0	0
Model Predictive Control	I	7.5	75	113	0	0
Dynamics and Motion Control	I	9	75	150	0	0
Mechatronics basic Course	I	6	75	75	0	0
Robust Mechatronics	I	6	100	0	50	0
Engineering Acoustics	I	6	138	0	12.5	0
Experimental Structure Dynamics, Project Course	I	9	75	0	150	0
Flow Acoustics	I	6	50	50	50	0
Vehicle Acoustics and Vibration	I	6	0	150	0	0
Applied Vehicle Dynamics Control	I	7.5	0	0	188	0
Sustainable Vehicle Design	I	7.5	0	188	0	0
Lightweight Structures and FEM	I	8	100	0	100	0
Structural Optimisation and Sandwich Design	I	6	75	0	75	0
Fluid Mechanics	I	7.5	113	75	0	0
Degree project	O	30				

Legend: L – lectures, E - exercises, LAB - laboratories, S - seminars, O – obligatory, I - elective

MSc. Aerospace Engineering – Aeronautic track

The MSc programme in aerospace engineering at KTH lasts for 2 years and consists of 120 ECTS. It offers a specialisation in Aeronautics, Space, Lightweight Structures and Systems Engineering.

During the autumn semester of the first year of study, all students take one fundamental mandatory course in each of four tracks. Towards the end of the autumn semester, students choose one of the four available tracks. Each track has a selected number of mandatory courses, with the majority being elective. A set of recommended courses are also provided, but students may also choose elective courses entirely based on personal interests. The specialisation tracks start during the spring semester of the first year of study. The spring semester of the second year of study is usually spent on a five-month degree project required to complete the course of study. The project is conducted either in the industry or at a university, in Sweden or abroad.

The aeronautics track focuses on modelling, analysis, and design of aircraft. Students in the track will learn how to estimate the performance of an aircraft, compute its aerodynamic properties, simulate its motion in flight, and analyse how the aerodynamic and structural properties influence stability and control. The track is characterised by a strong interaction between theory and practice. Students will, for example, plan, perform and evaluate a wind tunnel test during their education. [7]

Table 13 Curriculum of the aerospace engineering program [8]

Courses	Type	ECTS	L	E	LAB	S
Theory and Methodology of Science	O	4.5	75	0	0	37.5
Lightweight Structures and FEM	O	8	100	0	100	0
Fundamentals of Flight	O	7.5	75	113	0	0
Fundamentals of Spaceflight	O	7.5	0	100	87.5	0
Systems Engineering	O	7.5	150	38	0	0
Flight Mechanics	O	9	75	75	75	0
Control Theory and Practice, Advanced	I	7.5	113	75	0	0
Human Spaceflight	I	7.5	88	100	0	0
Spacecraft Dynamics	I	9	125	100	0	0
Computational Fluid Dynamics	I	7.5	75	0	113	0
Compressible Flow	I	7.5	75	75	37.5	0
Aeroelasticity	O	9	75	75	75	0
Degree Project in Aeronautics	O	30	0	0	0	0
Management of Projects	I	7.5	0	168	0	20
Jet Propulsion Engines, General Course	I	6	125	0	25	0
Advanced Topics in Aeronautics	I	6	0	150	0	0

Legend: L - lectures, E - exercises, LAB - laboratories, S - seminars, O - obligatory, I – elective

General comments on the course structure

Courses at KTH are structured in a very specific way that might differ from other universities in Europe. As clearly visible in the tables above there are hardly any courses with less than 6 credits, in fact most courses have 7.5 credits. The semester is split in two periods (~10 weeks) during which the whole course is held and assessed.

Each course, however, consist of different modules. One of these courses is usually a lecture. These are given one, two or three times a week, depending on the course. It is common that one lecture is taught by multiple teachers, each of them focussing on a specific topic. Almost all courses include a group project during which the students are asked to apply the knowledge they acquire during the lectures. The projects are run in parallel with the lectures and students must display their progress and results to the class in form of presentations. Furthermore, a final report is to be submitted. In the present analysis the projects are included in the 'exercise' category.

Besides lectures and projects, many courses include exercises during which students solve problems supported by teachers or teaching assistants. During labs students either do hands-on work themselves or work on simulations or other tools.

Statistical and comparative analysis

Possibilities to modify the curriculum individually

All investigated programmes are on master level, last for 4 semesters, and consist of 120 ECTS each. The railway engineering programme offers 22 courses, of which seven are obligatory and 15 are elective. In vehicle engineering 20 elective and five obligatory courses are offered (25 total). The aeronautic engineering program consist of 16 courses with half of them being obligatory and elective respectively. However, it is to be noted that the lists presented are not necessarily comprehensive. Students have the possibility to choose other courses according to their interests, given that the program responsible agrees.

To gain a better understanding of what this means for the students, table 4 shows how much of the whole program is taken up by mandatory courses. In all programs investigated at least half of the courses are obligatory. However, the share varies from 50% (Vehicle Engineering) to 69% (Aerospace Engineering). It is to be noted that the degree project, although treated as an obligatory course, leaves the students high flexibility in their choice of a topic.

Table 4. Shares of obligatory ETCS to total ECTS for each program (120)

program	percentage of obligatory courses	Semester equivalents[2]
Railway Engineering	62%	2.48
Vehicle Engineering (Railway track)	50%	1.98
Aerospace Engineering	69%	2.77

In the interview with program director Carlos Casanueva Perez, he explained that the relatively high number of obligatory courses in railway engineering originate from the

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[2] One semester is dedicated to the degree project; thus, all values are higher than 1. The programs consist of 4 semesters each.

collaboration with UIUC. Both universities set courses as obligatory according to their emphasis, which leads to more obligatory courses in the end. The interview with teachers from the aerospace engineering program reviled that many obligatory courses are needed to make sure all students are on the same level. This becomes necessary since most students are internationals and have different backgrounds and foreknowledge.

Teaching methods & course structure

Table 14 shows the distribution of different teaching methods in the investigated programs at KTH. As already mentioned above, KTH courses include a high amount of group projects, which are here classified as exercises. Thus, all programs consist at least to a quarter of exercises (26% in Railway Engineering, up to 38 in Aerospace). The dominant teaching method remains to be lectures ranging from 41% (Aerospace Engineering) to 49% (Railway Engineering). Seminars hardly play any role in teaching which in technical disciplines is not surprising. Laboratories are offered throughout the programs (16% in Vehicle Engineering – RT to 21% in Railway Engineering). However, it must be noted that labs are almost exclusively part of elective course.

Table 14 Structure of lectures hours

Program	**L**	**E**	**LAB**	**S**
Railway Engineering	49%	26%	21%	4%
Vehicle Engineering (Railway track)	46%	37%	16%	0%
Aerospace Engineering	41%	38%	18%	2%

Legend: L - lectures, E - exercises, LAB - laboratories, S – seminars

When it came to teaching methods during the interviews, all interviewees agreed that the choice of teaching methods mainly depends on two parameters: the topic/level of the course and the number of students. The more general a course is, the more lectures are the preferred means. The same is valid for high numbers of students. Since exercises, projects, laboratories, and seminars require lots of time per student, they are less practical in large classes. All teachers, however, agreed that they enjoy teaching small groups using different teaching methods more than giving lectures to large classes.

During this discussion the topic of blended learning was discussed as well. As face-to-face teaching was not an option for long times during the pandemic, teachers and students got online learning methods. Some courses of the railway engineering program were available as online lecture even before the pandemic, to allow UIUC students to take them.[3] All interviewees agreed on the high potential of well-developed blended learning even in post-pandemic times. Concise online lectures could provide the students with theoretical knowledge that they can then deploy in exercise sessions in class. Much experience had been acquired in the last few years but updating the courses on this basis takes a lot of time and resources, which the teachers rarely have.

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[3] E.g., SD 2313 Rail Vehicle Dynamics was recorded professionally in a studio when the collaboration started.

As university programs, all courses investigated manly focus on theoretical knowledge. However, hands-on experience becomes more and more important even for graduates. The aeronautics program for example includes wind tunnel testing. The railway programs lack of real hands-on facilities, manly due the sheer size of the equipment. There is, however, a roller rig, that is meant to be included in teaching activities soon in form of a site visit. Both programs offer courses that require working with software used in the industry.

The KTH railway group established an internal review process for their courses including all staff members involved. This procedure allows for an open discussion about what went well and wrong in the course respectively.

Industry connections and involvement

Industry connections and involvement can be roughly split in two aspects: The industries involvement in the design of the curricula and the industries presence in the actual courses. The following information has been acquired in the priorly mentioned interviews.

Industries involvement in design and development of the curricula take place differently in the railway engineering and the aerospace engineering program, although there are similarities. The aerospace engineering program has a so-called advisory board that among other partners consists of members of the industry (namely SAAB, GKN[4], SSC[5], and others [Swedish companies only]). This allows for a constant dialog between the industry and the university. As a result of this a whole course taught by members of the industry is being developed right now. In the KTH railway group things are done similarly. The group has several industry partners (SJ AB[6], WSP[7], green cargo[8], SWECO[9], Alstom[10] [formerly Bombardier], …) that either actively approach the program or course responsibles (WSP did so and will now develop a lecture and a chapter for the compendium on “Reliability and Maintenance” for SD 2307 Rail Vehicle Technology. Furthermore, the railway group is part of the Swedish Railway industry collaboration forum JBS to establish more systematic industry connections. This is especially important for more strategic topics as sustainability. JBS also organizes an annual master thesis fair where companies present possible topics to interested students. In both railways and aerospace at KTH master theses are a major and vital part of industry’s involvement in the educational programs.

On a course level the industry involvement in form of guest lectures and site visits is mostly handled on an individual level. The course responsibles contact members of the industry they know personally, or they find during the development process of the course. E.g., a course on sustainable air traffic management has been developed in cooperation with a start-up in this area and pilots respectively. In SD 2307 Rail Vehicle Technology an annular site visit to an SJ

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[4] Specialist for aircraft windows with facilities in Sweden.

[5] Swedish space cooperation.

[6] Swedish national passenger railway operator (“Statens Järnvägar”).

[7] Engineering consulting company with presence in Sweden.

[8] Swedish national freight railway operator.

[9] Engineering consulting company (“*Swe*dish *co*nsultants”)

[10] French rolling stock manufacturer.

depot in Hagalund is the result of a former student's engagement who started working there after graduation. Besides this, the affiliation in JBS is intended to provide a more systematic connection to the industry also for direct industry involvement in the classroom.

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4.1.3 UNIZA

Brief overview of the University of Žilina

University of Žilina (UNIZA) with its more than sixty-five years of history belongs to one of the leading educational and scientific institutions in Slovakia. With its rich tradition it occupies a significant place among Slovak universities. This fact is not only connected with the number of students or offer of interesting and quality study programmes, but the university also has the significant research and foreign activities. The current university is no longer focused only on transport and communications. It is a broadly conceived university located in a unique university campus at Veľký Diel. It has seven faculties:

- Faculty of Operation and Economics of Transport and Communications,
- Faculty of Civil Engineering,
- Faculty of Mechanical Engineering,
- Faculty of Electrical Engineering and Information Technology,
- Faculty of Management Science and Informatics,
- Faculty of Security Engineering, and
- Faculty of Humanities (University of Žilina, 2021).

The university also has the following workplaces: Institute of High Mountain Biology, Institute of Physical Education, Institute of Forensic Research and Education, Institute of Information and Communication Technologies, Institute of Continuing education, Institute of Competitiveness and Innovations and the Aviation Training and Education Centre. At present there are about 8 000 students being educated at seven faculties in 175 accredited study programmes in all forms and degrees of university studies at the University. In its successful existence it has become the alma mater for almost 84 000 graduates, highly skilled professionals specialising mostly in transport and technical fields as well as management, marketing, or humanities. The quality and readiness of our graduates for the needs of practice is proved by a long-term high interest in hiring them by employers who cooperate with the University in the recruitment process. With its professional profile it is unique in Slovakia. The profile consists of:

- transport (road, railway, water, air),
- transport and postal services,
- transport and civil engineering,
- electrical engineering,
- telecommunications,
- informatics,
- information and communication technologies,
- management and marketing,
- mechanical engineering,
- materials and technologies,
- robotics,
- machinery design,
- energies,
- civil engineering,
- crisis and security management,
- civil security,
- fire protection,
- forensic engineering,
- applied mathematics,
- teaching of academic subjects,
- library and information science, and
- high mountain biology (University of Žilina, 2021).

In the field of science and research the University of Žilina is involved in the solution of nearly 200 national and 65 international scientific projects and organises about 60 scientific and professional events annually. The results of science and research activities of the University have a major influence not only on educational activities, but also on the development of international cooperation or application in practice. Achieving the competitiveness objective of the university was accomplished by a gradual implementation of the state-of-the-art equipment of the university and its laboratories through several projects. 15 scientific research centres and 2 research centres – the University Science Park and the Research Centre were created thanks to these projects. In both centres' conditions are created for new business incubators and regional support. Despite the short time of existence, there is a strong perspective of active support for research and innovations in national and international context and the centres are actively engaged in project and publishing activities (University of Žilina, 2021).

Cooperation with foreign universities and institutions is crucial for our university. The University of Žilina has signed bilateral agreements with more than 60 countries worldwide, not only within Europe, but also in America (USA, Mexico, Brazil, Argentina, Cuba), Asia (Korea, Japan, China, Taiwan) and Africa (South Africa). In the field of university bilateral cooperation, the university moves forward in developing with the universities, higher education institutions and other institutions concerning the scientific and educational activities. In the history of the ERASMUS programme, the University of Žilina belongs to the most active and successful Slovak universities in terms of student mobilities. It is the most successful Slovak university concerning the lectures given by its lecturers at foreign universities. The University of Žilina is a member of international organizations (Magna Charta Universitatum, EUA, IGIP, ECTRI, FEHRL, EARPA, EUROSIS, SDT) and cooperates with them through its representatives. The University of Žilina has a great ambition to continue in its dynamic growth, to provide high quality education, to educate well-prepared and demanded graduates, to develop international cooperation both in science and education, but its great effort is mainly to provide the space and opportunities for the young generation (University of Žilina, 2021).

The quality of higher education is the indicator of the level and success of the university. The quality of higher education at UNIZA is governed by internal quality assurance system of education (IQAS) which was created in accordance with the requirements of the amendment (Act No. 455/2012 Coll.) Act No. 131/2002 Coll. on Higher Education and On the Change and Supplement to Some Acts (Higher Education Act), respecting the areas defined by ESG (Standards and Guidelines for Quality Assurance in the European Higher Education Area). IQAS arises from the long-term aim of UNIZA for the years 2014 – 2020. The results and experience of using quality management systems (ISO 9001, CAF model) at UNIZA and faculties and outputs from UNIZA quality projects (IBAR, DEQUA) were used for its formation. The system was introduced in 2013 at UNIZA and a year later it was implemented at all its faculties and parts (University of Žilina, 2021a).

Railway transport (MSc. Eng.)

The master´s study programme Railway transport is offered by Faculty of operation and economics of transport and communications of the University of Žilina. This study programme is directly linked to the bachelor study programme with the same name. It is offered only in Slovak language and can be studied as a full-time (2 years) or part-time (3 years). The standard length of the study is 4 semesters for full-time (6 semesters for part-time).

The theoretical basis of master study programme is formed by the disciplines of applied mathematics (including operational research), applied mechanics and statistics, as well as theories of systems modelling. Further knowledge in specialized disciplines on rail transport technology, management and economics is developed, such as transport processes (including passenger transport and transport process modelling), commercial processes (including passenger transport, international transport, logistics and transport technologies and modelling). transport processes), rail transport economics (including costing, prices and tariffs in transport, controlling and modelling of economic processes), logistics, business strategy and management (Department of railway transport, 2021).Graduates are employed at all levels of railway transport management in the Slovak Republic and within the EU, especially as technologists and managers of railway infrastructure manager, railway companies, transport operators, including professional transport groups and associations in the EU. There are also opportunities for graduates to work as coordinators of integrated transport systems in forwarding and logistics companies, in design, research and development organizations with a transport focus, in transport departments of industrial companies, state administration and self-government bodies, as well as at higher education institutions (Faculty of operation and economics of transport and communications, 2021).

Department of railway transport also in cooperation with the Railways of the Slovak Republic, runs courses to acquire professional competence for the type position of an ŽSR employee as a signalman, switch supervisor, switchman and dispatcher. The courses are implemented outside the regular teaching. Upon successful completion of the course, the student receives a ŽSR corporate scholarship (Faculty of operation and economics of transport and communications, 2021).

The exercises and laboratory exercises of the study programme also takes place in specialized laboratories. On the department of railway transport, there is the laboratory of railway traffic operation in which students can try out railway traffic management and the activities of operational staff in railway transport. The laboratory also includes a model track with simulation of 5 different railway signalling systems. Nowadays is the laboratory under reconstruction, which will bring new opportunities and challenges for students and research. There is also a multimedia laboratory with specialized simulation, railway management and modelling software, as Open track, or software for construction of timetables.

The curriculum of the Railway transport master’s degree programme is shown in Table 15.

Table 15: Curriculum of the Railway transport master´s degree programme (University of Žilina, 2021b)

Modules	Type	ECTS	L	E	LAB
First semester					
Operational research 1	O	6	39	26	0

Foreign language A	O	2	0	26	0
Logistics	O	5	26	26	0
Controlling in railway transport 1	O	7	39	52	0
Mechanics in railway transport	O	5	26	26	0
International railway transport	O	5	26	26	0
Practicum in rail laboratory	EL	2	0	0	39
Professional excursion 1	EL	2	0	13	0
Physical education	EL	1	0	26	0
Physical education camp	EL	1	0	13	0
Total	**O**	**30**	**156**	**182**	**0**
	EL	6	0	52	39
Second semester					
Operational research 2	O	5	26	26	0
Foreign language B	O	3	0	26	0
Prices and tariffs in railway transport	O	7	26	39	0
Technology of railway transport	O	5	26	26	0
Management in railway transport 2	O	5	26	26	0
Obligatory elective subjects (student must choose 1 subject)					
Information and its transmission	OEL	5	26	26	0
Forecasting in railway transport	OEL	5	26	26	0
Quality management in railway transport	OEL	5	26	26	0
Railway infrastructure	OEL	5	26	26	0
Professional excursion 2	EL	2	0	13	0
Physical education	EL	1	0	26	0
Physical education camp	EL	1	0	13	0
Total	**O+OEL**	**30**	**130**	**169**	**0**
	EL	4	0	52	0
Third semester					
Passenger transport and transportation 1	O	6	39	26	0
Modelling of transport and logistics processes 1	O	5	26	0	26
Economics of railway transport 3	O	6	26	39	0
Obligatory elective subjects (student must choose 2 subjects -> 5+8 ECTS)					
Modelling of systems	OEL	5	26	26	0
Strategic management in railway transport	OEL	5	26	26	0
Logistics and transportation technologies	OEL	5	26	26	0
Project from transport processes	OEL	8	0	52	0
Project from commercial processes	OEL	8	0	52	0
Professional excursion 3	EL	2	0	13	0
Physical education	EL	1	0	26	0

Physical education camp	EL	1	0	13	0
Total	**O+OEL**	**30**	**117**	**143**	**26**
	EL	4	0	52	0
Fourth semester					
Modelling of economics processes	O	6	12	6	18
Modelling of transport and logistics processes 2	O	6	12	6	18
Final thesis	O	15	0	12	24
Obligatory elective subjects (student must choose 1 subject)					
Controlling in railway transport 2	OEL	3	0	24	0
Passenger transport and transportation 2	OEL	3	0	24	0
Organization of transport chains	OEL	3	0	24	0
Professional excursion 4	EL	2	0	6	0
Physical education	EL	1	0	12	0
Physical education camp	EL	1	0	6	0
Total	**O+OEL**	**30**	**24**	**48**	**60**
	EL	4	0	24	0

Legend: L – lectures, E - exercises, LAB - laboratories, O – obligatory, EL – elective, OEL – obligatory elective

One semester at University of Žilina is 13 weeks long.

Engineering constructions and transport structures – Railway constructions (MSc. Eng.)

The master´s study programme Engineering constructions and transport structures is offered by Faculty of civil engineering of the University of Žilina. This study programme is directly linked to the bachelor study program Civil engineering. It is offered only in Slovak language and can be studied full-time (2 years) or part-time (3 years). The standard length of the study is 4 semesters for full-time study programme. The study programme has several specializations, one of which students have to choose in first year of their master´s study:

- road constructions,
- railway constructions,
- transport construction objects, and
- planning of transport infrastructure (Faculty of Civil engineering, 2021).

The graduate is able to analyse, design, construct and maintain engineering and transport structures, conduct research with a high degree of creativity and independence. The graduate has gained deep knowledge in the field of analysis of load-bearing structures, enabling him to design, maintain and reconstruct safe, usable, durable, and aesthetic constructions. The study program is focused to acquire theoretical and practical knowledge and to develop the ability to apply them creatively in the practice. After graduating, the graduate of engineering studies knows the principles and methods of analysis of load-bearing structures of engineering and transport structures, principles of their design, diagnostics and evaluation.

In addition to the above knowledge, he has knowledge related to the economics of construction, their preparation and management as well as the environmental impact of construction works. The graduate is qualified to perform the profession of designer and authorized engineer in the design and construction of engineering and transport structures, preparation of investment constructions, engineering activities, construction, administration, operation, and maintenance of the transport infrastructure (Faculty of Civil engineering, 2021).

By completing the study program and obtaining a second-level university degree, the graduate will obtain a qualification for a regulated profession. After completing the appropriate internships and examinations before the examination committee, can obtain the right to practice the profession "authorized civil engineer" (Faculty of Civil engineering, 2021).

We will focus in this comparison on the specialization for railway constructions. The curriculum of the Engineering constructions and transport structures – Railway constructions master's degree programme is shown in Table 16.

Table 16: Curriculum of the Engineering constructions and transport structures - Railway constructions master´s degree programme (University of Žilina, 2021b)

Modules	Type	ECTS	L	E	LAB
First semester					
Applied mathematics	O	5	26	26	0
Flexibility and plasticity 2	O	5	26	26	0
Foundation of constructions 2	O	5	26	26	0
Design, construction, and reconstruction of railway lines	O	5	26	26	0
Technology of railway transport	O	5	26	26	0
Constructions of railway lines and stations	O	5	26	26	0
Physical education 1	EL	1	0	26	0
Total	**O**	**30**	**156**	**156**	**0**
	EL	1	0	26	0
Second semester					
Underground structures 1	O	5	26	26	0
Concrete bridges 1	O	5	26	26	0
Metal bridges 1	O	5	26	26	0
Professional practice Eng.	O	1	0	0	26
Dynamics of building structures	O	5	26	26	0
Professional excursion Eng.	O	1	0	0	13
Semester project in civil engineering and transport structures 1	O	2	0	0	26
Design, construction, and reconstruction of railway stations 1	O	5	26	26	0

Constructions of railway lines and stations 2	O	5	26	26	0
Physical education 2	EL	1	0	26	0
Total	**O**	**34**	**156**	**156**	**65**
	EL	1	0	26	0
Third semester					
Environmental Impact Assessment	O	4	26	13	0
Quality management	O	5	26	26	0
Reconstruction and maintenance of transport structures	O	5	26	0	26
Semester project in civil engineering and transport structures 2	O	2	0	0	26
Technology and mechanization of track works	O	5	26	0	26
Design, construction, and reconstruction of railway stations 2	O	5	26	0	26
Obligatory elective subjects (student must choose 1 subject)					
Airports	OEL	5	26	26	0
Composite reinforced concrete structures	OEL	5	26	26	0
Transport structures management system	OEL	5	26	26	0
Urban engineering	OEL	5	26	26	0
Urban routes	OEL	5	26	26	0
Underground structures 2	OEL	5	26	26	0
Concrete bridges 2	OEL	5	26	26	0
Metal bridges 2	OEL	5	26	26	0
Dynamics of transport structures	OEL	5	26	26	0
Urban communications 1	OEL	5	26	26	0
Physical education 3	EL	1	0	26	0
Total	**O+OEL**	**31**	**156**	**65**	**104**
	EL	1	0	26	0
Fourth semester					
Management of investment projects	O	5	12	12	0
Final thesis	O	9	0	0	60
Construction business economics	O	5	12	12	0
Expert debate - final thesis	O	3	0	0	1
Obligatory elective subjects (student must choose 2 subjects -> ECTS 5+3)					
Intelligent transport systems	OEL	5	12	12	0
Law in civil engineering	OEL	3	12	6	0
Concrete bridges 3	OEL	5	12	12	0
Metal bridges 3	OEL	5	12	12	0
Intermodal transport	OEL	3	12	6	0

Total	**O+OEL**	**30**	**48**	**42**	**61**

Legend: L – lectures, E - exercises, LAB - laboratories, O – obligatory, EL – elective, OEL – obligatory elective

Forwarding and logistics (MSc. Eng.)

The master study program Forwarding and logistics is offered by Faculty of operation and economics of transport and communications of the University of Žilina. This study program is directly linked to the bachelor study program with the same name. It is offered in Slovak and English language and can be studied only full-time (2 years). The standard length of the study is 4 semesters.

Graduates of the master´s level of university studies in the field of Transport Services study program Forwarding and Logistics acquire comprehensive knowledge in the field of transport services, including solving complex problems in the design of transport chains and logistics systems with emphasis on service quality. Graduates are prepared for the management of transport and forwarding organizations and logistics departments of production and distribution companies, retail chains and in state administration and self-government bodies in the transport departments. The profile of the graduate corresponds to the requirements for obtaining the international diploma "Forwarding Expert", developed by FIATA (World Federation of Shipping Associations) (Department of road and urban transport, 2021).

