SKILLRAIL

Education and Training Actions for high skilled job opportunities in the railway sector

Funding Scheme: Supporting Action
Thematic priority: Sustainable Surface Transport
Project Identification Number: 233649

D1.3

Analysis of Results of Research Projects with strong potential for T&E education activities and corresponding course material

Due date of deliverable: 31/09/2010
Actual submission date: 31/03/2011

Start date of Project: 01/12/2009 Duration: 24 months

Organization name of lead contractor for this deliverable: IST

Dissemination Level: PU, Public

Document ID	D1.3
Document Type	Deliverable
Title	Analysis of Results of Research Projects with strong potential for T&E education activities and corresponding course material
Author(s)	R. Macário, V. Reis
Partner	IST
Date	31 / 03/ 2011
Status	Final

Document history		
Revision	Date	Description/reviewers

Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission	
RE	Restricted to a group specified by the consortium (including the Commission	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1 Introduction

The recent dynamics and evolutions have indisputably brought changes in the demand of professional competences for working in rail transport- and railways-related professions. Arguably, the very nature of the professional competences has evolved in parallel with the progressive modification in economies, societies and, ultimately, in the rail transport systems. As such, we naturally conclude that prospective employees have to master the current (and ideally future) competences, so that they could aspire to become competent professionals. Since prospective employees are firstly students, this entails universities and other education institutions to permanently update the courses and the curricula.

In face of the constant changes, there is a real risk of mismatch between the prospective employees' competences and the market's actual requirements. And if such mismatch is not addressed, there is the danger of creating a significant competence gap that will inevitably affect the competitiveness and efficiency of the European rail transport sector. Figure 1.1 attempts to represents the competence gaps and the likely causes.

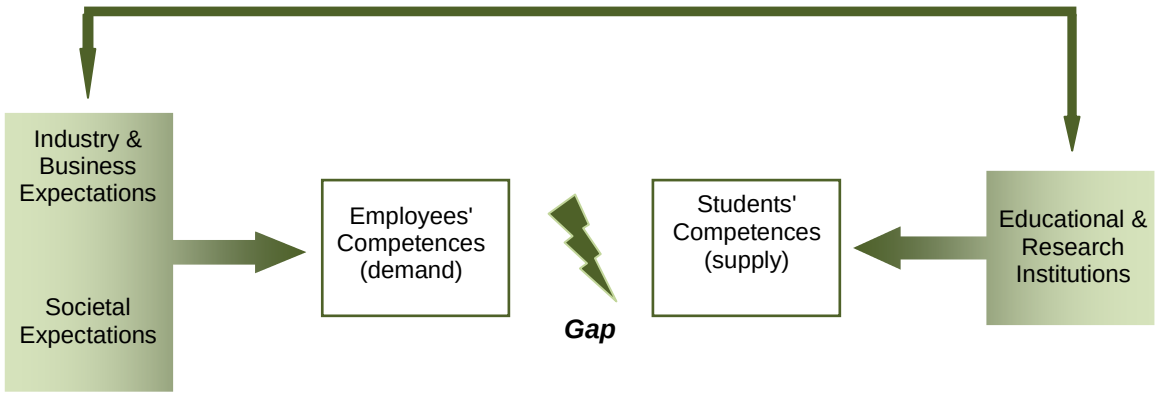


Figure 1.1 - Potential competence gap

Indeed, this threatening gap had already been identified by the European Commission that has deployed a series of efforts (such as: funding research, directives and regulation, or incentives and dissemination) to foster the education of students and qualification of employees aiming precisely to bridge this competence gap.

For example, concerning road sector a set of projects have been funded over the last decade, such as:

- GADGET- Driver training, testing and licensing: towards theory-based management of young drivers' injury risk in road traffic (Work Package 3), 4th Framework Programme, 1999;
- DAN - Description and analysis of post licensing measures for novice drivers, 4th Framework Programme, 2000;
- ADVANCED - Description and Analysis of Post-licence Driver and Rider Training, 5th Framework Programme, 2002;
- BASIC – Driver training: New models, 5th Framework Programme, 2003;
- NovEV - Evaluation of post-licence training schemes for novice drivers, 5th Framework Programme, 2004;
- HERMES - High Impact approach for Enhancing Road safety through More Effective communication Skills for driving instructors, 6th Framework Programme, 2005;
- TEST - Towards European standards for driver testing, 6th Framework Programme, 2005;
- SUPREME project - Summary and publication of best Practices in Road safety in the EU Member States, 6th Framework Programme, 2007.

The Directive 2003/59 establishes the minimum requirements for the qualification and ongoing training of professional drivers (only for category C and D vehicles), but thus far no legislation have been implemented for the other two category vehicles (A and B).

With regard to the maritime sector, as of 1994 a whole arsenal of specific rules on the training and the certification of seafarers were adopted, aiming to transpose in Community legislation the international standards enacted by the International Convention on Standards of Training, Certification and Watchkeeping (Convention STCW) and to ensure that seafarers working on board Community ships are trained at least according to the international requirements'. The training of seafarers (Directive 2008/106/EC) is essential to

define a minimum level of training for seafarers in the Community having regard to training standards agreed at international level. Thus far, the main funding instruments in the sector are the Socrates and Leonardo da Vinci programmes. No research projects have been fund aiming to explore the education and formation needs in this transport sector.

The aviation sector has also received a great deal of attention. Over the past couple of decades, multiple research and consultancy projects have been funded and various legislative packages were released in the domains of education and formation. In terms of projects, we may refers the following ones:

- *SESAM* - Single European Sky ATM Research, European Union funded, 2004-2013,
- *ESSAI* - Enhanced safety through situation awareness integration in training, 5th Framework Programme,
- *ECOTTRIS* - European Collaboration on Transition Training Research for Improved Safety, 4th Framework Programme,
- Methods Used to Evaluate the Effectiveness of Flightcrew CRM Training in the UK Aviation Industry, Civil Aviation Authority, Paper 2002/05,
- *CAST* - Consequences of Future Air Traffic Management Systems for Air Traffic Controller Selection and Training.

In terms of legislation we may refer the following directives and regulations:

- *Council Directive 91/670/EEC* - which established the rules for the mutual acceptance of licences for persons working in civil aviation,
- *Regulation (EC) No 1592/2002* - which established the European Aviation Safety Agency (EASA) as the cornerstone of the European aviation safety policy. These new rules currently cover all issues related to the initial airworthiness, including the training and the licensing of aeronautical mechanics, technicians and engineers,
- *Directive 2006/23/EC* - which established the rules for the licensing of on the Community air traffic controller.

Finally, in what concerns the mode of transport of interest in SKILLRAIL, the rail sector has received a great deal of attention over the last decades, with the successive implementation of several legislation packages aiming to liberalise the sector. The liberalisation process, in line with what has happened in the air transport sector, has brought fundamental changes at multiple levels, such as: legal, technological, demographic and market changes that the railways need to deal with in the coming years (COM(2002)18 final). The main changes include:

- Introduction of *new European legislation* that, among others, promotes cross-border interoperability and common standards in the railway sector, requiring training of staff in the new legislation.
- *Technological developments* affect the professional requirements related to the operation of trains and networks, as well as the maintenance of rolling stock and infrastructures.
- The *demographic situation* in railway undertakings implies that a significant number of railway staff have to be replaced in the coming years, creating a need to recruit a considerable number of staff for the railway sector.
- *New railway undertakings are emerging* as a result of the opening of rail markets. These undertakings require access to training facilities that provide the necessary professional training. However, new undertakings do not necessarily have access to their own training facilities and therefore need to buy training services on the market – either from other railway undertakings with their own training centres or from independent rail training centres.

The European Commission has meanwhile assigned several projects and consultations aiming at understanding the current and future needs of education and training. For example, the Rail Training 2020 project, finished in 2007, aimed to identify the needs and offers in the European railway area the next 10 - 15 years. Other research projects dedicated to educational issues in railways include:

- *EURNEX* - European Rail Research Network of Excellence, 2004-2007, 6th Framework Programme. IST partner in Pole 10 - Training and Education,
- *FUTURAIL* - Job Opportunities for the Railway Community of Tomorrow, 2008-2010, 7th Framework Programme. IST is the project leader,
- *SKILLRAIL* - Education and Training Actions for high skilled job opportunities in the railway sector, 2009-2011, 7th Framework Programme. IST is the project leader.
- *TRAINER* - System for Driver Training and Assessment using Interactive Evaluation Tools and Reliable Methodologies, 5th Framework Programme,
- *RRTC* - Regional Railway Transport research and training Centre foundation, 6th Framework Programme,
- *2TRAIN* - Training of Train Drivers in safety relevant issues with validated and integrated computer-based technology, 6th Framework Programme.
- *PORTAL* - Promotion Of Results in Transport Research and Learning, 5tf RTD Framework Programme.

SKILRAIL is indeed based on the assumption i) that in several areas, the academic courses will in the short run fail to meet the needs of practitioners, and ii) that there is a rather consensual opinion that, when arriving the industry, the students tend to have a rather shallow knowledge on the real world problems and how to tackle these, which evidences the lack of adequate competences. These difficulties, although with a negative connotation, do open a window of opportunity for research based technical courses to be developed in a more tailored or, better said, industry-orientated way. This Deliverable reports the works produced in Task 1.3 - Research based training and education. Task 1.3 explored and characterised the competences gap, with the purpose, to propose technical courses to fill in that gap (Figure 1.1).

