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ASTONRAIL – REPORT – Intellectual Output 1 – Final Report

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1 Task 1.1 Review of existing studies and structured information from various sources

1.1 Description

Task 1.1 was about the review of existing studies and the acquisition of information from various sources. In particular, they are:

1. Previous EU projects:
    a. EURNEX (2004),
    b. TUNRAIL (2010),
    c. SKILLRAIL (2011),
    d. RIFLE (2013),
    e. SKILLFUL (2019);
2. Papers published on journals specialized on training and education, as well as railway technical and economic aspects:
    a. A Successful Cooperation between Academia and Industry in Higher Rail Education: The Postgraduate Course in "Railway Infrastructure and Systems Engineering" at Sapienza [12],
    b. Data analysis of current and emerging skills development and training schemes in the rail transport sector [13],
    c. Railway Education for the 21st Century [14],
    d. A Model Suggestion for Improving the Efficiency of Higher Education: University–Industry Cooperation [15],
    e. Enhancing the scientific level of engineering training of railway transport professionals [17],
    f. Barriers to eLearning in rail [18],
    g. Back On Track: Gearing up to meet the increased demand for talent in the rail industry [19];
3. Web portals dedicated to present the educational offer to potential learning audiences:
    a. *Studyportals* (Masters),
    b. Advertisement in other websites;
4. International and national reports issued by railway operators, Industries, Public bodies responsible for education and training.
    a. Rail training 2020 [20],
    b. EU Transport Research & Innovation Status Assessment Report.

1.2 Review of data from previous EU projects

The EU projects hereby cited are relevant for this work, both for the similar scope (skills, trends and education in the transportation/railway sector) and for the targeted groups. The first action in order to build the database that resulted from task 1.3 was collecting the list of

partners and target groups from the aforementioned projects, as well as best practices in teaching and criticalities, with an emphasis on the skills required by industry and the innovation.

EURNEX (2004) pursued the main targets of integrating the fragmented rail research landscape in Europe and providing excellent research and education [1]. The EURNEX association, established at the end of this project is a member of the ASTONRAIL partnership, participated in many projects, some of which reported in the following paragraphs. The list of EURNEX partners was useful for the first draft of the database, though, being the project the oldest considered in this research, the data were subject to verifications and updates by web researches.

TUNRAIL (2010) was developing a transatlantic function between USA and EU on railway higher education. As its nature was the comparison and tuning of the current learning outcomes and competencies, its outcomes could be quite relevant for ASTONRAIL. The main result of TUNRAIL is a railway education handbook [2] that outlines:

1. Comprehensive inventory and analysis (comparison and benchmarking) of railway higher education programmes or practices in the EU and the USA;
2. Examples of better practices and successful approaches in railway higher education;
3. Specific recommendations and strategies for enhanced transatlantic knowledge transfer and for development of new programmes or improvement of current programmes;
4. Dissemination of the obtained results to the interested parties in academia and industry;
5. Better understanding of the synergies and differences of railway systems in the EU and USA and a solid foundation for increased transatlantic cooperation in rail higher education and training.

Important benefits are found from the interaction of universities and industries, where USA has been found with a stronger interaction between industry and society that EU. The benefits in cementing such collaboration are multiple, here presented [3]:

1. *Placement and sourcing of students*: deeper university-industry interactions create good opportunities for student internships that could easily result in permanent jobs after graduation; the rail industry can also be a valuable source of students for graduate or other courses and thus feed universities' classrooms; on the other hand, graduates with rail exposure during their studies are better prepared to contribute to the company immediately upon hiring and possess higher potential to remain with the employer;
2. *Insight into industry needs*: universities get a better understanding on the actual requirements and demands placed by the industry that could encourage improvements to the curricula and identify new research opportunities;
3. *Research and continuing education opportunities for faculty*: industry's problems and challenges are an endless source of new research opportunities and collaboration projects tend to be more beneficial and valuable for both parties;

4. *Additional source of funding*: industry is more willing to fund university research if collaboration and interaction is strong;
5. *Customized education and training*: universities can provide customized courses (or workshops) at special fees;
6. *Influence on academic programs*: industry may comment and advise on the curricula and course content so that it better meets their needs;
7. *Access to new knowledge*: a strong interaction with universities may open the door to industries to access new technologies, models, techniques, materials, or processes, etc. before other competitors;
8. *New revenue sources*: industries may develop new products and markets based on academic research outputs; in addition, universities may leverage industry to access certain types of funding.

On the other side, some problems may arise and create difficulties in the alignment of curricula to industry's needs [4]:

1. University-industry interaction is not included in university's promotion and rewarding schemes;
2. Heavy teaching loads do not leave time for engagement in university-industry interactions;
3. University career development does not require interaction with industry and many faculty staff have never held a position outside of the university environment;
4. University research is valued in terms of publication record and not on their practical nature for industry application;
5. University research timing is not suitable for the industry's rhythm; University develops research on long-term cycles and expectations, whereas industry's goals are short term oriented;
6. Economies are highly volatile and dynamical and industries are always exploring and introducing new services and products; this economic paradigm requires permanently new knowledge, skills and, ultimately, competences; both new and experienced employees must be up to date with such evolutions and requirements.

These difficulties produce a gap that can invalidate most of the efforts made during the education of students: The inadequacy of students' skills delays the market entrance and requires self-funded education or courses from industry, with a rise of the costs for the employers. The gap can be between competences that the employee needs against the competences of the student, it can be in the knowledge generated in the universities by research and how much of this is into the courses and between the knowledge companies need versus the one that universities have. All of these will be addressed in the ASTONRAIL research too, between the analysis of the outcomes of WP1 (Universities point of view) and WP2 (Industry point of view).

Industry considers very beneficial for graduate's previous experience in working and previous experience in railway related work, such as internships. Grades were important and university degree or courses in the railway field were a plus. Gaps were in certain categories, such as environment, highly requested by companies but not taught as specific courses.

1.2.1 Key competences and skills

Most of those projects defined and grouped the key competences in different ways. For the purpose of the ASTONRAIL project the key competences were kept the same to what can be found in, as an example, TUNRAIL (8 core competence areas and 35 keys skills), RIFLE and SKILLRAIL (8 areas and 66 sub domains) projects [5] [6]; although grouped in a convenient way to carry out a web-based survey.

General topic	Rail systems activities – Innovative materials and production methods – Safety Intelligent mobility – Environment – Other							
2nd level topic	Economics	Traction	Rail Vehicles	Civil Engineering	Operations	Systems Engineering	Control Systems	General Terms
3rd level topic	Whole life or life cycle cost	Diesel	Wheel	Track	Resource management	Interoperability	ERTMS	Human factors
	Business cases	Electric (including supply systems)	Wheel set	Stations	Timetable management	Risk analysis	ETCS	Simulation
	Demand forecasting	Traction drives	Wheel/rail interface	Bridges	Track capacity management	Failure mode analysis	Route-based signalling	Verification
	Revenue Forecasting	Magnetic levitation	Active steering	Tunnels	Passenger management	System modelling	Speed-based signalling	Testing
	Government regulation	Gas turbine	Suspension (passive)	Earthworks	Freight management		Computer-based interlocking	Remote monitoring
	Business strategy	Distributed power	Suspension (active)	Drainage	Security		Solid state interlocking	Reliability
		Braking	Body construction	Level crossings	Train regulation		Electric/mechanical interlocking	Availability
		Fuel Cells		Heating and ventilation			Automatic train control	Maintenance
				Lighting				Safety
								Component
								Passenger
								Freight
								Noise pollution
								Air pollution
								Sustainability
								Light rail and tram systems
								Electromagnetic compatibility

Figure 1. SKILLRAIL matrix of competencies

At the time of the TUNRAIL project, in the EU most courses were focusing on operation, rolling stock and traction, civil engineering and infrastructure.
While in the USA, most courses focused on the development of competences on multidisciplinary issues related to railways or on civil engineering and infrastructures.
The multidisciplinary nature of the courses in USA provides students with exposure of many competences, but it is often at the introductory level.
A gap in the competence environment, although highly valuated by the railways industry, was not present in any course. It could be a critical gap in the student's education but it may also be a competence taught in courses not specific on railways.
RIFLE (2013) focused on the development of a rail freight and logistic curriculum for a Master programme, high priority was in the analysis of the gap between industry expectation and skills provided by the universities. Some data about educational level of employees performing railway activities are in Figure 2, alongside key findings.

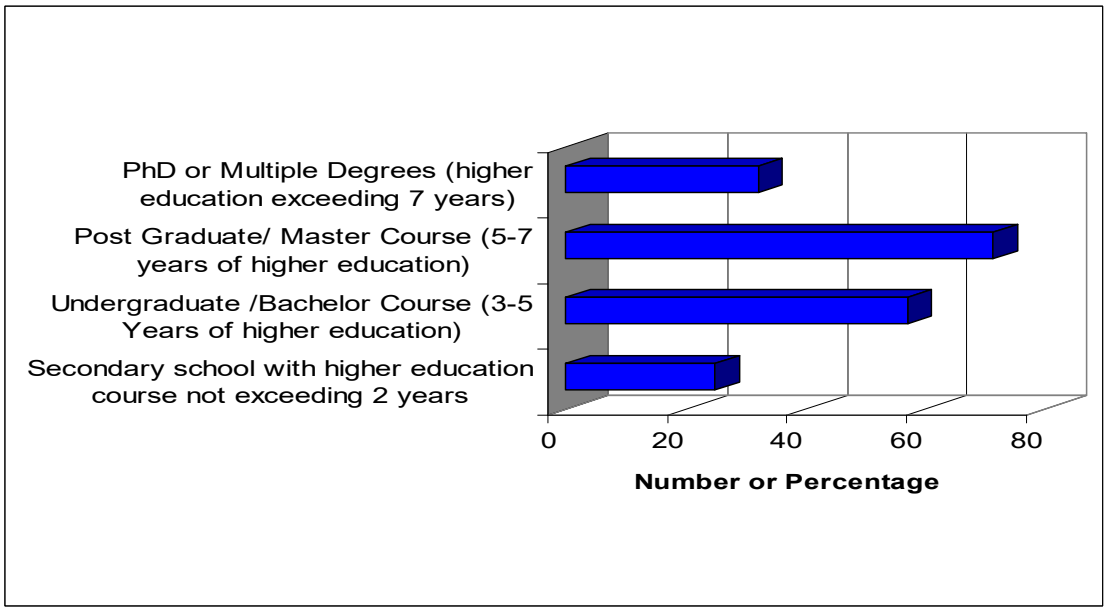

Figure 2. Educational level of the employees performing railway activities

The companies assessed the connections with Higher Education Institutions as having advantages for both parties and rated the activities of collaboration in the following way:

- Providing guest lectures (80%),
- Working with Carrier Centers (58%),
- Offering scholarships (57%).

The majority of companies were SME; therefore, funding research was the least supported activity (4.35%) and only a few of them were sponsoring Master courses.

SKILLRAIL (2011) was contributing to European surface transport research program implementation and to the enhancement of the sector by fostering a better match between the human resources needs to make railways a more competitive and innovative sector and the offer of skills coming out of the different research-based education and training institutions across Europe.

There are several outcomes from SKILLRAIL that are worth mentioning and are relevant for ASTONRAIL, generally, a lack of practical skills is in academia, with companies having the need to offer training course, labeling as *unlikely* the possibility to outsource such internal training. The gap that is also addressed in ASTONRAIL offers the possibility for technical courses that may be research-based and industry oriented.

1.2.2 Innovative teaching approaches in railway higher education

The use of innovative approaches in railway higher education obtained various results. The rail sector is a field of practical application and students should have a fundamental knowledge of rail related aspects of civil, mechanical, electrical engineering and computer

science. All these areas of engineering together support the process of operation where they interact (Figure 3).

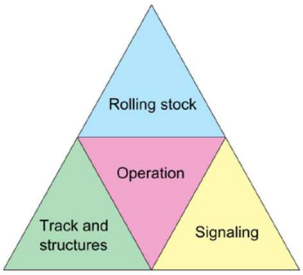

Figure 3. Railway system triangle

The RIFLE project tried to model a Railway engineering Master course according to the structure depicted in Table 1.

Table 1. Railway engineering Master course structure according to RIFLE project

Compulsory Modules		***Optional Modules***	
1	*Fundamentals of Railway Engineering*	*1*	*Advanced Railway Technologies*
2	*Rail Control and Signalling*	*2*	*Maintenance of Railway Systems*
3	*Rail Infrastructure*	*3*	*Railway Traffic Management*
4	*Railway Operations*	*4*	*Rail Freight Yards*
5	*Railway System Design*		
6	*Railway Operations Safety*		
7	*Rail Passenger and Freight Terminals*		
8	*Railway Vehicles*		

This complex interaction cannot be by the separate study of the different subsystems and the teaching methods should consider this: railway operation laboratories could be a perfect way to exhibit such interconnections. The new technologies have expanded the possibilities, and laboratories that integrates modeled tracks with computer simulations were extremely valuable for students as a part of their railway studies. Furthermore, without diminishing hands-on work, laboratory can be set as virtual, to be experienced from other locations through web technologies.
Field visits and tours were successful, such as visits to railway dispatching centers and track construction projects.
Global education program formats considered that the industry involves many rail related and globally focused disciplines. According to Parkinson, Harb and Magleby [7], the key abilities that a student should acquire are: appreciation to other cultures; proficiency in working in or in directing a team of ethnic and cultural diversity; ability to communicate across cultures; effective dealing with ethical issues arising from cultural or national differences; engineering practice in a global context. It could be by an international internship, a service-learning opportunity, a virtual global engineering project or some other form of experience.