The graduate is able to orient and develop the theoretical basis of transport services and find their own solutions to customers' transport problems, select and creatively apply appropriate procedures, methodologies and methods in solving and assessing transport and logistics tasks. The graduate will be able to analyse and creatively develop knowledge in solving practical tasks of procurement of transport services, choice of mode of transport and suitable means of transport, can define, rationalize, model and design comprehensive solutions to ensure optimal range of transport services and related activities in packaging , storage and use of handling equipment, manage transport and related processes through the selection and evaluation of quality of transport service suppliers in terms of customer requirements and their current development and adaptation to new requirements, demonstrate a thorough understanding of technological processes, transport - legal and business relations in transport and forwarding together with the ability of critical judgment in the whole spectrum of problems related to their management (Department of road and urban transport, 2021).

Graduates will find employment in forwarding and transport organizations in the logistics departments. They will also apply in the positions of operational managers of logistics departments in large production and distribution organizations for ordering transport services. The graduate has knowledge of business in transport and forwarding and is ready to establish their own company. The employment of graduates is also expected in research and development organizations with a transport focus, in state administration bodies, as well as teachers at high schools and universities (Faculty of operation and economics of transport and communications, 2021).

The curriculum of the Railway transport master's degree programme is shown in Table 17.

Table 17: Curriculum of the Forwarding and logistics master´s degree programme (University of Žilina, 2021b)

Modules	Type	ECTS	L	E	LAB
First semester					
Operational research 1	O	6	39	26	0
English language 1	O	3	0	52	0
Technology of public passenger transport	O	5	26	26	0
Logistics	O	5	26	0	26
Business and financial management in the company	O	6	26	26	0
Express and courier services	O	5	26	0	26
Physical education	EL	1	0	26	0
Physical education camp	EL	1	0	13	0
Total	**O**	**30**	**143**	**130**	**52**
	EL	2	0	39	0
Second semester					
Operational research 2	O	5	26	26	0
Packing and loading of goods	O	5	26	26	0
English language 2	O	3	0	52	0
Economics of road and city transport	O	6	26	26	0
Integrated transport systems	O	6	26	26	0
Sea transport and sea containers	O	5	26	0	26
Physical education	EL	1	0	26	0
Physical education camp	EL	1	0	13	0
Total	**O**	**30**	**130**	**156**	**26**
	EL	2	0	39	0
Third semester					
Forwarding and logistics	O	5	26	26	0
Quality management	O	5	26	0	26
Economic analysis in road transport and forwarding company	O	5	26	26	0
Technology of freight transport	O	6	26	0	26
English language 3	O	3	0	26	0
Electronic business	O	6	26	0	26
Physical education	EL	1	0	26	0
Physical education camp	EL	1	0	13	0
Total	**O**	**30**	**130**	**78**	**78**
	EL	2	0	39	0
Fourth semester					
Transport of dangerous goods	O	5	18	0	12

Information and communication technologies in forwarding and logistics	O	4	18	0	12
Customs procedures and insurance	O	6	18	0	18
Final thesis	O	15	0	12	24
Physical education	EL	1	0	12	0
Physical education camp	EL	1	0	6	0
Total	**O**	**30**	**54**	**12**	**66**
	EL	2	0	18	0

Legend: L – lectures, E - exercises, LAB - laboratories, O – obligatory, EL – elective, OEL – obligatory elective

Analysis and comparison of the degree programmes

All these study programmes are available on master´s level and have the duration of 4 semesters. The last (fourth) semester has only 6 weeks, due to work on the final thesis. In all programs the students gain minimum of 120 ECTS credits, which is the mandatory value for successful graduation. The maximum of ECTS credits varies from 128 to 138, depending on the range of elective courses.

A comparison of the degree programmes regarding the average hours per semester and the teaching types is shown in Table 18.

Table 18: Comparison of the master´s degree programmes

Study program	ECTS obligatory	L	% L	E	% E	LAB	% LAB
Railway transport	120	106,75	40,47%	135,5	51,37%	21,5	8,15%
Railway structures	120	129	44,29%	104,75	35,97%	57,5	19,74%
Forwarding and logistics	120	114,25	43,32%	94	35,64%	55,5	21,04%

In study programme Railway transport, 59.5 % of hours per semester are exercises and laboratories, which is the highest amount of all compared study programmes. On the other side, the percentage of laboratories (8.15 %) is the lowest, comparing to the Railway structures (19.74 %) and Forwarding and logistics (21.04 %) study programmes. In these two study programmes, around 44 % of all hours per semester are lectures.

Railway transport and Forwarding and logistics study programmes include in average 6 obligatory and obligatory elective courses per semester, except of last semester, when there are 4 courses. Total number of courses for the whole study in these two programmes is 22. Study programme Engineering constructions and transport structures – Railway structures include more obligatory and obligatory elective courses than other two study programmes (total number of 28 courses), but the number of ETCS is same (or a little higher, depending on obligatory elective courses). For all study programmes, there is a possibility of elective courses focused on the free time activities – physical education and physical education camp.

Study programme Railway transport also offers elective courses Professional excursion for all semesters and Practicum in railway laboratory in first semester.

All degree programmes include the following modules:

- Quality management,
- Final thesis, and
- Physical education.

The programmes Railway transport and Engineering constructions and transport structures – Railway structures also include the common module Technology of railway transport. Programmes Railway transport and Forwarding and logistics also include the following modules:

- Operational research 1,
- Operational research 2,
- Foreign language, and
- Logistics.

The professional practice is an obligatory part of study programme only in the case of Railway structures programme. Other two study programmes have included the professional practice already as a part of their bachelor alternatives.

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4.1.4 DICEA

Brief overview of the University of Rome La Sapienza

In 1294, Benedetto Caetani became Pope Boniface VIII after convincing his predecessor, Pope Celestine V, to abdicate. A firm supporter of the universal supremacy of the papacy, Pope Boniface clashed with Philip IV of France and excommunicated him after emanating the *Unam Sanctam* Bull, which confirmed the supremacy of the papacy over all lay rulers. During that same year, 1303, Pope Boniface VIII issued the *In suprema praeminentia dignitatis* Bull and founded the *Studium Urbis*, Rome's first university.

The university was erected outside of the Vatican walls, and while this did not completely resolve the many issues between the university and the clergy, it surely catalysed a new relation between the City of Rome and the many scholars that arrived at the new university from around the world.

The *Studium Urbis* gradually grew more prestigious. In 1363, it began to receive a permanent subsidy from the City of Rom and soon grew too large for its original site in the Trastevere area. In 1431, Pope Eugene IV reorganised the university, appointed four administrators to help the Rector and purchased a series of buildings in the *Rione Sant'Eustachio* area between Piazza Navona and the Pantheon in what is now downtown Rome.

At the beginning of the 16th Century, Pope Leo X, the son of Lorenzo De' Medici, injected new vitality in Rome's university by hiring prestigious scholars from around Europe and promoting history, humanities, archaeology and science. The University began to introduce new courses of study such as the *Simplicia Medicamenta*, a forerunner of the Spagyric, an herbal medicine based on alchemical procedures, but also a precursor of holistic medicine. Bartolomeo Eustachio, one of the founders of modern anatomical science, also worked at the *Studium Urbis* in this period.

In 1592, Pope Clement VIII hired Andrea Cesalpino, the man who demonstrated the circulation of blood and the existence of an opposite centripetal force respect to that which, through the aorta and its branches, pumped blood from the heart to the peripheral blood system.

In 1660, the *Studium Urbis* relocated to a new building on the Corso Rinascimento and came to be known as Sapienza from the engraving over its main gate: *Initium Sapientiae Timor Domini*.

In 1670, Pope Alexander VII founded the *Biblioteca Alessandrina* on the new premises. In the meantime, papal envoys were dispatched throughout the Near East to acquire manuscripts, volumes and other precious treatises.

The Roman University received new lymph in the mid-eighteenth century when Pope Benedict XIV reformed the university's degree courses and procedures for hiring professors. Benedict XIV also introduced new courses, such as experimental physics, chemistry and mathematics, and brought the degree programmes from three to five: Sacred Studies, Law, Medicine and Surgery, Humanities (Arts and Philosophy) and Languages. A practical man, Pope Benedict also provided the university with all the resources that were necessary to enact the many new reforms.

In 1798, the spirit of the French Revolution lead to the proclamation of the Roman Republic. The creation of a National Institute for Sciences and Arts made both the university and its degree courses more culturally autonomous. However, the new wave did not last long. The lay spirit of Roman students would have to wait until the Revolutions of 1848.

In 1849, a battalion of university students fought to defend Mazzini, Saffi and Armellini's Roman Republic from the French troops of Napoleon III. Then, in 1870, the *Bersaglieri* liberated the City of Rome from the rule of the papacy and completed the unification of Italy. The new lay spirit, Education Minister Terenzio Mamiani, a philosopher and intellectual, and his successors, ushered a new European context into Sapienza University.

At the dawn of First World War, the campus witnessed clashes between interventionists and internationalists, anti-German rallies and forced the interventionist Rector Alberto Tonnelli to suspend lessons and close the university. The war would leave a profound scar on university life. Indeed, at the end of the conflict, all of Sapienza's fallen students received an honorary degree.

In the years following the war, social conflict drove Italy towards the Fascist dictatorship. In 1931, the Fascist Regime, which viewed the university and schools as a prime tool for propaganda, called all faculty to take an oath of allegiance to the *Duce.* Those who refused would lose their job. Only twelve Italian professors out of 1200 had the courage to stand up against the dictatorship. There were four Sapienza professors amongst them: Ernesto Buonaiuti, History of Christianity; Giorgio Levi Della Vida, Oriental Studies; Vito Volterra, Mathematics and Physics; and Gaetano De Sanctis, Ancient History. A few other professors requested early retirement to avoid clashing with the Regime.

The professors who swore allegiance to the regime were rewarded with the edification of a splendid new university campus, the so-called *città universitaria*. The new campus, designed by Marcello Piacentini, was opened in 1935 and inaugurated with a grandiose ceremony at the presence of the Italian Royal Family.

The environment in Italy was no longer conducive to scholarly studies and research. Professors began to emigrate. Enrico Fermi remained in Rome until 1938, but by the time he received the Nobel Prize for Physics, the regime already promulgated its infamous Racial Laws. After accepting the Nobel Prize in Stockholm, Enrico Fermi left for New York. Emilio Segrè, one of Fermi's students, who had been a professor at Sapienza for over ten years, followed his mentor. The following year, a young Law graduate also left for the United States. Franco Modigliani was to receive the Nobel Prize for Economics in 1985.

After World War Two, Italy began a painstaking process of national reconstruction. The professors who had been forced to resign were reintegrated and democratic processes were reinstated for the free election of the rector and other university charges.

The 1960s heralded the beginning of a new era. Italy was enjoying an unprecedented economic boom and the country was quickly modernising. The first Italian centre-left government introduced a wide-ranging series of reforms, while the Second Vatican Council veered the Catholic Church towards a greater respect of the contribution of science to the progress of humanity. When Hungary was invaded, the Italian Communist Party broke all direct links with the Soviet Union.

Student enrolment was on the rise, but the university remained an extremely conservative environment. Suddenly, clashes erupted between left- and right-wing students. On April 27, 1966, a student called Paolo Rossi died at the Faculty of Humanities after an attack by right wing students. Students and professors occupied the university as a form of non-violent protest and for the first time in the history of the university, its Rector, Ugo Papi, was forced to resign. Student movements requested more rights for students and workers and forced the government to liberalise university access in 1969.

It was a period of great hopes and communal participation. The social sciences, which had been constrained by the ideas of Giovanni Gentile, were free welcome new ideas. In the 1970s, the university introduced two new degree programmes in Psychology and Sociology, although these two disciplines would have to wait until 1991 to be organised as true faculties.

The rest is recent history: the tumult of 1977 and the fallout between the student movement and the trade unions that drew students away from politics, until the Panther Movement of the 1990s rekindled a new form activism amongst students. During the so-called *Anni di Piombo*, the university was twice hit by the assassination of illustrious professors: Vittorio Bachelet in 1980 and Ezio Tarantelli in 1985.

Rector Antonio Ruberti, who directed the university from 1976 to 1987, brought Sapienza to the forefront. The university was to play a key role in the development of new university policy in Italy. Ruberti was also responsible for revamping the University's original name. Antonio Ruberti later became Italy's first Minister for University and Scientific Research. Meanwhile, the alarming growth rate of the Sapienza student body lead to the creation of two new universities in Rome: Tor Vergata and Roma Tre.

After a slight drop in enrolment, Sapienza is once again Europe's largest university with ca. 112,000 students and over 8,000 employees, including professors, staff and technicians.

The reforms enacted at the end of the nineties, increased the number of degree programmes and the infrastructure at Sapienza. In 2010, the university adopted a new statute, based on rationalisation and meritocratic principles. The Faculties, today 11, were called to coordinate and supervise academic life, while 58 Departments became responsible for all didactic and research activities [1].

Overview of the Master Degree in Transport Systems Engineering

The establishment of the Master Degree in Transport Systems Engineering was on 2001-2002. In 2014-2015, it became an international course where all the educational activities are in English. It enrols yearly about 80 students from 10-15 different countries. More details are available at
https://web.uniroma1.it/cdaingtrasporti/general-information

The professional skills of the Transport System engineer comprise a knowledge of the methodologies and models required to simulate mobility demand, transport offer, and the integration of demand-supply to create the best possible systems from a technological, functional, economic and environmental point of view. More specifically:

- Methodologies to plan transport systems: dimensioning and definition of the performance of their components,
- Formulating mobility models for people and goods, models of transport supply on multi-modal networks, demand/supply interaction models,
- Assessment of the interventions from a technical, economic and environmental point of view, and
- Management and operational models of the transport systems.

The transport system engineer will be involved in the technical-economic planning of transport systems: transport and mobility plans at various levels, operational plans of transport companies, assessment of the infrastructure interventions from a technical, economic and environmental point of view, dimensioning and definition of the infrastructural interventions from a technical, economic and environmental point of view, dimensioning and definition of the functional components of the transport system [2].

The Academic programme for the Master's Degree provides for an in-depth study of the specific disciplines of transport systems, completed through core, related and integrative disciplines in the Civil Engineering study programme. Given the multi-disciplinary nature of the sector, the programme is characterized by flexible educational programmes that can adapt, as far as possible, to the different potential and vocation of the individual student. The study programme comprises compulsory subjects and elective subjects, which must be chosen from homogeneous groups.

The student must hand in his /her study plan, which may be modified each year in which the student is enrolled.

The educational activities are organized in modules. The curriculum comprises the following modules for 120 ECTS (*Table 19*):

- 4 obligatory modules (48 credits) related to compulsory courses (light yellow),
- 12 credits for elective modules concerning related or integrative educational activities (dark yellow),
- 24 credits for elective modules, related to compulsory studies and selected by the student (green),
- 12 credits for elective modules, selected by the students, (to maintain coherence with the educational objectives of the study plan, the Study Programme recommends a selection of modules) (light blue),
- 3 credits for the acquisition of additional language skills, computer and telematics skills, interpersonal skills or internships and placements, and
- 21 credits for the final test.

The table shows the breakdown of hours for each course. The division is made between lecture and practical hours only. During the practice hours, the lecturer decides to use the time available for seminars, laboratory hours and so on, without fixing the amount at the beginning of the year.

Table 19: Curriculum of the Master in Transport Systems Engineering study programme

OBLIGATORY COURSES	TYPE	ECTS	L	E/LAB/S
TRANSPORT NETWORKS AND VEHICLES	O	12	60	36
Traffic engineering and ITS 1	O	6	30	18
Traffic engineering and ITS 2	O	6	30	18
TRANSPORT MODELLING AND PLANNING	O	12	60	36

RAILWAY ENGINEERING	O	12	60	36
URBAN AND REGIONAL POLICY	O	6	40	20
SAFETY AND RISK ANALYSIS	O	6	30	18
ELECTIVE COURSES (for a total of 24 CFU)				
GEOLOCATION AND NAVIGATION (1)	I	6	30	18
PROGRAMMING FOR TRANSPORT SYSTEMS (1)	I	6	60	
AIR TRANSPORT (1)	I	6	40	20
MARITIME TRANSPORT (1)	I	6	30	18
ROAD SAFETY (1)	I	6	30	18
TRANSPORT INFRASTRUCTURES (1)	I	6	40	20
FREIGHT TRANSPORT AND LOGISTICS (2)	I	6	30	18
MARITIME CONSTRUCTIONS (2)	I	6	42	18
PUBLIC TRANSPORT MANAGEMENT (2)	I	6	40	20
TRANSPORT POLICIES AND TERMINAL DESIGN (2)	I	6	30	18
ELECTIVE MODULE(S) (for a total of 12 CFU)				
AIRPORT INFRASTRUCTURES	I	6	60	
RAILWAY INFRASTRUCTURES	I	6	60	
LEGISLATION OF PUBLIC WORKS AND WORKS	I	6	60	
URBAN PLANNING AND TECHNIQUE	I	6	60	
ROAD CONSTRUCTION TECHNIQUE	I	6	60	
MANAGEMENT OF BRIDGES AND LARGE STRUCTURES	I	6	60	
EXCAVATIONS AND TUNNELS IN URBAN AREA	I	6	60	
ROAD DESIGN AND CONSTRUCTION	I	6	60	
FLIGHT DYNAMICS	I	6	60	
VEHICLE SYSTEM DYNAMICS	I	6	60	
AIR TRAFFIC CONTROL	I	6	60	
***				
EDUCATIONAL ACTIVITY (3 CFU)				
Can include stages, technical visits,…				
MASTER'S THESIS (21 CFU)				

*** there are many other courses from which students can choose to complete the 12 CFUs. Only a few have been mentioned in the table.

Parallel Experiences

The presence of many different courses dealing with different sectors (maritime, aeronautical, railway, traffic, logistics, etc.) allows the student to choose the training pathway he likes best.

The analysis of parallel experiences was therefore carried out considering the three micro-areas enclosed within the same master's degree course from which the student can decide:

Table 20. Master of engineering of Transport Systems with fucus on Aeronautical and Maritime

CURRICULUM OF THE MASTER OF ENGINEERING OF TRANSPORT SYSTEMS WITH FOCUS ON AERONAUTICAL AND MARITIME				
COURSES	TYPE	ECTS	L	E/LAB/S
TRANSPORT NETWORKS AND VEHICLES	O	12	60	36
Traffic engineering and ITS 1	O	6	30	18
Traffic engineering and ITS 2	O	6	30	18
TRANSPORT MODELLING AND PLANNING	O	12	60	36
RAILWAY ENGINEERING	O	12	60	36
URBAN AND REGIONAL POLICY	O	6	40	20
SAFETY AND RISK ANALYSIS	O	6	30	18
AIR TRANSPORT	I	6	40	20
MARITIME TRANSPORT	I	6	30	18
FREIGHT TRANSPORT AND LOGISTICS	I	6	30	18
MARITIME CONSTRUCTIONS	I	6	42	18
AIRPORT INFRASTRUCTURES	I	6	60	
FLIGHT DYNAMICS	I	6	60	

Table 21. Master of engineering of Transport Systems with fucus on Road Traffic

CURRICULUM OF THE MASTER OF ENGINEERING OF TRANSPORT SYSTEMS WITH FOCUS ON ROAD TRAFFIC AND LOGISTICS				
COURSES	TYPE	ECTS	L	E/LAB/S
TRANSPORT NETWORKS AND VEHICLES	O	12	60	36
Traffic engineering and ITS 1	O	6	30	18
Traffic engineering and ITS 2	O	6	30	18
TRANSPORT MODELLING AND PLANNING	O	12	60	36
RAILWAY ENGINEERING	O	12	60	36
URBAN AND REGIONAL POLICY	O	6	40	20
SAFETY AND RISK ANALYSIS	O	6	30	18
GEOLOCATION AND NAVIGATION	I	6	30	18
ROAD SAFETY	I	6	30	18
TRANSPORT INFRASTRUCTURES	I	6	40	20
FREIGHT TRANSPORT AND LOGISTICS	I	6	30	18
ROAD DESIGN AND CONSTRUCTION	I	6	60	
ROAD CONSTRUCTION TECHNIQUE	I	6	60	

Table 22. Master of engineering of Transport Systems with fucus on Railway

CURRICULUM OF THE MASTER OF ENGINEERING OF TRANSPORT SYSTEMS WITH FOCUS ON RAILWAY				
COURSES	TYPE	ECTS	L	E/LAB/S
TRANSPORT NETWORKS AND VEHICLES	O	12	60	36
Traffic engineering and ITS 1	O	6	30	18
Traffic engineering and ITS 2	O	6	30	18
TRANSPORT MODELLING AND PLANNING	O	12	60	36
RAILWAY ENGINEERING	O	12	60	36
URBAN AND REGIONAL POLICY	O	6	40	20
SAFETY AND RISK ANALYSIS	O	6	30	18
TRANSPORT INFRASTRUCTURES	I	6	40	20
FREIGHT TRANSPORT AND LOGISTICS	I	6	30	18
PUBLIC TRANSPORT MANAGEMENT	I	6	40	20
TRANSPORT POLICIES	I	6	30	18
RAILWAY INFRASTRUCTURES	I	6	60	
VEHICLE SYSTEM DYNAMICS	I	6	60	

Statistical and comparative analysis

The master's degree in Transport Systems Engineering is spread over 2 years (4 semesters) in which students must obtain a minimum of 120 ECTS.

In the tables above it can be seen that it consists of 6 obligatory courses for a total of 60 ECTS, and 6 elective courses. from which students can choose for a total of 36 ECTS. Specifically, in order to achieve 36 credits, students must choose 24 from a more restricted list (yellow in the tables). The remaining 12 credits can be chosen from a wider list of courses that can belong to different areas (listing some of them: airport infrastructures, road infrastructures, flight dynamics, air traffic control, public works legislation, excavation and tunnels in urban areas, etc.).

Therefore, the study path can be divided into:

- 50% of ECTS for compulsory exams,
- 30% of ECTS for elective exams,
- 17,5% of ECTS for the final examination (thesis) and
- 2.5% of ECTS with other learning activities.

For each of the courses indicated, it can be seen that the hours of theoretical lessons (L) are almost always close to 62% of the total hours and that, therefore, the hours used for exercises, seminars or laboratories do not exceed 38% (indicating a good ratio between theory and practice).

Obviously, the structure of the teaching hours is the same for the three paths (Table 23).

Table 23. *Structure of lectures hours*

	L	E/LAB/S
AERONAUTICAL AND MARITIME	310	182

TRAFFIC AND LOGISTICS	310	182
RAILWAY	310	182

Legend: L - lectures, E - exercises, LAB - laboratories, S - seminars, O - obligatory, I - elective

On the other hand, it can be observed that among the obligatory courses there are all the basic fundamental subjects that can help students in their choice of elective exams.
Furthermore, we can observe that the aeronautical and maritime sector and the traffic sector offer more choice than the railway sector.

References for Italy:

[1] Sapienza Università di Roma, Our History, https://www.uniroma1.it/en/pagina/our-history
[2] Sapienza, Programme Regulation, https://corsidilaurea.uniroma1.it/en/corso/2021/30841/cds

4.1.5 Aston University

Brief overview of the Aston University

Aston University (AU) has the stated aim to be recognised as a research-intensive institution of international repute. As a leading university for business and the professions it has strong links with industry, commerce and the life sciences sector. Aston research has an emphasis on exploitable research and impact - translating world-class research into benefits for the economy and society. Aston promotes cross-School, cooperation and encourages interdisciplinary research cultures.
Aston University is one of the country's leading higher education institutions. The 2014 Research Assessment Framework (REF) recognised 78% of the research submitted by Aston as 'World Leading' (4*), or 'Internationally renowned' (3*).
Importantly, 88.7% of Aston's research was assessed as having the highest levels of impact.
The AU Computer Science subject group was ranked 9th in the UK out of 120 universities in The Guardian league table for 2017. For the third year in a row, the University was ranked 1st in the UK for Subjects Allied to Medicine by the Sunday Times University Guide 2016 and achieved a Global '5 Star' rating from QS Stars University Ratings 2016. A priority area for Aston University is identifying a "high end" research niche that is 'excellent', 'different' and 'distinctive' from other HEIs in the region and beyond.

Current Involvement in Research and Training Programmes

Aston has a significant portfolio of current research and training projects.
Aston has the following live H2020 ITNs - 2015, MASSTRPLAN (675132) + PHA-ST-TRAIN-VAC (675370); 2016, CircEuit (721909) + EU-GliaPhD (722053) + GreenCarbon (721991); 2017, FONTE (766115) + Iplacenta (765274); 2018, MOCCA (814147) + REAL-NET (813144) + WON (814276; 2019, MEFISTA (861152) + POST-DIGITAL (860360) + MONPLAS (860775).
The following RISE proposals, 2016, RDC2MT (734796) CID (731143) + FRAMED (734485) + VISGEN (734862); 2017, COSAFE (824019) + ATM2BT (824022) + BIOMASS-CCU (823745); 2018,

AMR-TB (823922) + HALT (823937) + HOPE (823958) + MEDIPOL (871650); 2019, STEPforGGR (871998) + DORNA (872001) + IPN-Bio (872049).

Aston also leads the following COFUND proposals 2015, MULTIPLY (713694) + 2018, MemTrain (847419). There have been 42 IF awards since 2014. Aston leads Erasmus one ERASMUS Mundus program (SMARTNET) and is a partner in PIXNET, the two project will recruit and train 60 Masters students.