Yet, the Competence Gap, as presented in Figure 1.1, is represented in an aggregated level, masking other dimensions and types of gaps that can potentially emerge. Consequently, the

Competence Gap was further explored to uncover the fundamental gaps and building blocks. This has resulted in the assessment framework presented in Figure 1.2. The framework of analysis lies on two core concepts, being: competence and knowledge. Competence may be understood as proficiency, i.e. the ability to retrieve the right skill from our mental warehouse of skills to solve some problem. The better our skill solves the problem, the higher will be our competence. Knowledge may be understood as the information, understanding and skills of someone on some domain. A person's competence depends on the ability to pin-point in her body of knowledge the adequate skill to do something. Naturally, if either there is no knowledge or the skill is not correctly identified, then the person's competence is affected.

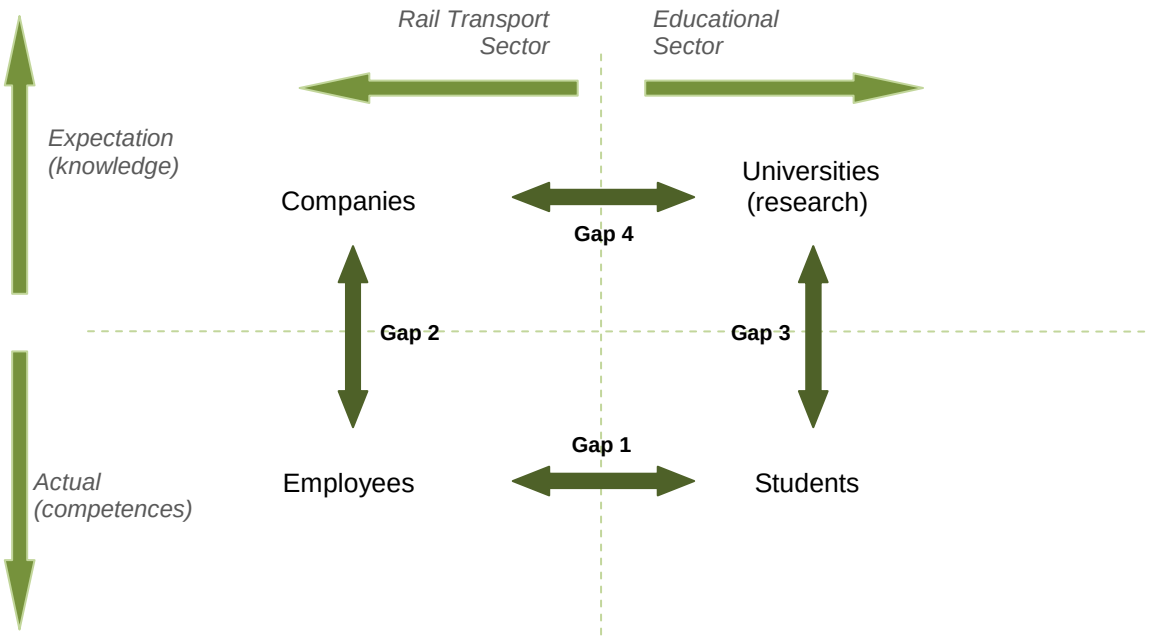


Figure 1.2 - The four gaps framework

Using the concepts of competence and knowledge, and analyzing it from two perspectives: industry (demand) and educational institutions (supply), the assessment framework presented in Figure 1.2 identifies four gaps, focusing on life long learning, being:

- Gap 1 - Competence Gap - Gap between the competencies that the employees need and the actual competencies of the students (i.e. to what extent are the students' competencies actually useful in their working daily activities?);
- Gap 2 - Gap between the knowledge that the companies expect to receive and the actual proficiency the employers perceive on the employee (i.e. to what extent do the employees' competencies actually fit in the companies' requirements?)
- Gap 3 - Gap between the knowledge that the universities generate and the actual competencies of the students (i.e. is the knowledge generated in the research transferred in the courses?)
- Gap 4 - Gap between the knowledge the companies need and the knowledge the universities have (i.e. is the universities' research and teaching activities of relevance for the companies?)

Looking again to Figure 1.1 and using this assessment framework, we may identify the four gaps and better understand the positioning and origin of the Competence Gap (Gap). Figure 1.3 identifies the four gaps.

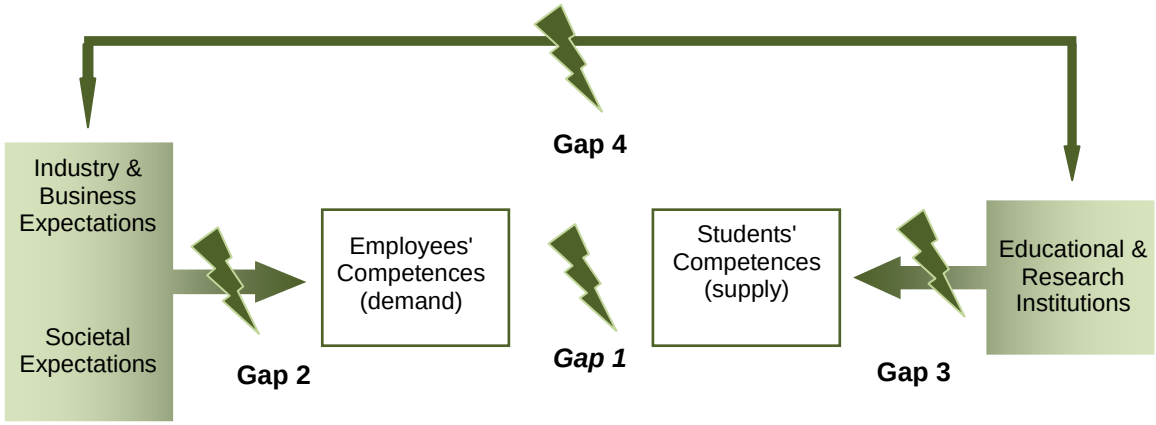


Figure 1.3 - Competence Gaps

Accordingly with the Description of Work, Task 1.3 has the following three specific objectives:

- To cluster projects around thematic areas where research exists and there is potential to develop short-run training courses;

- To identify didactic material to support those courses, which can be delivered in several mixed pedagogical packages;
- To identify projects' best practices in science and research for knowledge transfer processes and subsequent dissemination purposes.

As such, Task 1.3 aims to provide the vast body of research on the railways domains with an educational relevance. So, returning to the framework of analysis of the competence gaps (as schematised in Figure 1.2 and Figure 1.3), we may then conclude that Task 1.3 will contribute to bridge the horizontal competence gaps (i.e.: Gap 1 and Gap 4). Task 1.3 identified a set of educational opportunities and, consequently, proposes a set of courses. As such, this task aims to bring the research closer to the real world practice.

The following picture (Figure 1.4) presents the reasoning deployed in the identification of the courses. Step 1, presented in Chapter2, identified the needs of competences of the railways stakeholder. These needs will define the courses to be developed. Step 2, presented in Chapter 3, describes the assessment process undertaken to identify the available information produced by the research projects and that will be used to feed the courses' contents. The final step - Step 3, presented in Chapter 4, conducted a filtering process whereby the initial list of competence needs was checked against to the available information, in order to identify which courses can actually be developed.

The work of Lautala (2007) was also taken into account when analyzing the mismatch between the demand of the industry (regarding competencies needs) and the supply of the university (regarding education and training), in particular, the following questions:

- The lack of workforce hiring for a long period (which may give rise to an older workforce and a generation gap);
- The economic decline of the specific industry sector, and the respective decoupling between the education supply and the industry requirements;
- Competition from other industries, both for the industry and university sectors;
- Cultural differences between industry and universities;
- Influence of economical factors (funding and financing) on education.

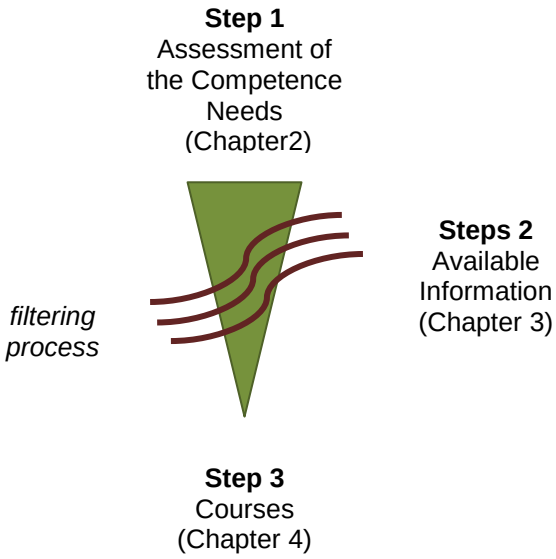


Figure 1.4 - Process for the choice of the course

The scheme of Figure 1.5 presents the sequence of the works undertaking in this task and the structure of the deliverable. Indeed the structure of the deliverable reflects the structure of the work.

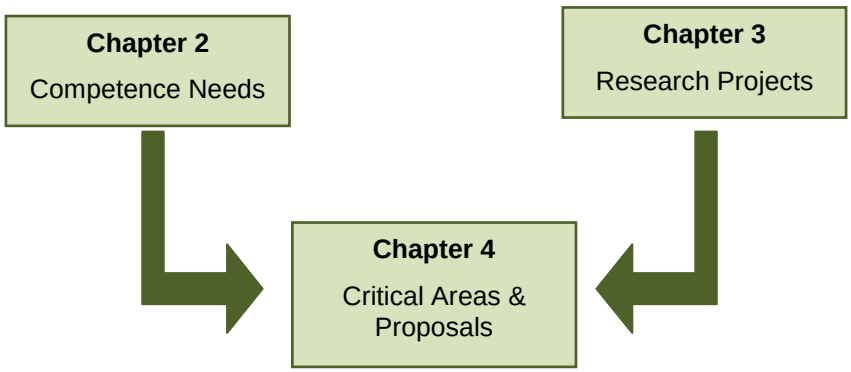


Figure 1.5 – Structure of Deliverable

The next chapter (Chapter 2) explores the competences' needs of the railway stakeholders. This analysis will provide information on the domains where the Competence Gaps are most likely to emerge. In Chapter 3, we analyse the list of research projects with interest for SKILLRAIL, that have been collected. The research projects are then clustered around a set

of thematic areas (already defined in the EURNEX project). This process revealed the availability and distribution of information on the various thematic domains. The information is supposed to be used as teaching material in the technical courses. Finally, Chapter 4 bridges the information provided by Chapter 2 with needs obtained from Chapter 3 to identify the most critical areas and, with it, to propose the technical courses.