SKILLRAIL set the framework for an EU Railway University, with the creation of EURAIL *virtual university* based on knowledge, experience and people from *real* universities, to deliver with eLearning methods.
Different courses resulted from this study, with the collaboration of EURNEX, UIC and many other institutions:

1. Railway Dynamics (54 hours intensive course),
2. Rolling stock summer school (short intensive course, 1 week),
3. Asset Management and KPIs for Railways (3 days intensive course),
4. Energy Efficiency Calculator and Efficiency Technical Requirements (eLearning course).

Those kinds of courses can come in many forms and shape, because the target groups are various: from managers in rail companies to students starting a postgraduate degree.
The target groups should consider also the current issues and future changes. SKILLRAIL and SKILLFUL projects gave special attention to gender and demographic Issues. Regarding female scientists, women are about 50% of the student population but hold on average 15% of senior academic positions, and even lower percentages in engineering subjects. A helpdesk support and promote gender equality in the railway sector, providing a toolbox and a set of recommendations.
According to the results of the WISE project, concerning the women employment in urban public transport sector, the percentage of female employees in relevant companies varies from 5% to 31% with an average of 17,5%, while in technical and/or operational divisions, the number of women is especially low (often under 10%). The number of female employees is not only low, but it also remains stagnant for big periods in every country that participated in the project.
In RIFLE, different innovative learning methods were experimented, such as inverted classroom: This technique inverts the phases of learning where students receive the facts and main concepts on videos or audio files before the lecture starts so that during the lecture there is more time for interaction and *questions & answers* sessions. Innovative forms of teaching and learning create environment for more intensive interaction. The lecturer is no longer a speaker as in the conventional teaching forms and methods.
In the conclusions paragraph of the RIFLE handbook [6], some considerations are relevant for whenever a similar programme is developed.

- Finally, the main issues are the ones related to student mobility and its funding.
- Not every student is willing to study abroad (especially in the United Kingdom) and have the finances to do it. Moreover, language and cultural barriers are to overcome.
- On the other hand, the level of mobility may play the role of attractor for studying rail programme and for working with passion in the rail field. Students would have a chance to compare different academic institutions, cultures, interests, rail administrations, rail authorities.
- Therefore, in order to solve the student mobility issue, RIFLE team suggest managing carefully various aspects: Erasmus Agreements between partner institutions, funding, language, cultural and practical (e.g. accommodation) issues and information to

prospective students (e.g. information regarding career opportunities after completing the course).

1.2.3 Trends and changes within the transport sector

SKILLFUL (2019) [8] studied the changes within the transport sector, as demographic trends, such as population age are going to play a key role over the next years: large groups of professionals will retire, being replaced by young professionals. An additional challenge is whether enough professionals having the right skills could be attracted to the transportation sector workforce. This development and expansion will also probably increase the pressure on a workforce that is older than the average of the economy and where female employees represent a small minority.

The European Commission policy stresses the role of education in equipping graduates with the knowledge, skills and competences they need, in order to succeed in occupations that are changing due to the various developments occurring in the field of transport and other expected to happen in the future. It also underlines the importance of involving sector organizations in the design and delivery of education programmes, ensuring that programmes include at least an element of practical work experience [9] [10] [11].

The *Whitepaper* by the European Commission underlines the need to implement new technologies to ensure sustainability. Several driving forces and technologies and the impact on future transportation system of Europe were as shown In Figures 4 and 5.

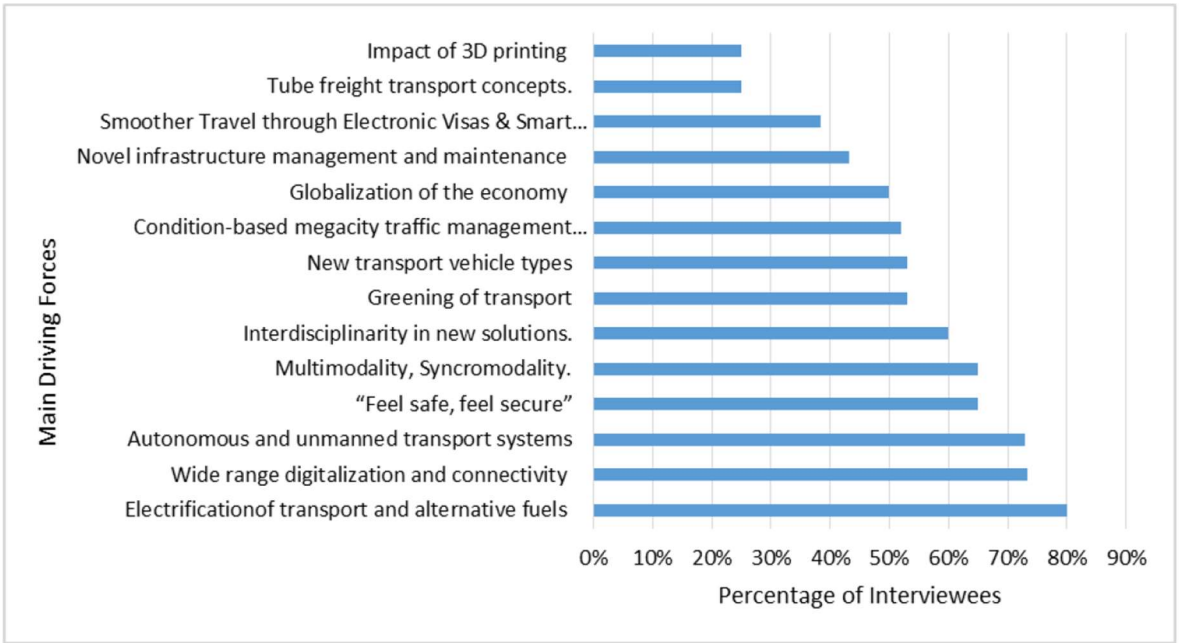

Figure 4. Prioritization of driving forces expected to affect the transportation systems in Europe

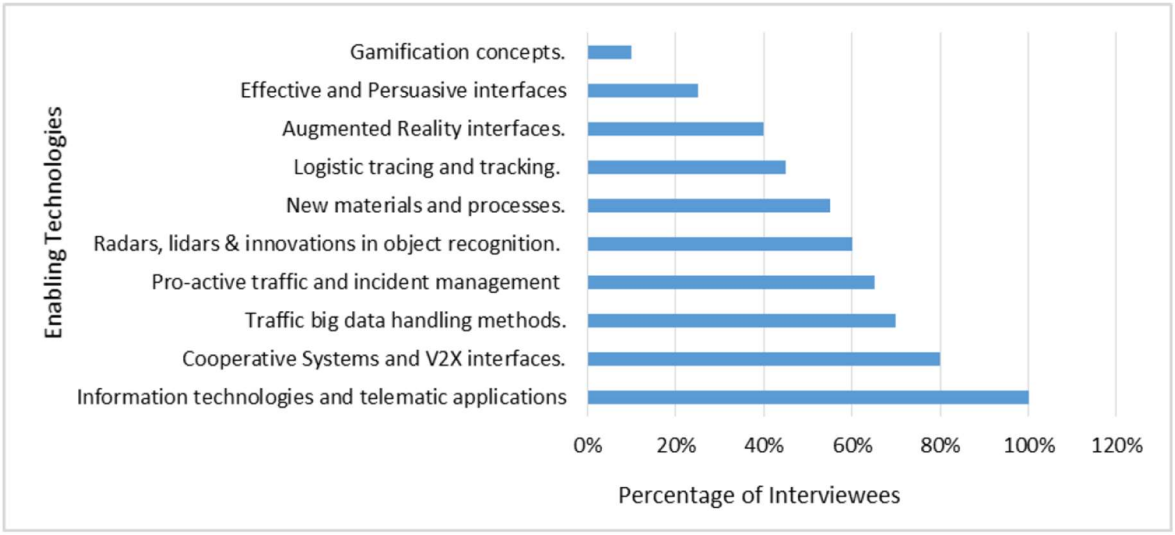

Figure 5. Prioritization of technologies expected to affect the future transportation systems in Europe

In addition, Artificial Intelligence and Machine Learning were also there.
The emerging technologies will affect future jobs, eliminating or changing some duties. More advanced software competences and transport professional will have to adapt accordingly.

1.3 Review of Papers published on journals specialized on training education as well as railway technical and economic aspects.

Several papers are available regarding training education. In particular, the Post-Master course in Railway Infrastructure and Systems Engineering (Figure 6) could be relevant for ASTONRAIL [12].

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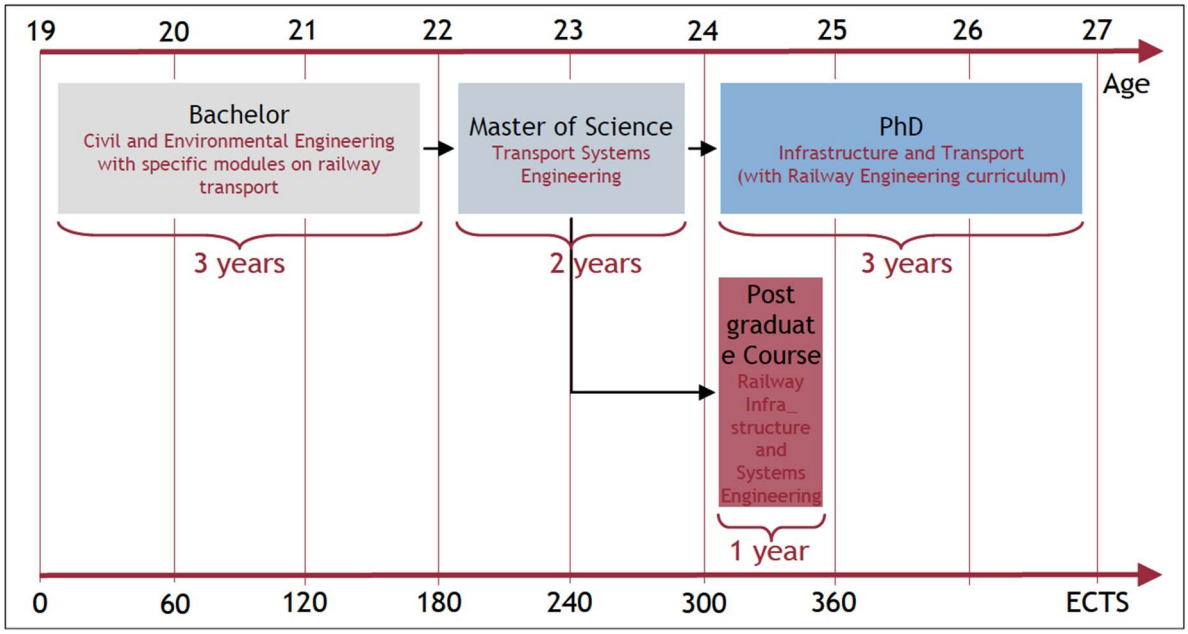


Figure 6. Courses level and durations

This course represents a successful example of cooperation between academia and industry in the field of railway transport. The success of the program is attested by its placement (90% of the graduates finding an employment within six months in the companies supporting the course) and by the increase of the applications. It offers multidisciplinary training (technical, legal and economical subjects) and a very close collaboration with Industry partners.
The course is annual, equivalent to 60 ECTS and entry requirement is having completed a Master in Engineering. The course includes 12 modules with theoretical lessons, tests, project works, technical visits and Internships in the partner companies.
The modules for 2020/2021 academic year are:

1. Principles of railway engineering,
2. Railway track and fixed installations,
3. Traction systems and vehicle dynamics,
4. Infrastructure designing and planning,
5. Railway traffic technologies,
6. Management of railway safety,
7. Passenger and freight terminals,
8. Freight transport and logistics,

9. Service planning and quality,
10. Railway works planning and regulations,
11. Corporate culture, economic and environmental evaluation of railway planning,
12. Exchange of internships experiences.

The programme is multidisciplinary, in each module, 50% of the lectures are by professors and 50% by managers of partner companies. This prevents the restrictions to theory and up to date the contents. Managers also take part in the examinations and companies can evaluate students at each stage. Internships are essential and part of the course, so that the company can assess the student furtherly. At the end, the companies can employ engineers already formed in the railway field with almost no risk.

The paper [13] introduces the Rail Career Matrix to list the job categories and positions in the rail transport sector against the three management levels for transport planning, used as it is in the present study.