Aston leads two prestigious FET projects and is a partner in a third. Finally, Aston is currently leads or is a partner in seven Research and Innovation projects.

Previous Involvement in Research and Training Programmes

Aston University has an excellent track record with EU funded research and training programmes. Just within H2020 Aston has coordinated two completed ITN projects - 2014, EDEN (642760) ChildBrain (641652); five RISE projects 2014, REDOXIT (644035), 2015 MAKERS (691192) + CARTHER (690945) + CARDIALLY (691051) + SOLIRING (691011). Aston has approximately twenty completed IFs. There have been 40 IF awards since 2014.

Transport related degrees at Aston University

Transport related degrees began at Aston in the early nineteen seventies when the Department of Civil Engineering put on an offering as part of a combined honours programme (students studied 3 subjects in their first year and continued with 2 subjects in their second and final years). The *Transport* Option was called 'Transport Planning and Operation' and had core themes related to the four modes; Road, Rail, Maritime and Air.

The combined honours degree became very successful and therefore moves were made to convert what was a half degree into a full-time programme. This transition was successful and a full degree in Transport Management was launched (sometime in the nineteen eighties) which consisted of the four transport modes with the addition of management subjects e.g. Economics, Finance and Accounting etc. together with other subjects such as Operational Research to underpin the Transport topics.

As the term 'logistics' became in popular use the degree programme in Transport Management was rebranded (around 2000) and students could either enrol on a 'Logistics' programme or on a 'Transport Management' programme. These programmes had a common first year and several common modules in year 2 and final year. Recent additions have seen 'degree apprenticeship' programmes launched in either Logistics and Supply Chain based subjects or in Transport Planning.

e.g. *Degree Apprenticeship in Logistics and Supply Chain Management*. This programme is led by the industry and is highly attractive to students, who will have the opportunity to complete a full Honours degree while in full employment. This programme is expected by employers, who are able to access the related government funding while addressing the skills shortage in the UK Logistics industry.

In relation to the Aston 2020 aims and strategy, the Degree Apprenticeship in Supply Chain and logistics enables the development of learning experiences based on the needs of students for professional success. Also the programme helps creating long term, reliable relationships with the Logistics community and improve our business engagement.

This programme meets the educational requirements for the Degree Apprenticeship Supply Chain Leadership Professional Level 6 standards.

The educational requirements closely match the current Foundation Degree Logistics and BSc part time Logistics and Operations Management delivered by the ESM subject group.

The target market for the programme is Logistics and Supply Chain employees/managers with high potential who are sponsored by their employer in gaining a Logistics level 6 qualification while in full employment.

Modules including Freight Rail content:

- LT1F01 Introduction to Logistics,
- LT2F07 Transport Operations, and
- LT3323 Multimodal Transport Management.

The programme has been validated against the Trailblazer group standard. A Trailblazer is group of employers developing apprenticeships standards specific to job roles in their sector. These standards are completely new, for job roles which have never had an apprenticeship programme, or will replace existing programmes for other job roles. The Trailblazer group standard included the following companies: Royal Mail, DHL, Marks and Spencer, Florette, PD Ports, Bis-Henderson, John Lewis, Amazon, Siemens, Wincanton, Morrisons, Travis Perkins, Robert Dyas, Ltk consulting, Connect Group, Arla Foods, Hoyer-Group, Halfords, Nestle, NetworkRail, Yodel, Sainsburys, Howdens, XPO, Regatta, Perkins, LCP Consulting, Southern Water, Dixons Carphone, Kuehne-nagel, Thames Clippers, Ceva Logistics, Asos, TJX Europe, Lisi-aerospace, and Smith News.

Engineering Systems and Supply Chain Management (ESSCM)

Engineering, Systems and Supply Chain Management (ESSCM) specialises in the integrated design and operation of complex technological solutions to real world problems. It cuts across the boundaries of traditional engineering disciplines and other fields.

The department has particular expertise in transport logistics, rail in particular (both passengers and freight), and supply chain management (SCM) engineering management, systems thinking and engineering education on the whole.

ESSCM coordinates and contribute to international and national research and education projects, and works in partnership with firms and other organisations to improve the capability of these firms and organisations through the development of human capital, people engagement, expertise, capacity building and improved production processes. The aim is to bring world class practices to our partner companies through an integrated portfolio of activities, including knowledge transfer, workshops, seminars, guest speakers and other joint ventures.

Courses provided by the department include: BEng Civil Engineering, BSc Construction Project Management, BSc Logistics with Supply Chain Management, BSc Transport Management, BSc Logistics with Purchasing Management, MSc Engineering Management, MSc Supply Chain Management.

An Impressive programme portfolio at all levels:

- FD in Logistics
- Transport Planning (DA)
- Supply Chain Management (PP) (DA)
- Engineering Leadership & Management (DA & W-B MSc)
- Supply Chain Leadership & Management (DA & W-B MSc)
- BSc in Business & SCM
- BSc in Logistics & SCM
- BSc in Logistics & SCM (Muscat)
- BSc in Logistics and Operations Management (Part Time)
- BSc in Transport Management
- MSc in Engineering Management
- MSc in Engineering Management-Jan intake
- MSc in Supply Chain Management
- MSc in Supply Chain Management-Jan intake
- MSc in Mechanical Engineering
- MSc Photonic Integrated Circuits, Sensors & Networks
- MSc Smart Telecom & Sensing Networks
- MSc Communication Systems & Wireless Networking
- MSc in Sustainable Engineering
- MSc in Future Vehicle Technologies
- Chartered Management DA (run by BSS)
- Plus: Apprenticeships

BSc in Transport Management

Outline:

Programme Title	Transport Management with International Foundation Year
HECoS Code	100093 (Logistics)
School/Subject Area	College of Engineering and Physical Sciences Engineering Systems & Management
Final Award	BSc
Interim Award(s)	Certificate of Higher Education (CertHE) Diploma of Higher Education (DipHE) No credits are awarded for the pathway part of the programme, therefore achievement of the pathway does not count towards the interim award.
Attendance Pattern	Full Time
Predominant delivery method	Campus-based

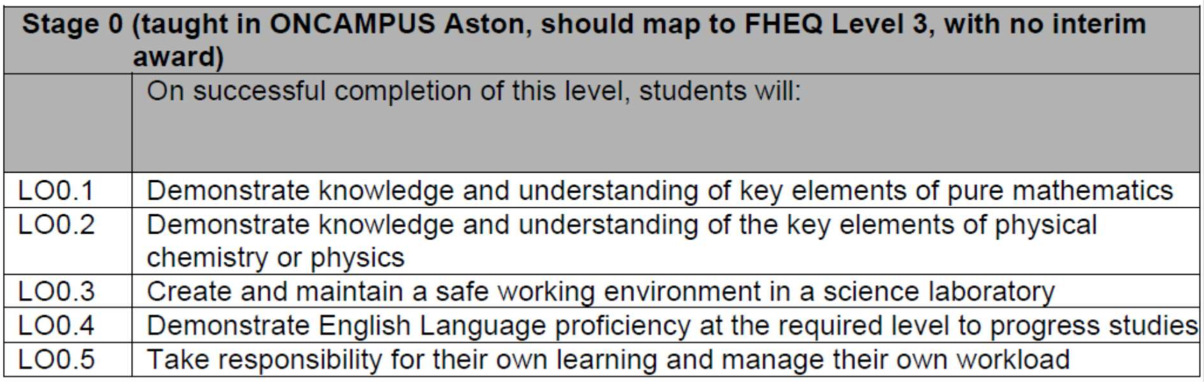
Location of Study	Students are located at Aston University. The pathway part of the programme is studied at ONCAMPUS Aston, which is based on the Aston University campus. The location of placements will be dependent upon the nature of placements available which will be subject to change.
Normal Length of Programme	4 Years (if students choose to study a placement year their degree will be extended to a 5 year programme)
Total Credits	BSc Honours degree: 360 (If a student completes a placement year this will be 480 credits) Certificate of Higher Education: 120 credits (at the appropriate level) Diploma of Higher Education: 240 credits (at the appropriate level)
Programme Accredited by	n/a
Entry Requirements	Entry requirements for each individual student are stated in their offer letter.

The Programme aims to:

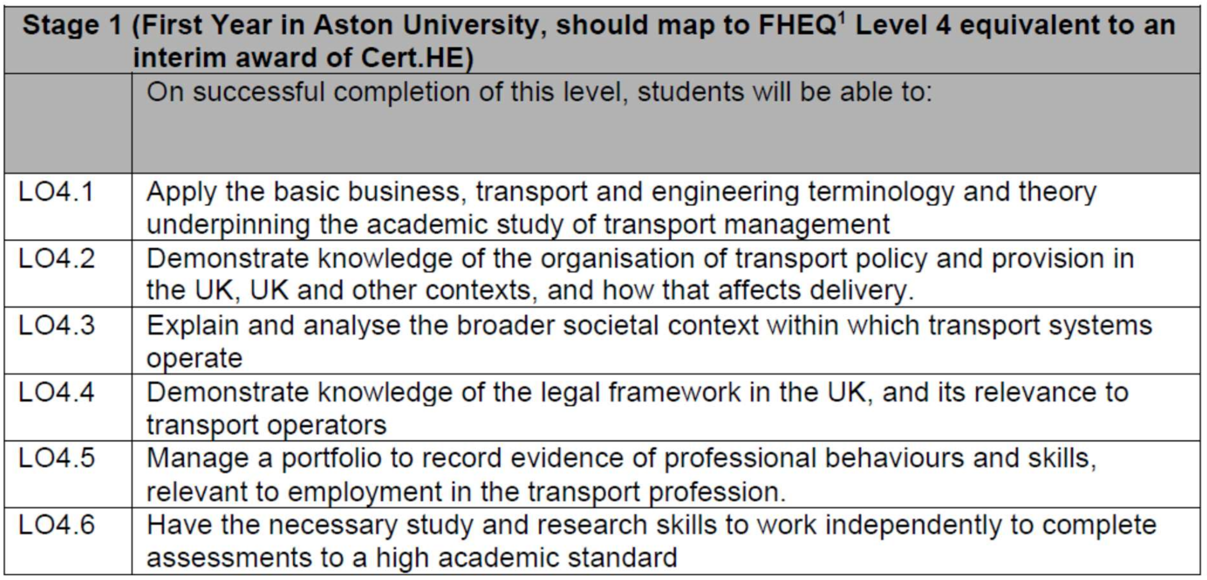
Aim 1: Provide students with opportunities to realise their academic potential through appropriately conceived learning experiences.
Aim 2: To develop an understanding of the physical (engineering) and economic processes involved in the movement of people and goods.
Aim 3: To produce graduates with the specific academic and professional skills demanded by transport employers both in the UK and internationally.
Aim 4: To offer students the opportunity to obtain relevant industrial experience, fully integrated with their academic studies.
Aim 5: To introduce students to the principles of research processes and their relevance to management within the context of transport engineering.

Programme learning outcomes

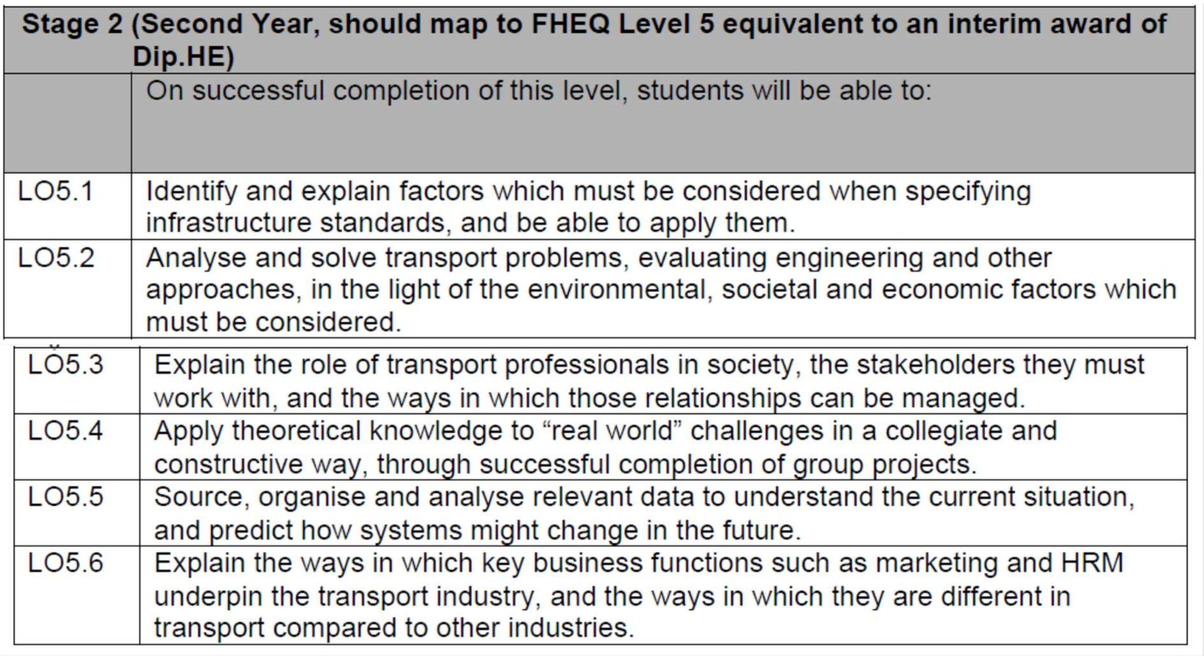
Achievement of programme learning outcomes is demonstrated through module assessment at the appropriate level/year of study.



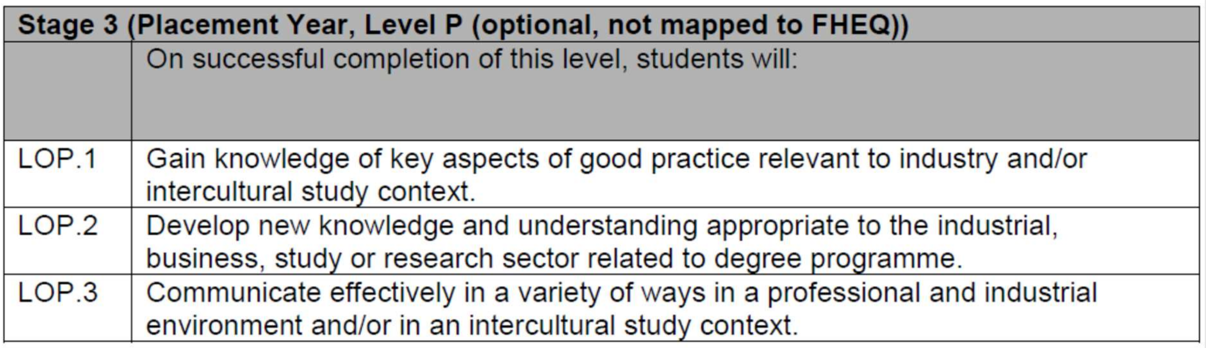
Stage 0 (taught in ONCAMPUS Aston, should map to FHEQ Level 3, with no interim award)	
	On successful completion of this level, students will:
LO0.1	Demonstrate knowledge and understanding of key elements of pure mathematics
LO0.2	Demonstrate knowledge and understanding of the key elements of physical chemistry or physics
LO0.3	Create and maintain a safe working environment in a science laboratory
LO0.4	Demonstrate English Language proficiency at the required level to progress studies
LO0.5	Take responsibility for their own learning and manage their own workload



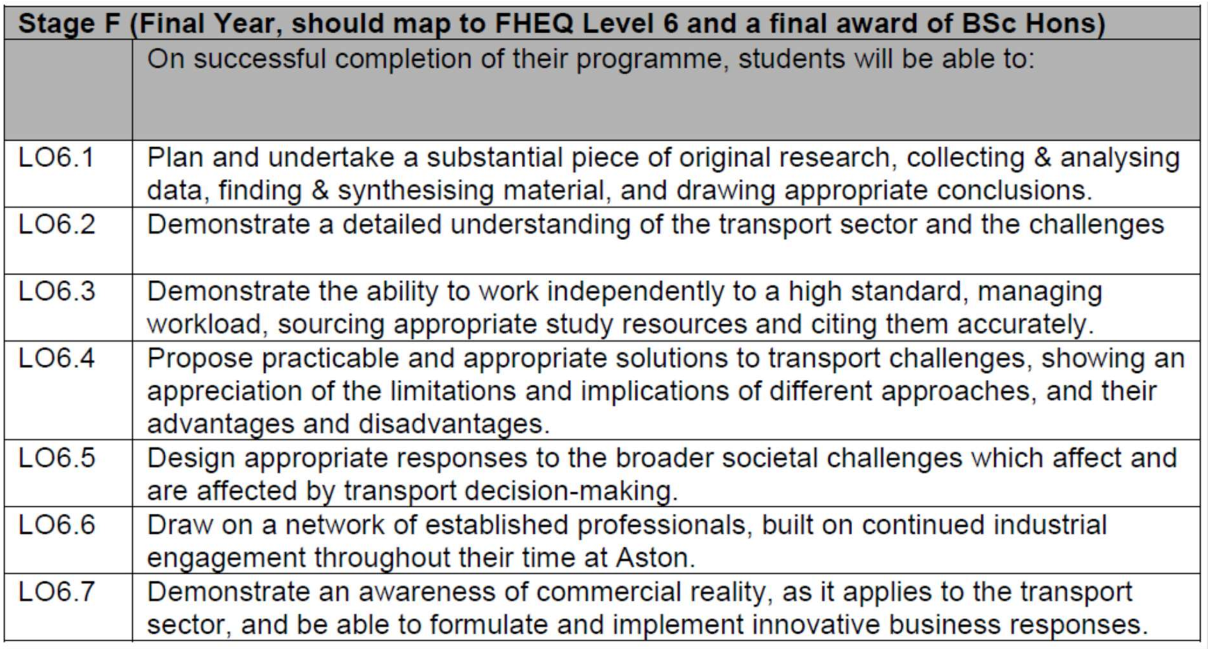
Stage 1 (First Year in Aston University, should map to FHEQ[1] Level 4 equivalent to an interim award of Cert.HE)	
	On successful completion of this level, students will be able to:
LO4.1	Apply the basic business, transport and engineering terminology and theory underpinning the academic study of transport management
LO4.2	Demonstrate knowledge of the organisation of transport policy and provision in the UK, UK and other contexts, and how that affects delivery.
LO4.3	Explain and analyse the broader societal context within which transport systems operate
LO4.4	Demonstrate knowledge of the legal framework in the UK, and its relevance to transport operators
LO4.5	Manage a portfolio to record evidence of professional behaviours and skills, relevant to employment in the transport profession.
LO4.6	Have the necessary study and research skills to work independently to complete assessments to a high academic standard



Stage 2 (Second Year, should map to FHEQ Level 5 equivalent to an interim award of Dip.HE)	
	On successful completion of this level, students will be able to:
LO5.1	Identify and explain factors which must be considered when specifying infrastructure standards, and be able to apply them.
LO5.2	Analyse and solve transport problems, evaluating engineering and other approaches, in the light of the environmental, societal and economic factors which must be considered.
LO5.3	Explain the role of transport professionals in society, the stakeholders they must work with, and the ways in which those relationships can be managed.
LO5.4	Apply theoretical knowledge to "real world" challenges in a collegiate and constructive way, through successful completion of group projects.
LO5.5	Source, organise and analyse relevant data to understand the current situation, and predict how systems might change in the future.
LO5.6	Explain the ways in which key business functions such as marketing and HRM underpin the transport industry, and the ways in which they are different in transport compared to other industries.



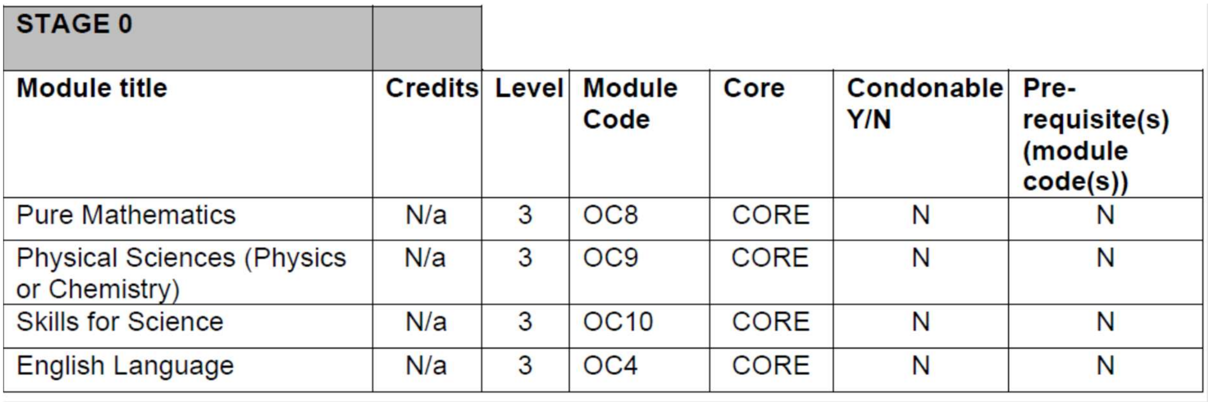
Stage 3 (Placement Year, Level P (optional, not mapped to FHEQ))	
	On successful completion of this level, students will:
LOP.1	Gain knowledge of key aspects of good practice relevant to industry and/or intercultural study context.
LOP.2	Develop new knowledge and understanding appropriate to the industrial, business, study or research sector related to degree programme.
LOP.3	Communicate effectively in a variety of ways in a professional and industrial environment and/or in an intercultural study context.



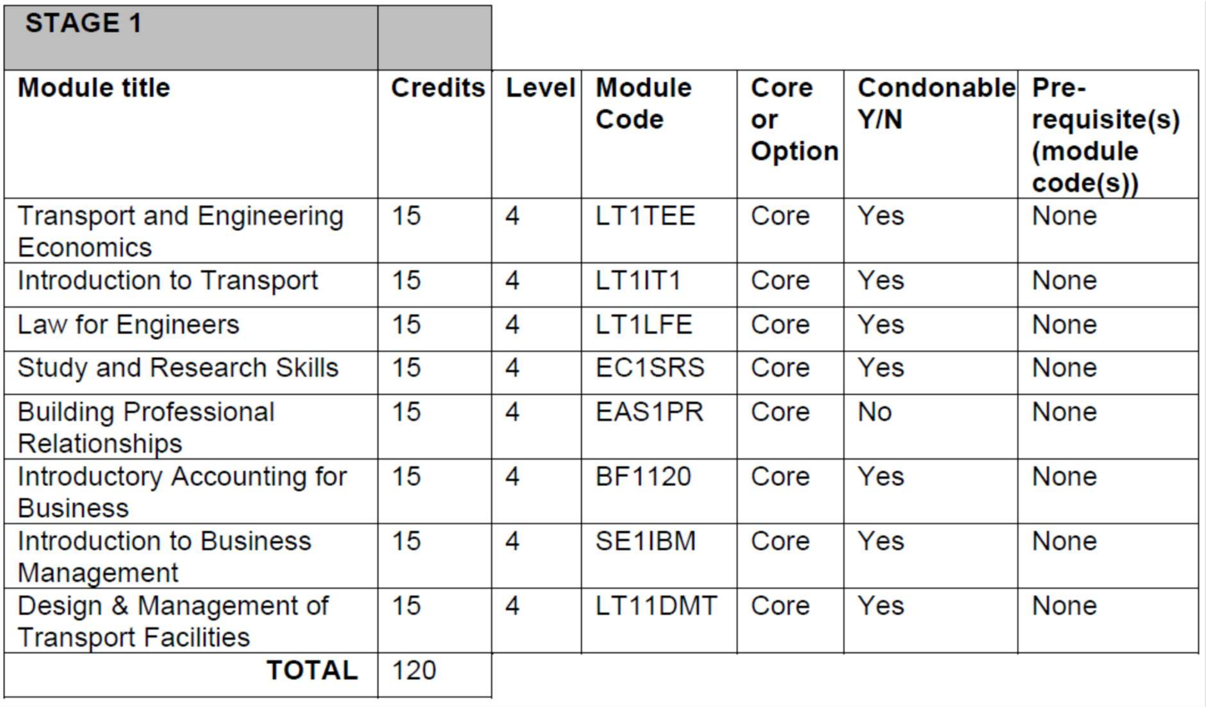
Stage F (Final Year, should map to FHEQ Level 6 and a final award of BSc Hons)	
	On successful completion of their programme, students will be able to:
LO6.1	Plan and undertake a substantial piece of original research, collecting & analysing data, finding & synthesising material, and drawing appropriate conclusions.
LO6.2	Demonstrate a detailed understanding of the transport sector and the challenges
LO6.3	Demonstrate the ability to work independently to a high standard, managing workload, sourcing appropriate study resources and citing them accurately.
LO6.4	Propose practicable and appropriate solutions to transport challenges, showing an appreciation of the limitations and implications of different approaches, and their advantages and disadvantages.
LO6.5	Design appropriate responses to the broader societal challenges which affect and are affected by transport decision-making.
LO6.6	Draw on a network of established professionals, built on continued industrial engagement throughout their time at Aston.
LO6.7	Demonstrate an awareness of commercial reality, as it applies to the transport sector, and be able to formulate and implement innovative business responses.