Finally, it must be mentioned that the work produced in Task 1.3 was grounded in the information collected in EURNEX Network of Excellence project and, later on, made available through the Knowledge Management Centre (KMS). As such, the clustering process (Chapter 2) adopted the same thematic areas as defined in the EURNEX Network of Excellence project. Furthermore, we updated the extensive list of projects in KMS from the Member States and FP6 and FP7 programs in a total around 90 projects.

Moreover, EURNEX pole leaders will be expected to contribute in the final definition of course materials from finished and ongoing projects, and also in the promotion of these courses. From the survey on the research projects best practices in science and research based innovation have been identified and treated for knowledge transfer processes and subsequent dissemination purposes.

2 Stakeholders needs

2.1 Introduction

This chapter looks into the demand of competences. The demand side corresponds to the expectations and requirements from the industry and other commercial companies, towards the employees and students.

The evaluation of the stakeholders' needs is based on the early work carried out within the EURNEX NoE project. Within this project several railway stakeholders of umpteen countries in Europe were identified and their needed competences were defined based on a questionnaire. These results are described detail on Deliverable 16 of EURNEX NoE project[1] and we recap it here in summary for the importance it has in the definition of priorities for training courses.

Stakeholders' needed competences were identified making 35 in total. These competences were then regrouped into 8 categories, being:

- TR – Rolling stock and traction:
  - TR1 – Car body design and construction
  - TR2 – Bogies, running gear and braking
  - TR3 – Interiors, auxiliaries, HVAC
  - TR4 – Traction and power supply
- SE – Systems engineering
  - SE1 – Interoperability
  - SE2 – System integration and engineering interfaces
  - SE3 – Testing, verification and qualification
- CE – Civil engineering and infrastructures
  - CE1 – Tracks, switches and crossings
  - CE2 – Bridges and structures

[1] "Report on offered educational courses and railway operators needs - D16", EURNEX - EUropean Rail research Network of EXcellence, 2004

  - CE3 – Tunnels
  - CE4 – Stations
- CS – Control systems
  - CS1 – Signalling, control-command and interlocking
  - CS2 – Train control, positioning and communication
  - CE3 – Electromagnetic compatibility
- OP – Operation
  - OP1 –Passenger
  - OP2 – Freight
  - OP3 – Resources management
  - OP4 – Technical and commercial exploitation
  - OP5 – Intermodality
- EN – Environment
  - EN1 – Noise and vibrations
  - EN2 – Air pollution and energy savings
  - EN3 – Sustainable development, recycling and waste management
- EC – Economics, business, regulations
  - EC1 – Economics
  - EC2 – Costs, asset management, life cycle costs
  - EC3 – Market analysis
  - EC4 – Business management
  - EC4 – Regulations
  - EC5 – Public service, social and political issues
- GE – Multidisciplinary issues
  - GE1 – Security and safety
  - GE2 – Risk analysis and failure mode analysis
  - GE3 – Human factors
  - GE4 – Reliability, availability, maintenance and safety (RAMS)
  - GE5 – Quality management

- GE6 – Light rail, tram and tram-train systems
- GE7 – Computer technology and networking

As expected, there is a clear similarity between these 8 categories (and 35 competence needs) and the above analysed research domains (Chapter 2). This was necessary to enable the identification of the projects that could feed the future courses' curricula.

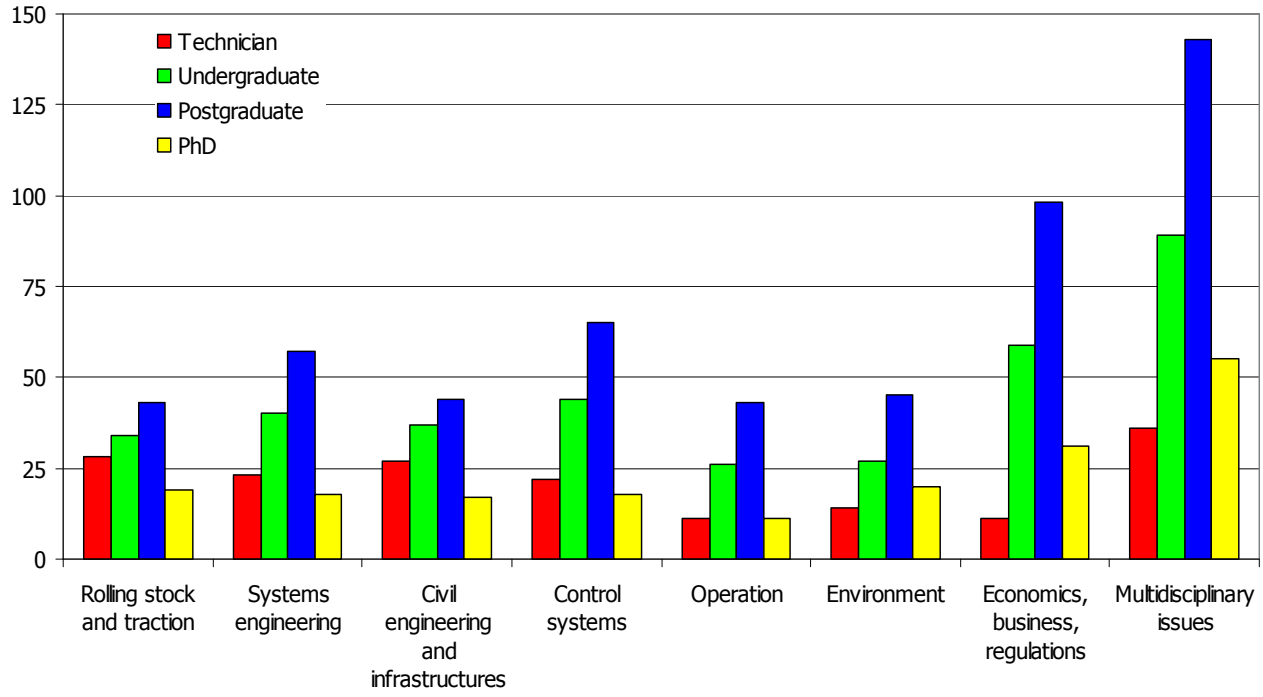
2.2 Analysis of the competence needs

The respondents covered most domains of railways industrial activities, including: rolling stock; infrastructure contractor; signalling control and information; infrastructure manager,; operator; railways research; authorities and public organisation; testing, inspection and qualification; engineering and consultancy; and education and training. Such coverage provided confidence on the reliability and robustness of the findings.

The competences needs were evaluated for three levels of education being: Technicians, Undergraduates, Postgraduates and PhDs. There was also an analysis of the needs per participant country (in the questionnaire).

The following graph (Figure 2.1) presents the distribution, by category, of the competence needs. The vertical axis represents the number of responses (recall that each category is divided into several competences, and that each respondent could mark one or more competence in each category).

The distribution between all categories shows a balanced pattern, with the exception of Multidisciplinary issues and Economics, that exhibit a significantly higher number of selections. Indeed, the first position occupied by Multidisciplinary issues is explained by the fact that these competences are needed by most stakeholders, whatever their domain of activity. There is also a homogeneous repartition of the qualification levels, with competences being mostly needed at the Postgraduate level and to a somewhat less extent at the Undergraduate level. Finally, the selections for the PhD level range between 12% and 17% of the total number of selections for each category, which may evidence a gap between the current employment of highly specialized personnel and the actual needs.



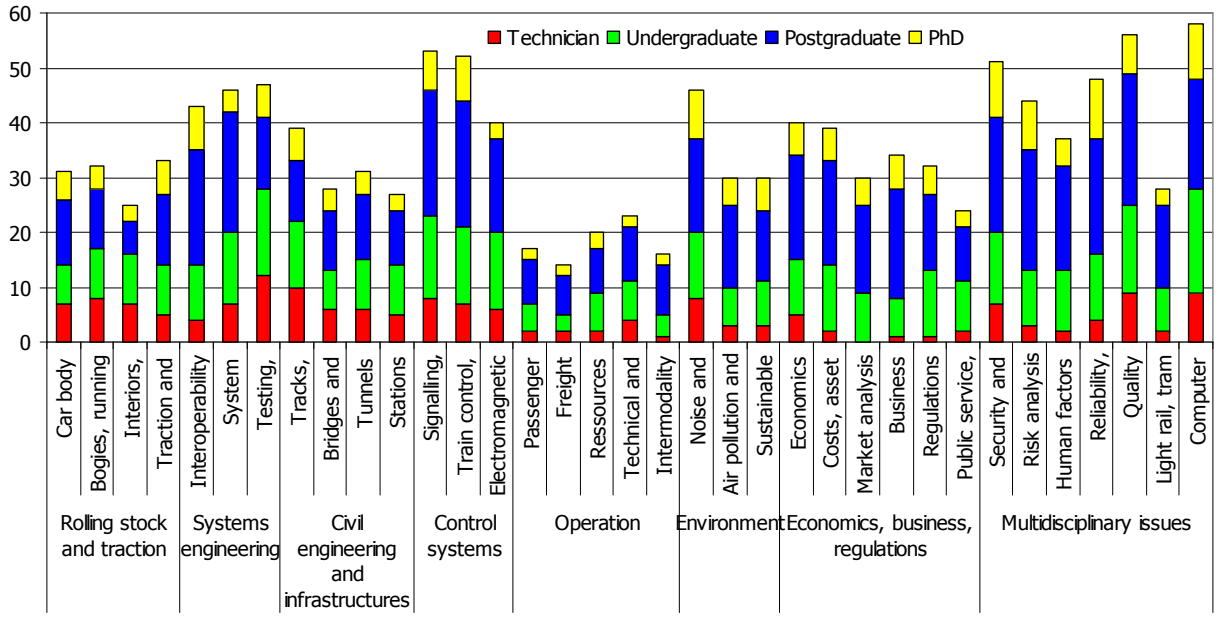
Source: EURNEX (2004) Deliverable 16

Figure 2.1 - Competence needs by category

Looking now with more detail into the results, Figure 2.2 to Figure 2.6 presents for each category the distributions of the respondents' needs for competences. Figure 2.2 presents the aggregated values, whereas Figure 2.3 to Figure 2.6 present for each educational level.