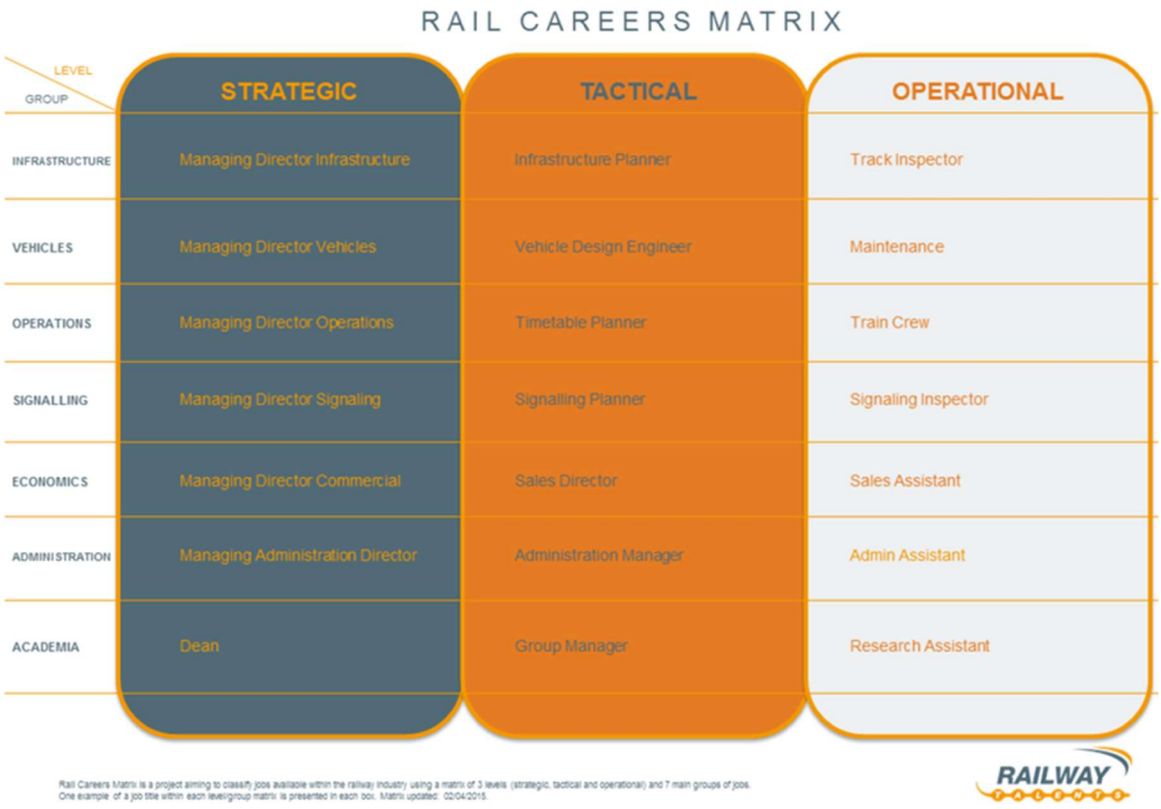


Figure 7. Rail Careers Matrix

The article also discusses how in the future a workforce shortage is foreseeable and how the training should change to include hands-on learning experience, with apprenticeship schemes and other forms of training.

Some Articles were useful to integrate the database of rail training courses, particularly from [14] were selected several courses, also from outside Europe.

Moreover, some suggestions on Improving the efficiency on the cooperation between industry and higher education comes from [15]: the transfer of knowledge between university

and Industry can be useful both ways, with university knowledge being applied to industry to support innovation and new technologies, knowledge that often is inward-oriented and could benefit from sector-oriented education. Five methods can strengthen this collaboration:

1. Improving connection between higher education institutions and industries,
2. Organising conferences and technical visits,
3. Increasing internship periods,
4. Increasing the active role of trade associations,
5. Assigning projects to students directing them to industry.

Good example of cooperation are Techno parks, where the line between Academia and Industry is short. The triple helix model for Cooperation between industry and university is another example [16].

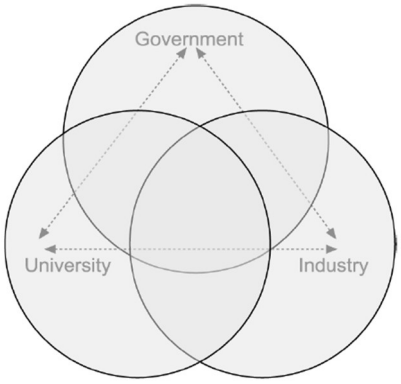


Figure 8 Triple helix model [16]

In this research, the distinction between exogenous (curiosity driven innovations) and endogenous (market driven innovations) components of academic research is made and discussed how this can be influenced by stronger funding from industry rather than government only.

Another case of Railway course integrated with industry comes from [17], where international scientific and technical cooperation of the Dnipropetrovsk National University of Railway Transport (DNURT) in Ukraine) and the Czech Technical University (CTU) in the field of engineering students training. At the CTU students of the specialty *Railway Vehicles* acquire knowledge in all technical areas, including mechanics, material strength, thermodynamics, theory of internal combustion engines, electrical engineering, mechanical and hydraulic gears, motor vehicle theory, etc. CTU successfully cooperates with leading manufacturers of railway vehicles, within project-oriented training.

The paper [18] investigates the challenges in developing an e-learning portfolio, from types of technologies to cost/benefits, as perceived by training providers. Responses from a survey showed that it could be a positive add-on a traditional teaching method. Lack of personal contact and relationships with the students were the most significant barriers, along with lack of control over plagiarism. In addition, the respondents highlighted a lack of training and pedagogical skills by the staff and the often-inadequate resources. An effort would be necessary from the organizations on policies, training and support regarding such activities.

The conversion of courses from a traditional method to eLearning was difficult in many some cases, as shown in Figure 9.

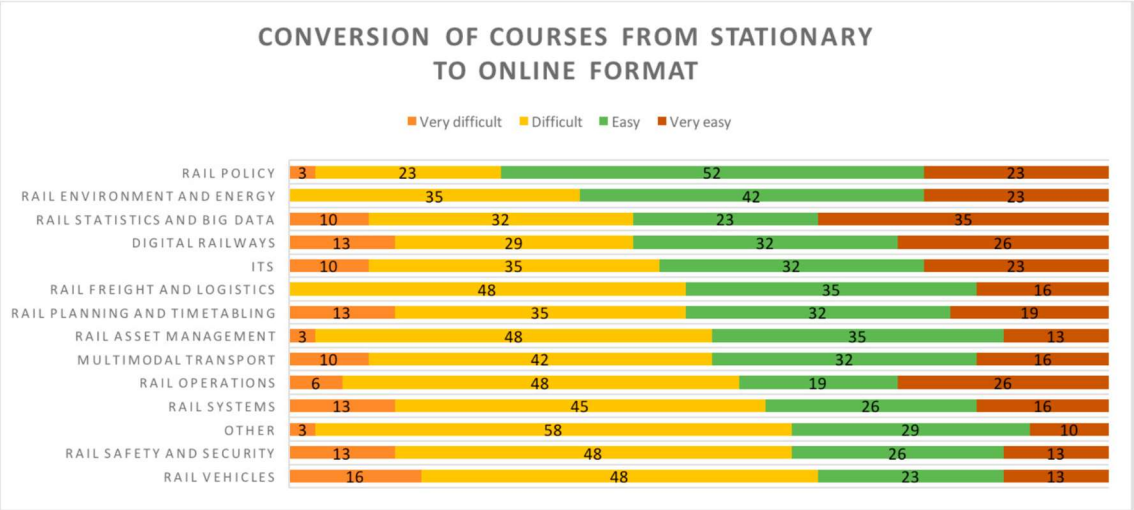


Figure 9. Conversion of courses from stationary to eLearning [18]

From [19], despite limited to the description of the scenario in the United Kingdom, comes the growth of the infrastructure sector and the confirmation that the skill gap still exists and the ageing workforce constitutes a threat in the near future.
In addition to that, a career in rail lacks widespread appeal from the general population and even more by gender, with women considering a career in rail scoring at 24% while men at 41%, with lack of awareness of career opportunities and necessary skills as two major barriers, keeping people away from considering the rail industry for it. The shift to new technologies as green transport, such as hydrogen vehicles, will require a new set of skills needed for the workforce.

1.4 Review of International and national reports issued by railway operators, industries and public bodies responsible for education and training

A Research about training needs and offers in the European railway area in the next 10-15 years [20] offers insights in the new changes: technological, legal, demographic and market. The research is projected to year 2020, but not less interesting. It identifies the main technological changes with impact on the training needs in the period until 2020 as:

- ETCS (as part of ERTMS),
- GSM-R,
- Galileo, the European positioning system,
- Energy-efficient driving,
- Electronic ticketing,
- Modularization and standardization of trains,

- Information systems,
- Operational information on computer.

The main topics in the area of legal changes in the rail transport area of the European Union until 2020 are:

- Interoperability,
- Safety,
- Working conditions,
- Certification of train crews,
- Environment.

Even though they might not be concerned about young people's interest in jobs in the rail sector, the demographic developments and the situation of companies in the sector suggest that rail-companies need to focus on making young people aware of job opportunities in the rail sector. It is necessary for rail companies to ensure that jobs in the sector are attractive by providing attractive working conditions and ensuring that the education and career opportunities in the sector are interesting and meet young people's expectations (e.g. the Network Rail Advanced Apprenticeship Scheme).

About Internationalization, despite the huge international activity of good and passengers across European border, the training centers appear to be very nationally oriented.

The research cites several examples of partnerships between universities and private enterprises to bridge the skills gap, such as the one between Network Rail and Sheffield Hallam University to provide specifically targeted knowledge to the railway sector, as engineers were lacking to maintain and improve Britain's rail infrastructure.

The EU Transport Research & Innovation Status Assessment Report 2020 [21] has a section on emerging transport technologies and trends that in the railway field emerge as the following:

- Smart sensors and smart running gear components for self-diagnosis,
- On-board testing systems for ETCS,
- Open platform concept for mobility services,
- Field demonstrations of sustainable urban mobility,
- Collaborative logistics ecosystem,
- ICT support system for multimodality,
- Multimodal border management technologies,
- Communication network for intelligent mobility.

1.5 Research on web-portals dedicated to present the educational offer to potential learning audiences

As mentioned in the first paragraphs, data collected from multiple sources fed a database, containing rail-related courses and modules. If the first step was using past research and projects, to validate older sources and to extend the research, web research was the most reliable source.

The courses, searched one by one on thousands of web pages consulted in university portals by keywords, such as *Railway engineering*, *Rail*, *Transportation*, *Electric vehicles*, *Transport systems* and many more, frequently with their counterpart in the concerned languages.
Additional courses were web portals dedicated to present curricula, such as *Studyportals Masters*.
In that case, the research extension was to rail-related courses from the level 5 to 8 of the EQF and not limited to Europe.

2 Task 1.2: Europe wide step-wise survey

2.1 Consolidation of data from Task 1.1

The data collected in Task 1.1 were useful to proceed with the survey, articulated into several steps, at first the consolidation of the obtained data, by aggregating the information from all the sources (past projects, ASTONAIL partners, other academic partnerships, websites) a list of Universities that may offer courses relevant to the project was built.
The following step was to gather more information about each one of those courses, by researching on the Universities websites. For each relevant course, when available, the useful data were stored in a preliminary database, coupled with the website where the original information was from and later investigated more accurately if needed.

2.2 Preliminary database

The preliminary database consists of an excel sheet, where a row corresponds to a course, which can be a full course, a short course or a module of a wider course, depending on the percentage of rail subjects within the course and the availability of information.
The queries of this preliminary database were the most indicative to the general description of the course, along with basic contact information (public e-mail found on website and the website itself). The evaluation of the queries were together with other members of ASTONRAIL and some fine-tuning was necessary. As an example by adding a column for the department other than the name of the course and the institution.
The use of *European Qualifications Framework* (EQF) and *European Credit Transfer and accumulation System* (ECTS) for the description of the level of the qualification and the credits count of each course was necessary. Even so, this was not always possible. The choice to include in the database extra-European universities (with the aim to widen the pool and gaining an insight of different realities) and to short courses (that cannot always be classified in this way) led to some inconsistency. In the database, a ND data validation field identifies such cases, while it remained blank when the information was not available. If available, the use of a different system, described in a note, is possible.
In the end, the preliminary database consists of over 370 courses, from 190 different institutions. For each course, the following fields are available:

- University/Organization,
- Department/Institute,
- Course,
- Provided by,
- Country,
- City/state/region,
- Active (Yes/No),
- EQF Level,
- Language,
- ECTS on rail,

- Contact (e-mail),
- Website.

The quality of the data stored in this preliminary database may vary, even if it is surely a good starting point. On some websites, the information was partial or not up to date, and this was the basis of further steps, starting from the survey.

2.3 Survey creation, tools and actions

In order to assess the criticalities found during the construction of the preliminary database, the contacted ASTONRAIL members provided different implemented inputs. The data collection is basing on a questionnaire.

The most appropriate tool for distributing the questionnaire was *Google Forms*, the free online platform that provides basic survey functionalities. The survey tool stores each answer in a separate row of an electronic spreadsheet and the questions respected the preliminary database to just copy and paste the answers on it.

The questionnaire included three sections: the first one about the confirmation of the data in the preliminary database, the second about the basic course information (if the data in the preliminary database is not correct, otherwise automatically skips to the third section) and the third about the further information needed.

For each University/Organization, the courses, grouped in different tables accompanied the individual survey.

An important step for the preparation of the survey was the coordination with the leaders of Work package 2, responsible for the evaluation of the skills needed by the industry, the objective of ASTONRAIL being the study of gaps and mismatches between Industries expectations and the topics provided by academia. In particular, the skill set was on the results of task 1.1 and divided in 4 categories (vehicles, infrastructures, systems and operations, Innovations and digital competencies), with some minor differences between the two questionnaires due to the different target groups. For the full list of the keywords identified, the reference is the Handbook paragraph.