Programme Structure, Stage by Stage:

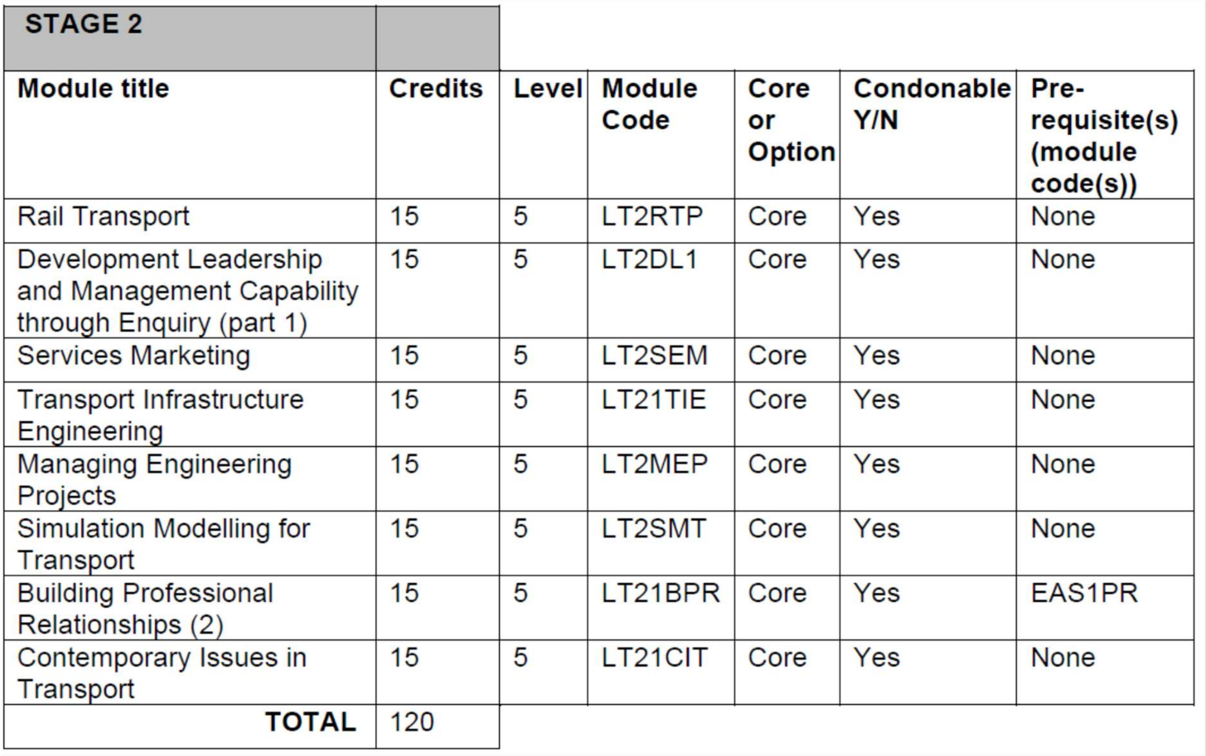
The programme starts with Stage 0.
For stages 1, 2 and F, each credit of study is equivalent to 10 learning hours (e.g. 15cr reflects 150 hours of learning). The learning hours may include but are not limited to lectures, seminars, tutorials, lab sessions, practicals, online activity, reading, other independent study, reflecting on assignment feedback, field trips and work placements.
Optional modules are reviewed each year and may change to reflect the expertise of staff, current trends in research, as a result of student feedback, or demand for certain modules.



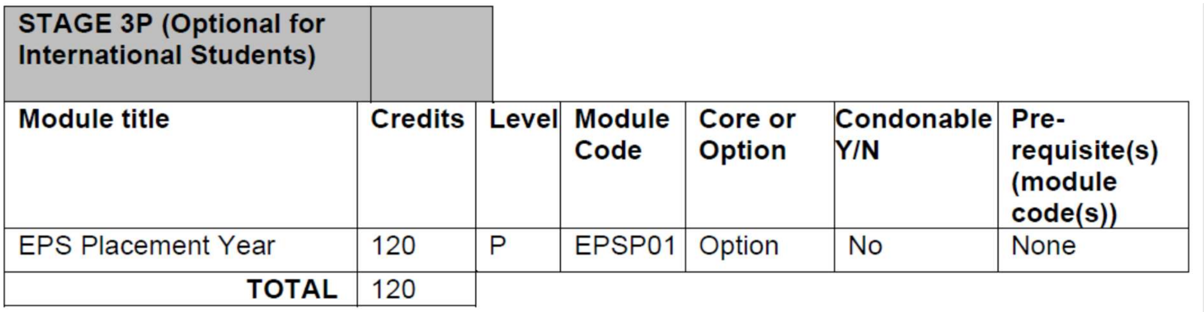
STAGE 0						
Module title	**Credits**	**Level**	**Module Code**	**Core**	**Condonable Y/N**	**Pre-requisite(s) (module code(s))**
Pure Mathematics	N/a	3	OC8	CORE	N	N
Physical Sciences (Physics or Chemistry)	N/a	3	OC9	CORE	N	N
Skills for Science	N/a	3	OC10	CORE	N	N
English Language	N/a	3	OC4	CORE	N	N



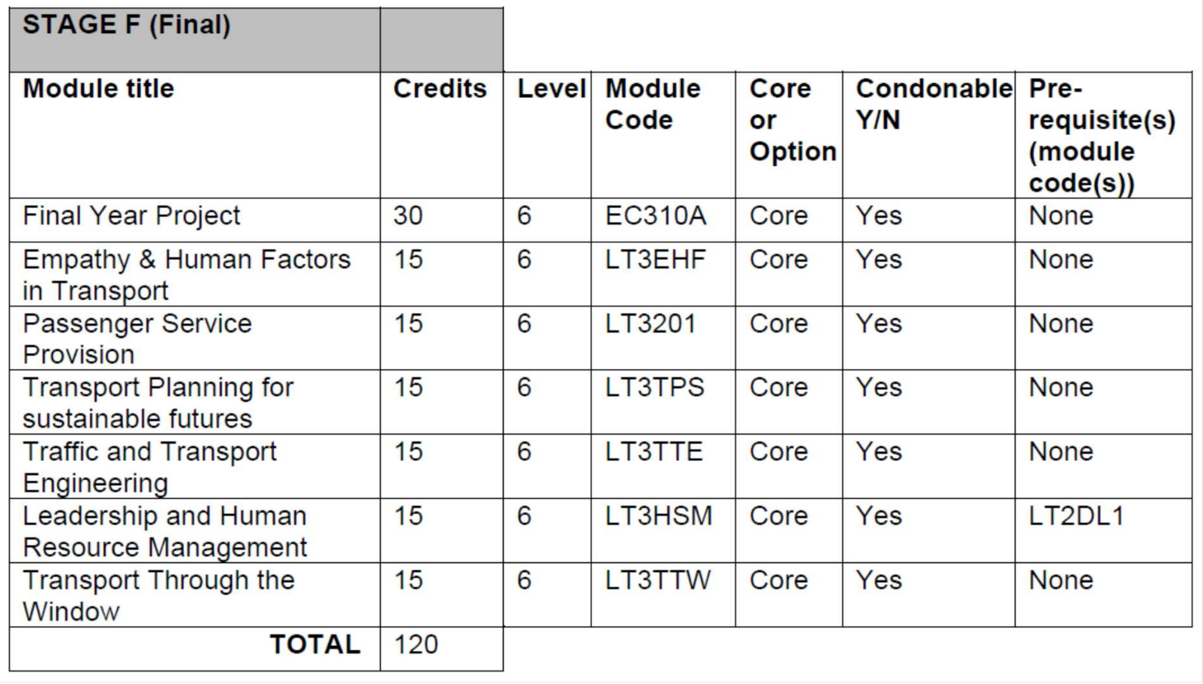
STAGE 1						
Module title	**Credits**	**Level**	**Module Code**	**Core or Option**	**Condonable Y/N**	**Pre-requisite(s) (module code(s))**
Transport and Engineering Economics	15	4	LT1TEE	Core	Yes	None
Introduction to Transport	15	4	LT1IT1	Core	Yes	None
Law for Engineers	15	4	LT1LFE	Core	Yes	None
Study and Research Skills	15	4	EC1SRS	Core	Yes	None
Building Professional Relationships	15	4	EAS1PR	Core	No	None
Introductory Accounting for Business	15	4	BF1120	Core	Yes	None
Introduction to Business Management	15	4	SE1IBM	Core	Yes	None
Design & Management of Transport Facilities	15	4	LT11DMT	Core	Yes	None
TOTAL	120					



STAGE 2						
Module title	**Credits**	**Level**	**Module Code**	**Core or Option**	**Condonable Y/N**	**Pre-requisite(s) (module code(s))**
Rail Transport	15	5	LT2RTP	Core	Yes	None
Development Leadership and Management Capability through Enquiry (part 1)	15	5	LT2DL1	Core	Yes	None
Services Marketing	15	5	LT2SEM	Core	Yes	None
Transport Infrastructure Engineering	15	5	LT21TIE	Core	Yes	None
Managing Engineering Projects	15	5	LT2MEP	Core	Yes	None
Simulation Modelling for Transport	15	5	LT2SMT	Core	Yes	None
Building Professional Relationships (2)	15	5	LT21BPR	Core	Yes	EAS1PR
Contemporary Issues in Transport	15	5	LT21CIT	Core	Yes	None
TOTAL	120					



STAGE 3P (Optional for International Students)						
Module title	**Credits**	**Level**	**Module Code**	**Core or Option**	**Condonable Y/N**	**Pre-requisite(s) (module code(s))**
EPS Placement Year	120	P	EPSP01	Option	No	None
TOTAL	120					



STAGE F (Final)						
Module title	**Credits**	**Level**	**Module Code**	**Core or Option**	**Condonable Y/N**	**Pre-requisite(s) (module code(s))**
Final Year Project	30	6	EC310A	Core	Yes	None
Empathy & Human Factors in Transport	15	6	LT3EHF	Core	Yes	None
Passenger Service Provision	15	6	LT3201	Core	Yes	None
Transport Planning for sustainable futures	15	6	LT3TPS	Core	Yes	None
Traffic and Transport Engineering	15	6	LT3TTE	Core	Yes	None
Leadership and Human Resource Management	15	6	LT3HSM	Core	Yes	LT2DL1
Transport Through the Window	15	6	LT3TTW	Core	Yes	None
TOTAL	120					

Assessment Types

The programme is assessed through a combination of written and oral examinations, class tests, individual and group coursework, projects, presentations and practical assessments.

Rail Content

Transport Management modules with Rail related content			
Module Code	***Module Title***	***Year of study***	***Link to Rail sector***
LT1TEE	Transport and Engineering Economics	First	Rail Market structure Transport externalities Land use and planning Deregulation, privatisation and transport systems funding

LT11DMT	Design & Management of Transport Facilities	First	Rail infrastructure design principles in term of accessibility, mobility and usability Technical standards of infrastructure interoperability Sustainable design
LT2RTP	Rail Transport	Second	Understanding of the present function of rail travel, and ability to identify the travel markets it can serve: and the technological economic and political factors influencing the future role of rail transport, at inter- urban and conurbation levels. Knowledge of the factors on which the market for rail transport depends, and of the technical and economic limits faced by railway management. Understanding of the role of rail transport and its place and function within transport and logistics with respect to other forms of transport. Judgement and decision making skills in respect of rail transport approaches
LT2SMT	Simulation Modelling for Transport	Second	Rail systems simulation and performance measurement
LT3TTE	e: Traffic and Transport Engineering	Final	Traffic flow modelling Traffic management decisions (constraints, capacity).
LT3TPS	Transport Planning for Sustainable Futures	Final	Rail travel demand forecasting and transport planning Economic evaluation of rail transport investment Limitations of planning approaches and the significance of uncertainty

BSc in Logistics and Operations Management

Outline

Programme Title	Logistics and Operations Management
HECoS Code	UCAS/JACS Code
School/Subject Area	College of Engineering and Physical Sciences Engineering Systems & Management
Final Award	BSc
Interim Award(s)	NA
Attendance Pattern	Part Time Students are required to attend the University for a determined number of weeks in the first and the second year. In order to qualify for the award of the degree a student must have attended the required proportion of tutorials, seminars, practical classes and lectures specified by the Head of School.
Predominant delivery method	See *Attendance Pattern* above
Normal Length of	2 years

Programme	
Total Credits	120
Programme Accredited By	Chartered Institute of Logistics and Transport (CILT)
Entry Requirements	The general entry requirement of the programme is a Foundation Degree in Logistics qualification gained at Aston University. Application from applicants offering alternative qualifications (including other foundation degrees), as approved by the course Programme Director will be considered on merit.

The Programme aims to:

Aim 1. To develop an understanding and managerial processes involved with the procurement movement, storage and use of resources throughout the supply chain.

Aim 2. To provide students with appropriately structured curricula, combining teaching in theoretical and knowledge based principles with practical training skills.

Aim 3. To ensure that development and modification of the programme prepares graduates able to respond appropriately to the rapidly changing industrial environment.

Aim 4. To produce graduates with the specific academic and professional skills that are in demand by employers in UK and international business.

Aim 5. To produce graduates with the generic transferable skills to enable them to make a valuable contribution to business and society.

Aim 6. To introduce the students to the principles of the research process and their relevance to modern methods of management within the contexts of transport and the supply chain.

Aim 7. To maintain professional accreditation by the Chartered Institute of Logistics and Transport.

Aim 8. To create an awareness of self-development as a component of education and to develop the skills and attributes of lifelong learning.

Programme learning outcomes, by skill category A - D:

A. Knowledge and Understanding

- General management and business concepts.
- The specific concepts, tools and techniques required by the professional context.
- The external environment within which business operates.
- Data acquisition and analysis, the models tools and techniques and analytical methods used in Logistics.

B. Intellectual Skills

- Analyse the requirements of a problem and select the appropriate methodology to apply to and solve that problem.
- Integrate and apply knowledge and methods from a variety of sources.
- Plan, conduct, evaluate and report on a programme of work.

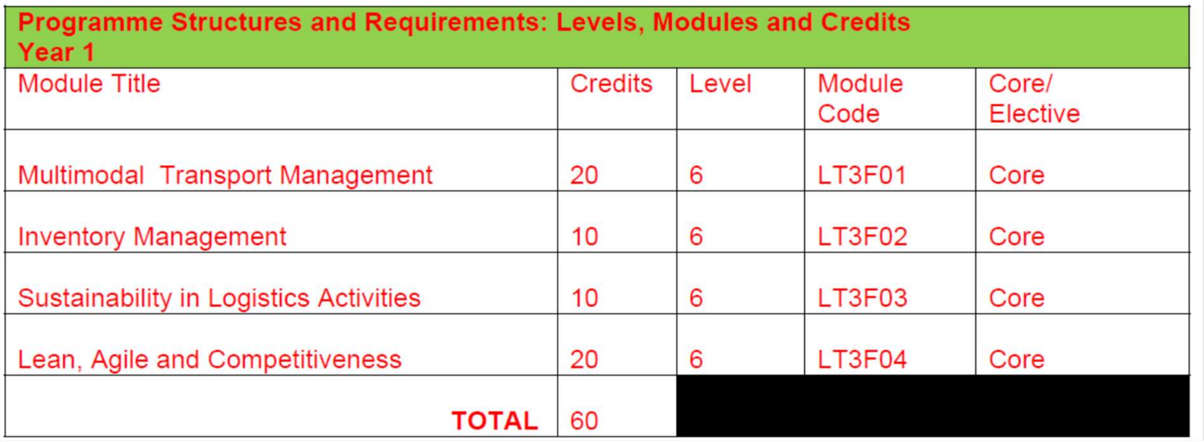
C. Professional Skills

- Apply the tools and techniques gained in A.
- Assess the business environment of a company and formulate continuous improvement strategies;

D. Transferable Skills

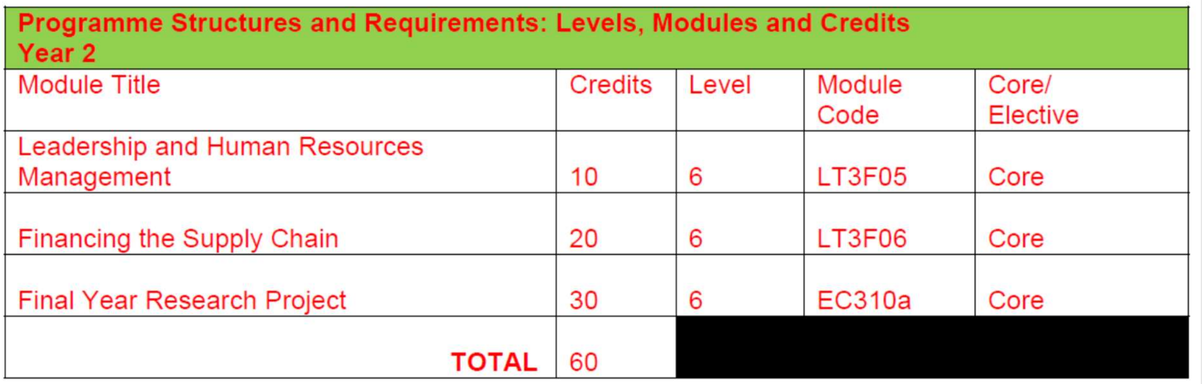
- The ability to communicate effectively both in writing, orally, and graphically.
- Team working skills.
- Problem solving skills.
- Study skills.
- ICT skills.
- Time management skills.
- Independent learning skills to facilitate professional development.

__Programme structure:__



Programme Structures and Requirements: Levels, Modules and Credits
Year 1

Module Title	Credits	Level	Module Code	Core/ Elective
Multimodal Transport Management	20	6	LT3F01	Core
Inventory Management	10	6	LT3F02	Core
Sustainability in Logistics Activities	10	6	LT3F03	Core
Lean, Agile and Competitiveness	20	6	LT3F04	Core
TOTAL	60			



Programme Structures and Requirements: Levels, Modules and Credits
Year 2

Module Title	Credits	Level	Module Code	Core/ Elective
Leadership and Human Resources Management	10	6	LT3F05	Core
Financing the Supply Chain	20	6	LT3F06	Core
Final Year Research Project	30	6	EC310a	Core
TOTAL	60			

__Assessment Types:__

Unseen (open and closed book) written examinations, written continuous assessment (in the form of essays, project reports, practical reports, analysis of data, output from computer software with critical analysis), supervisor assessed project work and presentations.

Rail Content:

BSc Logistics and Operations Management			
Module Code	**Module Title**	**Year of study**	**Link to Rail sector**
LT3F01	Multimodal Transport Management	Final	Integrating the different modes of transport within one Transport. Operations Service. Understanding and appreciate how logistics chains especially for international operations involve the use of several modes of transport including Rail. Analysing and modifying the structure of a unimodal transport services company into a multimodal operator. Planning, monitoring, and costing the logistics operations of a physical international distribution chain.

Foundation Degree in Logistics

Outline:

Programme Title	Foundation Degree in Logistics
HECoS Code	UCAS/JACS Code
School/Subject Area	College of Engineering and Physical Sciences Engineering Systems & Management
Final Award	Fd Sc
Interim Award(s)	Cert HE
Attendance Pattern	**Full time** In order to qualify for the award of the Foundation Degree a student must have attended the required proportion of tutorials, seminars, practical classes and lectures specified by the Executive Dean. The Programme Handbook provides details of procedures for monitoring attendance and dealing with poor attendance. **Industrial/Professional Training** Students will be required to complete work-based assignments and projects in this Foundation Degree. Employment in a logistics business environment is an essential requirement of the work-based projects. It is the responsibility of the student to ensure compliance with this regulation.

	Progression to Honours Degree Students who successfully complete the Foundation Degree in Logistics may continue to the final year of the BSc (Honours) Logistics degree programme.
Predominant delivery method	Day or block release
Normal Length of Programme	2 years
Total Credits	240
Programme Accredited By	-
Entry Requirements	Admission to the programme is available to candidates from a wide diversity of backgrounds and with a wide range of prior learning experience. Applicants must demonstrate their suitability for entry on to the programme to the Associate Dean of Undergraduate Programmes, School of Engineering & Applied Science (or her/his nominee at Aston or at a partner institution approved for the delivery of this programme). In addition to satisfying the general entry requirements, candidates are expected to demonstrate prior knowledge and skills equivalent to BTEC NC, NVQ or similar vocational awards. To be accepted on the programme a student must normally be supported by the head of department in their place of work. Students not currently in employment must secure the offer of a work placement before being admitted to this programme.

The Programme aims to:

Aim 1. To provide students with the opportunities to achieve their professional and academic potential through appropriate learning experiences.

Aim 2. To develop an understanding of operational and managerial processes involved with procurement, movement, storage, distribution and use of resources throughout the supply chain.

Aim 3. To provide students with appropriately structured curricula combining professional experience and teaching in theoretical and knowledge based principles.

Aim 4. To produce graduates with the specific professional and academic skills required by logistics companies.

Aim 5. To produce graduates with the generic transferable skills which enable them to make a valuable and long term contribution to the industry.

Programme learning outcomes, by skill category A - D:

A. Knowledge and Understanding

- The specific concepts, tools and techniques required by the professional context.
- General management and business concepts.

- The general external environment within which business operates.
- Data acquisition and analysis, the models tools and techniques and analytical methods used in Logistics.

B. Intellectual Skills

- Analyse the requirements of a problem and select the appropriate methodology, choose the suitable concepts and techniques to apply to and solve that problem.
- Integrate and apply knowledge and methods from a variety of sources.
- Plan, conduct, evaluate and report on a programme of work.

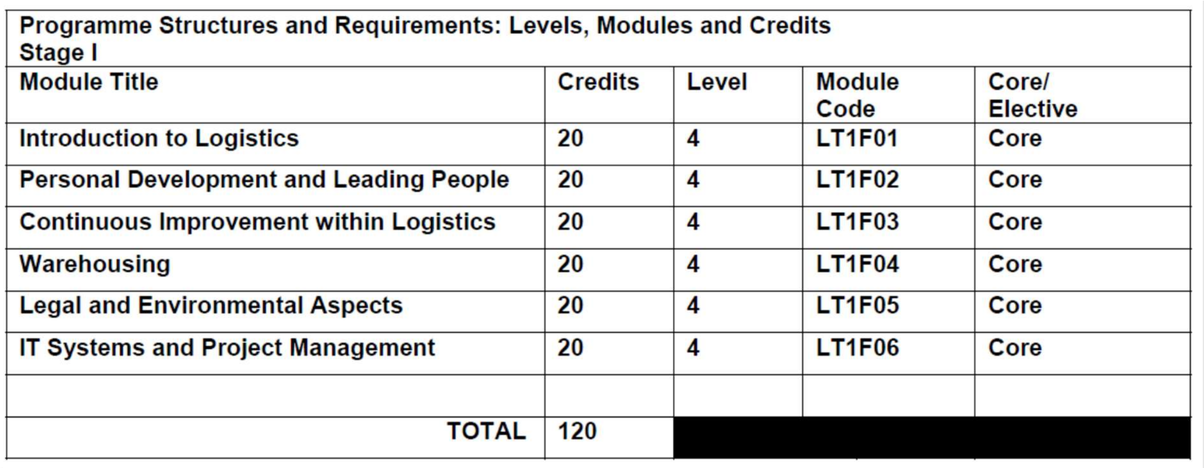
C. Professional Skills

- Apply the appropriate tools and techniques gained in A.
- Be adaptive and make relevant operational and managerial choices within a specific Logistics' professional environment.

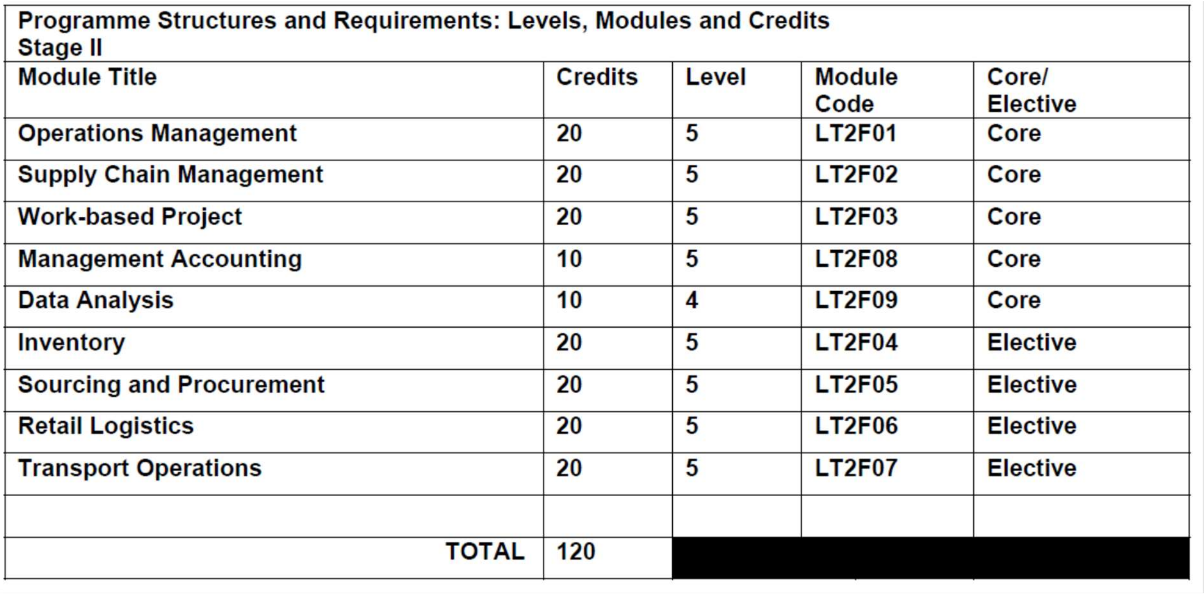
D. Transferable Skills

- The ability to communicate effectively in writing, orally, and graphically.
- Team working skills.
- Problem solving skills.
- Study skills.
- ICT skills.
- Time management skills.