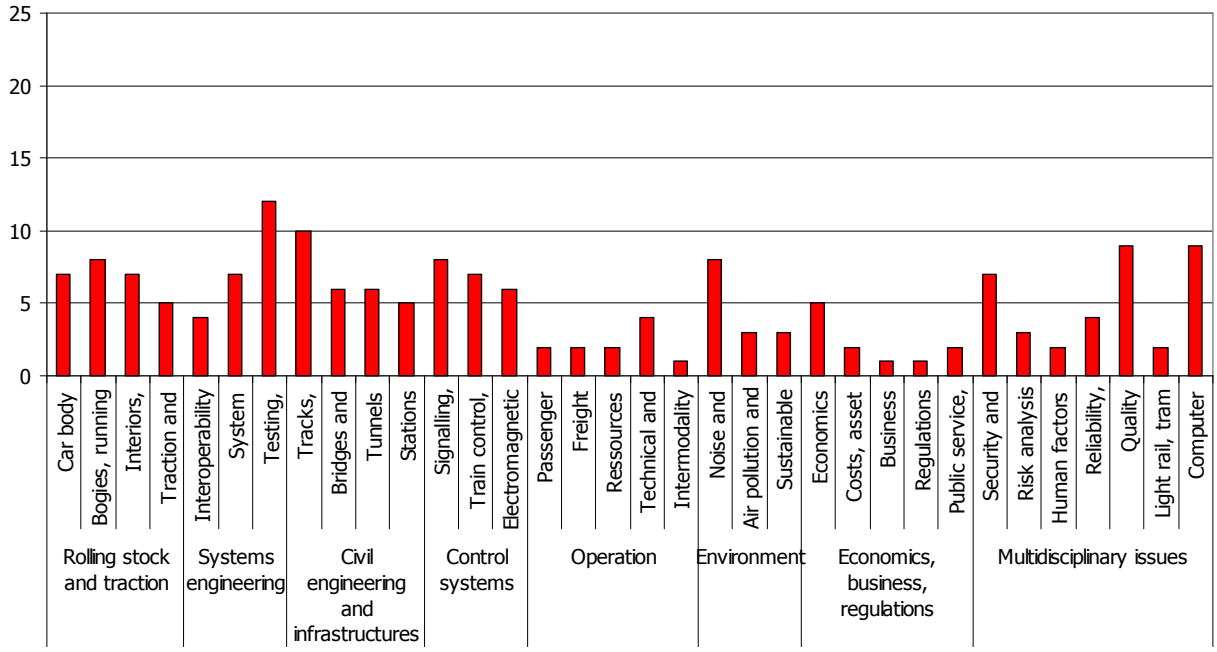
The five most needed competences irrespective of the degree were:

1. Computer technology and networking (58)
2. Quality management (56)
3. Signalling, control-command and interlocking (53)
4. Train control, positioning and communication (52)
5. Security and safety (51)