2.4 Results of the survey

The survey schedule was by the end of February 2021, but as some organizations asked for more time, one-week extension was setup. Information gathered was about 49 courses from 16 countries (Figure 10).

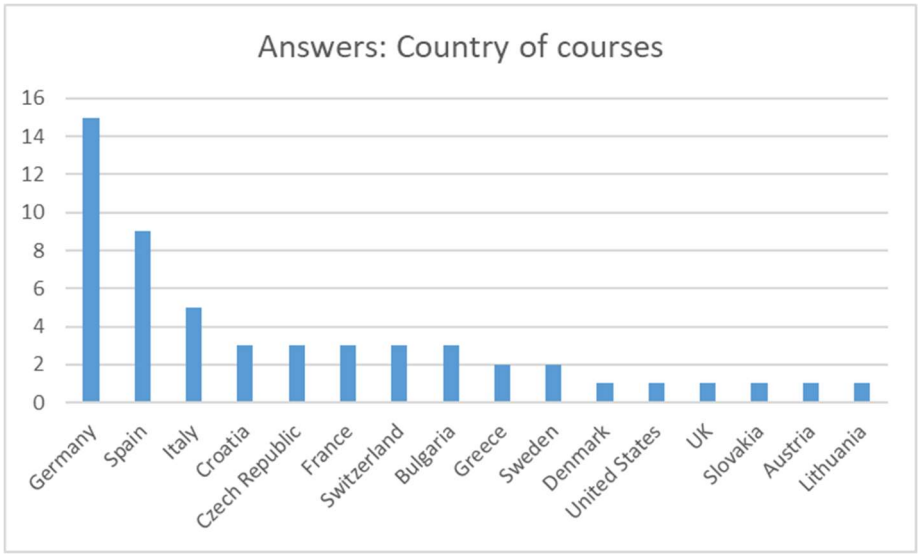


Figure 10. Number of answers to the survey from different countries

Some answers were incomplete, and this is imputable to the fact that:

1) As mentioned before, not always is possible to insert data about ECTS, due to different methods or intrinsic differences;
2) In one case only, the respondents provided the data in the form of a document (pdf file) filled manually with a note.

About the data obtained, a first insight can be the EQF level of the courses, a short description of which is in Figure 11.

Level	Knowledge	Skills	Responsibility and autonomy	Example
5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	a comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others	(UK) HNC, HND, Foundation Degree, RQF levels 4 & 5, Certificate of Higher Education, Diploma of Higher Education, Scottish Advanced Higher, HTL
6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups	(UK) Bachelor's degree with honours, Bachelor's Degree without honours, RQF level 6, Graduate Certificate, Graduate Diploma; (Germany) Vocational university German State-certified Engineer, Business Manager and Designer (Fachhochschule) Bachelor, German Fachwirt / Fachkaufmann, German Operative Professional, German Meister; (Spain) Diplomado or Grado; (Italy) Laurea
7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research Critical awareness of knowledge issues in a field and at the interface between different fields	specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams	(UK) Master's degree, Postgraduate Certificate, Postgraduate Diploma, RQF level 7; (Germany) Vocational university (Fachhochschule) Master's, Geprüfter Betriebswirt (IHK) (Certified Business Administrator); (Italy) Laurea Magistrale, Master universitario di primo livello;(Spain) Licenciado or Máster;(Portugal) Mestrado; (Greece) NTUA Diploma
8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	the most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research	Doctorate, PhD, Professional Doctorate, RQF level 8; (Italy) Dottorato di ricerca, Master universitario di secondo livello

Figure 11. EQF levels with description and examples

The choice of those thresholds focuses on higher education, while a ND option identifies courses that did not fit in the categories (e.g. short courses made by Industries).

Figure 12. EQF level from the answers

The prevalence is for courses corresponding to EQF level 7 (Master), with 51% of the answers, In the EQF level 7 are also included courses (such as diplomas) that covers EQF levels from 5 to 7 during several years.

Courses at EQF level 8, such as PhD or post-Master courses are only 6% of the total. The evidence is that while some doctorate programs offer specific formation in rail, often the path

is individual, and no information are easy to gain. Of the courses offering 100% ECTS on railway, 1-year Masters (60 ECTS) are the majority, providing in depth knowledge to already trained students. Other courses are 2-years Masters (120 ECTS) and lastly three years Bachelors or equivalent (180 ECTS).
Of the respondents, all of them are from Universities or Universities of applied sciences that may include also technical schools at the lower EQF Levels. At the time of the survey, all the courses are active with two exceptions: Karlsruhe Institute of Technology that wrote about the suspension of the railroad engineering lectures and the future course *Railway Vehicles* from the University of Pardubice that will launch it during 2021. Those courses are in the database with an explanatory note.
While evaluating the language of instruction, the English taught courses are present in many curricula (19% of the total of answers) but most of the courses are taught in the country's native language (Figure 13).

Figure 13. Language of teaching of different courses

An important topic is the presence of Internships and technical visits during the programme, as this emerged, in previous research, of great importance. Of all the answers, 25 mentioned the presence of a mandatory or eligible Internship: railway and transportation companies being the most common. A 33% of the contacted organizations offers technical visits.
The participation to a student interchange program provided with a small prevalence of positive answers (Figure 14).

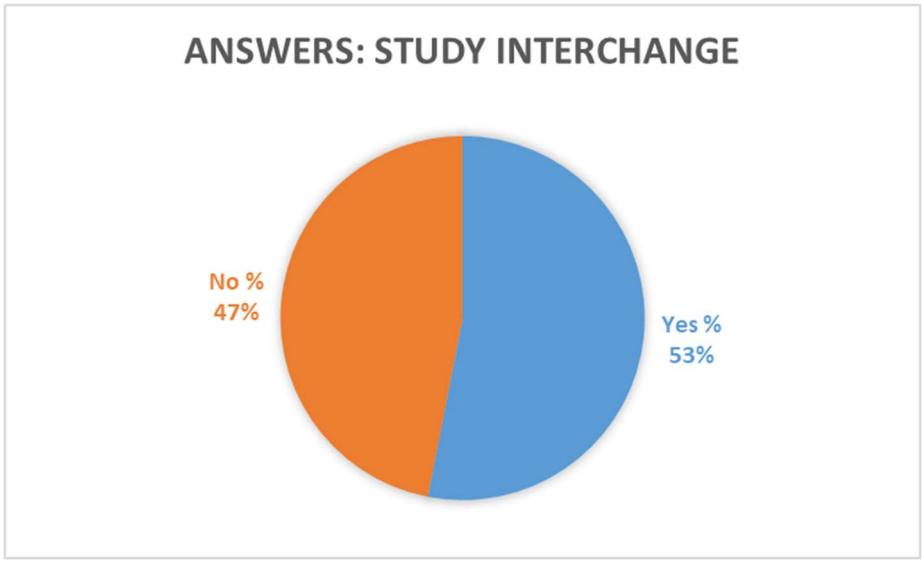


Figure 14. Student Interchange in the courses

Since job position after graduation is relevant for the scope of this project, and before the analysis of skills and rail career matrix, is worth to mention that most of the organizations are not in possess of data about employment after graduation. In fact, to the question about employment data, only 39% declared to have them (Figure 15). If more information is required in the future, the analysis should focus on positive answers only.

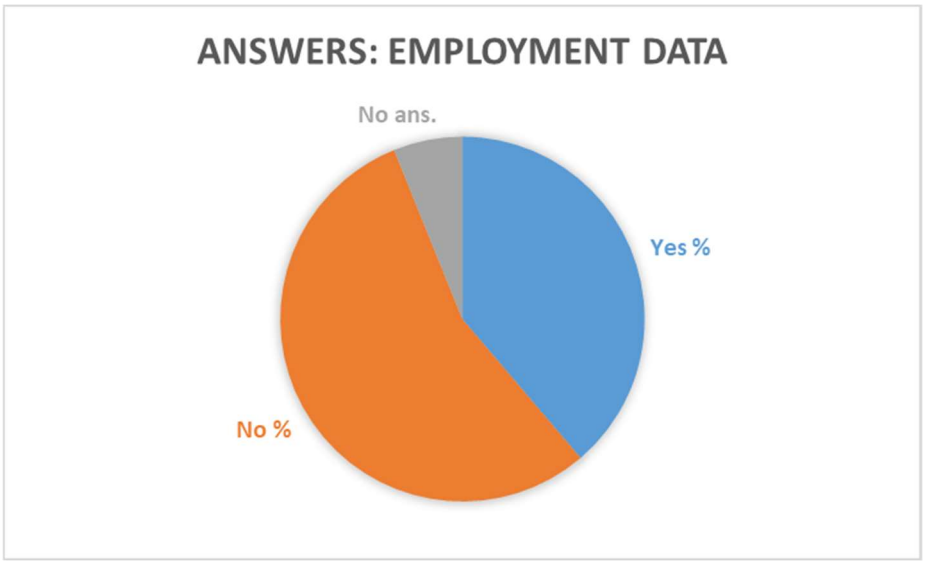


Figure 15. Availability of employment data by the respondents

The distribution of training programmes within different management levels is coherent with the targeted EQF levels (Figure 16) and while it is on average evenly spread across different levels, there is a slight prominence of tactical level over operational and strategic.

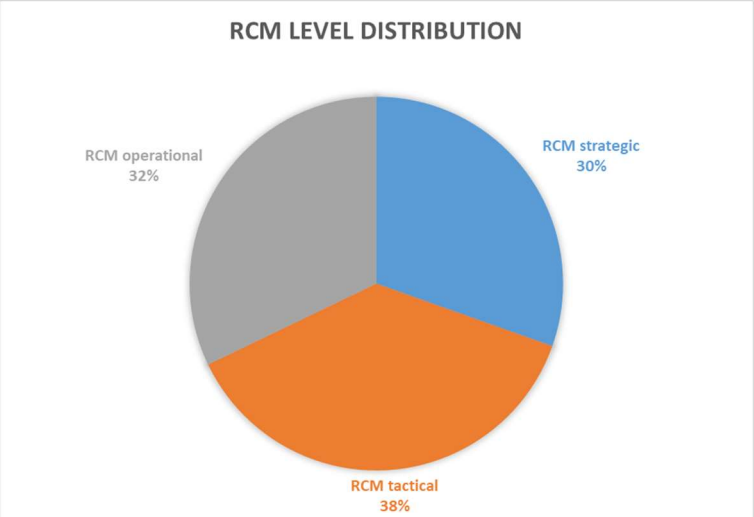


Figure 16. Distribution by rail career level, as stated by respondents

That is not true by shifting the analysis on different job groups. In that case, there is high variability and, in certain job groups as Academia, the share of strategic level is just over 10% and strategic and tactical combined under 50%. Strategic level is prominent also on Economics and Vehicles groups, while Tactical level ranks higher for all the other groups (Administration, Signaling, Operations and Infrastructure) (Figures 17 and 18).

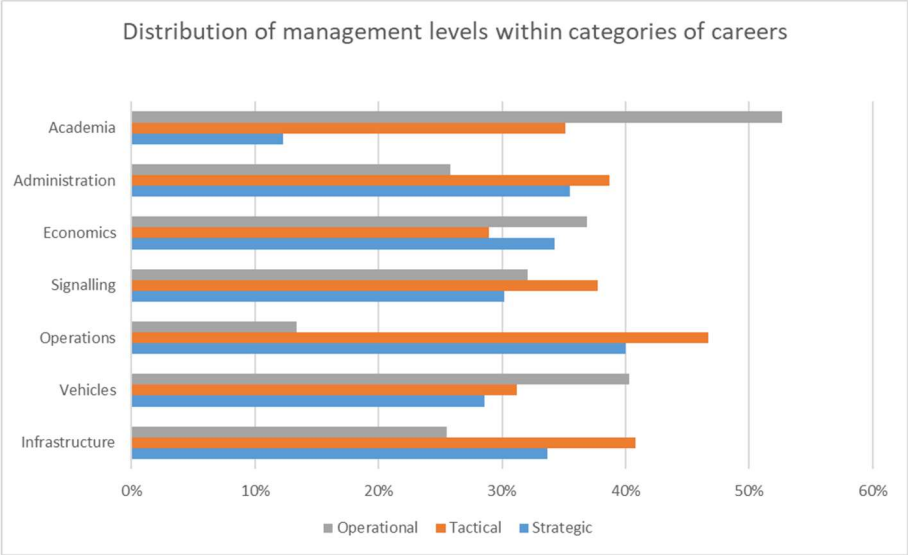


Figure 17. Distribution of management by categories of the rail career matrix

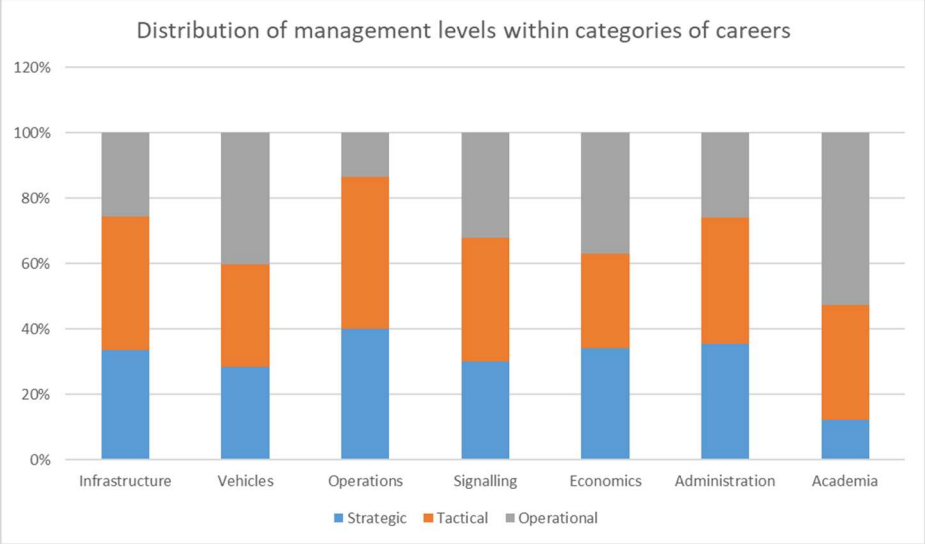


Figure 18. Different visualization of the graph above

The analysis of the career groups can go further, by studying the career corresponding to different groups in each Level separately, in this case we obtain the following graphs with the distribution of careers per group (Figures 19, 20 and 21).