Programme structure:



Programme Structures and Requirements: Levels, Modules and Credits Stage I				
Module Title	**Credits**	**Level**	**Module Code**	**Core/ Elective**
Introduction to Logistics	**20**	**4**	**LT1F01**	**Core**
Personal Development and Leading People	**20**	**4**	**LT1F02**	**Core**
Continuous Improvement within Logistics	**20**	**4**	**LT1F03**	**Core**
Warehousing	**20**	**4**	**LT1F04**	**Core**
Legal and Environmental Aspects	**20**	**4**	**LT1F05**	**Core**
IT Systems and Project Management	**20**	**4**	**LT1F06**	**Core**
TOTAL	**120**			



Programme Structures and Requirements: Levels, Modules and Credits **Stage II**				
Module Title	**Credits**	**Level**	**Module Code**	**Core/ Elective**
Operations Management	**20**	**5**	**LT2F01**	**Core**
Supply Chain Management	**20**	**5**	**LT2F02**	**Core**
Work-based Project	**20**	**5**	**LT2F03**	**Core**
Management Accounting	**10**	**5**	**LT2F08**	**Core**
Data Analysis	**10**	**4**	**LT2F09**	**Core**
Inventory	**20**	**5**	**LT2F04**	**Elective**
Sourcing and Procurement	**20**	**5**	**LT2F05**	**Elective**
Retail Logistics	**20**	**5**	**LT2F06**	**Elective**
Transport Operations	**20**	**5**	**LT2F07**	**Elective**
TOTAL	**120**			

Assessment Types:

Unseen (open and closed book) written examinations, written continuous assessment (in the form of essays, project reports, practical reports, analysis of data, output from computer software with critical analysis), supervisor assessed project work and presentations.

Professional experience gained during employment.

Rail Content

Foundation Degree Logistics			
Module Code	*Module Title*	*Year of study*	*Link to Rail sector*
LT1F01	Introduction to Logistics	First	Identify the contributions that freight transport operations make to the business as a whole.
LT2F07	Transport Operations	Second	Developing an understanding of the principles of effective, safe and legal movement of goods and people by the principal modes in a national and international context Evaluating advantages and disadvantages of different modes of transport, in relation to customer requirements (road, rail, ship, air) Understanding the concept of the seamless journey and transport integration

LT2F03	Second Year Project	Second	Understanding of the general principles and techniques for continuous improvement and waste reduction within a logistics context. Applying those concepts to modal shift projects (World Class Mail)

References for UK:

[1] Framework for Higher Education Qualifications, http://www.qaa.ac.uk/en/Publications/Documents/qualifications-frameworks.pdf
[2] Trailblazer-group, https://www.instituteforapprenticeships.org/developing-new-apprenticeships/trailblazer-group/
[3] ONCAMPUS Programme Handbook
[4] General Regulations, https://www2.aston.ac.uk/clipp/quality/a-z/general-regulation

4.1.6 UMA

Brief overview of the University of Malaga

The origins of the University of Malaga date back to the 1960s, at which time there was an evident need of Málaga society, which, through its citizens, authorities and media, demanded the setting up of a university. Their argument was based mainly on the number of university institutions found in northern and southern Spain and the fact that Málaga was the only European city of over 300,000 inhabitants which did not have a University and Higher Technical School.

One of the loudest voices demanding the birth of a university in Málaga was the Association of Friends of Málaga University, created in 1968, which counted on important figures from local life. This Association produced the biggest effort and initiative ever in the history of Málaga, all destined to create a higher teaching institution. The Association of Friends of Málaga University emerged from society itself, which was represented by a group of local Málaga people from different sectors of the province. In its beginnings as an entity set up to demand a university, it echoed the power of the media, informing the entire population of Málaga of the importance of creating a university in the city.

The basis for the creation of this higher institution was already in place since Málaga counted on an Industrial College, a Higher College, a Faculty of Economics (at that time dependent on the University of Granada) and a Seminary, which imparted different subjects of philosophy and theology.

The birth of the University was marked by a long process, which included, most notably, the creation of the University College of Málaga, which started to operate for the 1970/1971 academic year (initially including the sections of Sciences, Arts and Humanities, Medicine and Pharmacy), and the decree for the creation of Málaga University (along with the universities of Córdoba and Santander), which was signed on 18th August 1972 and published in the Official State Journal on 30th September 1972, this being the final act in the process of the creation of the University of Málaga. The University counted initially on the already existing Faculty of Economics and Business Studies, and the Faculty of Medicine, which was created at this moment.

In the first years, the main location of the university buildings was the campus of El Ejido, although it continued to count on faculties in the centre of the city and in different outlying districts, such as the Faculty of Medicine, which was the first to be established at the new campus of Teatinos, which would be the future location of most faculties and schools, including the School of Engineering.

The faculties have slowly changed location. This is the case of School of Engineering, which was initially housed in two buildings in the campus of El Ejido and was definitively transferred to the campus of Teatinos in 2010. Nevertheless, some buildings are still located in different parts of the city.

With little more than 25 years of existence, Málaga University has become a significant promoter of culture in the city, whilst providing a considerable basis for technology and research in the future. Málaga University is one of the points of the so-called "productive triangle" of the city, which also comprises the Malaga international airport and Andalusia Technology Park. The Technology Park is bound to the university through the constant flow of ideas, highly qualified professionals and advanced technologies.

The ultimate goal of the infrastructure policy of Málaga University is to bring all the university centres and services together in the campus of Teatinos. Over the next few years, the construction of new centres and the division of buildings that house more than one centre will lead to the configuration of the future University City, which will cover a surface area of nearly two million square metres.

The former Post Office building in the centre of the city is another outstanding building that houses the Rectorate of the University of Malaga, including the Secretariat and Administrative services. One of the attractions of this building is the public display of the archaeological remains of the wall of the city port, which was discovered in the subsoil; jointly with other temporary exhibitions.

Moreover, Andalusia Technology Park (PTA) also forms part of the future expansion of the university. This can be clearly seen in the recently constructed Employment and Business Promotion building, which houses the business creation centre, the employment initiative office and the university business incubator. This accompanies the existing University Institutes buildings, to round off the presence of Málaga University in the PTA.

The Higher Polytechnic School of the University of Malaga came from the Industrial School created as a result of the application of the Industrial Education Statute of 1924 and its Regulations, of October 6, 1925, which remodelled the first attempt to implement modern technical education in Spain, designed in the Elizabethan period in accordance with the Royal Decree of September 4, 1,850, which regulates engineering studies in our country. After several periods with various changes in the legislation regulating studies, various names and changes of location, the School was integrated in 1973 into the University of Malaga, the latter created by RD, on August 18, 1972.

The Higher Technical School of Industrial Engineering of Málaga was founded in 1990 by Decree 208/199, of July 3, 1990 (BOJA 66 of August 4, 1990), beginning to operate in October 1990.

The Governing Council of the University of Malaga, in a session held on March 4, 2016, agreed to approve the proposal to create a new centre with the name of School of Industrial

Engineering that integrates the Higher Polytechnic School and the Higher Technical School of Industrial Engineering.

This proposal was made effective through the publication of Decree 140/2016, of August 2, (BOJA 151 of August 8, 2016) where this denomination and the corresponding university studies leading to the obtaining of official degrees were included, being assigned to the new School of Industrial Engineering.

Some figures related to the School of Engineering of the University of Málaga are the following:

- 17 departments
- More than 240 academic staff
- More than 4000 students
- 23 research groups
- 59 Laboratories
- 9 Workshops
- 8 degrees
- 6 masters
- doctoral programs

The following Degrees, Masters and PhD Programs are offered in the School of Engineering of the University of Málaga:

Degree programs:

- Mechanical Engineering (ME)
- Electric Engineering (ElE)
- Electronic Engineering(EE)
- Industrial Design and Product Development (ID)
- Doubles: ME+ElE, ME+ID, ElE+EE
- Industrial Technologies
- Energy Engineering
- Industrial Organization
- Electronic, Robotics and Mechatronics
- Master Programs
- Industrial Engineering
- Intelligent Systems in Energy and Transportation (UMA+US)
- Hydraulics (UMA + UGR)
- Mechatronics
- Design in Engineering and Architecture
- Representation and Design in Engineering and Architecture

PhD Programs:

- Mechanical Engineering and Energy Efficiency
- Mechatronics
- Electric Energy Systems (UMA + US + EHU + UPC)

In this document, a comparative analysis among the three masters offered by the School of Engineering of the University of Malaga is carried out. This way, a parallel experience between the Master in Intelligent systems in Energy and Transportation and the Masters in Industrial Engineering and the Masters in Mechatronics will be evaluated.

Intelligent systems in Energy and Transportation (MSc.Eng.)

The Official University Master's Degree in Intelligent Systems in Energy and Transport (MSIET) is an initiative framed within the Andalucía Tech International Campus of Excellence that aims to respond to the need for highly qualified technicians in certain areas related to the application of ICTs to sectors such as Energy, the Environment or Transport.

Today's engineering requires the use of Artificial Intelligence techniques, including mathematical modelling, Big Data processing and Data Mining methods. Innovative technologies will be applied to engineering results in the areas of Mechanics, Electricity, Thermal Efficiency, Materials, ...

In the professional itinerary, the Master's Degree in Intelligent Energy and Transport Systems (SIET) includes 18 credits of Internships in companies. Some of the companies that have received students in internships in the SIET Master are: SAIMGAS, CORPORACION EMPRESARIAL ALTRA, ERFRI, IMVENTA INGENIEROS, LABORATORIO ORTOPLUS, MELFOSUR, ZENCER.

The course plan consists of 90 ECTS credits, taught over 3 semesters, structured around two specialisations: Smart Cities (at the University of Seville) and Mechanics and Energy (at the University of Malaga). In both specialisations, students can choose between a professionally-oriented pathway (with work experience in companies) or an introduction to research (for those students interested in pursuing a PhD). In both cases, these are two official specialisations and will therefore be reflected in the degree diploma, in accordance with the provisions of article 20.13 of the Spanish Royal Decree 1393/2007.

The Master's Degree has been designed with three main objectives in mind:

- To complete the training of graduates with an adequate background of excellence to take on R&D&I projects and activities in companies with a high technological level.
- To respond to the demand for professionals in a sector considered to have "high growth potential".
- To prepare students to carry out research work, making it possible, for those who wish to do so, to complete a Doctoral Thesis in the Master's specialisation areas, after joining a Doctoral Programme.

The SIET Master's program provides MECES level 3, which gives access to Ph.D. studies. In the research pathway, knowledge of Research Methodology will be acquired to provide a solid foundation for the future completion of a Doctoral Thesis.

All Master's students must take 36 compulsory ECTS in Common Training (module M01) and the Master's Final Thesis (12 ECTS) and, depending on their chosen specialisation, they must take 24 optional ECTS from either module M02-SC (Specific Training in Smart Cities) or module M02-ME (Specific Training in Mechanics and Energy).
In addition, during the third term, students must choose one of the following three options (all with 18 ECTS):

- Itinerary of professional orientation, through the Work Placement in companies (M03-PE).
- Itinerary of initiation to research in Smart Cities (M03-SC).
- Itinerary of initiation to research in Mechanics and Energy (M03-ME).

Web
https://www.uma.es/master-en-sistemas-inteligentes-en-energia-y-transporte/
http://master-siet-eii.uma.es/

The curriculum of the Intelligent Systems in Energy and Transportation is shown in Table 19.

Table 24: Curriculum of the Master programme in Intelligent Systems in Energy and Transportation (UMA)

Modules	**Semester**	**Type**	**CP acc. to ECTS**	**Hours**	**Of which**			
					L	**E**	**LAB**	**M**
Common subjects (Module M01, 36 ECTS) (US and UMA)								
Intelligent Systems for Data Processing and Decision Support	1	O	6	45	30	0	15	0
Industrial communications	1	O	6	45	15	15	15	0
Smart Grid	1	O	6	45	30	0	15	0
Smart buildings and energy efficiency	2	O	6	45	30	0	15	0
Intelligent Transport Systems Technologies and advanced vehicle Technologies	2	O	6	45	25	10	8	2
Innovation and	2	O	6	45	20	5	5	15
Courses of the intensification in Smart Cities (M02SC Module, 24 ECTS) (US)								
Industrial information systems	1	O	6	45	15	15	15	0
Industrial software development	1	O	6	45	15	15	15	0

Advanced infrastructure of sensor networks	2	O	6	45	15	15	15	0
Transversal aspects of Smart Cities	2	O	6	45	30	15	0	0
Courses of the intensification in Mechanics and Energy (M02MEC Module, 24 ECTS)								
Computational Methods in Engineering	1	O	6	45	30	0	15	0
Modelling of mechanical systems for transport	1	O	6	45	28	4	10	3
Electives (choose 2):								
Materials analysis in transport and energy	2	I	6	45	15	0	30	0
Photovoltaic systems: basic principles and applications	2	I	6	45	15	10	20	0
Electrical efficiency	2	I	6	45	22.5	4.5	15	3
SECOND YEAR (30 ECTS)	The student must take one of the three possible orientations (18 ECTS) and complete a Master's Thesis (12 ECTS). Three possible orientations; choose one of these options:							
Option 1: Professional Orientation (Module M03-PE, 18 ECTS) (US and UMA):								
Internship in companies	3	O	18	135	--	--	--	--
Option 2: Initiation to research in Smart Cities (M03-SC, 18 ECTS) (US):								
Research Methodology and Data Analysis	3	O	6	45	15	15	15	0
Applied research in data mining	3	O	6	45	15	15	15	0
Applied research in Smart Cities	3	O	6	45	15	15	15	0
Option 3: Initiation to research in mechanics and energy (M03-ME, 18 ECTS) (UMA):								
Research Methodology and Data Analysis	3	O	6	45	30	15	0	0
Railway systems and electric traction	3	O	6	45	31.5	0	0	13.5
Choose two courses from								

Geographic Information Systems	3	I	3	22.5	22.5	0	0	0
Industrial applications of lasers	3	I	3	22.5	10	4	4	4.5
Simulation of geometric models in mechanical and energy engineering.	3	I	3	22.5	7.5	0	15	0
Common to both plans								
Master's Thesis	3	O	12	--	---	--	--	--

Legend: L – lectures, E - exercises, LAB - laboratories, M – miscellaneous (student presentations, company visits, projects, specialist talks), O – obligatory, I – elective. One semester at UMA is 15 weeks long.

All theory classrooms are equipped with a blackboard, projector, computer and network access. They are adequate in quantity and quality to the needs of the group of students to be accommodated in each case and to the methodologies planned for the development of teaching: participatory classes, teamwork, etc. For the study and development of individual and teamwork outside contact hours, students have (shared with all the students of the school), free-access team rooms, several workrooms in the library, two project rooms and 8 computer rooms with computers connected to the network, which guarantee the individual use of these computers. In addition, the building is connected to the university's wireless network. The Intranet informs them of the information systems resources available and explains how the computer rooms work during teaching and non-teaching hours. The needs for classrooms and computer equipment for teaching are managed by the person in charge of managing the timetables of the computer rooms together with the Deputy Director of the Centre in charge of the subject; and the discretional use by the students is attended to by the classroom technicians themselves, depending on the availability of the aforementioned resources The classrooms and experimental spaces required by the students are adapted to the safety and general accessibility standards.

All the Departments and Areas that teach in this master have one or more teaching laboratories and at least one research laboratory in the Industrial Engineering Building.

There are 9 workshops with special foundations and two bridge cranes, dedicated to teaching practices with conditions. The total surface area of these workshops is 2824 m^2, assigned to the following areas: Manufacturing Processes Engineering. Materials Science. Mechanical Engineering Fluid Mechanics Continuous Media Mechanics Systems and Automation Engineering Electrical Engineering. Machines and Thermal Engines Centre Workshop.

Industrial Engineering (MSc. Eng.)

The Master programme Industrial Engineering (Ingeniería Industrial) is a Master's Programme in which the postgraduates obtain a Master of Engineering. It is offered in the Spanish language and can be studied full-time or part-time. The standard duration is 4 semesters (full-time). The EII (Industrial Engineering School) is the responsible centre.

The multidisciplinary training of the Master programme Industrial Engineering addresses problems of a very diverse nature, which makes Industrial Engineers play a prominent role in economic, industrial and social activity. The master programme is systematically among the most demanded university profiles. This demand corresponds to the high professional consideration of Industrial Engineering and its extensive training, which allows its master graduates to be employed in practically all the productive sectors of our country, with occupations ranging from R + D + i, to management or exploitation. Furthermore, the Master of Industrial Engineering is an enabling Master for the development of the career of industrial engineer in all the branches that cover their competencies.

Fifty-six professors are involved in teaching In the Master programme Industrial Engineering. Many of them teach as well in other degree and master programmes. In addition, experts from the industry are invited as guest lecturers to speak about currently important topics which are of special interest in many of the subjects of the master programme.

Within the Industrial Engineering master programme nine laboratories are used. In the laboratories, the postgraduate students carry out practical laboratory exercises on several subject areas e.g. in electrical technology, hydraulic technology, transport engineering and railway technology. The laboratories offer modern equipment and measurement technology. The laboratory for railway technology is used to explain the pantograph-catenary interaction and their simulation. The laboratory for transport engineering is equipped with: two tire test benches, one static and the other dynamic; a test bench of suspensions; a motorcycle power test bench; an instrumented car and motorcycle; a test bench of hydraulic bearings and another of ball bearings. Students can work with all these test benches.

Web: https://www.uma.es/master-en-ingenieria-industrial/cms/menu/informacion-general/

The curriculum of the Industrial Engineering Master programme is shown in *Table 25*.

Table 25: Curriculum of the Industrial Engineering Master programme (UMA)

Modules	**Semester**	**Type**	**CP acc. to ECTS**	**Hours**	**Of which**			
					L	**E**	**LAB**	**M**
First semester (30 ECTS)								
Electric technology	1	O	5	37.5	34	0	3.5	0
Integrated manufacturing	1	O	5	37.5	37.5	0	0	0
Machine technology	1	O	5	37.5	10	19.5	8	0
Electronic systems in industry	1	O	5	37.5	19.5	3	7.5	7.5
Chemical technology	1	O	5	37.5	19	15	0	3.5
Automation and control	1	O	5	37.5	37.5	0	0	0
Second semester (30 ECTS)								
Energy technology	2	O	5	37.5	25	7.5	0	5
Hydraulic technology	2	O	5	37.5	12.5	12.5	12.5	0
Industrial construction	2	O	5	37.5	22.5	0	0	15
Transportation engineering	2	O	5	37.5	20	0	15	2.5
Structure design and calculation	2	O	5	37.5	12	16	6	3.5
Management and quality control	2	O	5	37.5	30	0	3	4.5
Third semester: expansion module (choose one of the following four blocks) (30 ECTS)								
Levelling block								
Mathematics extension	3	I	6	45	45	0	0	0
Computer basics	3	I	6	45	20	0	25	0
Electrical installations	3	I	6	45	45	0	0	0
Industrial organization	3	I	6	45	36	0	0	9

Graphic engineering and topography	3	I	6	45	31.5	13.5	0	0
Professional block								
Manufacturing engineering in industry	3	I	6	45	30	0	9	6
Entrepreneurs in engineering	3	I	6	45	30	0	0	15
The profession of engineering and public administration	3	I	6	45	36	0	0	9
Control and pathologies in urban planning and building	3	I	6	45	30	0	0	15
Railway technology	3	I	6	45	28.5	0	6	10.5
Research block (30 ECTS)								
Mobility block and internships semester (30 ECTS)								
Fourth Semester (30 ECTS)								
Administration AND BUSINESS MANAGEMENT	3	O	5	37.5	20.5	6	0	11
Integrated production systems	3	O	5	37.5	30	0	0	7.5
Prevention and ergonomics	3	O	5	37.5	20	10	0	7.5
Integrated project management	3	O	3	22.5	11	0	7	4.5
Master Thesis	3	O	12	--	--	--	--	--
Total sum of CP			**120**					

Legend: L – lectures, E - exercises, LAB - laboratories, M – miscellaneous (student presentations, company visits, projects, specialist talks), O – obligatory, I – elective. One semester at UMA is 15 weeks long.

Mechatronics (MSc. Eng.)

Mechatronics Engineering represents the fusion of technologies such as control, mechanics, electricity, electronics and computer science that make it possible to address the engineering challenges posed by the new intelligent machines. It is a natural choice to explain a process whose purpose, from its origin, is the creation of advanced products and engineering systems that are inextricably linked by the synergic combination of mechanical, electronic, control and computer technologies.

The main objective of the Master's Degree in Mechatronics Engineering is to offer students comprehensive training in Mechatronics Engineering, including the analysis, design and implementation of mechatronic systems in industrial environments. These students will acquire a capacity for development and even research, in Mechatronics Engineering and in the methodologies and technologies that will allow the creation of engineering products and systems defined by the synergic combination of mechanical, electronic, electrical, control and computer technologies.

The professional interest of the proposed degree is given by the growing need of companies to hire engineers with multidisciplinary profiles. Companies often complain about the excessive specialisation of engineers and the effort they have to invest in their training. Graduates of this degree could improve production processes, eliminating inefficiencies and increasing competitiveness. Mechatronic engineers are distinguished by their inventiveness and originality, as well as their ability to lead interdisciplinary work teams, possess an entrepreneurial and leadership attitude, and adapt creatively to changes that take place. The Mechatronics Engineer has a high sense of organisation that generates a high capacity for analysis and synthesis, which leads him/her to transform his/her knowledge and the physical elements at his/her disposal into intelligent instruments

The proposed study plan for the Masters in Mechatronics Engineering of the University of Malaga lasts for 1 year, divided into two semesters and with a total of 60 ECTS. The master programme was approved in 2016. It is an on-site master included within the branch of engineering and architecture studies.

The teaching staff is composed of 25 members, most of them are associate professors and full professors. Five research lines within the departments involved are intimately related to this master. They are the following:

- Dept. of Systems Engineering and Automatics: Robot Control. Mobile Robots. Telerobotics. Systems of Perception Systems in Robotics. Advanced Control.
- Electronics Dept: Electronics for Instrumentation and Systems.
- Dept. of Electrical Engineering: Advanced Actuators. Advanced Optimisation in Electrical Energy Systems.
- Dept. of Computer Architecture: Architectures for Signal Processing.
- Dept. of Mechanics and Fluid Mechanics: Hydrodynamic Stability and Numerical Simulation of Flows.
- Dept. of Applied Physics II: Rheology.
- Dept. of Mechanics of Continuous Media, Materials and Manufacturing. Structure Stability

The following laboratories, guided by the Departments and Areas participating in the Master's course, are available for practical work and activities:

- Robotics Laboratory
- Control Laboratory
- Perception Systems Laboratory
- Electronics Laboratory
- Electrical Machines Laboratory
- Fluids Laboratory
- Computational Fluid Mechanics Laboratory
- Rheology and Electrokinetic Laboratory
- Computing Laboratory
- Parallel Computing and Simulation Laboratory
- Unmanned vehicle aerohydrodynamic laboratory

Web: https://www.uma.es/master-en-ingenieria-mecatronica/
The curriculum of the Mechatronics Master programme is shown in Table 26. There are 4 courses (20 ECTS) that are compulsory. In addition, students have to pass 6 optative courses (30 ECTS) and the Mater's Thesis (10 ECTS).

Table 26: Curriculum of the Master programme in Mechatronics (UMA)

Modules	**Semester**	**Type**	**CP acc. to ECTS**	**Hours**	**Of which**			
					L	**E**	**LAB**	**M**
First semester (30 ECTS)								
Design of Mechatronic Systems	1	O	5	37.5	37.5	0	0	0
Modelling and control of Mechatronic system and robots	1	O	5	37.5	37.5	0	0	0
Intelligent sensors	1	O	5	37.5	7.5	0	30	0
Real Time for Mechatronic	1	O	5	37.5	37.5	0	0	0
Intelligent Control Systems	1	I	5	37.5	37.5	0	0	0
Advanced Electrical Actuators	1	I	5	37.5	16	8	12	1.5
Writing and Communicating Research Publications in Engineering	1	I	5	37.5	37.5	0	0	0
Initiation to knowledge transfer	1	I	5	37.5	37.5	0	0	0
Second semester (30 ECTS)								
Motion Control	2	I	5	37.5	18	5	14	0.5
Advanced Mechanics	2	I	5	37.5	16	0	12	9.5
Advanced Electronic Design	2	I	5	37.5	10	2	25.57.5	0
Mobile Robots	2	I	5	37.5	37.5	0	0	0
Teleoperation and Telerobotics	2	I	5	37.5	37.5	0	0	0
Perceptual Systems	2	I	5	37.5	37.5	0	0	0
Multiprocessor Programming	2	I	5	37.5	10	0	27.5	0
Numerical simulation of flow around vehicles	2	I	5	37.5	12	9.5	16	0
Advanced Physics for Mechatronics	2	I	5	37.5	6	0	15	16.5
Curricular Internships in Companies	2	I	5	37.5	0	0	0	0
Master's Thesis	2	O	10	-	-	-	-	-

Legend: L – lectures, E - exercises, LAB - laboratories, M – miscellaneous (student presentations, company visits, projects, specialist talks), O – obligatory, I – elective. One semester at UMA is 15 weeks long.