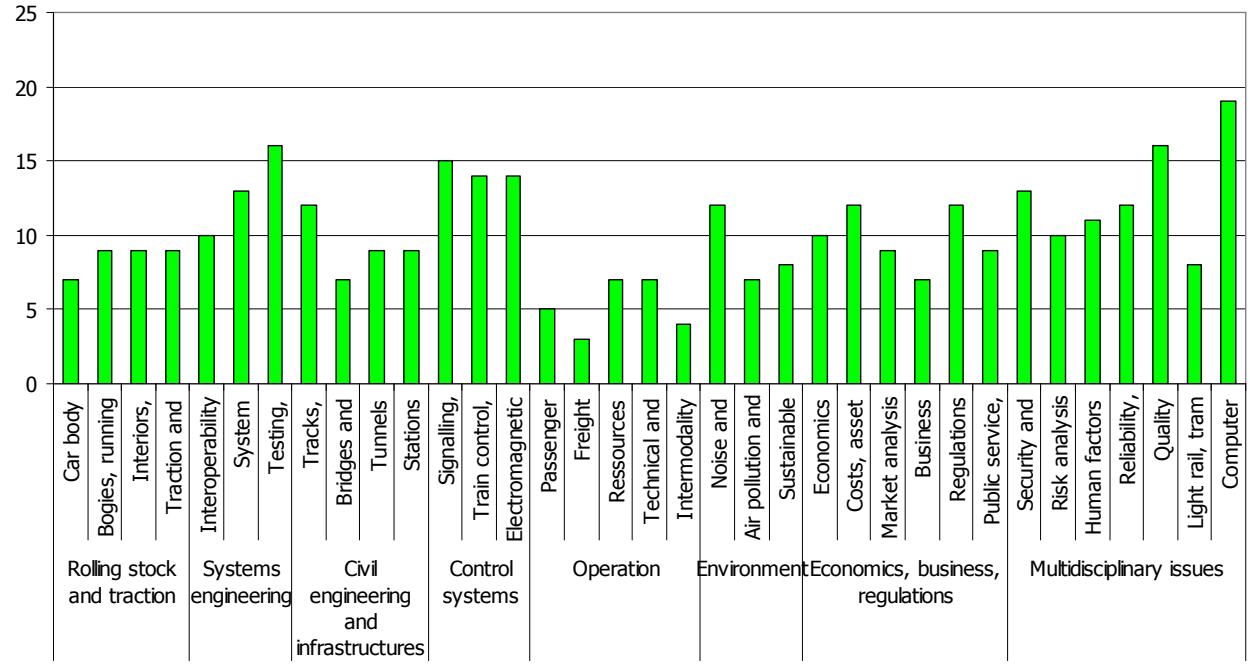
Source: Eurnex (2004) Deliverable 16

Figure 2.2 - Competence needs for all degree levels



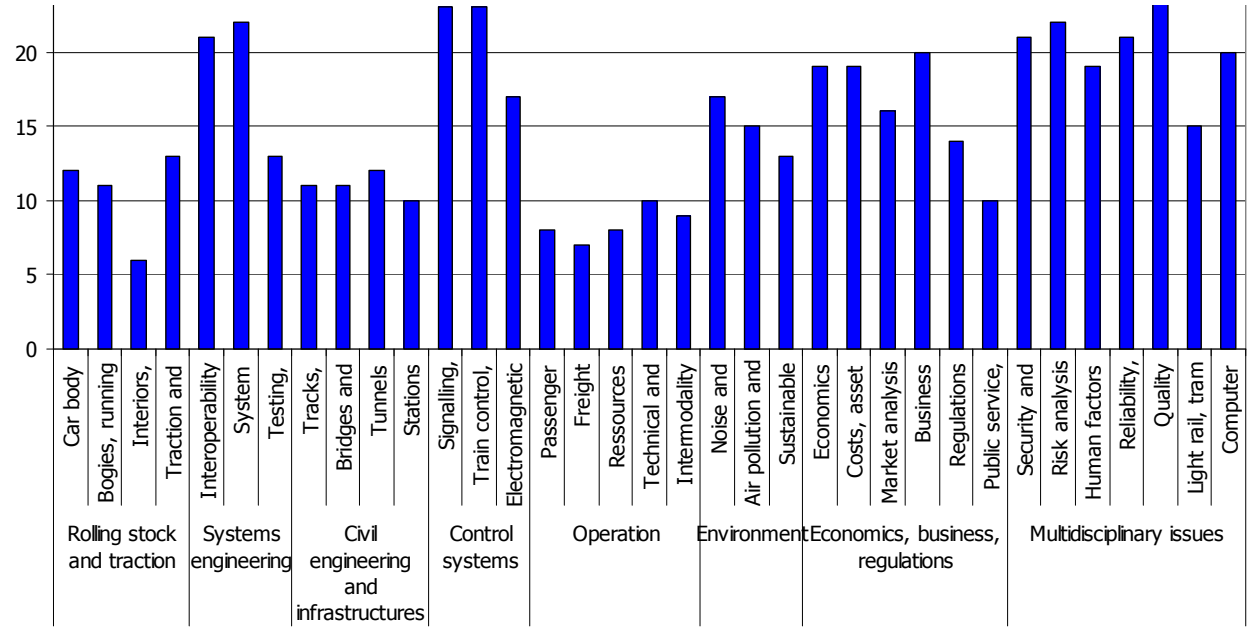
Source: Eurnex (2004) Deliverable 16

Figure 2.3 - Competence needs for Technicians



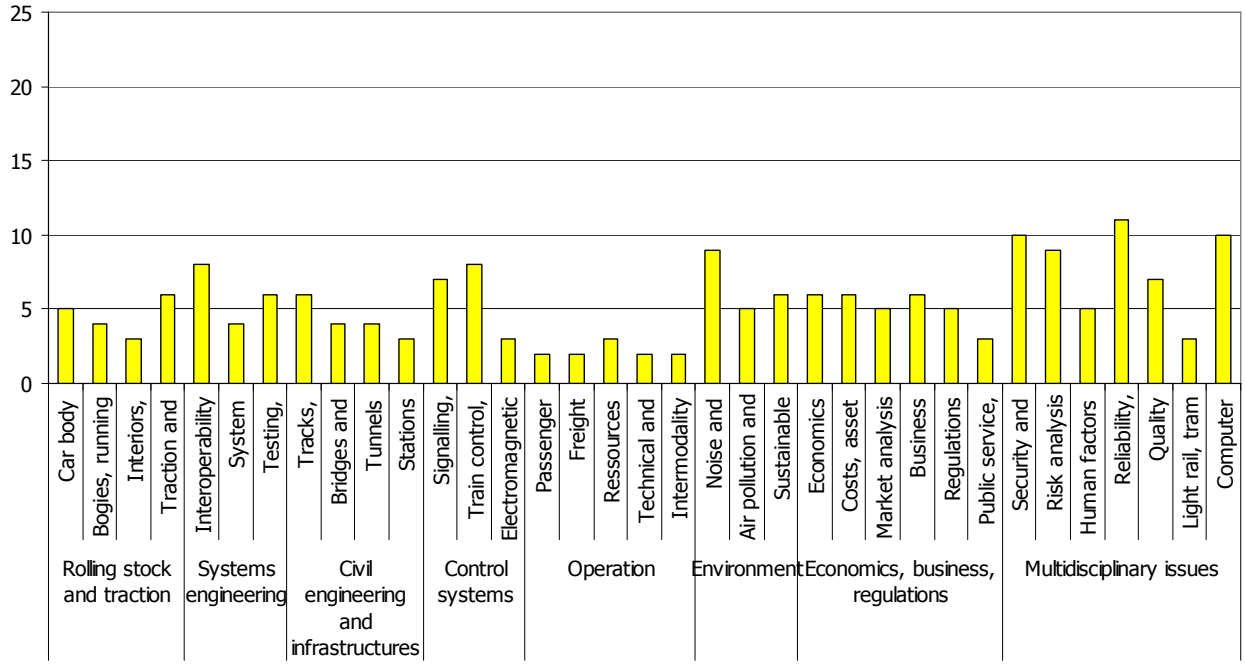
Source: Eurnex (2004) Deliverable 16

Figure 2.4 - Competence needs for Undergraduates



Source: Eurnex (2004) Deliverable 16

Figure 2.5 - Competence needs for Postgraduates



Source: Eurnex (2004) Deliverable 16

Figure 2.6 Competence needs for PhDs

'ith few exceptions, the competence needs differ amongst educational levels. This is expected, since each educational level refers to employees performing different tasks and with different responsibilities and missions. Most respondents revealed they were expecting a strong commitment from universities in educational tasks dedicated to railway applications. The most demanded competences depend on the qualification level. However, some of them did appear recurrently. These are:

- Railway-specific competences:
  - Train control, positioning and communication
  - Signalling, control command and interlocking
- Multidisciplinary competences:
  - Computer technology and networking
  - Quality management

The incidence of the needs reported in multidisciplinary competencies at postgraduate levels is very significant. In addition, a lack of knowledge of the railway system (holistic perspective) is strongly reported by the different types of stakeholders.

Table 2.1 - Competence needs per educational level

Category	Competence needs
Technicians	- Testing, verification and qualification (Systems Engineering); - Tracks, switches and crossings (Civil Engineering and Infrastructure); - Computer technology and networking (Multidisciplinary Issues).
Undergraduates	- Computer technology and networking (Multidisciplinary Issues); - Testing, verification and qualification (Systems Engineering); - Signalling, control-command and interlocking (Control Systems).
Postgraduates	- Quality management (Multidisciplinary Issues); - Train control, positioning and communication & Signalling, control-command and interlocking (Control Systems); - Risk analysis and failure mode analysis (Multidisciplinary Issues); - System integration and engineering interfaces (Systems Engineering).
PhDs	- Reliability, availability, maintenance and safety (RAMS) (Multidisciplinary Issues); - Computer technology and networking (Multidisciplinary Issues); - Security and safety (Multidisciplinary Issues); - Risk analysis and failure mode analysis (Multidisciplinary Issues); Noise and vibrations (Environment).

Legend: Category within brackets
Source: EURNEX (2004) Deliverable 16

The survey reported that the following methods for skills acquisition in the industry are:

- A rather homogeneous contribution of training (both modes together) for all competences. Training accounts for 43% of the acquisition process on the average, with a largest part for light rail, tram and tram-train systems (62%).
- On-the-job specialization is very common, always above 25%, and represents a large part of the Operations competences (Freight, Intermodality, Passengers)

- University courses and curricula are unequally participating to specialization, with values ranging from 9% to 42%. The contribution of universities is most significant for competences in the category Economics, business, regulations (Economics, Market analysis, Business management).

2.3 Inputs from TUNRAIL project

A similar survey was conducted in 2010 within the scope of the research project TUNRAIL - Tuning Transatlantic Cooperation in Rail Higher Education. TUNRail is a policy oriented measured project founded under the EU-US Atlantis Programme. TUNRail is a 24 month long project that started in September 2009 and will be completed in August 2011. TUNRail intends to tune and intensify the railway higher education knowledge exchange and collaboration between European Universities (Instituto Superior Técnico, Technische Universität Braunschweig and University of Newcastle) and United States Universities (Michigan Technological University, University of Illinois Urbana-Champaign). The project will use benchmarking and comparisons to investigate the current higher education programs, namely, it will identify similarities and differences between railway systems and educational programs. The overarching goal is providing a solid foundation for more extensive cooperation and for the establishment of new programs on both sides of the Atlantic[2]. The scope of TUNRAIL project in terms of the educational levels is the bachelor and master degrees.

A survey was conducted in the last quarter of 2010, targeting rail industry professional working around the globe. A total of around 550 responses were obtained. Due to the nature of the project respondents have been clustered into three groups: Europe, United States and Rest of the World.

[2] TUNRail Project's contents were developed under an E.U.-U.S. Atlantis grant from the Fund for the Improvement of Postsecondary Education, U.S. Department of Education and the Executive Agency for Education Audiovisual and Culture , European Commission. More info at www.tunrai.info

One part of the survey inquired on the current needs of competence for the following two categories: Engineering, and Operations and Management. Each category was sub-divided into a set of subcategories.

The surveys are still being gathered and analysed, yet, it is already possible to present some preliminary results. The following three tables present the results for each category and subcategory. For the European responses, subcategories with mark above 3.0 (important) are shadowed in green.

Comparing with the initial EURNEX results (Table 2.1), and starting with the undergraduate level, we may conclude that only the subcategory "Testing, verification and qualification" is not considered important in TUNRAIL survey, the other two are still considered important.

Comparing now the results for the postgraduate level, we may conclude that all EURNEX subcategories are still considered relevant, which evidences that the key issues remain fairly the same.

Table 2.2 - Engineering Competences

	United States	European Union	Other
Rolling Stock and Traction			
Car Body and Construction	**2.27**	**2.68**	**2.95**
Bogies, Running Gear and Braking	**2.41**	**3.20**	**3.14**
Interiors, Auxiliaries, HVAC	**2.04**	**2.89**	**2.43**
Traction and Power Supply	**2.63**	**3.51**	**3.57**
Systems Engineering			
Interoperability	**2.84**	**3.65**	**3.00**
System Integration and Engineering	**3.08**	**3.67**	**3.19**
Testing Verification and Qualifications	**3.04**	**3.56**	**3.35**
Civil Engineering and Infrastructure			
Tracks, Switches, and Crossings	**4.34**	**2.88**	**4.19**
Structures (Bridges, Tunnels, (etc.)	**4.31**	**2.55**	**4.00**
Stations	**3.81**	**2.93**	**3.35**
Other	**2.53**	**0.87**	**1.33**
Control Systems			
Signaling, Control Command and Interlocking	**3.62**	**3.23**	**4.14**
Train Control, Positioning and Communications	**3.50**	**3.47**	**4.14**
Electromagnetic Compatibility	**2.61**	**3.33**	**3.00**

Question: What types of university education would you consider most beneficial for graduates?
Grade: 1 – Not Important, 2 – Somewhat Important, 3 – Important, 4 – Very Important, 5 – Extremely Important

Table 2.3 - Operations and Management Competences

	United States	European Union	Other
Operations			
Passenger	**3.48**	**3.77**	**3.60**
Freight	**3.70**	**2.79**	**3.85**
Technical and Commercial Exploitation	**2.93**	**3.37**	**3.71**
Resources Management	**3.01**	**3.44**	**4.14**
Intermodality	**3.26**	**2.79**	**3.90**
Environment			
Noise and Vibrations	**3.38**	**3.58**	**3.81**
Air Pollution and Energy Savings	**3.49**	**3.86**	**4.00**
Sustainable Development, Recycling and Waste Management	**3.20**	**3.60**	**3.84**
Economics, Business, Regulations			
Economics	**3.33**	**3.58**	**3.84**
Regulations	**3.76**	**3.93**	**4.20**
Business Management	**3.29**	**3.60**	**3.85**
Cost, Asset Management, Life Cycle Costs	**3.59**	**3.86**	**4.00**
Marketing Management	**2.93**	**3.14**	**3.67**
Public Service, Social and Political Issues	**3.12**	**3.05**	**3.95**
Multidisciplinary Issues			
Security and Safety	**3.63**	**4.00**	**4.15**
Risk analysis and Failure Mode Analysis	**3.30**	**3.88**	**4.25**
Human Factors	**3.29**	**3.51**	**4.29**
Reliability, Availability, Maintenance and Safety (RAMS)	**3.49**	**4.05**	**3.95**
Quality Management	**3.71**	**3.86**	**4.14**
Computer Technology and Networking	**3.51**	**3.67**	**4.10**
Light Rail, Tram and Tram-train Systems	**3.34**	**2.74**	**3.65**

Question: What types of university education would you consider most beneficial for graduates?
Grade: 1 – Not Important, 2 – Somewhat Important, 3 – Important, 4 – Very Important, 5 – Extremely Important

Analysing now the results of TUNRAIL survey, the five top ranked needed competences are:

- **Reliability, Availability, Maintenance and Safety**, Operations and Management Competences (Multidisciplinary Issues);
- **Security and Safety**, Operations and Management Competences (Multidisciplinary Issues);
- **Regulations**, Operations and Management Competences (Economics, Business and Regulations);
- **Risk analysis and Failure Mode Analysis**, Operations and Management Competences (Multidisciplinary Issues);
- **Air Pollution and Energy Savings**, Operations and Management Competences (Environment).