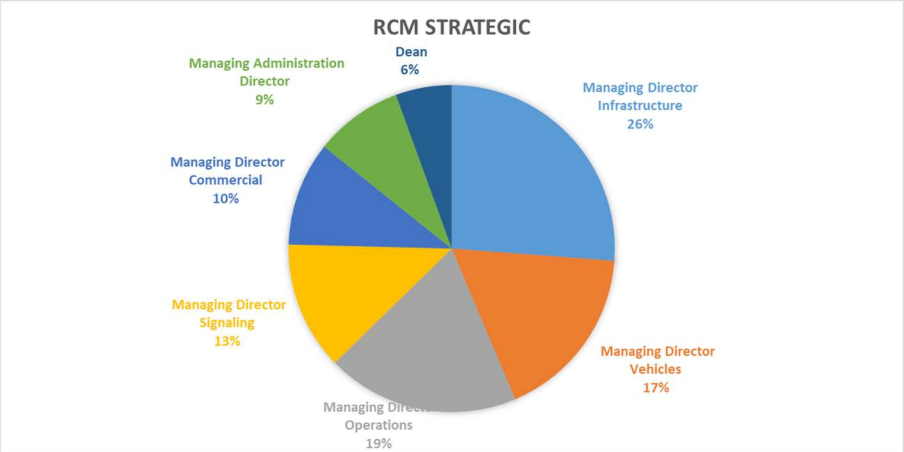


Figure 19. RCM Strategic level - Distribution by groups

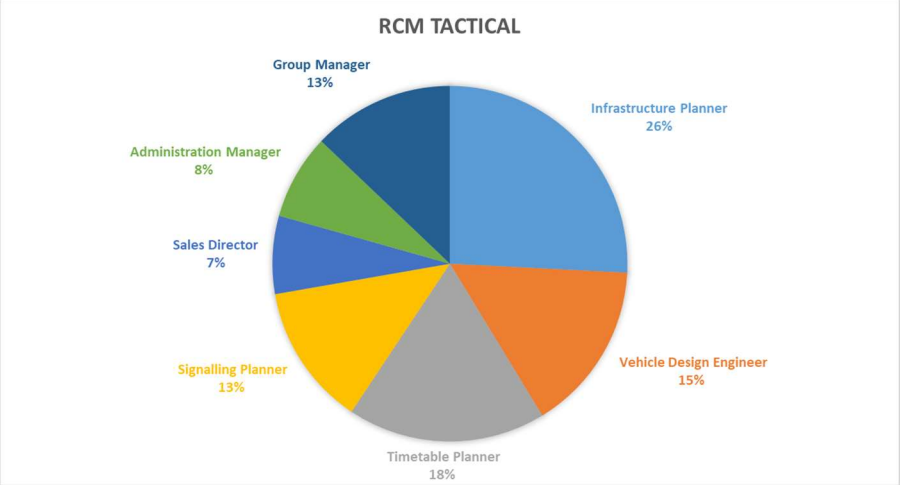


Figure 20. RCM Tactical level - Distribution by groups

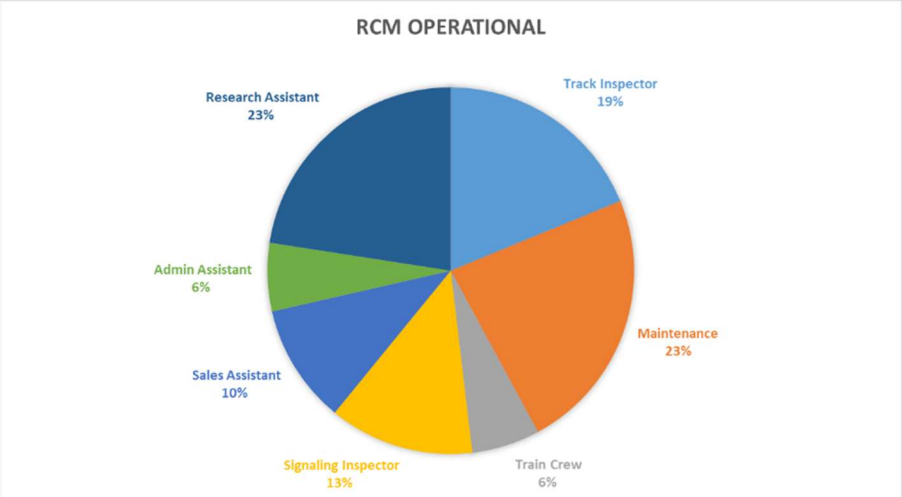
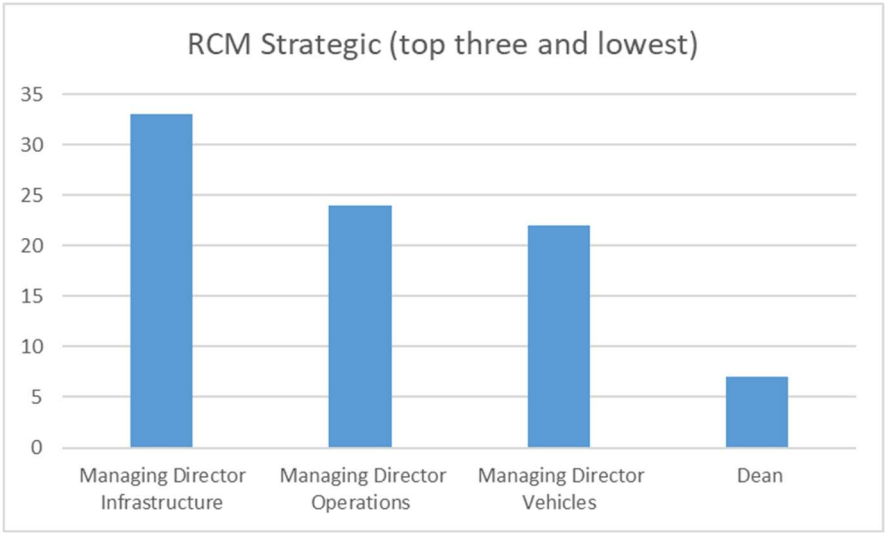


Figure 21. RCM Operational level - Distribution by groups

Another way of showing the results is by highlighting the top three careers vs. the one that ranks lower. In this case, is evident as an example how in the Strategic, Tactical and Operational level the lowest ones are respectively Dean, Sales Director and Train crew (Figure 22).



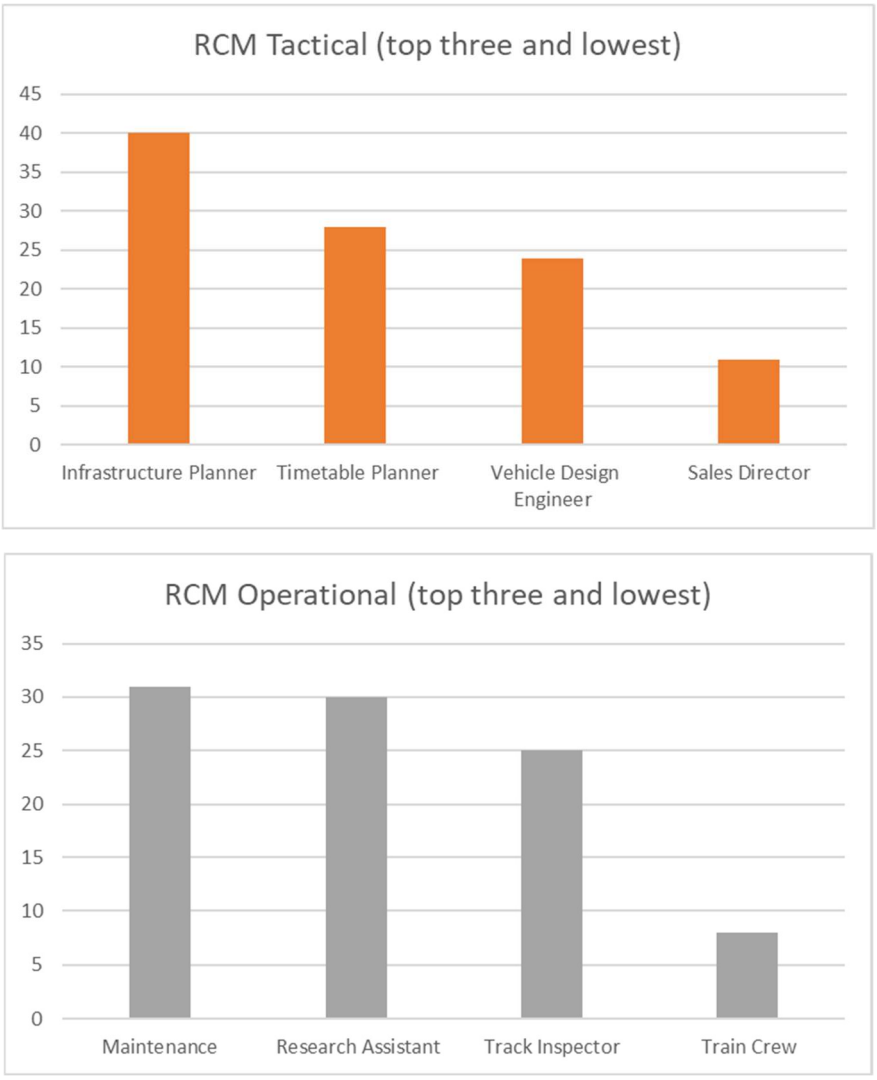


Figure 22. Top three and lowest careers per Strategical, Tactical and Operational levels

The graph in Figure 22 shows the distribution of job groups on all levels that is quite balanced. Infrastructure leads with 24% and Vehicles follows with 19%. Administration and Economics are the least represented. Should the profiles needed by industry, fit into these last two categories, a new program should try to fill this gap.

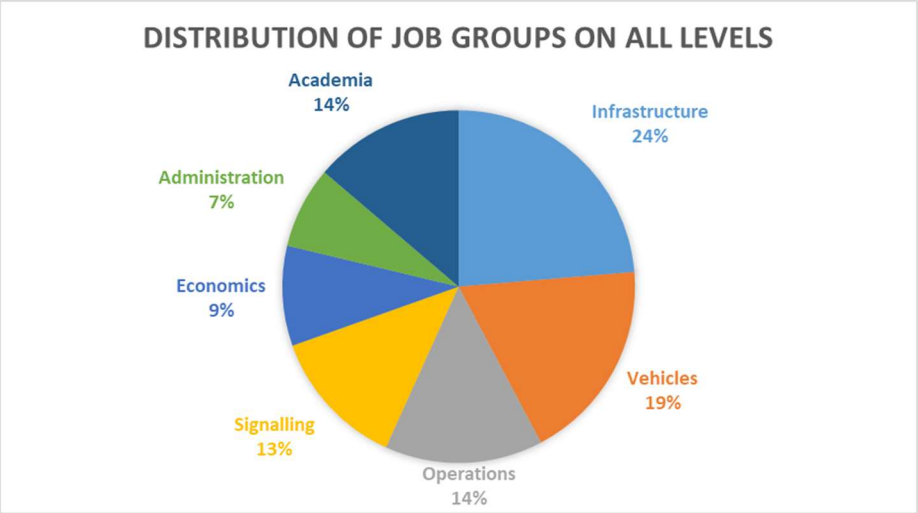


Figure 22 Distribution of job groups on all levels

The database offers more information, such as the credits of single modules, where that information was available, and the skill set for each course, also jointed with data about expected career. This will require a crosscheck with the results of WP2, to quantify the skill gap and as the modules of the courses are there, it will be possible to identify what is lacking in terms of content. The next chapter provides the handbook to the database and the explanation on where to find the information needed and how it was stored.

3 Task 1.3: Organization and homogenization of survey results

3.1 Handbook to the database

The database is the result of the integration of data acquired from the survey with the preliminary database in a complete one that includes general information on all the higher education courses offering rail related modules. The Handbook, also available as a standalone file, provides a detailed description.

3.2 Database

The database, built on excel, includes two complementary sections:

1. Data obtained from research: from columns *A-P*;
2. Data obtained from the survey: from column *Q-AG*.

3.2.1 Data obtained from research

This section of the database (figures 23 and 24) is the result of Task 1.1 and consists of more than 380 courses, obtained from different sources. Most of the data come from web researches, on university portals, such as *Masterportal.com*, and ASTONRAIL partners. Other Documents and past projects are also there and, for each course, a link to its website is included to check for further information.