Analysis and comparison of the master programmes

The master's program in Intelligent systems in Energy and Transportation is spread over 1.5 years (3 semesters) in which students must complete a minimum of 90 ECTS. The master is established in the universities of Sevilla and Malaga simultaneously in a coordinated way. According to Table 1, it consists of between 10 to 13 obligatory courses (depending on the chosen option) for a total of 60 to 68 ECTS. There are not many elective courses. UMA students have to choose 4 courses from 6 courses offered. In addition, students can select a professional orientation module that consists of an internship in a private or public company. The hours of lectures are quite well-balanced between the three terms, being about 50-70 % of the total hours. Similarly, classes dedicated to exercises represent around 10-15 % of the hours. Laboratory hours are quite important in the first two terms, being around 30 % of the total hours. Finally, other activities represent around 10 % of the hours in terms 2 and 3, being almost inexistent in the first term. (see Table 27).

Table 27: Summary of main figures of Master in Intelligent Systems in Energy and Transportation by UMA

	Intelligent systems in Energy and Transportation (90 ECTS)	
	Hours per semester	**Percentage**
TERM 1		
Total	225	100%
of which:		
Lectures	133	59%
Exercises	19	9%
Laboratories	70	31%
Miscellaneous	3	1%
TERM 2		
Total	225	100%
of which:		
Lectures	105	47%
Exercises	25*	11%*
Laboratories	78*	35%*
Miscellaneous	17*	7%*
TERM 3		
Total	135	100%
of which:		
Lectures	135 (opt. 1) /94 (opt. 3)*	100% / 69.6%*
Exercises	19 (opt.3) *	14.1%*
Laboratories	4 (opt.3) *	3 %*

Miscellaneous	135 (opt. 1) / 18(opt.3) *	100 %/ 13.3 %*
Project		

*Approximately, depending on the chosen courses.

The master's program in Industrial Engineering is spread over 2 years (4 semesters) in which students must obtain a minimum of 120 ECTS.
According to Table 2, it consists of 16 obligatory courses for a total of 80 ECTS. Students can choose 4 different blocks: levelling block (for students who don´t have access to the master from the Degree in Industrial Technologies Engineering degree); a professional block, with courses focused on being an entrepreneur; research block (with courses from the Mechatronics or Environmental Hydraulic Masters of the UMA) and Mobility and Internship block, with courses abroad and internship in companies.
The hours of lectures represent about 50-70 % of total hours in all terms. Similarly, classes dedicated to exercises represent around 10-15 % of the hours, except for the third term. Laboratory hours are quite low in all terms, being below 20 % of the total hours in all cases. Other activities increase progressively from 5% to 23 %. (See Table 28)

Table 28. Summary of main figures of Master in Industrial Engineering by UMA

	Industrial Engineering (120 ECTS)	
	Hours per semester	**Percentage**
TERM 1		
Total	225	100%
of which:		
Lectures	157.5	70%
Exercises	37.5	17%
Laboratori	19	8%
Miscellan	11	5%
TERM 2		
Total	225	100%
of which:		
Lectures	122	54%
Exercises	36	16%
Laboratori	36.5	16%
Miscellan	30.5	14%
TERM 3		
Total	225	100%
of which:	Levelling block / Prof block / Research and mobility block	Levelling block / Prof block / Research and mobility block
Lectures	177.5/ 154.5 / 0	79 % / 69 % / 0%

Exercises	13.5/ 0 / 0	6% / 0 % / 0%
Laboratori	25/ 15 / 0	11% / 6% % / 0%
Miscellan	9 / 55.5 / 225	4% / 25% / 100%
TERM 4		
Total	135	100%
of which:		
Lectures	81.5	60%
Exercises	16	12%
Laboratori	7	5%
Miscellan	30.5	23 %
Project	12 ECTS	

The master's program in Mechatronics is spread over 1 year (2 semesters) in which students must obtain a minimum of 60 ECTS.
According to Table 3, it consists of 4 obligatory courses for a total of 20 ECTS. Students can choose 30 ECTS of a wide range of elective courses.
The hours of lectures represent about 70-80 % of total hours in all terms. Similarly, classes dedicated to exercises represent less than 5% of the hours, except for the third term. Laboratory hours are quite low in all terms, being around 25 % of the total hours in all cases. Other activities represent 3% of the total hours. (See Table 29)

Table 29. Summary of main figures of Master in Mechatronics by UMA

	Mechatronics (60 ECTS)	
	Hours per semester	**Percentage**
TERM 1		
Total	225	100%
of which:		
Lectures	173.5*	77%*
Exercises	8*	4%*
Laboratories	42*	18%*
Miscellaneous	1.5*	1%*
TERM 2		
Total	150	100%
of which:		
Lectures	101	67%
Exercises	2	1%
Laboratories	37.5	25%
Miscellaneous	9.5	7%

Project	10 ECTS	

*Approximately, depending on the chosen courses.

Table 30 includes a summary of the comparison of the three previously described Master's programs in the UMA. The Industrial Engineering program has the biggest number of places available due to the fact that it is the natural choice for students who have finished their Degree in Industrial Technologies Engineering. It has to be noted that this master can be combined with the Master in Mechatronics or the Master in Environmental Hydraulics of the UMA. This way, the student can get a double-master diploma after conducting 120 ECTS + 30 additional ECTS of the latter masters plus an additional master's thesis. This option is not possible up to now with the Master in Intelligent Systems in Energy and Transportation.

All of them are on-site masters primarily taught in Spanish, but some courses are taught in English in the Master in Intelligent Systems in Energy and Transportation. The balance between lectures, exercises, laboratory practices and miscellaneous is quite similar in all masters. Lectures are of utmost relevance followed by laboratory practices. Less relevance is given to exercises and other activities.

Table 30. Comparison between Master programmes in UMA

	Comparison		
	Intelligent systems in Energy and Transportation	**Industrial Engineering**	**Mechatronics**
Maximum number of places available	20	80	25
Language	Spanish / English	Spanish	Spanish
Location	On-site	On-site	On-site
1st Term ECTS	30	30	30
2nd Term ECTS	30	30	20
3rd Term ECTS	18	30	---
4th Term ECTS	---	18	---
Master's Thesis	12	12	10
TOTAL ECTS	90	120	60
Hours / % total	585 / 100 %	810 / 100 %	375 / 100 %
of which:			
Lectures	332 / 57%*	515.5/ 63%	274.5 / 73 %*
Exercises	63 / 11 %*	89.5 / 11%	10 / 3 %*
Laboratories	152 / 26%*	77.5 / 10%	79.5 / 21 %*
Miscellaneous	38 /6%*	127.5 / 16 %	11 / 3%*

*Approximately, depending on the chosen courses.

References for Spain (all accessed on November 10, 2021)

[1] https://www.uma.es/conoce-la-uma/info/5576/historia/

[2] https://www.uma.es/escuela-de-ingenierias-industriales/

[3] https://www.uma.es/master-en-sistemas-inteligentes-en-energia-y-transporte/

[4] http://master-siet-eii.uma.es/

[5] https://www.uma.es/master-en-ingenieria-industrial/cms/menu/informacion-general/

[6] https://www.uma.es/master-en-ingenieria-mecatronica/

[7] https://oas.sci.uma.es:8443/pls/apex/f?p=101:1:3216967304295912::NO::INICIO_LOV_TIPO_ESTUDIO,INICIO_LOV_CURSO_ACAD,INICIO_LOV_CENTROS,INICIO_LOV_TITULACIONES,INICIO_LOV_CICLOS,INICIO_LOV_CURSOS,INICIO_BUSCAR:4,2020,-1,-1,-1,-1,

4.1.7 TH WILDAU

Brief overview of the Technical University of Applied Sciences Wildau

The Technical University of Applied Sciences Wildau (TH Wildau) is located south of Berlin, in the city of Wildau. TH Wildau was founded in 1991 and is the largest university of applied sciences in the federal state of Brandenburg (TH Wildau 2019).

The university campus is located on a historic industrial and manufacturing site. In 1898 the construction of a locomotive factory started in Wildau and in 1949 the Wildau Technical College for Locomotive and Rolling Stock Construction was founded at which the training of engineers started on the site (TH Wildau 2021e).

Where once locomotives were built in huge production halls, today people study, teach and research on a modern campus. About 3,600 students (3,646 winter semester 2018/19) are studying in 15 Bachelor’s and 15 Master’s programmes. Almost 20% of TH Wildau’s students are international students from over 60 countries. More than 100 professors and over 350 staff members are working at the TH Wildau. Since 2001 TH Wildau belongs to the top universities of applied sciences doing research in Germany. The university has more than 100 active research and scientific contacts and over 220 research projects. One of TH Wildau’s distinctive characteristics is the practical orientation of the degree programmes. Students can work with modern laboratories and computer technologies carrying out experiments and practical exercises. TH Wildau has many collaborations with small and medium-sized enterprises and large companies. Due to the collaborations TH Wildau can design the curricula for the degree programmes with input from business partners and students get the opportunities for project work within the companies gaining valuable practical experience within their studies. TH Wildau has more than 70 partner universities around the world and promotes exchanges for researchers and students (TH Wildau 2019).

TH Wildau’s degree programmes are organized in two faculties. The Faculty of Engineering and Natural Sciences offers degree programmes in e.g. Industrial Engineering, Logistics, Telematics and Transportation System Engineering (TH Wildau 2021c). In the Faculty of Business, Computing and Law degree programmes as e.g. Business Computing, Business Administration, Business and Law and European Management are organized (TH Wildau 2021b).

The most railway related degree programme at TH Wildau is Transportation System Engineering. For the benchmarking of parallel experiences the Logistics degree programme as a transport related programme is used. Professors involved in the degree programmes are active and interested in doing research. Research topics related to the Transportation System Engineering degree programme are, e.g.:

- Periodic Timetable Optimisation

- Railway operations
- Traffic Light Signal Optimisation
- On-Demand Mobility
- Autonomous Driving
- Driver Assistance Systems (DAS)
- Traffic Telematics in Rail Traffic
- Signalling
- New Mobility Concepts
- Environmentally oriented traffic management
- Traffic management by information
- User-centred and integrated transport planning

Research topics with regard to the Logistics degree programme are, as an example:

- Intermodal environmentally-friendly freight transport solutions
- Development of innovative, digitally supported mobility offers
- Electric mobility
- City Logistics
- Development and implementation of ICT systems
- Logistics-centred security research – critical infrastructures, emergency personnel logistics and disaster logistics (TH Wildau 2021p)
- Analysis and design of secure supply chains (TH Wildau 2021o)
- Logistics for last-mile delivery in SMEs (TH Wildau 2021l)
- Industry 4.0 – support of SMEs (TH Wildau 2021m)

Transportation System Engineering (B.Eng.)

The degree programme Transportation System Engineering is a Bachelor's Programme in which the graduates obtain a Bachelor of Engineering degree. It is offered in German language and can be studied full-time, part-time or dual. The standard duration is 7 semesters (full-time). (TH Wildau 2021s).

Currently (Oct 2021) only full-time students are enrolled with the exception of one student who is completing his degree in a similar way to a part-time degree.

The Transportation System Engineering degree programme is a semi-technical programme which provides graduates with interdisciplinary skills. They get technical knowledge, administrative skills as well as organisational skills in logistics. Graduates will be able to solve practical problems using their skills from engineering, business administration and information technology and they will be able to e.g. work in operating, analysing an improving existing transportation solutions. For transportation system technology engineers career opportunities include e.g. fleet manager for railways and subway systems, project engineer for traffic management systems and municipal traffic planning consultant (TH Wildau 2021s).

In the Transportation System Engineering degree programme seven professors (e.g. for operations of transport and traffic, transportation management, transportation systems) are involved in teaching as well as two lecturers employed by TH Wildau. Some of them teach as well in other degree programmes. Additionally involved in the Transportation Systems Engineering degree programme are two laboratory engineers and one programme coordinator/internship officer.

Besides, the following modules and topics are taught by four external lecturers from industry:

- Basics in Law for Logistics, Transportation and Mobility, five credit points
- Road Traffic Simulation, two credit points
- Depot Management, one credit point
- Investment and Financing, five credit points

In addition, experts from the industry are invited as guest lecturers to speak about currently important topics which are of special interest.

Within the Transportation System Engineering degree programme three laboratories are used. In the laboratory for transportation systems engineering the students carry out practical laboratory exercises on several subject areas e.g. in electronics, measurement and control technology and vehicle systems. The laboratory offers modern equipment and measurement technology. (TH Wildau 2021w) The laboratory for transport planning and aviation logistics is e.g. used for traffic simulations and for modelling and simulation of transportation systems. The laboratory consists of computer workstations with special software equipment, e.g. for interlocking simulations. (TH Wildau 2021v) The laboratory for vehicle measurement technology offers soldering stations and various small machines for the mechanical processing of prototypes. Students can work in the laboratory e.g. within the modules project work, vehicle systems and components, electronics or measurement and control technology (TH Wildau 2021u).

The curriculum of the Transportation System Engineering degree programme is shown in Table 15.

Table 31: Curriculum of the Transportation System Engineering degree programme (TH Wildau 2021r)

Modules	**Se-mes-ter**	**Type**	**CP acc. to ECTS**	**Hours per week per semester**	**Of which**			
					L	**E**	**LAB**	**P**
Introduction to Informatics 1	1	O	5.0	4.0	2.0	1.0	1.0	0.0
Introduction to Transport Engineering	1	O	5.0	4.0	2.0	2.0	0.0	0.0
Electronics	1	O	5.0	4.0	2.0	0.0	2.0	0.0
Basics of Scientific Writing and Presenting	1	O	5.0	4.0	2.0	2.0	0.0	0.0
Mathematics 1	1	O	5.0	4.0	2.0	2.0	0.0	0.0
Mechanics 1	1	O	5.0	4.0	2.0	2.0	0.0	0.0
Introduction to Informatics 2	2	O	5.0	4.0	2.0	1.0	1.0	0.0
Communication and Localisation	2	O	5.0	4.0	2.0	2.0	0.0	0.0
Mathematics 2	2	O	5.0	4.0	2.0	2.0	0.0	0.0
Mechanics 2	2	O	5.0	4.0	2.0	2.0	0.0	0.0
Project work	2 (*)	O	10.0	8.0	2.0	0.0	0.0	6.0
Quantitative Methods in Business Administration	2	O	5.0	4.0	2.0	2.0	0.0	0.0
Introduction to Transportation Telematics	3	O	5.0	4.0	2.0	1.0	1.0	0.0
Basics of Measurement and Control Technology	3	O	5.0	4.0	2.0	0.0	2.0	0.0
Quality, Safety and Security in Transportation	3	O	5.0	4.0	3.0	0.0	1.0	0.0

Stochastics	3	O	5.0	4.0	2.0	2.0	0.0	0.0
Transport Policy and Transport Market	3	O	5.0	4.0	4.0	0.0	0.0	0.0
Colloquium for the internship semester	4	O	5.0	0.0	0.0	0.0	0.0	0.0
Internship semester	4	O	25.0	0.0	0.0	0.0	0.0	0.0
Information Technology for Transportation 1	5	O	5.0	4.0	2.0	1.0	1.0	0.0
Infrastructure Design	5	O	10.0	8.0	2.0	2.0	0.0	4.0
Modelling and Simulation of Traffic and Transportation Systems	5	O	5.0	4.0	2.0	0.0	2.0	0.0
Basics in Law for Logistics, Transportation and Mobility	5	O	5.0	4.0	4.0	0.0	0.0	0.0
Specification of Technical Systems	5	O	5.0	4.0	1.0	0.0	0.0	3.0
Vehicle Systems and Components	6	O	10.0	8.0	4.0	0.0	2.0	2.0
Information Technology for Transportation 2	6	O	5.0	4.0	2.0	1.0	1.0	0.0
Investment and Financing	6	O	5.0	4.0	3.0	1.0	0.0	0.0
Transport Planning and Operations	6	O	10.0	8.0	4.0	4.0	0.0	0.0
Bachelor Colloquium	7	O	3.0	0.0	0.0	0.0	0.0	0.0
Bachelor Internship	7	O	10.0	0.0	0.0	0.0	0.0	0.0
Bachelor Thesis	7 (*)	O	12.0	0.0	0.0	0.0	0.0	0.0
Transportation Logistics	7	O	5.0	4.0	2.0	2.0	0.0	0.0
Total semester hours per week				**124**	**63**	**32**	**14**	**15**
Sum of CP to be reached from elective modules			**0**					
Sum of CP from obligatory modules			**210**					
Total sum of CP			**210**					

Legend: L – lectures, E - exercises, LAB - laboratories, P - project, O – obligatory, I – elective
(*) Module extends over several semesters
One semester at TH Wildau is 15 weeks long.

Logistics (B.Eng.)

The Logistics degree programme concludes with a Bachelor of Engineering degree and is offered in German language. The standard duration is seven semesters (full-time). It is offered full-time and part-time. (TH Wildau 2021h) Most of the time only full-time students are enrolled, occasionally a few part-time students. The Logistics degree programme is a semi-technical programme which provides graduates with interdisciplinary skills. They will be able to solve complex problems in the fields of Logistics and Supply Chain Management using their skills from engineering sciences, business administration and information technology. There is a wide range of career opportunities for logistics specialists. Example positions can be found in transport and logistics, in the engineering of material flow components or in production planning and control (TH Wildau 2021h).

The team of the Logistics degree programme consists of six professors (for e.g. information logistics and supply chain management, logistics management, integrated development and production management, production logistics, technical logistics and transport logistics) and one lecturer/scientific assistant (for information processing in logistics) employed by TH Wildau. Some of them are as well active in other degree programmes. Additionally involved in the Logistics degree programme are two laboratory engineers and one programme coordinator/internship officer (TH Wildau 2021j).
Besides, four external lecturers from industry (e.g. from automotive industry) teach the following modules:

- Change Management (elective module from the catalogue special aspects in logistics), five credit points
- Planning and Evaluation of Logistics Locations (elective module from the catalogue special aspects in logistics), five credit points
- Healthcare Logistics (elective module from the catalogue special aspects in logistics), five credit points
- Fundamentals of Operational and Corporate Management, five credit points

Economic experts are invited for guest talks about various topics. Within the entire course the students can listen to approx. ten different guest lectures.
Within the Logistics degree programme five modern laboratories and one competence centre are used. They function as learning and testing environment for students as well as for research and industry partners (TH Wildau 2021d). The intralogistics laboratory offers a practical environment in which the students can work with the latest industrial technology and have a variety of opportunities to test application scenarios of various systems. The laboratory consists, among other things, of driverless transport systems, an automatic small parts warehouse, conveyor technology and an order picking system with pick-by-light and pick-by-voice mode. (TH Wildau 2021f) The production logistics laboratory offers different software solutions e.g. for planning and visualisation of warehouses, factories and production facilities and for the simulation of logistics and production systems (TH Wildau 2021k). In the transport logistics laboratory students work with modern logistics software solutions e.g. for the disposition of vehicles in freight road transport, the optimisation of cargo load for containers or for creating timetables for rail transport (TH Wildau 2021t). The laboratory for technical logistics models provides education sets to get first experience in programming of systems equipped with sensors and actuators and in testing of switching logics (TH Wildau 2021g). State-of-the-art media technology to be used by the students is provided in the business start-up laboratory (TH Wildau 2021a). The SAP Competence Centre offers SAP components to give the students the opportunity to experience the world of ERP systems (TH Wildau 2021n).
Table 32 shows the curriculum of the Logistics degree programme.

Table 32: Curriculum of the Logistics degree programme (TH Wildau 2021q)

Modules	Semester	Type	CP acc. to ECTS	Hours per week per semester	Of which			
					L	E	LAB	P
Introduction to Informatics 1	1	O	5.0	4.0	2.0	2.0	0.0	0.0
English for Logistics	1	O	5.0	4.0	0.0	4.0	0.0	0.0
Fundamentals of Operational and Corporate Management	1	O	5.0	4.0	2.0	2.0	0.0	0.0

Basics of Logistics and Supply Chain Management	1	O	5.0	4.0	2.0	2.0	0.0	0.0
Mathematics 1	1	O	5.0	4.0	2.0	2.0	0.0	0.0
Methodology and Communication	1	O	5.0	4.0	1.0	3.0	0.0	0.0
Introduction to Informatics 2	2	O	5.0	4.0	0.0	2.0	2.0	0.0
Engineering Fundamentals	2	O	10.0	8.0	3.0	4.0	1.0	0.0
Materials Handling Technology	2	O	5.0	4.0	2.0	1.0	1.0	0.0
Quantitative Methods in Business Administration	2	O	5.0	4.0	2.0	2.0	0.0	0.0
Statistics	2	O	5.0	4.0	2.0	2.0	0.0	0.0
Digital Production	3	O	5.0	4.0	2.0	2.0	0.0	0.0
ERP 1 - Basics	3	O	5.0	4.0	1.0	0.0	3.0	0.0
Introduction to Database Systems	3	O	5.0	4.0	2.0	2.0	0.0	0.0
Mathematics 2	3	O	5.0	4.0	2.0	2.0	0.0	0.0
Planning of Logistics Systems 1 - Analysis	3	O	5.0	4.0	2.0	2.0	0.0	0.0
Telematics in Logistics	3	O	5.0	4.0	2.0	2.0	0.0	0.0
Colloquium for the internship semester	4	O	5.0	0.0	0.0	0.0	0.0	0.0
Internship semester	4	O	25.0	0.0	0.0	0.0	0.0	0.0
Freight Transport Logistics	5	O	5.0	4.0	2.0	2.0	0.0	0.0
Planning of Logistics Systems 2 - Design	5	O	5.0	4.0	2.0	0.0	1.0	1.0
Quality Management	5	O	5.0	4.0	2.0	2.0	0.0	0.0
Legal Aspects for Logisticians	5	O	5.0	4.0	4.0	0.0	0.0	0.0
Specification of Technical Systems	5	O	5.0	4.0	1.0	0.0	0.0	3.0
Economics and Macro logistics	5	O	5.0	4.0	4.0	0.0	0.0	0.0
ERP 2 - System Integration	6	O	5.0	4.0	1.0	0.0	3.0	0.0
Logistics Management	6	O	5.0	4.0	2.0	2.0	0.0	0.0
Logistics Projects in Companies	6	O	10.0	8.0	0.0	0.0	0.0	8.0
Transport Chains and Networks	6	O	5.0	4.0	2.0	1.0	0.0	1.0
Elective module 1 (from catalogue special aspects in logistics 1)	6	O	5.0	4.0	4.0	0.0	0.0	0.0
Bachelor Thesis	7	O	12.0	0.0	0.0	0.0	0.0	0.0
Bachelor Colloquium	7	O	3.0	0.0	0.0	0.0	0.0	0.0
Bachelor Internship	7	O	10.0	0.0	0.0	0.0	0.0	0.0
Elective module 2 (from catalogue special aspects in logistics 2)	7	O	5.0	4.0	4.0	0.0	0.0	0.0

Total semester hours per week				**124**	**57**	**43**	**11**	**13**
Sum of CP to be reached from elective modules			**0**					
Sum of CP from obligatory			**210**					
Total sum of CP			**210**					

Legend: L – lectures, E - exercises, LAB - laboratories, P - project, O – obligatory, I - elective
One semester at TH Wildau is 15 weeks long.

Analysis and comparison of the degree programmes

Both degree programmes are on bachelor level and have seven semesters. In both programmes the students gain 210 CP. Both programmes include a complete internship semester (25 CP). The Transportation System Engineering degree programme requires a pre-study internship which can be finalized until the end of the third semester. In both programmes the students gain five CP for the internship semester colloquium, three CP for the Bachelor Colloquium, 10 CP for the Bachelor Internship and 12 CP for the Bachelor Thesis. This means that 55 CP are dedicated to internships, colloquia and thesis and 155 CP to teaching.

A comparison of the degree programmes regarding the hours per week per semester and the teaching types is shown in Table 33.

Table 33: Comparison of the teaching types of the degree programmes

	Transportation System Engineering		**Logistics**	
	Hours per week per semester	**Percentage**	**Hours per week per semester**	**Percentage**
Total	124	100%	124	100%
of which:				
Lectures	63	50.81%	57	45.97
Exercises	32	25.81%	43	34.68
Laboratori	14	11.29%	11	8.87
Project	15	12.10%	13	10.48

Both degree programmes require in total 124 semester hours per week. In Transportation System Engineering 50.81%, half of the total semester hours per week, are lectures, 25.81% are exercises, 12.10% are related to project work and 11.29% are activities in laboratories. In Logistics 45.97% of the total semester hours per week are taught in lectures, 34.68% are exercises, 10.48% are project work and in 8.87% of the total semester hours per week the students work in laboratories. The comparison shows that the proportion of lectures in Transportation System Engineering is higher than in Logistics. In Logistics, however, the proportion of exercises is with one third of the total semester hours per week higher than in Transportation System Engineering, where only one quarter of the total semester hours per week is taught as exercises. The proportion of laboratory activities and project work is a bit higher in Transportation System Engineering than in Logistics.

The Transportation System Engineering degree programme includes 32 modules, the Logistics degree programme 34 modules. In the Transportation System Engineering degree programme all modules are obligatory. In the Logistics degree programme two modules are elective modules. The participation in both

modules is obligatory, but students can selected the content from the catalogue "special aspects in logistics". For both modules together the students gain 10 CP which equals 4.76% of the total credit points of the degree programme.
Both degree programmes include the following modules:

- Introduction to Informatics 1 + 2
- Mathematics 1 + 2
- Specification of Technical Systems
- Quantitative Methods in Business Administration
- Project work: In both degree programmes the students gain 10 CP for working in practical projects and solving complex and realistic problems (module Project Work in Transportation System Engineering and module Logistics Projects in Companies in the Logistics degree programme).