Out of this top ranked subcategories, only one is shared with EURNEX survey, being the "Risk analysis and Failure Mode Analysis".

TUNRAIL survey also inquired on the level key success factors for working in the railway industry. The results are very interesting and are presented in the following table (Table 2.4).

Table 2.4 - Keys to Undergraduate Employee Success in Railway Field

	United States	European Union	Other
Education			
University Grade	**3.26**	**3.20**	**3.76**
History of Leadership (e.g.: Academic Activities, Voluntary Working)	**3.27**	**2.91**	**3.18**
University Course(s) in an area close to railway domain	**3.56**	**3.04**	**3.94**
University Degree in Railway Program (Bachelor or Masters)	**3.23**	**2.79**	**3.81**
Previous experience in working (e.g.: Internship)	**3.61**	**3.15**	**3.59**
Previous experience in railway related work (e.g.: Internship)	**3.61**	**3.09**	**3.53**
Personal Profile			
Demonstrated interest in railways	**3.72**	**3.33**	**3.94**
Mobility and willingness to relocate	**3.63**	**3.30**	**3.39**
Willingness to work outdoors	**3.89**	**2.70**	**3.61**
Willingness to work irregular schedules and long days	**3.84**	**3.09**	**3.72**
Ability to work in a fast pace environment	**4.14**	**3.35**	**4.28**
Ability to work under stress and time constraints	**4.20**	**3.77**	**4.28**
Skills			
Problem Solving	**4.42**	**4.11**	**4.44**
Analytical and Technical	**4.24**	**4.11**	**4.39**
Theoretical	**3.35**	**3.26**	**3.72**
Oral and Written Communications	**4.10**	**4.07**	**4.11**
Leadership	**3.99**	**3.47**	**3.65**
Ability to work in multidisciplinary teams	**4.11**	**4.24**	**4.00**

What types of university education would you consider most beneficial for graduates? (1 – Not Important, 2 – Somewhat Important, 3 – Important, 4 – Very Important, 5 – Extremely Important)

Three categories of keys to success were proposed, being:

- The educational background - related with the academic history and other complementary education;

- The personal profile - related with the working characteristics of the student/employee;
- The skills - related with the intellectual characteristics of the student/employee.

Although the figure change from region to region, the results are consistent are reveal that the most important kay factor are the *Skills*, follows the *Personal Profile* and, only in last, appeasr the *Educational Background.* These results raise important questions: firstly, the actual relevance for the industry of longer educational programs, such as: master or doctoral programmes; secondly, the need to develop educational courses focussed on the development of the skills; or thirdly, the need to rethink the structure of the courses to foster and stimulate the students' skills.

Although having a different scope, TUNRAIL project's results must and will be taken into consideration in the following chapter (Chapter 4) in the proposal of new courses, since this survey is far more recent and it aims the same purpose of assessing the competence gaps.

3 Available material to feed training and education needs

3.1 Introduction

Chapter 2 presents the analysis undertaken to assess and evaluate the research projects on railways. The research projects were assessed along a set of 8 research domains. A quantitative classification based on the available amount of projects was then elaborated to cluster the research domains. The clusters provide valuable information on the likely availability of information to later on feed the courses' contents.

The classification[3] includes three groups, accordingly the number of research projects, being:

- **No research project** - when no research project has been found on the specific research domain and, consequently, no information is available to feed the courses' contents;
- **Few research projects** - when a maximum of five research projects have been found of the specific research domain. In this cluster the reduced amount of projects raises some doubts on the availability of enough information to feed the courses' contents. This does however not mean that (enough) information is not available to feed the courses, but simply, that a deeper analysis on the actual contents is required, before proposing the course.
- **Enough research projects** - when the amount of research projects is more than five. In this cluster, and owing to the amount of projects, we may be confident of the likely availabiity of information to feed the courses. In this case, we may already lauch the courses.

The assessment work was based on the previous analysis undertaken in the EURNEX Network of Excellence (NoE) project. This project conducted an exhaustive collection of concluded and on-going research projects yielding a total of 629 projects. The list includes projects funded by the European Union, European National Members and Third Countries (such as: the United States or Japan).

[3] The classification is based on the assumption that at least one deliverable is available for every research project.

In SKILLRAIL project, this list was updated to include newly funded projects and to identify existent projects that might have not been identified. The search process was mainly conducted on the web, resorting to the known databases, including: CORDIS (cordis.europa.eu), TRANSPORT RESEARCH (www.transport-research.info), TRANSPORTATION RESEARCH BOARD (www.trb.org), etc. This new search yield a total of 88 new projects. Therefore, we end up with a total amount of 717 research projects. The list of projects is presented in Annex I to this report.

Several studies and research has been done for railways in order to improve this sector and produce increasingly good professionals. Universities and private companies are the main responsible for these activities either individually or in partnership. Consortia including universities and railway companies funded by European Commission are quite common in Europe to develop research on projects launched by this Commission.

As already mentioned, the research projects will feed the curricula of the future technical courses. The projects were then clustered around thematic areas, in order to shed light on the current availability and distribution of information and knowledge. The clustering process was again based on the early works undertaken in EURNEX NoE project, in order, to ensure the consistence of the analysis. The EURNEX NoE project developed a competence matrix, divided into 8 knowledge areas, which were further decomposed, in a total of 66 competences. The following scheme presents the EURNEX NoE competence matrix (Figure 3.1).

3.2 Analysis of the Research Projects

Figure 2.2 and Figure 3.3 present the distribution of the projects in the domains of research (2nd level analysis). The first graph presents the absolute figures, whereas the second one presents the relative figures. Excluding for the time being the domain 'General Terms' because it includes a heterogeneous set of domains, the domains with more research are: 'Rail Vehicles', with 148 projects,, 'Operations', with 93 projects, and 'Economics' and 'Civil Engineering' with 85 project each. On the other hand, the research domains with lesser amount of research are: 'Control Systems', with 32 projects, and, 'Traction' with 49 projects.

Despite the variability of research projects, the distribution indicates the likely availability of a considerably large amount of information in all domains of research (with of course, higher availability in those with more projects.).

Although helpful for understanding the state and amount of research in the various domains of research, the previous analysis (2nd level analysis) does not provide information on the distribution of the research on the various specific topics, which is necessary to understand the actual availability of information and knowledge (in particular, in what concerns the 'General Terms').

Figure 3.4 to Figure 3.11 present the distribution of projects per sub-topic (3rd level analysis) for the eight research domains (2nd level of analysis).

In the research domain 'Economics' (Figure 3.4), projects were found in every sub-topic, although the sub-topic 'Revenue Forecasting' with only two projects may raise the doubt on the availability of enough information for the courses. The 'Whole Life or Life Cycle Costs' and 'Business Strategy', with 28 and 20 research projects are, respectively, the sub-topic most researched and, thus, with more information available. Certainly, rich contents would be drawn from these two sub-topics. For the remaining three sub-topics, the amount of available projects provides confidence on the availability of data for the courses' contents.

Looking now to the 'Traction' research domain (Figure 3.5), there are two sub-topics with no project found, being 'Magnetic Levitation' and Distributed Power', which naturally denotes the non-availability of information in these areas. Also, for the sub-topics 'Traction Drives', 'Fuel Cells' and 'Gas Turbine', with one, three and three projects, respectively, may raise some doubts on the availability of information for the production of courses. For the three remaining sub-topics: 'Diesel', 'Electric', and 'Braking' the amount of research projects provide confidence on the availability of enough information.

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 3.1 – EURNEX NoE project competence matrix