University/Organisation	Department/institute	Course	Provided by	Country	City/state/region

Figure 23. Columns from A to F

The structure of this first section is the following:

A. *University/Organization*: full name of the university/organization, in English when available;
B. *Department/Institute*: nested within the name of the University, the department name was included when available;
C. *Course*: it can be the name of the course or the module, in English: a further distinction is made in the data obtained from the survey;
D. *Provided by*: can accept only validated data as expressed by the *RULES* sheet, in particular University, Railway operator, Other;
E. *Country*: validated from a Country list, to avoid misspelled countries, in English;
F. *City/State/Region*: nested within the country data, a further classification is made with the possibility to be precise when possible (city) or to write the region/state if the course, as an example, is shared between institution; although it is not possible to insert double countries, more than a city can be chosen.

Figure 24. Columns from G to P

G. *Active*: indicates whether the course is still active or not; more information on this topic are in the survey results.
H. *EQF level*: can accept only numeric data or *nd*, as expressed by the validation rules.
I. *Language*: a list of languages was on the rules sheet, but this can create problems when the course is dual-language or a module taught is in a language different from the course; nevertheless, to avoid misspells or repetition while filtering, it was set up this way;
J. *ECTS on Rail*: Total number of ECTS on rail related course; it was the most difficult to fill in and even the results of the survey were not completely helpful; the ECTS, when available, considered that they could be incomplete;
K. *Source*: deleted; it just kept track of the sources in the draft database before the survey;
L. *Contacts*: when available, it includes a contact person; normally the course coordinator, alternatively the department coordinator and so on, up to the general mail address of the organization when better information was not available, finally, if the contact is missing, a *request of contact web page* is included;
M. *Website*: it contains the website's URL; the webpage of the module/course or department or the link to a pdf sheet, when available; the level of detail can vary but this was considered one of the most important queries, since it can provide easily further information, when the page looks as empty, the browser might recognize the country of the user and move to the *alternative language* page of the website, normally incomplete or empty; highlighted by a flag on the website switching it to the original language (e.g. by using the google translator on the same page);
N. *Link*: A hyperlink added to the previous column, since Excel sometimes does not recognize the URL as a link; it just opens the website from the URL of the nearest column in the same row.
O. *Notes* (*Internal*): it is for internal use, it contains the notes from ASTONRAIL partners building the database, such as other information potentially useful later, double language and explanation of the lack of information or other email addresses.
P. *Members of ASTONRAIL*: deleted; it was for internal use.

Moreover, a color-coding was included for internal use, since most of the organization that replied to the survey did not include information for all the courses they provide. The questionnaire asked for confirmation of data and different colors were used to distinct the organizations that confirmed the data/or did not:

Header, with the description of the columns.
Specific information about this course or more than one without specification.
Answer in columns *A-P* correct and answer about another course and not about this one.
It was not possible to send the questionnaire; the only valid data is in the first section.

Answer in columns *A-P* not correct and answer about another course and not about this one.

3.2.2 Data obtained from survey

The second section of the database includes the data obtained through the questionnaire and it is stored in the columns from *Q* to *AE*. The further column *AG* stores 1 if the organization answered, even partially, to the questionnaire, or it is empty if it failed to do so.
The title of each column appears in the figures from 25 to 30.

Course duration (months)	Launched in	last year of activation	ECTS of singles disciplines

Figure 25. Columns from Q to T

Q. *Course duration* (*months*): sometime expressed with other information;
R. *Launched in*: year of first launch of the course;
S. *Last year of activation*: if it is not active anymore; useful to know if the data can be considered still relevant or if it is suspended but it could be activated again in the future;
T. *ECTS of single disciplines*: the format is the following one: name credits comma to separate them if more than one (e.g. Railway engineering 12, Railway infrastructure 6).

Keywords, Vehicles	Keywords Infrastructures	Keywords, Systems & Operations	Keywords Innovation and digital competencies

Figure 26 Columns from U to X

U. *Keywords, Vehicles*: selected from a list of twenty and separated by a comma:
   1. Active steering
   2. Air pollution
   3. Body construction
   4. Braking
   5. Diesel
   6. Distributed power
   7. Electric
   8. Electromagnetic compatibility
   9. Fuel cells
   10. Gas turbine
   11. Heating and ventilation
   12. Lighting
   13. Magnetic levitation
   14. Maintenance of vehicles
   15. Noise pollution
   16. Safety
   17. Suspensions
   18. Traction drives

19. Wheel set
20. Wheel-rail interface

V. *Keywords, Infrastructures:* selected from a list of sixteen and separated by a comma:
1. Bridges
2. Cost benefit analysis
3. Drainage
4. Earthworks
5. Electrification
6. Government regulations
7. Infrastructure costs modelling
8. Interoperability
9. Level crossing
10. Life cycle costs
11. Maintenance of infrastructure
12. Reliability
13. Safety and security
14. Stations
15. Track
16. Tunnel

W. *Keywords, Systems & Operations:* selected from a list of twenty and separated by a comma:
1. Automatic Train Control
2. Interlocking
3. Demand forecasting
4. Delay management
5. ERTMS
6. ETCS
7. Financing & competition
8. Freight management
9. Human factors
10. ITS
11. Passenger management
12. Railway operations
13. remote monitoring
14. Resource management
15. Route assignment
16. Route/speed based signaling
17. Safety regulations
18. Timetable management
19. Train regulations
20. Track capacity management

X. *Keywords, Innovation and digital competencies:* selected from a list of eight and separated by a comma:
   1. CAD Computer aided design
   2. BIM Building Information Modelling
   3. Artificial Intelligence and Automation
   4. Machine learning
   5. 3D printing
   6. Advanced condition monitoring
   7. Advanced modelling and simulation
   8. Programming and software development

Figure 27. Columns Y and Z

Y. *Internships/Technical visits*: If the course includes Internships for students, technical visits, or both. The answer is not limited to just yes and no but can include the type and duration.
Z. *Student interchange*: If the course is a member of a program of student interchange. This column can be Yes or No.

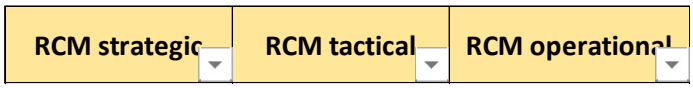


Figure 28. Columns from AA to AC

Columns *AA, AB* and *AC* represent the three different levels of the Rail careers matrix (*figure 6.*). In each column, for each answer to the survey the user was able to select more than one group in a multiple selection format. The answers to the multiple selection questions are stored in each cell separated by a comma.

Figure 29. Rail Careers matrix

AA. *RCM strategic*: it contains the groups related to the strategic level.

1. Managing Director Infrastructure
2. Managing Director Vehicles
3. Managing Director Operations
4. Managing Director Signaling
5. Managing Director Commercial
6. Managing Administration Director
7. Dean

AB. *RCM tactical*: it contains the groups related to the tactical level.

1. Infrastructure Planner
2. Vehicle Design Engineer
3. Timetable Planner
4. Signaling Planner
5. Sales Director
6. Administration Manager

7. Group Manager

AC. *RCM operational*: it contains the groups related to the operational level.

1. Track Inspector
2. Maintenance
3. Train Crew
4. Signaling Inspector
5. Sales Assistant
6. Admin Assistant
7. Research Assistant

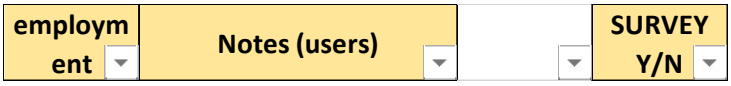


Figure 30. Columns AD, AE and AG

AD. *Employment*: stores the answer to the question: *For any future survey, do you have available data about the employment of graduates*? It can be either *Yes* or *No*.
AE. *Notes* (*users*): additional information optional for the user; it can be info on dual degrees, if the responsible is also responsible for other courses or if the course is not active and it will launch later.
AG. *Survey Y/N*: already mentioned earlier, each cell can be either 1 or empty, whether the organization answered to the survey or not.

3.2.3 Filtering and validating

A filter is applicable to all columns of the database but, given the open nature of most of the queries, this is not advisable.
The filtering operation is applicable on the validated columns, such as:

- D. provided by,
- E. Country,
- G. Active,
- H. EQF,
- I. Language,
- Z. Student Interchange.

In addition, the filter is applicable to Name of the course (column *A*) and the City/State/Region (column *F*), but as this section it was not possible to apply a double check to avoid excluding misspelled items or double entries (e.g. both *Munich* and *München* were wrongly considered as separate entities).

3.2.4 Data manipulation and visualization

Most of the data obtained from the survey was transferred in another excel file, for data manipulation and visualization. In this second excel sheet, there are only the information taken from the answers to the survey, divided in the following pages:

1. *Data*: the raw data copied from the database,
2. *Credits*: for the storage and analysis of data relative to ECTS,
3. *Keywords Veh.*: for the distribution of skills in the Vehicles subsection,
4. *Keywords Infr.*: for the distribution of skills in the Infrastructure subsection,
5. *Keywords Sys. & Op.*: for the distribution of skills in the Systems and Operation subsection,
6. *Keywords Innov.*: for the distribution of skills in the Innovation and digital competencies subsection,
7. *Rail-career matrix*: For the rail-career groups' distribution amongst different organizations and levels,
8. *Data answered + not answered*: include also the courses not mentioned by the institutions that replied to the survey,
9. *Data only green*: data from the previous page filtered with only the answers color coded in green (see handbook color-coding),
10. *Analysis*: basic analysis performed on the first questions of the survey and information of the database, such as EQF of courses, Language, Country, Internships/technical visits, Student interchange, Employment data, duration of the course,
11. *RCM Vs Keywords*: data obtained from the RCM related questions jointed with data from the keywords questions, linking the skills to the expected career.

3.2.4.1 Credits

In this page, for each answer the columns include *A, B, C and T* of the database and the data from the column *T* (ECTS of singles disciplines).
A sum of the number of credits for each course was in the column *D* (*TOT course*), compared to the total from the course if available, in order to understand the relevance that railway related topics have in the concerned course. This data was not always available or provided and a further investigation is advisable.

3.2.4.2 Keywords: Vehicles, infrastructure, Systems and Operations, Innovation and digital competencies

In these pages, there are only the copy of the name of the university (column *A* of the database) together with the column of the database containing the Keywords relative to each subcategory:

- In the Keyword *Veh.* page column *U* was copied, representing the keywords of the vehicle's subcategory,
- In the Keyword *Infr.* page, column *V* was copied, representing the keywords of the Infrastructure subcategory,
- In the Keyword *Sys & Op.* page, column *W* was copied, representing the keywords of the Systems & Operations subcategory,
- In the Keyword *Innov.* page, column *X* was copied, representing the keywords of the vehicles subcategory

The separation by each new addition was by a comma and put in the respective category. Each column must contain only the keyword indicated in the first row. A further category named *other* includes the additional keywords that the organizations who answered to the survey decided to add.
For each keyword and for the *other* category, the sum was in order to measure the distribution on the total of the skills. In addition to that, the sums were in percentage.
Some different layouts for data visualization were tried (examples in figure 31 and 32).

3.2.4.1 Rail careers matrix

Since the RCM matrix includes three levels with seven groups each, in this page there are three different tables, one for the strategic level, one for the tactical level and one for the operational level.
For each table, the answers to the survey (columns *AA, AB, AC* of the database) extracted and placed in the respective column. For each group, the sum was again for each level. The result is that is possible to analyze the distribution of a group within a level (figure 33), that the distribution of the levels on the total (figure 34).