Both degree programmes involve external lecturers from the industry. In Transportation System Engineering four external lecturers teach two modules and topics within two other modules (13 CP). In Logistics four complete modules are taught by external lecturers (20 CP). The analysis shows that in the Transportation System Engineering degree programme 8.39% of the total credit points (155 CP) for teaching are taught by external lecturers and 12.9% in the Logistics degree programme. Guest lecturers are additionally invited in both degree programmes.

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4.2 Best and worst practices

After collecting and explaining the study programmes (curriculum), light statistical analysis, and comparative analysis between two programs of each partner institution in this subchapter, we collect best and worst practices. The best and worst practices are exploring that different study paths can be found and run on some institutions. These findings can lead to establishing a new concept for teaching and learning approaches. Of course, these findings will help us to build a new master programme.

4.2.1 For UNIZG

- Existing of laboratories but not using enough in the teaching process
- ASP because of World/Europe legal framework has aligned all teaching activities to be recognised at those levels (World/Europe)
- ASP offer more elective courses, so it is more interesting for students
- RSP and ASP using different EU mobility (ERASMUS+ and CEEPUS) programmes for attracting foreign invited lecturers
- The range of ECTS is relatively high on RSP and very uniform on ASP
- Both RSP and ASP do not use field trips for educational purposes.
- ASP organise a student club for different activities like additional lectures, building different types of plains, quizzes, Xmas party and similar activities

4.2.2 For KTH

- Aeronautics use of the wind tunnel as hands-on work for the students. +
- Internal course assessment in the KTH railway group. +
- Strong encouragement to conduct master theses in the industry. +
- Railway Engineering’s collaboration with the University of Illinois at Urbana-Champaign. +
- Platforms consisting of members of the university and the industry to allow for on open discussion on programme contents. +
- JSB master thesis fair connects future graduates and companies systematically. +
- High amount of obligatory courses limit potential to individually shape the Railway Engineering program. –
- Few hands-on activities in Railway Engineering. –

4.2.3 For UNIZA

Best practices in the Railway transport programme:

- Specialization only on the railway transport with three main areas – transport processes and modelling, commercial processes and economics and management
- Link to the industry – possibilities for students to take part in an internship or to work on final thesis, lectures from the industry
- Use of the railway laboratory
- Excursions during all semesters – possibility to choose the elective module Professional excursion
- Higher percentage of exercises than in other two study programmes

Best practices in the Railway structures programme:

- Specialization directly on the railway structures
- Students can choose from a larger number of obligatory elective courses
- Link to the industry - possibilities for students to take part in an internship or to work on final thesis, lectures from the industry
- Excursions during semester – the professional excursion is a part of obligatory courses
- Mandatory professional practice in the company during semester

Best practices in the Forwarding and logistics programme:

- The study programme focuses on all modes of freight transport
- Link to the industry – possibilities for students to take part in an internship or to work on final thesis, lectures from the industry
- Higher percentage of laboratories than in other two study programmes
- Use of specialized software
- Larger range of foreign language courses

4.2.4 For DICEA

- Every year there are guided tours in which students can visit very interesting places such as:
  - Operations room Termini station;
  - National headquarters of Trenitalia;
  - Port of Civitavecchia;
  - Amazon warehouses;
- In addition, the most deserving students in their final year are offered a three-day trip to visit the main European railway, maritime and logistical sites.
- Seminars by professors or specialists from outside the university are planned.
- During lecture hours, some professors have their assistants present the most important aspects of certain projects and innovations conducted by the department.
- Every year, representatives of some multinationals (such as Trenitalia Spa, Bombardier, etc.) are hosted and present their companies' projects and objectives.

- There are different laboratories such as the Vehicle and Transport Systems Laboratory and the Road Materials Laboratory whose access and use is rarely allowed to students except for those writing their thesis.

4.2.5 For AU

- High education programmes with International Foundation Year
- Complete work-based assignments
- A mixture of formal lectures, tutorial classes, practical exercises
- Independent and group work associated with taught content
- Project-based learning
- Practical modules with industry focus
- Independent study as requirement
- Professional experience gained whilst studying
- Industrial placement in relevant companies for 12 months at the end of year 2
- Industrial visits organised in collaboration with professional bodies
- Final Year Dissertations with focus on industry problems solving
- University degree programmes accredited and endorsed by professional institutes like CILT and SIPS
- Creation of new Academic Programmes and modifications of current offerings in consultation with the appropriate accreditation bodies
- Acquisition of different set skills: *Knowledge and Understanding, Intellectual, Professional, Transferable*
- Internal and external moderation of assessment
- Every university degree programme requires an External Examiner, who will be appointed on a [3 + 1]-year contract
- External Adviser for internal programme approval
- Midterm and end term student surveys to collect student feedback
- Contentious student feedback throughout the academic year
- Formal and informal feedback given to students on scheduled basis (within 4 weeks after every submission of course work and assignments)
- Anonymous feedback given to the whole cohort after completion of every exam
- Collaborative teaching and learning student experience with internal and external participations including on-site teaching
- Aston member of staff acts as quality assurance certifier during on-site teaching to make sure that Aston standards for higher education delivery have been met
- Familiarising with academic writing
- Government funding available for addressing the skills shortage in the UK Logistics and Transport industry.

4.2.6 For UMA

- The Master in Intelligent Systems in Energy and Transportation organise every year guided tours in which students can visit very interesting places such as RENFE Integral Maintenance Base, the Metro of Malaga Operations room and the Metro Maintenance workshops.
- The Master in Intelligent Systems in Energy and Transportation and the Master in Mechatronics develop more than 20% of their teaching in the labs.
- Three masters contemplate more than 55% of their teaching as formal lectures. This way, a good balance between theory and practical learning activities is achieved.
- Every year, representatives of some companies, invited as guest lecturers, (such as Adif, Metro, Bombardier, Talgo, Abengoa, etc.) are hosted and present their companies' projects, activity and objectives.
- There are many laboratories that students use for practical demonstrations and expansion of knowledge.
- Some of these laboratories are also used by students to develop their master thesis. These facilities are shared with post-doc students and researchers, which create a synergy that booster the knowledge and the practical and personal experience of the students.
- Master programme in Intelligent Systems in Energy and Transportation and Master programme in Industrial Engineering offer the possibility to do Internships in companies. It makes the academic offer more attractive and reinforces the university-company-society link, creating a positive impact for all parties involved in the teaching-learning process. Likewise, it can be a way for companies to implement plans to "attract talent"
- The Master in Industrial Engineering can be combined with the Master in Mechatronics or the Master in Environmental Hydraulics at the UMA. This way, the student can obtain a double master's diploma with more complete and in-depth training. This contributes to the employability of recent graduates to a greater extent. In addition, it strengthens the recognition of studies by social agents (companies, professionals, families, associations ...)
- Seminars by professors or specialists from outside the university are planned in all the Master's programs, helping to maintain and strengthen the universal-company bond.
- The Master's program in Industrial Engineering is an enabling master to exercise the free profession as an industrial engineer throughout the Spanish territory. So the trained engineers will be able to develop all the acquired knowledge without limitation.

4.2.7 For THW

Best practices in the Transportation System Engineering degree programme:

- Transportation degree programme which focusses all modes of transport (students gain an understanding of systems); transportation is not only a specialization within a civil engineering or infrastructure related degree programme
- Practice-oriented teaching approach at a university of applied sciences
    - Extensive linking of teaching and practice
    - Strong practice orientation in the whole programme
    - Extensive practical phases: pre-study internship (has to be finalized until the end of the third semester) plus five months internship during the internship semester plus eight weeks Bachelor internship → students gain practical experience in companies
    - Most of the students write their Bachelor thesis in companies
    - → students get direct contact to companies and some students get a job in the companies after graduation
- Link to the industry:
    - Professors and lecturers have good contacts to the industry; students establish contacts to the industry through their internships/thesis
    - External lecturers from the industry teach two complete modules in the programme and parts of two other modules
    - Guest lecturers are invited
- Module Project Work:
    - Students are taught theory of project management in lectures; students listen to guest speakers; students define their topic of their project work and plan their project (e.g. planning of milestones), students carry out their project work
    - → students gain experience in project work and in solving practical problems and/or working on a complex topic, partial cooperation with public administration/institutions (e.g. carrying out practical surveys for the switching of a traffic light for a municipality)
- Use of laboratories: practical demonstrations, expansion of knowledge in addition to theory taught in lectures
- Varied group work with presentation of results
- Excursions: at least five excursions (e.g. control centres, railway yards, railway maintenance stations) are offered during the study period. Students are offered to visit and experience a railway operations laboratory within a two days excursion

Best practices in the Logistics degree programme:

- Practice-oriented teaching approach at a university of applied sciences
    - Extensive linking of teaching and practice
    - Strong practice orientation in the whole programme
    - Extensive practical phases: five months internship during the internship semester plus eight weeks Bachelor internship → students gain practical experience in companies
- Strong link to the industry

    - Long-term corporate partnerships e.g. with the automotive industry, manufacturing industry, transport service providers
    - External lecturers from the industry teach four modules in the programme
    - Additional guest talks by economics experts, changing topics, students listen to approx. ten different guest lectures during their studies
- Project work within companies (module Logistics Projects in Companies, 10 CP)
    - Project-based problem solving in companies (realistic problems)
    - Students gain insight into companies
    - Students are supported by company contact persons and TH Wildau professors

1. Presentation of the results

- Use of different laboratories: practical demonstrations, expansion of knowledge in addition to theory taught in lectures
- Varied group work with presentation of results
- Visits to companies (at least three or four excursions during the study period) and visits to trade fairs
- Broad course content, semi-technical degree programme, substantial content in business areas, IT and mathematical areas. Interdisciplinarity is an interesting aspect for students.

4.3 Lessons Learned

There is a variety of definitions connected with term “Lessons Learned”. Perhaps the most popular is the one used by NASA: “A lesson learned is knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. A lesson must be significant in that it has a real or assumed impact on operations; valid in that is factually and technically correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps or reinforces a positive result” [1]. In our research we used the above definition. Because we strive for positive change, we used the current study programs, which we have analysed in detail, as a basis for change.

The main driver is a student standpoint for effective and efficient learning process that is covered by advanced teaching methods. We can conclude that the number of theoretical hours is extremely high at some of the project partner universities and that this leads to an outdated teaching praxis of hearing and repeating. Detailed comparative analysis of theoretical hours and percentage among partner universities is shown in table 1. An immediately positive change is necessary especially in those countries where no change from classical theoretical lectures to modern teaching methods involving the students has taken place in the last 20-30 years. Besides, all other countries should as well adapt their teaching and learning methods to new approaches that will be developed in the ASTONRail project. At universities at which a very old-school teaching process is established, the positive change needs to be supported from university professors that understand the changing paradigm of today's education process.

Traditionally at engineering universities students gain a wide ranged basis of different engineering pillars. Positive about that is, that they can understand a wider range of problems. But a very negative aspects is, that the amount of knowledge is increasing exponentially and this approach is less efficient, than more modern teaching approaches for future generated occupations.

Table 1. Comparative analysis of theoretical hours and percentage among partner universities

Partner universities	Study program	Lecture (hours)	Lecture (%)
UNIZG	Railway study program	345	54
	Aeronautical study program	120	66
KTH	Railway Engineering		49
	Vehicle Engineering (Railway track)		46
	Aerospace Engineering		41
UNIZA	Railway transport	106.75	40.47
	Railway structures	129	44.29
	Forwarding and logistics	114.25	43.32
DICEA	Aeronautical and maritime	310	63
	Traffic and logistics	310	63
	Railway	310	63
UMA	Intelligent systems in Energy and Transportation	332	57
	Industrial Engineering	538.5	66
	Mechatronics	274.5	73
TH WILDAU	Transportation System Engineering	63	50.81
	Logistics	57	45.97

Legend: red – share of lecture are more then 50%

So, from the lessons learned it is necessary to weigh the quantity of basic engineering knowledge and build up new emerging knowledge. And nevertheless, introduce new emerging teaching activities.

Honestly, all partners in the project are using (in some cases) some very advanced teaching activities but they are mostly on a voluntary basis and depending strongly on the personal engagement of universities professors. This differs between the project partner countries. The analysis of parallel experiences shows that at some project partner universities the proportion of exercises in the curriculum is more than 30 %. In table 2 is comparative analysis of exercises hours and percentage among partner universities which include exercises held in lecture room or/and laboratories. In addition, some project partner universities offer practice-oriented teaching approaches including e. g. the use of laboratories or the integration of internship semesters.

Table 2. Comparative analysis of exercises hours and percentage among partner universities

Partner universities	Study program	Exercises (hours)	Exercises (%)
UNIZG	Railway study program	190	31
	Aeronautical study program	57	31
KTH	Railway Engineering		47
	Vehicle Engineering (Railway track)		53
	Aerospace Engineering		56
UNIZA	Railway transport	157	59.52
	Railway structures	162.25	55.71
	Forwarding and logistics	149.50	56.58
DICEA	Aeronautical and maritime	182	37
	Traffic and logistics	182	37
	Railway	182	37
UMA	Intelligent systems in Energy and Transportation	215	37
	Industrial Engineering	190.50	23
	Mechatronics	89.50	24
TH WILDAU	Transportation System Engineering	44	37.10
	Logistics	54	43.55

Legend: red – share of exercises are more then 30%

We can point out the following pillars, (differentiated between bachelor and master degrees pillar) we consider "Lessons Learned" in this task:

A. Bachelor level (3 years - 180 ECTS)
    1. Limitation the obligatory basic engineering courses within the first year (two semesters). This way, basic engineering is taught in the first year of study only, and the next two years are reserved for more specific railway courses.
    2. Introducing obligatory course about system engineering. In their root of existence, the railway is a system-oriented engineering study. So, system engineering is key and basic knowledge.
    3. Introducing laboratories in the curriculum as standalone courses with close didactic integration into the curriculum. Different Higher Education Institutions (HEIs) introduce laboratories in their curriculum. According to positive parallel experience, for example UNIZA, laboratories as the standalone course offer students a better understanding and focus on learning topics.
    4. Introducing soft skills seminar during the study period. In today's society, soft skills are crucial for understanding work and communication in the railway system. Therefore, these skills need to be implemented in various courses during the study period.

5. Teaching some courses in a foreign language (for example: English language, German language, etc.) There is a big difference in foreign language knowledge between European countries. To increase foreign language knowledge, it will be wise that the identical courses at different higher education institutions (HEIs), full or partially, be offered to students.
6. Establish elective modules that are focused on concrete knowledge (for example: automotive industry, transport services, railway operation, traffic planning) The railway system is a huge area of knowledge and expertise. In that sense, it will be feasible to offer students different modules. By choosing courses that fit the personal interests, the students are much more focused on their studies.
7. Invite external professors and professionals from the industry with a combination of lecture plus panel discussion Students should be given the opportunity to discuss similar or the same topics with external professors and/or practitioners. In this way, they gain experience of understanding the same or similar topics from different points of view.
8. Set up seminars in which students solve practical problems in groups (if possible with industry partners that formulate the problem). To get better acquainted with the practice or the real state of the industry, various seminars with practice can be introduced that are concentrated on real problem-solving.
9. Include internships to enable the students to gain practical experience during their studies as the Bachelor’s degree is the first professional qualification and practical experience is therefore needed The internship should be able to be provided to students during their studies. In this way, they will personally experience what it means to work in practice.
10. Write Bachelor thesis with/at industry partners. This approach enables a detailed acquaintance with the detection of the problem and its solution in the real environment.

B. Master level (2 years – 120 ECTS)

1. Only first semester with obligatory advanced engineering courses. This way, only advanced engineering courses is taught in the first semester of study, and the next semesters are reserved for advanced railway courses.
2. Introducing obligatory course about system specific useable, general scientific research methods that can be applied in railway engineering (for example operational research methods, game theory, e.g.) Today's engineering is based on different types of research methods e.g. in optimization. So that students can understand complex system relationships and system handling, e.g. in optimization it is recommended to introduce a specific optimization course.
3. Introducing laboratories in curriculum as standalone courses with close didactic integration into the curriculum. Different HEIs introduce laboratories in their curriculum. According to positive parallel experience, for example UNIZA,

laboratories as the standalone course offer students a better understanding and focus on learning topics.

4. Introducing seminars in curriculum as standalone courses (creating new product/services, benchmarking, debates) – strong connection with industry. Different HEIs introduce seminars in their curriculum very often as a part of the course. Seminars as the standalone course (with close didactic integration into the overall curriculum) offer students a better understanding and focus on learning topics. But also working and team and communication with industry.
5. Introducing soft skills seminar during the study period. The future master engineer is expected to communicate well (in speech and writing), allocate resources and manage teams or projects. These skills are soft skills and their training during the study period is essential.
6. A significant part of courses, there is an emphasis on European or international topics, such as ECTS or INCOTERMS, to teach English. There is a big difference in English language knowledge between European countries. To increase English language knowledge, it will be wise that the identical courses, full or partially, be offered to students at the master level of study. This also will increase student mobility opportunities and exchange of knowledge.
7. Introducing elective courses for different specific research topic (for example: intermodal transport, timetabling, fleet management, marketing of services, travel behavior, …) Although students are concentrated on studying the railway system, each of them has some personal preferences or subjects where he sees himself in the work environment, so it is necessary to offer different elective courses dealing with specific areas of railway engineering.
8. Invite external professors from different Universities/Faculties. Students should be given the opportunity to discuss similar or the same topics with external professors. In this way, they gain experience of understanding the same or similar topics from different points of view.
9. Invite professionals from industry with combination of lecture plus panel discussion. Students should be given the opportunity to discuss similar or the same topics with professionals. In this way, they gain experience of understanding the same or similar topics from different points of view.
10. Organize regular technical visits (2-3 days per semester). In order for students to gain practical insight into theoretical knowledge, technical visits are organized to various industrial partners.
11. Obligatory internship (at least 3 Months) during the study. The internship should be able to be provided to students during their studies. In this way, they will personally experience what it means to work in practice.
12. Connect study program with similar European union universities/faculties for establishing mobility among partners (professors and students). This way, students will be able to expand their knowledge beyond the context of their own country and certainly better understand the single railway area.

13. Organize once per whole study program student competition (Hackathons or similar events). Today's industry is a highly competitive area, so the introduction of competitions allows students to cope in such an environment.
14. Master thesis fully connect with industry partners. Preparation, research and presentation of master's theses should be fully related to the industry. This creates a win-win situation for all stakeholders involved.

5 Task 3.4 - Mapping out gaps and mismatches between Industry expectations and university provision

Task coordinator: EURNEX

This section will gather all the information in the previous sections and propose a good representation and visualisation of the correlation between the existing education and the industry needs, tailored for the prospective public (universities and companies). This will help find development needs, but also generate material that can be used for project outreach with high visual impact. For a thorough analysis, previous representation methods are first analysed in depth as a starting point for the discussion.

5.1 Representation of academic and industrial skills I the railway sector

The choice of methods shall not only ensure high quality results of the present research but also allow comparability with previous studies. To facilitate this, a similar approach to SKILLFUL (2018) has been chosen. However, this does not mean that SKILLFUL's methods are just applied to this project without further caution. On the contrary, potential strengths and shortcomings of the used methodology were to be assessed and the methods were adapted where necessary.

5.1.1 SKILLFUL (2018)

According to the Description of Work (DoW), the outputs of this task are to be delivered in a similar way as it has been done in the often-cited SKILLFFUL project (2018) [2]. For the present task, the SKILLFUL deliverable 2.1 is the relevant piece to be studied. The focus in this review process is veered off the bare contents, towards the methodological and systematic processes, to be able to follow this approach for the present research. The review follows the structure of the reports reviewed.

"Critical review of the educational and training systems and mechanisms in the transportation sector"

First the three management levels (Strategic, tactical & operational) are introduced and explained. Based on this, a careers matrix for each mode similar to the Rail Careers Matrix (see Figure 21) was designed using the expertise of each mode. To complete the template, different training schemes and programs are identified and listed on the left-hand side of each job category.

DOMAIN / LEVEL	STRATEGIC	TACTICAL	OPERATIONAL
INFRASTRUCTURE	Infrastructure Director	Infrastructure Planner	Track Inspector
VEHICLES	Vehicle Director	Vehicle Design Engineer	Maintenance Engineer
OPERATIONS	Operations Director	Timetable Planner	Train Crew
SIGNALLING	Signalling Director	Signalling Planner	Signalling Inspector
ECONOMICS	Commercial Director	Sales Manager	Sales Assistant
ADMINISTRATION	Administration Director	Administration Manager	Administration Assistant
ACADEMIA	Dean	Group Manager	Research Assistant

Figure 21 - Rail Careers Matrix (UIC, 2021)

15. College
16. University
17. Professional Training
18. Apprenticeships
19. VET & CVET
20. Others

The application of the matrix does not become entirely clear. I suppose that the questionnaires were designed to follow the previously developed matrixes for each mode and furthermore listed the educational categories (see above) to facilitate a blending of industry needs (represented by the matrix and its entries) and the educational opportunities available (represented by the training schemes listed above).

The respective results were presented country wise. For each country a table consisting of 4 rows for the 4 different modes (rail, air, road, maritime) was set up and filled with the results gathered using the questionnaires. Subsequently the obtained results were summarised in further tables for each mode. These tables consisted of the three columns “Category”, “Countries” and “Reasons”. The categories where “High respond to demand”, average response to demand”, low response to demand and “Others”.

“New and emerging training tools, methodologies, and schemes: Benchmark review”

Based on a wide consultation of experts and a thorough literature review (scientific and grey literature), new and emerging training tools, methodologies and schemes were identified and categorized in “Tools and technologies”, “Settings” and “Pedagogical model”.

The overall results of this section were that new innovative training scenarios had to be *blended* and *learner centred*. Blended means that different tools and methodologies (a clear distinction between both these terms is not possible) are used in the same course (e.g., face-to-face learning and distance learning or VR and lectures). Learner centred means an individually tailored learning opportunity for each trainee/learner.

Furthermore, these methods are rarely implemented nowadays and if so, then mostly to complement traditional forms of teaching/training, instead of changing the training experience as a whole.

The covid crisis in 2020 and 2021 boosted the implementation of distance/ubiquitous learning methods enormously. Although the following cannot be supported with empirical evidence, both teachers and students agree in claiming that a fully remote education is neither successful nor does it fulfil the participants needs in other regards [3]. This further affirms the blended learning approach.

"Gaps in training for transportation careers"

"A training need is the gap between current and future knowledge and skills that can be bridged by training or learning activities."

The SKILLFUL researchers used interviews and workshops to acquire knowledge about the industries future needs and the current educational opportunities. The results were presented in a table that displayed a short description of the gaps in the left, the applying modes in the middle, and possible training methods to close these gaps in the right column. For the rail sector these were:

Table 34: Gaps in the railway sector

Gap	Training tools/technologies/methodologies that might be used to bridge this gap
New technologies and IT skills	Smart Learning Technologies VLE[11] Heutagogy
Autonomous vehicles, connected vehicles	VLE Virtual/Augmented Reality Learning tools
Increased used of Augmented Reality in the workplace	Virtual/Augmented Reality Learning tools

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[11] Virtual learning environment

Source: SKILLFUL (2018) Deliverable 2.1

5.1.2 Discussion on the Rail Careers Matrix

The RCM is represented in Figure 21. UIC provides a thorough description for each matrix entry on its website (UIC, 2021). The respective descriptions can be broadly summed up as listed in below.

Table 35 - description of matrix levels

Strategic	Tactical	Operational
• Representation and management duties, • Strong team-leading skills required, • Board member and decision maker • University degree and high level of experience required.	• Liaison between operational and strategic • High levels of specific knowledge required • University degree not necessary • Team-leading skills required	• Mostly at-site and hands-on work • High level of practical, rail-specific skills required

Source: Own elaboration

The use of the RCM (and the derivative matrixes for the other modes) in the SKILLFULL project did not become clear in the report, though it was used. Other than expected, the gaps found were not specifically located in the matrix but were listed in far a broader way. Considering the small number of experts interviewed in the railways sector and the overall (broad) scope of SKILLFUL, this broadness and lack of specificity not surprising.

For the present research project more detail is clearly necessary and demanded. Using the RCM as a base for this endeavour almost seems natural. However, the current matrix certainly has its weaknesses and might face a need of adaptation.

Traditionally biased matrix

The current matrix most certainly covers the traditional railway related job fields. In present days, mostly through contemporary global challenges as global warming and digitalization, *new, emerging job groups* are necessary to complement the matrix. This would mean a deep analysis of the existing rows to ensure if new technologies or areas of interest (e.g data science, digitalisation, systems perspective, sustainability…) need to be added to the matrix. Challenges from this perspective were already noticed in WP 1 & 2.

Educational opportunities vs. industry demand

When trying to highlight the contingent gaps between the present educational opportunities and the industries demand in workforce in the matrix, it is necessary to check how both sides are represented/representable in the matrix. Already the name *Rail Careers Matrix* implies a focus on the industry side. Different job offers can rather easily be matched with entries in the matrix. We experienced this in WP 2. Allocating educational programs to one or more gaps, on the other hand, is way more challenging and vaguer. There are numerous difficulties occurring in this context:

- University education does not necessarily cover all levels of the matrix – the operational level is also served by other kinds of training or education (see WP2)
- University studies do not directly lead to a management position – for most strategic or tactical positions experience is, besides appropriate education, required (see WP2 and matrix description at (UIC, 2021)).
- Especially in technical positions, but in others as well, a university degree does not lead to a specific position but opens a broad variety of different jobs. It is thus difficult to exactly assign programs to a certain matrix entry (see WP2).
- Most positions do not require railway specific education – non railway specific candidates may need longer initial internal training but can still staff the same position as a railway specialist.