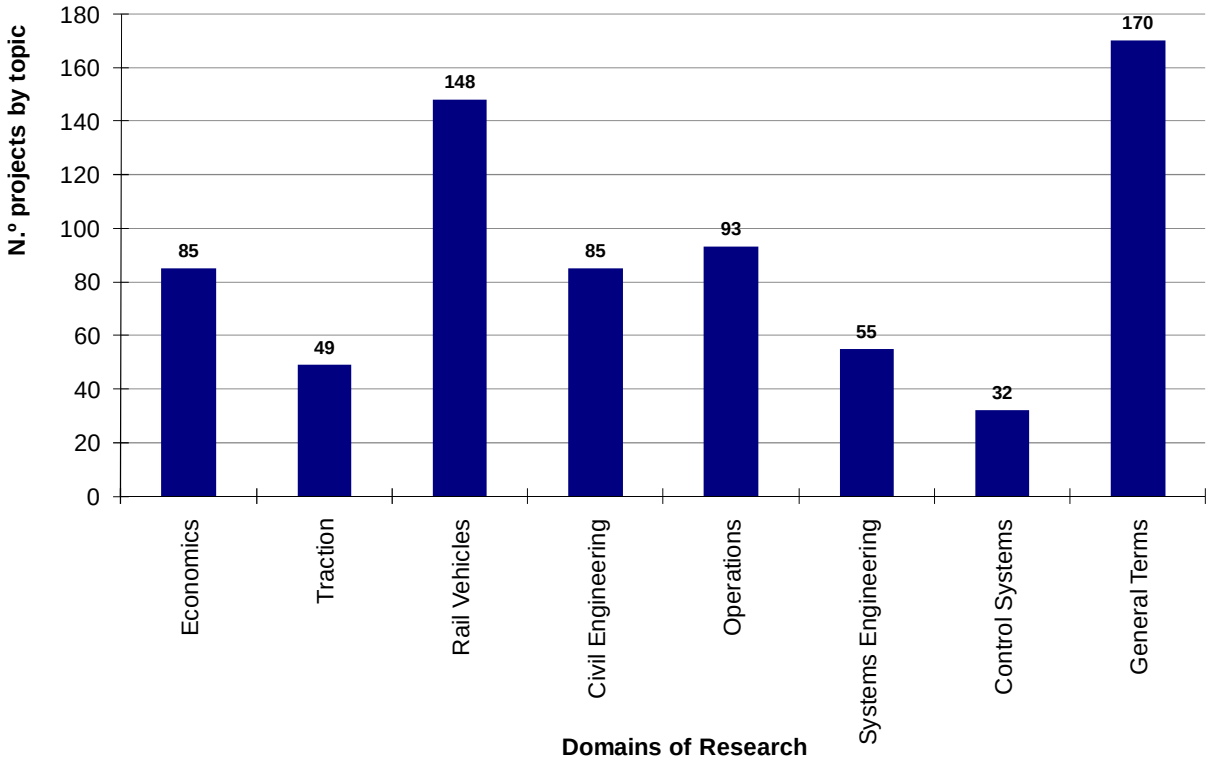


Figure 3.2 - Aggregation of projects per topic (absolute terms)

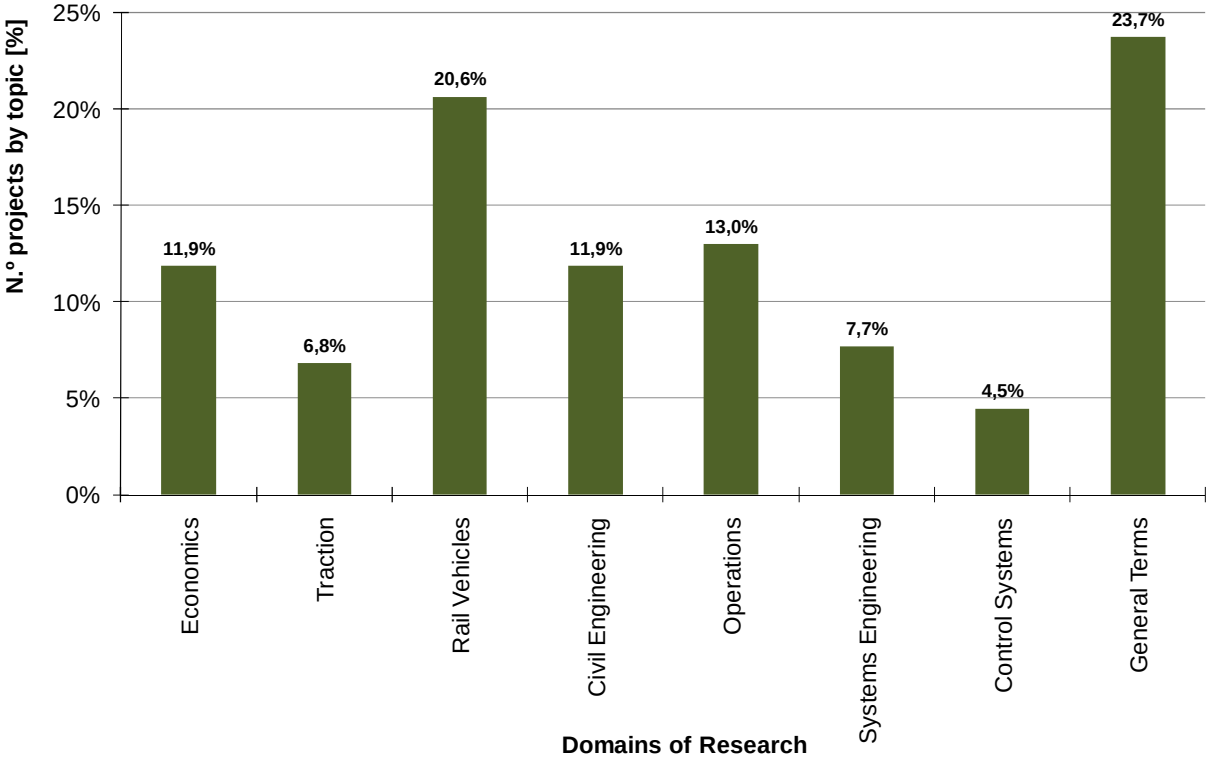


Figure 3.3 – Aggregation of projects per topics (relative terms)

In the research domain 'Rail Vehicles' (Figure 3.6), the sub-topic 'Body Construct', with 94 project concentrates the bulk of the research projects on this domain. Such amount of project will provide a large amount of information for the courses. Despite the large gap in terms of number of projects between this and the other sub-topics, we consider to exist enough projects in the wheel-related research projects (namely: 'Wheel rail interface', 'Wheel' and 'Wheel set') for the courses. Finally, in the last three research areas ('Active Steering', and active and passive 'Suspension'), all with a single identified research project may reveal not be sufficient.

The picture in research domain 'Civil Engineering' (Figure 3.7) is similar to the previous one. There is a sub-topic that concentrates the majority of the research, being 'Track', with 45 projects and then several other sub-topic with fewer projects, namely: 'Level Crossing', 'Bridges', 'Tunnels', 'Stations' and 'Earthworks', with 15, 11, 8, 4 and 2 research projects respectively. For the sub-topics 'Level Crossing', 'Bridges' and 'Tunnels' the available research projects are likely to provide enough information for the courses' contents; conversely, for the sub-topics 'Stations' and Earthworks' some doubts may be raised. Finally, no project was found for the sub-topics 'Drainage', 'Heating and Ventilation' and 'Lightning'.

Moving now to the research domain 'Operations' (Figure 3.8), the sub-topic 'Resource Management' concentrates the large majority of the research with a total of 54 projects. Such amount provides confidence on the existence of a rich information for feeding the courses' contents. The next sub-topics: 'Security', 'Train Regulation' and 'Passenger Management', with 12, 10 and 8 research projects, are also likely documented. Finally, 'Freight Management', 'Track Capacity Management' and 'Timetable Management', with 4, 3 and 2 research projects, may pose some limitations on the richness of the contents.