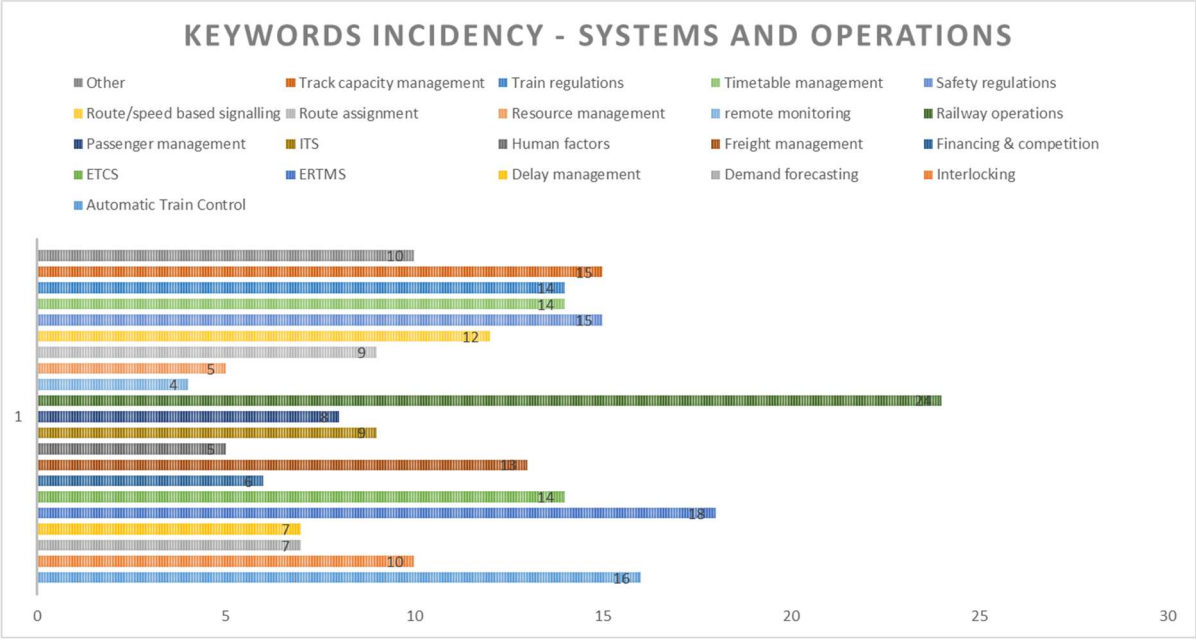


Figure 31. Data visualization for the incidence of keywords - Systems and Operations

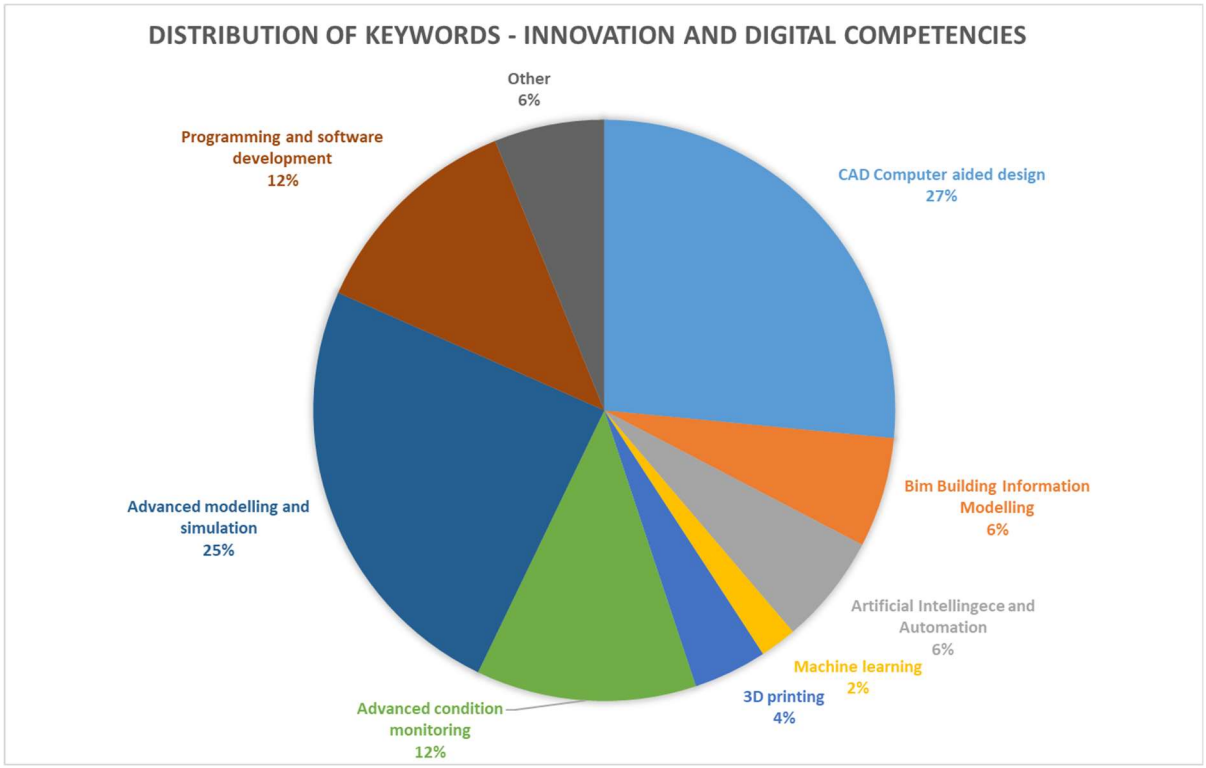


Figure 32. Data visualization for the distribution of keywords- Innovation and Digital competencies

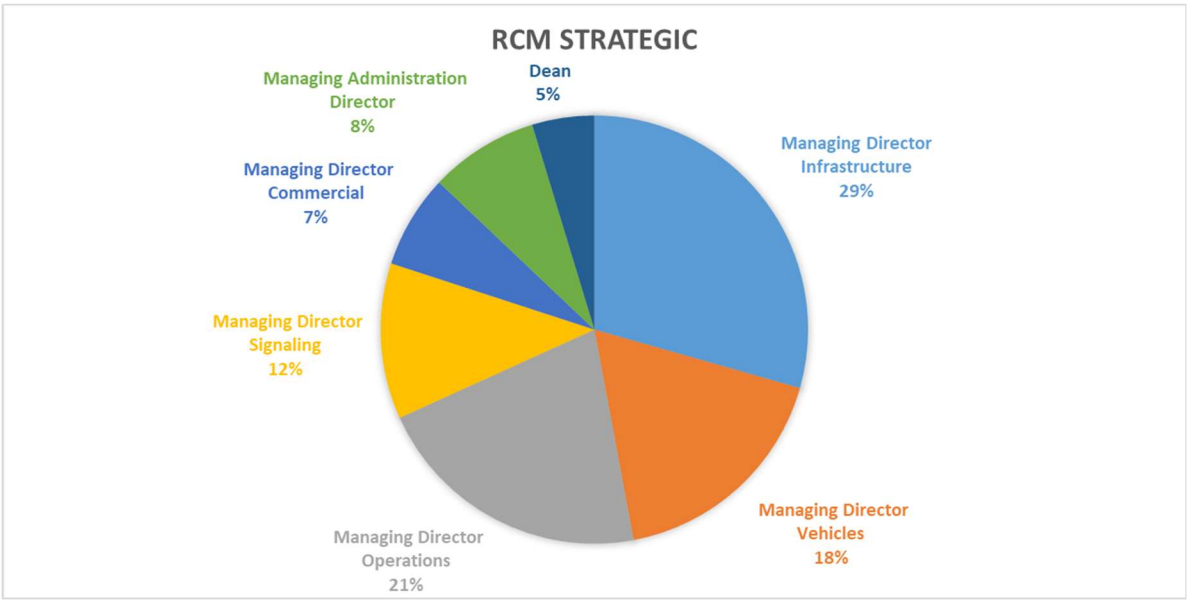


Figure 33. Distribution of groups in the RCM Strategic level

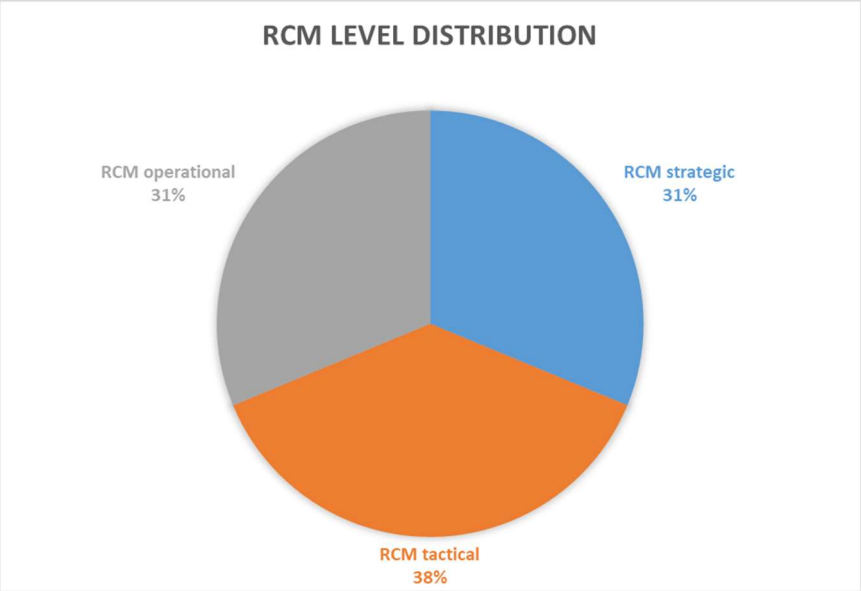


Figure 34. Distribution of RCM levels respect to the total

3.2.4.1 Data answered + not answered - Data only green

In those two pages, as mentioned before, the courses not mentioned by the respondents are stored. The filter was by the color code, with only green being the answers confirmed by the respondents.

3.2.4.1 Analysis

here some basic analysis was performed on the first questions of the survey and the information of the database, such as *EQF of courses*; *IT Country*; Internships/technical visits; *Student interchange*; *Employment data*; *Duration of the course*.
The data was from the other sheets, by using the function *count.If* when possible, or pasted and cleaned when needed. In most cases, the computation was the total N° and the share over the total.
Here are some examples of the tables, in raw form, from which the graphs in the report are derived (figures 35, 36 and 37).

EQF of courses				
EQF 6	EQF 7	EQF 8	ND	Blank
18	27	3	1	4

Figure 35. EQF level of courses

Language								
English	German	Italian	Spanish	Czech	Greek	French	Croatian	ND
10	15	3	9	1	2	1	1	12

Figure 36. Language of courses

Country														
Germany	Spain	Italy	Croatia	Czech Repu	France	Switzerlan	Bulgaria	Greece	Sweden	Denmark	United Sta	UK	Slovakia	Austria	Lithuania
15	9	5	3	3	3	3	3	2	2	1	1	1	1	1	1

Figure 37. Country of respondents

3.2.4.2 RCM Vs Keywords

Here the data obtained from the RCM related questions joins with the data from the keywords questions, linking the skills to the expected career.

A. The first column stores the Organization name,
B. Columns from B to H: Strategic level from the RCM,
C. Columns from I to O: Operational level from the RCM,
D. Columns from P to V: Tactical level from the RCM,
E. Column W is blank, to store additional information,
F. Columns from X to AV: Keywords vehicles,
G. Columns from AW to BU: Keywords Infrastructures,
H. Columns from BV to CU: Keywords Systems & Operations,
I. Columns from CV to DH: Keywords Innovation and digital competencies.

The single values, as per the different sheets in this page, are in the same order for an easy count and confront.

4 Task 1.4 Preparation of synthetic reports providing the key Intellectual Outputs O1 in suitable shape for dissemination by web and social media, as well as for the achievement of the next Intellectual Outputs (KTH)

This task will prepare the information gathered in WP1 for it for different contexts, such as input for upcoming WPs or dissemination.

4.1 Definition of goals

The overall goal of this Task is to process and present the data acquired in Task 1.2 and 1.3 in a readable and simple way for the target users, mainly prospective students of the railway sector. Therefore, data about courses and programs below EQF level 6, i.e. below Bachelor's degree, are not considered.
The two main sub goals addressed are the following:

- Standardization and consolidation of the educational database for further use in upcoming WPs;
- Simplification of the database into a visual guide of the educational opportunities in the railway sector targeting prospective students.

The different educational programs representation is mainly for the users (prospective students) needs. Therefore, the different criteria assigned are:

J. Present education on a program level, with whole programs displayed exclusively;
K. Give orientation about general course contents and fields of study;
L. Allow filtering by educational level;
M. Give a qualitative idea of the railway specification degree of the programs.

Eventually, by means of an interactive website (Figure 13) the various areas of the railway sector should be for prospective students' explorations, leading to the panel of educational possibilities and programs.

4.2 Data standardization

The database created and described in the forgoing Task 1.3 was the starting point for the present work. This refers to the version of the database dated 26/03/2021.
An initial reassessment of the database showed the following inconsistencies:

- The gathered information was not purely academic terms: the use of the job matrix in this context embedded the job market needs in the database, while WP1 must to study the educational part only;
- The input came directly from the interested parties and was not peer reviewed; therefore, the quality of the data was not uniform throughout the database, e.g. some entries referred to individual courses, while others referred to complete programs. Other

inconsistencies related to the percentage of course/program content directly related to railways made it much more challenging to understand what where specific entries offering as railway education.

- There were programs offered from educational levels lower than Bachelor, and by entities that were not universities. In a first step, all programs not delivered by universities or other higher education institutions were out; the same was with all non-European programs.

4.2.1 Methodology

To reach the goals, set in chapter 4.1, a specific system of categories and terms had to be stablished, with the final user in mind, prospective students, facilitating easy comprehension and accessibility.
It is in the very nature of categorisation itself that lines must be drawn, resulting in a loss of individuality and complexity. The work group includes then bachelor and master level students in order to ensure a younger user base perspective, with a final solution that reflects very well the users' demands.

4.2.1.1 Database modifications

To comply with the goals, set in chapter 4.1, it is useful to implement the solutions listed below, each followed by the list of respective keywords/terms and a short description of the relevant data acquisition:

N. The column *Program* replaces the column *Course* of the initial database; the respective entries are revised and adjusted;

O. The intuitive primary program categories give the user a broad idea about the contents covered in the programs. Due to the freedom that each entity has to name their own programs, it is necessary to tackle the widespread in program and course names. The categories chosen are the following:

- *Mechanical* Engineering,
- *Railway* Engineering,
- Environmental / Energy Engineering,
- *Civil* Engineering,
- *Electrical* Engineering,
- Logistics,
- *Vehicle* Engineering,
- *Transport* Engineering;

The primary program category depend on the program's name; in case this information was not sufficient, further indicators for the categorization are the analysis of the curriculum and the responsible faculty/department;

P. The programs classification is according to the qualification framework of the Bologna process (i.e. Bachelor, Master, and Doctor). On top of that, there are the duration of the

and the categories for programs that do not fit into the framework have been introduced. The categories chosen are the following:

- *Bachelor* (3 or 4 years),
- *Integrated* (5 years),
- *Master* (1, 2 or 3 years),
- Post graduate course (max. 1 year),
- Advanced Master (1 year),
- PhD.