Career not education matrix

When reading the descriptions of the single matrix entries, its career focus is undeniable. Required experiences in the railways or other sectors are mentioned in every description, whereas required educational backgrounds are rarely listed (almost exclusively for the tactical level). It is obvious that the RCM does not aim at freshly graduated students, but at professionals that are already taking part in the job market.

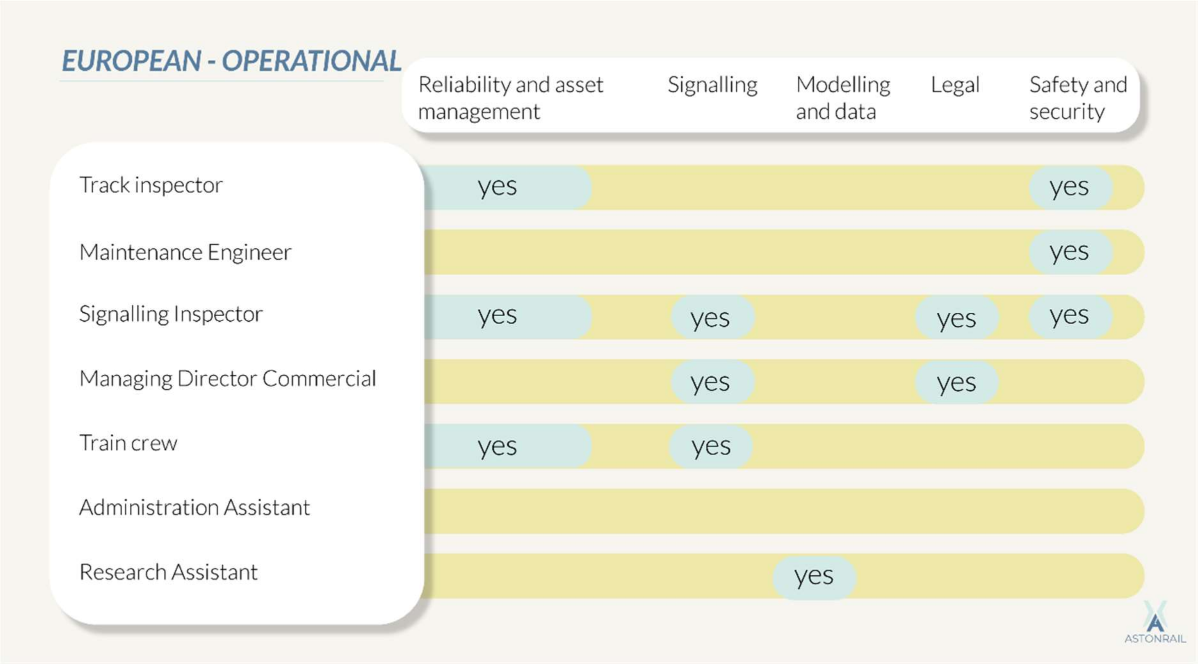
Final remarks

Considering all mentioned shortcomings, there definitely is a need to review and adopt the matrix for the purposes of the present research program. There are two main aspects that should be addressed:

- Are the gaps in the industry needs (Table *6*) visible and evident in the current Rail Careers Matrix, and does this need to be updated because of it?
- Is there a set of specific Study Paths that lead to specific RCM Careers? A more graduate-focused visualisation is necessary for successfully coupling educational solutions targeted in this project with the actual needs of industry.

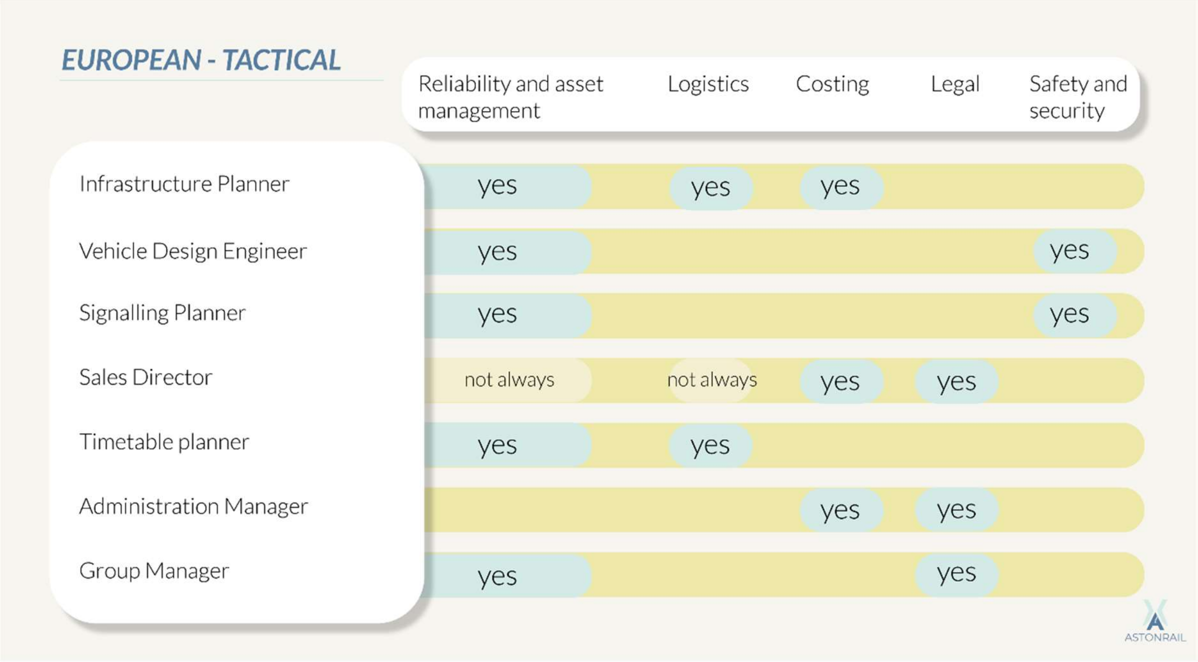
5.2 Finding gaps and mismatches in the RCM

The gaps in found in the industry analysis (Table *6*) are not necessarily directly related to the RCM. To understand where the needs are coming from, each RCM category description has been analysed, searching for references to the actual needs in Table *6*. The result is depicted in Figure 22, Figure 23 and Figure 24.



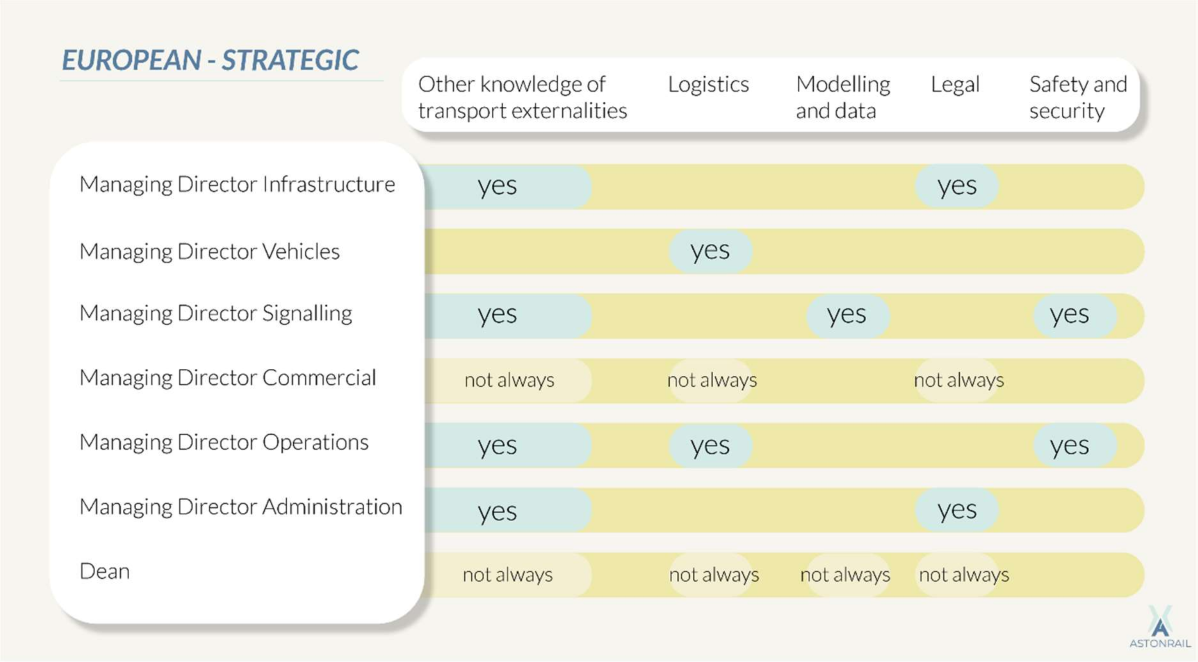
EUROPEAN - OPERATIONAL	Reliability and asset management	Signalling	Modelling and data	Legal	Safety and security
Track inspector	yes				yes
Maintenance Engineer					yes
Signalling Inspector	yes	yes		yes	yes
Managing Director Commercial		yes		yes	
Train crew	yes	yes			
Administration Assistant					
Research Assistant			yes		

Figure 22 – Location of Industry needs in the RCM Operational level



EUROPEAN - TACTICAL	Reliability and asset management	Logistics	Costing	Legal	Safety and security
Infrastructure Planner	yes	yes	yes		
Vehicle Design Engineer	yes				yes
Signalling Planner	yes				yes
Sales Director	not always	not always	yes	yes	
Timetable planner	yes	yes			
Administration Manager			yes	yes	
Group Manager	yes			yes	

Figure 23 - Location of Industry needs in the RCM Tactical level



EUROPEAN - STRATEGIC	Other knowledge of transport externalities	Logistics	Modelling and data	Legal	Safety and security
Managing Director Infrastructure	yes			yes	
Managing Director Vehicles		yes			
Managing Director Signalling	yes		yes		yes
Managing Director Commercial	not always	not always		not always	
Managing Director Operations	yes	yes			yes
Managing Director Administration	yes			yes	
Dean	not always	not always	not always	not always	

Figure 24 – Location of Industry needs in the RCM Strategic level

A more detailed analysis shows that:

- *Reliability and asset management* is over all the different categories
- *Modelling and data* is not described in many places in the matrix but is considered a big need from industry. This should be reviewed.
- *Safety and security* is mentioned in different job descriptions in the different level categories, so its consistency should be reviewed – it seems unrealistic to have gaps at different category levels for different job descriptions.
- *Legal* is a broad category that can cover many things, so a more specific analysis is needed, sadly the results from IO2 are limited.

6 Conclusions

The main output of this work is a clear depiction of the gaps existing between industry expectations and university provisions. The work has showcased the possibilities and limitations of linking higher education paths and outcomes with specific job offers or needs, and in doing so, *study path* and *permeability* have been defined.

- *Study path* is defined by its end point, the final academic title, and covers the yearly academic components from the first bachelor course until that end. Even if defined by the end result, an individual study path is already defined from start to end, so different study paths can lead to different
- *Permeability* defines how many different study paths reach a certain final outcome, i.e. how easy it is for students of different backgrounds to arrive to that academic title.

Defining a systematic scale, a more thorough picture has been depicted, showing some study paths that are narrow (Mechanical Engineering, Infrastructure Engineering as well as Material Science) and others that are broader (Transport and Logistics, Energy & Environmental Studies and Transport Systems Engineering).

From the job market and stakeholder analyses, a thorough consolidation job has been carried out to highlight the top five skill groups that are needed in the railway industry. There is an inherent uncertainty when dealing with data from surveys so the *stated preferences* were compared with the *revealed preferences* from the job offers investigated in task 2.3, with lukewarm results.

A systematic study of different sectors has also been performed, with a substantial amount of information coming from different university environments. A complete list of best practices has been assembled, and although this is extremely useful information for upcoming work packages, there is sadly no validation of this results in the sense that the described methods and techniques address student deep learning and engagement, but do not necessarily point to either positive or negative outcomes in the coupling between education provision and jobs market in their respective sectors. The output of this study is still a very powerful analysis of academic practices in Europe and the final discussion wil enable proposals in IO4.

Finally, all the previous work has been crystallised in a visual representation of the Gaps and Mismatches both from the RCM and Career Paths point of view, highlighting those skills and educational areas that need an increased amount of talent in the railway sector.

7 References

[1] P. K. Martin, "REVIEW OF NASA'S LESSONS LEARNED INFORMATION SYSTEM," Audit Report IG-12-012, 2012.

[2] "Best practices on current and emerging training schemes, methodologies and tools in the Transport sector and mapping to future training requirements and scenarios," SKILLFUL D2.1, 2017.

[3] S. Nikou and I. Maslov, "An analysis of students' perspectives on e-learning participation – the case of COVID-19 pandemic," *The International Journal of Information and Learning Technology*, vol. 38, no. 3, pp. 299–315, Jan. 2021, doi: 10.1108/IJILT-12-2020-0220.

8 Annex A - Parallel experience interviews Sweden

To get an insight in other departments/divisions teaching experiences, a short interview was conducted. At KTH one non-railway Master programmes, namely the MSc. Aerospace Engineering program was investigated. To allow for an appropriate comparison a second, similar interview was conducted with Carlos Casanueva Perez, the director of the MSc. Railway Engineering program at KTH and part of ASTONrail.

8.1 Approach

To use the scarce time of the interview efficiently a guideline was designed. This process had been aided by a so-called "mind map" (Figure 25). This is to ensure that as many aspects as possible were being incorporated in the guideline.
The interviews themselves were conducted via zoom and were being recorded. This allowed revisiting certain sections of the interview if needed in the aftermath during postprocessing.

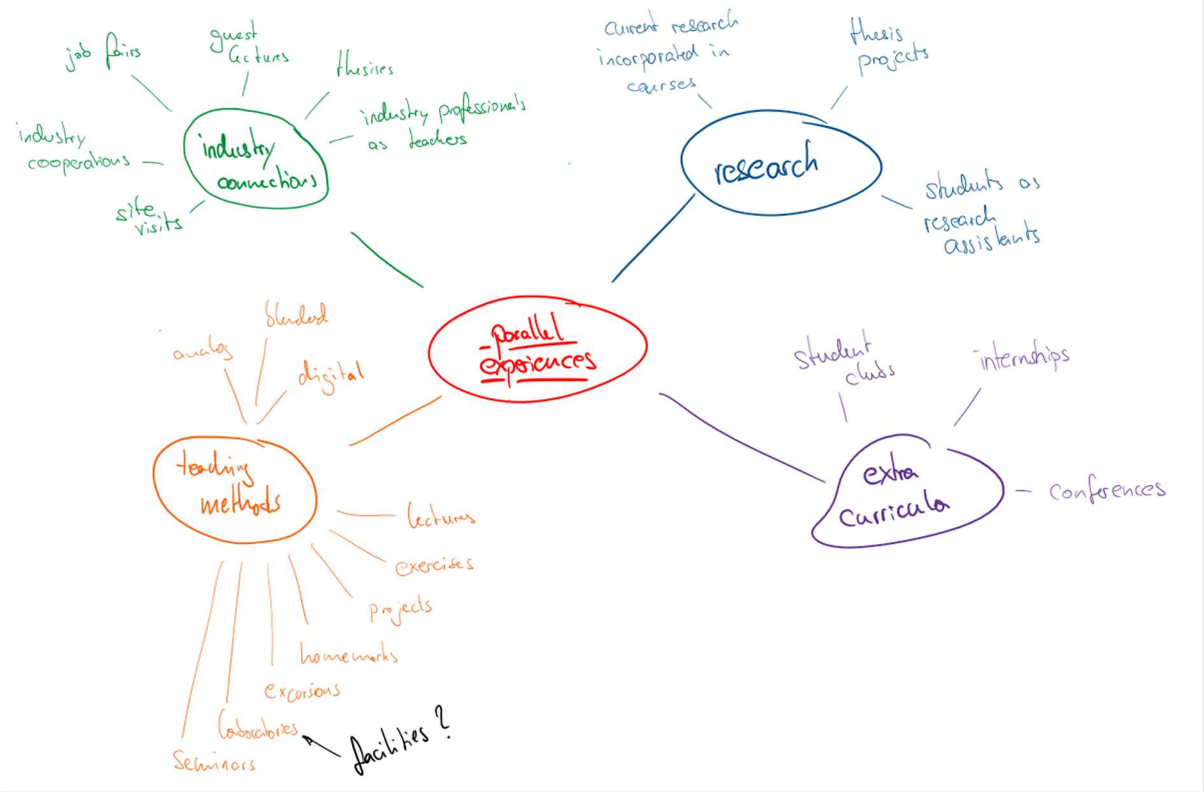


Figure 25 - Mind map of parallel teaching experiences

Guideline

As shown in Figure 25, the guideline uses four areas *industry connections*, *research*, *teaching methods*, and *extra curricula*. These four topics are obviously interdependent, but it seems reasonable to address them separately in the present context. Connections between the topics are outlined when necessary.

The interviewee was asked to give an insight about each of the four areas. The subtopics helped structuring the interview but were not necessarily being addressed. Also, more subtopics could be added if mentioned by the interviewee. A linearly structured list of the topics and subtopics can be found below.

- Industry connections
    - Industry cooperation
        - what companies?
        - how do you cooperate?
    - Professionals as teachers
    - Guest lectures
    - Site visits
    - Thesis projects
    - Job fairs
        - Internships
        - Theses
        - Traineeships
        - …
- Research
    - Current research incorporated in teaching
    - Thesis projects
    - Students as research assistants or in other positions
- Teaching methods
    - Analog
    - Blended
    - Digital
    - Lectures
    - Exercises
    - (Group) projects
    - Homework
    - Excursions
    - Laboratories
    - Seminars
    - …
- Extra curricula
    - Student clubs / associations
    - Internships
    - Conferences
    - …

Interviews

Table 36 Aerospace Engineering Interview

Date & time	October 4th, 2021, 16:00 – 17:20 (CET)
Interviewees	Evelyn Otero Sola (Assistant Professor, Vice-Director of CSA)
	Raffaello Mariani (Lecturer, Assistant Professor, Program Coordinator MSc Aerospace Engineering)
Interviewers	Christian Matz (MSc Railway Engineering student, research assistant)
	Carlos Casanueva Perez (Associate Professor, Program Director Railway Engineering) [joined at 16:30]
Description of the program	The **MSc program in Aerospace Engineering** is a 2-year (120 ECTS) program at the school of Engineering Sciences by the Department of Engineering Mechanics. The program which accepts between 80 and 100 (more international than Swedish students) new students every year is divided in four tracks namely Aeronautics, Lightweight structures, Space and Systems Engineering. Both interviewees are part of the aeronautics track.
Description of Interviewees	**Evelyn Otero Sola** is assistant professor at KTH in the school of engineering sciences. In her research she is focusing on sustainable aviation from an operational perspective and the analysis and optimization of aircraft trajectories. Besides she works on transportation mode comparison with respect to air travel in terms of sustainability from a holistic perspective. She teaches *Advanced Topics in Aeronautics*, Aircraft Performance and Air Traffic Management *and supervises Degree projects in Aeronautical Engineering and Aeronautics.* Further, she is Vice-Director of the Centre for Sustainable Aviation (CSA) at KTH.
	Raffaello Mariani is an assistant professor at in the Aeronautical and Vehicle Engineering Unit. In his research besides other topics, he worked on the development of quantitative schlieren for the analysis of supersonic jets and compressible vortex rings impinging on stationary surfaces. He is now part of the Green Raven project at KTH seeking to design a hybrid/electrical powered, small scale unmanned air vehicle. Besides teaching *Fundamentals of Flight* and *Projects in Aerospace Engineering*, he serves as a supervisor for Degree projects in *Aeronautical Engineering, Aeronautics, Mechanical Engineering and Vehicle Engineering.*
Content	**Industry connections** *Mrs. Otero Sola:* • Her new course involves a guest lecture from a company that focuses on sustainable aviation. Intended to be a partner for master's theses. • Site visits are planned but currently not the case due to the pandemic. • She developed her course considering some inputs from professionals (pilots). *Mr. Mariani:* • Members of the industry are involved in the Advisory board of the program (SAAB, GKN, SSC, …[only Swedish companies])

	• Guest lectures and guest seminars are interesting for many teachers in the department. More involvement is planned: a module and a whole course taught by a member of the industry respectively. • This results from a need of the industry for a specific topic, that KTH currently has no expertise on. The advisory board is set up to address these issues. • Difficult to implement site visits due to his course's topic (basic course on aerodynamics), the number of students, logistics (aerospace companies are typically not in the city centre) and security restrictions (e.g., for non-EU citizens...).
	Research *Mrs. Otero Sola:* • Created her new course based on her research and interest. • Students use her (simplified) code, go through similar questions and challenges as she did during her research. *Mr. Mariani:* • Keeps research and teaching mostly separate. Due to the fundamental character of his lecture.
	Teaching & teaching methods *Mrs. Otero Sola:* • There is no real exchange between different universities. It was difficult to find inspiration for her new course. • Lectures (to present theoretical concepts) → teamwork assignments → workshops and discussions (complemented by online quizzes and debates. The small group of students (6) was an advantage. • The small group also allowed to detect individual knowledge gaps among the students (e.g., in discussions) and to address them. • Very good experience with live recorded lectures (students could revisit). Will be continued. • Student focused teaching, enthusiastic delivery, try to create intrinsic motivation. → Some students will write their thesis in the field of the course. *Mr. Mariani:* • When developing a new course, teachers start by referencing to courses they took themselves as students. → Develop their own course with own material (compendium, slides, …)

	- Teaching methods vary manly by group size and by level of course and topic. - Even with a blended approach the focus is on the students in class. - “I am a lot more boring in a video than in class.” - Will implement pre-recorded (online) lectures and use in-class time for activities (projects, seminars, …). - Some students want to have more classical approaches to teaching. It is an iterative process. - There was a big conversation on how to implement digital teaching during and after the pandemic among the teachers.
	Extra curricula Unfortunately, the interview ended before we could address this topic.

Table 37 Railway Engineering Interview

Date & time	October 11th, 2021, 15:00 – 16:10 (CET)
Interviewee	Carlos Casanueva Perez (Associate Professor, Program Director Railway Engineering)
Interviewer	Christian Matz (MSc Railway Engineering student, research assistant)
Description of Interviewee	**Carlos Casanueva Perez** is associate professor for vehicle dynamics at the KTH Railway group. He is part of several Shift2Rail projects, working on wheel and rail damage, system and subsystem interaction, system cost, sustainability analysis and related issues. Besides contributions to several other research projects, he is majorly engaged in the present ASTONrail project. Apart from his role as director of the Master Program in Railway Engineering, he is responsible for the Rail Vehicle Technology course. He is furthermore contributing to other courses as a teacher and supervises and examines several master’s theses every year. In his role as a lecturer, he is interested in topics of equality and diversity.
Content	**Industry connections** - Involvement of the industry in courses (mostly guest lectures) is managed by the respective teachers. Teachers usually contact professionals that they know personally or former students that went in the industry. - This year a new chapter “Reliability and Maintenance” has been developed together with WSP (consulting company). They also give a 2h lecture on the topic. Furthermore, an assignment is adopted accordingly (students now perform LCC).

	• The KTH railway group has a number of industry partners (SJ, WSP, green cargo, SWECO, Alstom [formerly Bombardier] ..) which are also being approached if industry involvement is desired. • Several part time members of the research group/teachers work for the industry as well. Their hands-on experience is very much appreciated in the group. • The railway group is also part of the Swedish Railway industry collaboration forum JBS to establish more systematic industry connections. This is especially important for more strategic topics as sustainability. JBS also aims to develop the railway curriculums. • There is a master thesis fair every year for companies and students to meet. This year there also is a railway master thesis fair organised by JBS (systematic). • Students are encouraged to write their master theses in the industry. The partners are asked for thesis proposals (non-systematic).
	Research • Current research is mentioned in lectures, but due to the highly complex research and basic level courses this is mostly just mentioned on the last slide of the respective presentation. • Students are also regularly working for the group as assistants (e.g., in research) [The author of this paper is among them] • The main way of combining research and education are master theses.
	Teaching & teaching methods • Blended learning has been implemented when the collaboration with UIUC was started. • The lectures for one course (Rail vehicle dynamics) were recorded professionally. - “We learned a lot of that, but didn’t have the time or resources to apply what we learned yet” • Anther course (necessary for the UIUC collaboration) was recorded without professional help. • The current recordings are considered ok, but there is a lot of potential in further developing this: more compact lectures, online and IRL contents planned more strategically, ... But time and resources are needed. • Lectures and project assignments are design to run in parallel.

	- KTH has no hands-on facilities for railway students. Mostly due to size constraint. There is a roller rig but not yet clear how to include it in the courses (probably as a study visit). - Besides many advantages the collaboration with UIUC introduces constraints when it comes to course selection.[12] Also some contents are repeatedly taught on both sides of the Atlantic. - Courses are evaluated in the railway group. This group discussion is the basis for further course development. - The process of course development can be roughly described as follows: 1. Program director senses a need for an additional course (e.g., because industry partners report so) → 2. Is there an existing course that can be added to the program to fix that? 3. If not, can we create a course? Who wants to lead this course? - Many courses consist of units of instruction by different teachers.
	Extra curricula Unfortunately, the interview ended before we could address this topic.

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[12] E.g., the KTH signalling course is only offered in the fall semester and requires basic knowledge on railway systems. Hence it cannot be taken in the first year. In the second year however, the students are on their mandatory exchange semester in Illinois and are therefore not able to choose this course. Albeit there is a possibility of taking a railway signalling course remotely from UIUC during the spring semester of year one.
Also both schools define a number of obligatory courses, which in sum leads to a lower number of electives.