The determination of the type of program is self-explanatory based on these categories.

Q. One of the most complex points to address is the amount of railway specific education in each program. After considering different options, the adopted solution is to use a 4-level scale, where the programs categories are according to the amount of credits of railway specific courses they encompass; the chosen categories are the following:

- *Program*: ~ 50% of the program is rail focused,
- *Module*(*s*): 20-50% of the credits are rail focused,
- *Course*(*s*): less than 20% of the credits are rail focused,
- *None*: no railway specific courses;

The railway specification depends upon the respective curriculum. Due to the inconsistency in the data provided by the respondents to the questionnaire, a more detailed analysis ensured the validity of these figures. In this analysis, each programs curriculum has been double-checked, where a course is railway specific if *rail* appears in the course name, e.g. *Management of railway systems* is railway specific, whereas Traffic management is not.

The column *ECTS* on rail has not been used, because the values in this column varied extensively and no indication of the relation to the whole course was given (e.g., 20 ECTS on rail represent almost half of a one-year master's but a low share of a 3-year Bachelor).

4.2.1.2 Implementation

To implement the solutions mentioned, the introduction of columns from the initial database was necessary. Columns with orange background were new (*Programs*) and columns with yellow background represented the initial database. This process led to the following result.

University/Organisation	Program	Country	City/state/region	EQF	Language

Figure 14 Columns A-F of Railway programs for students

R. *University/Organization*: Full name of the university/school, in English if available (see chapter 3.3.1),

S. *Program*: Full name of the Study program, in English if available. This made some major changes necessary since the initial database also included single courses,

T. *Country*: The name from a Country list, to avoid misspelled countries. The name should be in English. (see chapter 3.3.1),

U. *City/State/Region*: Nested within the country data, a further classification is made with the possibility to be precise when possible (city) or to write the region/state if the course, as an example, is shared between institution. Although is not possible to insert double countries, but more than a city can be chosen (chapter 3.3.1),

V. *EQF level*: the EQF level is indicated (6, 7, 8 or 6-7),

W. *Language*: A list of languages on the rules sheet can create problems when the course is dual-language or is a module taught in a language different from the course. Nevertheless, to avoid misspells or repetition while filtering, it was set up this way (see chapter 3.3.1).

Type of program	full time / part time / dual	(Primary) program category	Railway specialisation

Figure 15. Columns G-J of Railway programs for students

X. *Type of program*: a list of applicable program types on the rules sheet, with entries including the type of program and the respective length (e.g. 1 or 2 years for the Masters; if available, the time always refers to the full-time option;

Y. *Full-time/part-time/dual*: a list of applicable options and the respective combinations in the rules sheet (e.g., full/part time);

Z. *Primary*: a list of nine different program categories according to chapter 4.4.2.1 was in the rules sheet.

AA. *Railway specialization*: a list of four different levels of railway specialization according to chapter 4.4.2.1 in the rules sheet.

BB.

Tuition fee	for homecountry citizen / semester	for EU and EEA citizens / semester	for third country citizens / semester	NOTES (new)	Website

Figure 16 Columns K-P of Railway programs for students

CC. *Tuition fee for no-EU students:* yes/no, depending on income in the rules sheet (Optional),

DD. *Tuition fee for home country citizens/semesters:* Amount per semester for students from with citizenship of the university's location (Optional),

EE. *Tuition fee for EU/EEA citizens/semester:* Amount per semester for students from the EU/EEA, also applied for students with a validated refugee status in one of these countries (Optional),

FF. *Tuition fee for third country citizens/semester:* Amount per semester (Optional),

GG. Notes (new): comments regarding the program (e.g. about length or specific railway courses (Optional),

HH. *Website:* This column contains the website's URL. It can be the link to a pdf sheet when available. The level of detail can vary but this is one of the most important queries, since it can provide easily further information. Sometimes the page can seem empty, because the browser might recognize the country of the user and goes to the *alternative language* page of the website, most of the time incomplete or empty. In this case, there should be a flag on the website, which changes it to the original language; if needed; it is possible to use the google translator on the same page (occasionally updated).

All remaining columns of the initial database kept the information content. They were useful in the process of prioritizing the programs and courses.

4.2.1.3 Workflow and prioritization

After the mentioned columns, it needed to fill it for all the different programs. In order to prioritize the data was first sorted by the column *ETCS on rail*. All entries that stated such a number were under investigation. With this order, the entry of the database was double-checked; than the new criteria were according to them.

Subsequently, once the most important programs in this category where analyzed, a second prioritization method was to search the initial database for courses and programs that contained the word rail in their name. The differences between actual courses and programs quick then be pinned down, allowing to introduce generic programs with railway specific courses in the database, and removing duplicities.

All other database entries had less priority.

4.3 Visualization

In order to give a comprehensible visualization, preferably in a website format, an easy but tangible concept had to be developed.

Based on a railway overview picture (Figure 17) the different railways connected applications and the respective disciplines involved, the aim is to facilitate an easy connection from the concrete real-world application to the more abstract fields of study.

By clicking on one of the program categories, the prospective students find a list of all programs in the database applicable. Here they can further filter for the level, the language, the place of study and so forth.

We want to emphasize that also non-traditional fields of study are to be visualized (e.g., Telecommunications) but based on the current database this is not yet necessary. We do believe that those emerging fields can be quite easily included in this approach. A trainline going through a rural landscape could visualize *Environmental* and *Energy* engineering and Telecommunications relate to antennas and Balises along the routes.

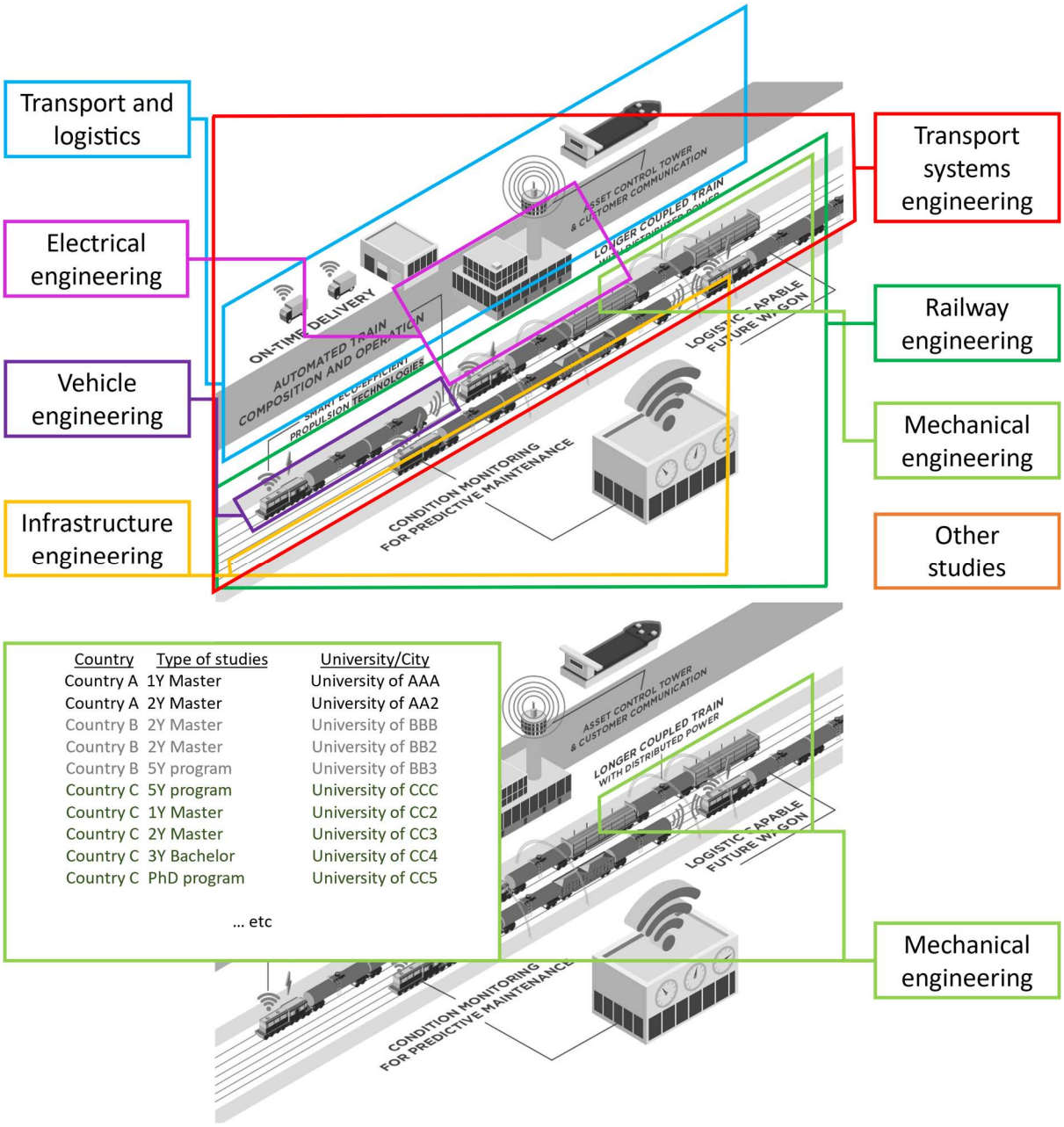


Figure 17. Conceptual Visualization

The current picture in Figure 17 is just a draft, with the base picture being the official visualisation of Shift2Rail Innovation Programme for Freight (IP5) and the captions in it are not applicable for our purposes. We believe that a custom-made visualisation would yield the best outcomes.

A final representation like this can easily create material for the different web pages off the participating project members, allowing also sharing easily the results in social media and official communications.

This implementation of the visualization is not WP1, but, if implemented in a future WP, for instance a deeper discussion on the topic is necessary in order to ensure that the resources needed for this implementation are available from the project.

4.4 Results

The results of Task 1.4 are a comprehensive excel based database *Railway programs for Students.xlsx* of rail related study programs in Europe combined with a visualization concept. These results should be easily visible for prospective students to facilitate information and orientation for their choice of study.
If such a service is to implement, it is strongly advising to update the database frequently to ensure its topicality.

4.5 Discussion

The chosen solutions provide a close to optimal output for future students interested in the railway sector given the provided data. Nonetheless, the database is far from claiming completeness. The two major apparent weaknesses are under discussion.

4.5.1 Traditional understanding of railways

The investigation of the present dataset clearly displayed the traditional understanding of railways that is still present today. Whereas during the whole investigation, only a single program in the category *Environmental Engineering* appeared, *Civil* and *Transport* Engineering, combined represent more than half of the programs studied (Figure 18). A category dealing with new technologies or digital competencies was very important: This displays that even the researchers have a traditional view on the railways and still, the search for railway related education in this context yielded no results, so there was no necessity for a specific category on the topic.

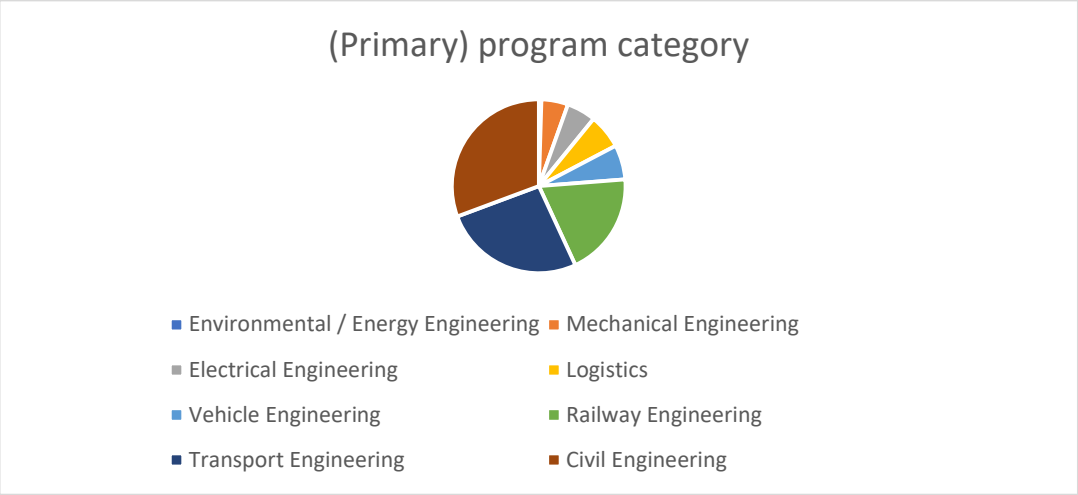


Figure 18. Distribution of primary program categories

4.5.2 Railway specification *no must-have*

Apart from the programs encompassed by this study, a rail specification in a program is not a strict necessity to work in the rail sector. On the contrary, new developments require skilled personnel beyond the traditionally close-to-railway fields, such as IT experts and environmental engineers.

Even in the more traditional métiers, the path to the railway industry is open for those who never specifically dealt with railways. This appears to be true in any of the categories investigated, and should be a major point for study in upcoming work packages.

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