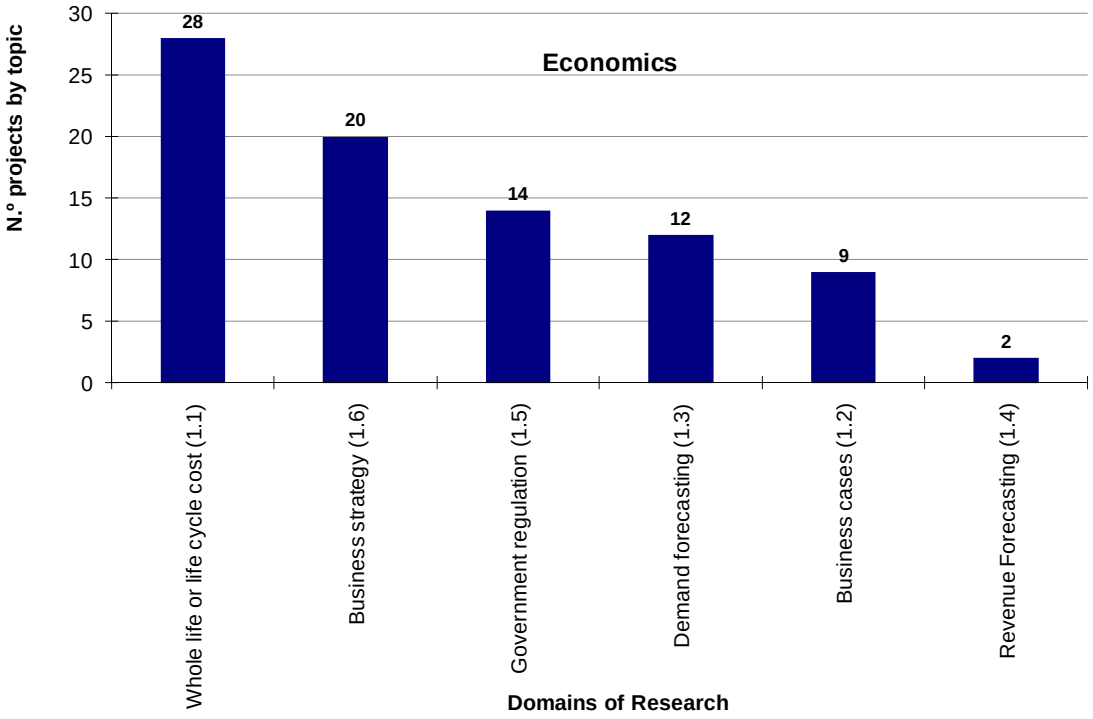


Figure 3.4 - Aggregation of projects per sub-topic in Economics

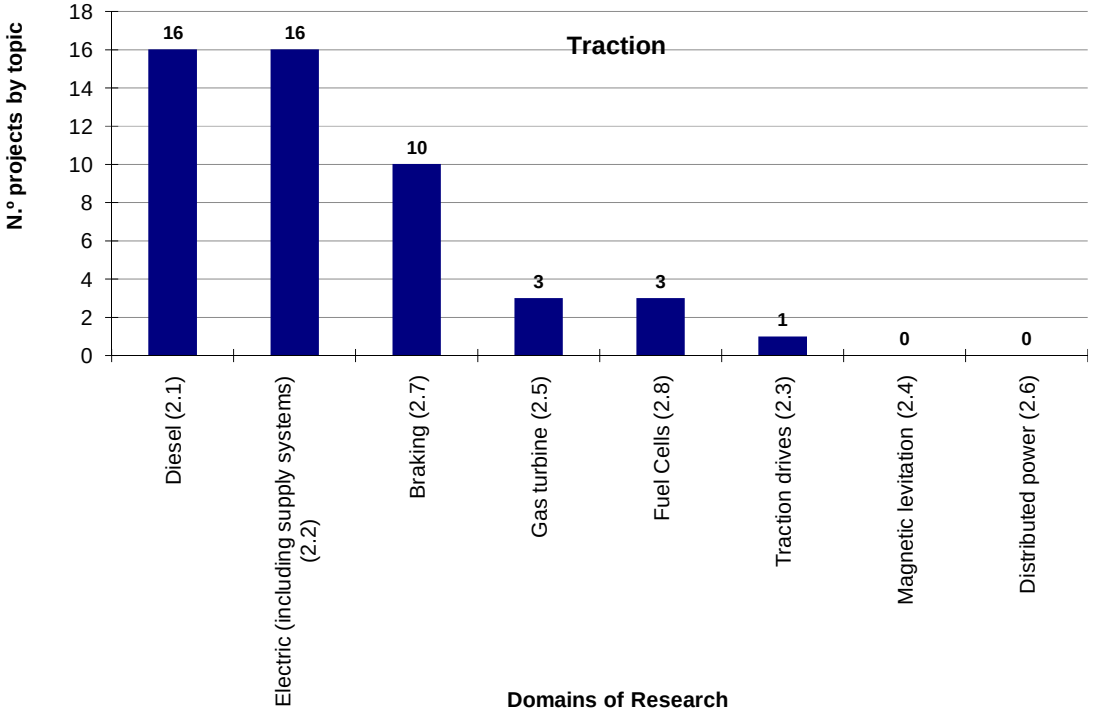


Figure 3.5 - Aggregation of projects per sub-topic in Traction

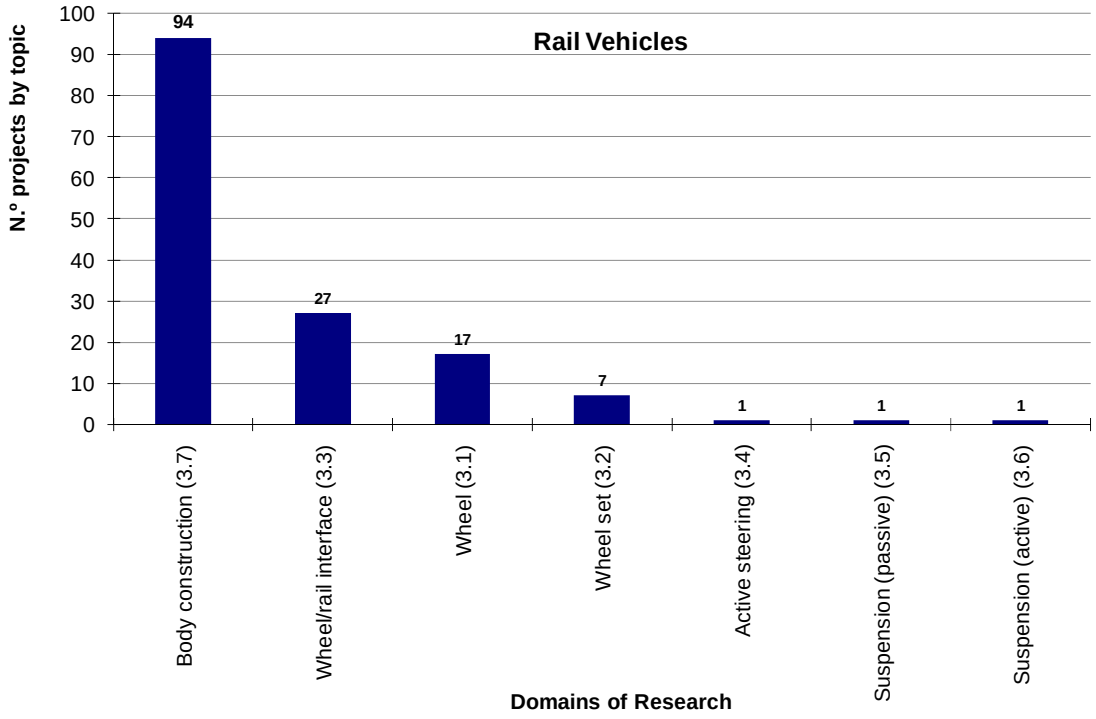


Figure 3.6 - Aggregation of projects per sub-topic in Rail Vehicles

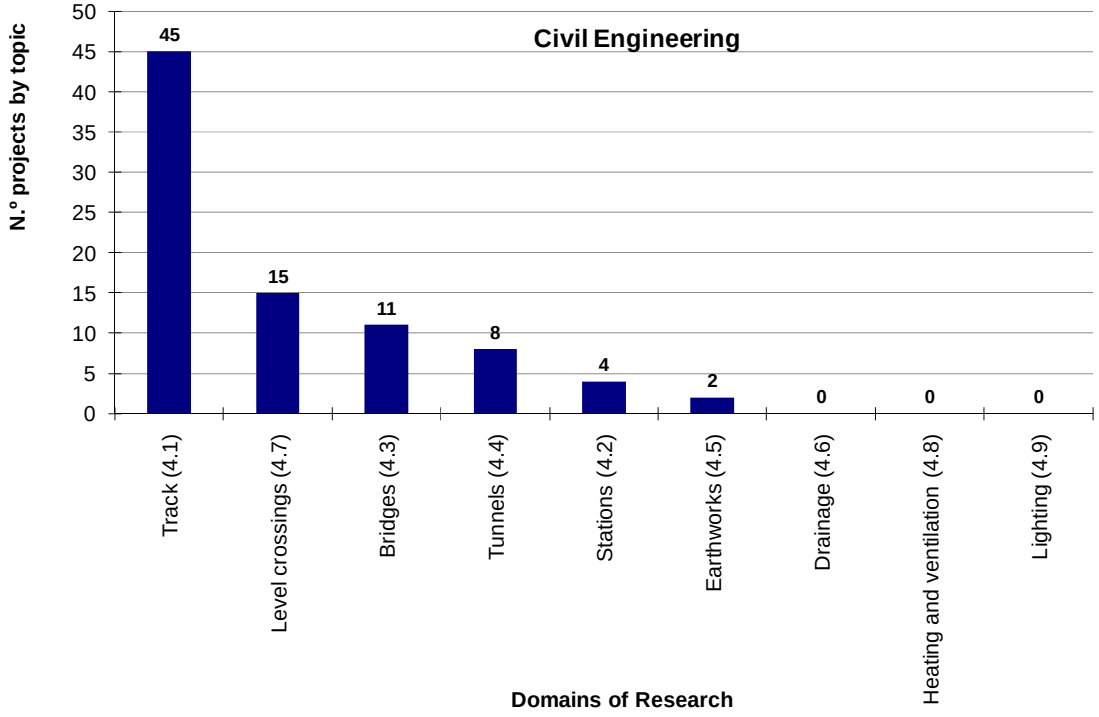


Figure 3.7 - Aggregation of projects per sub-topic in Civil Engineering

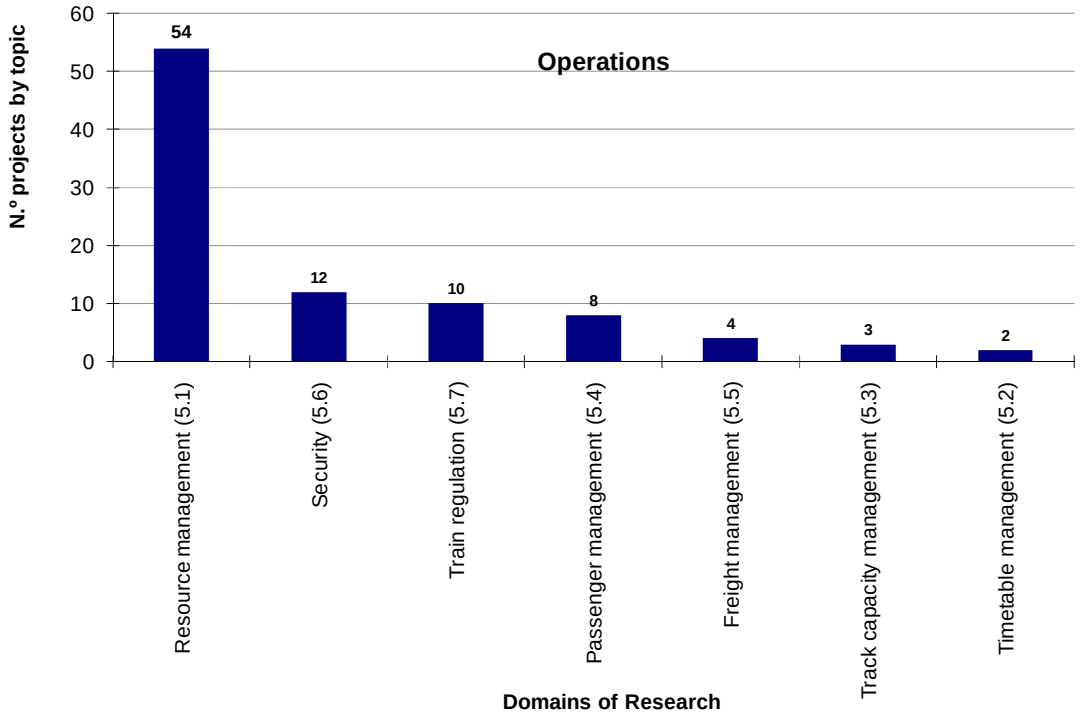


Figure 3.8 - Aggregation of projects per sub-topic in Operations

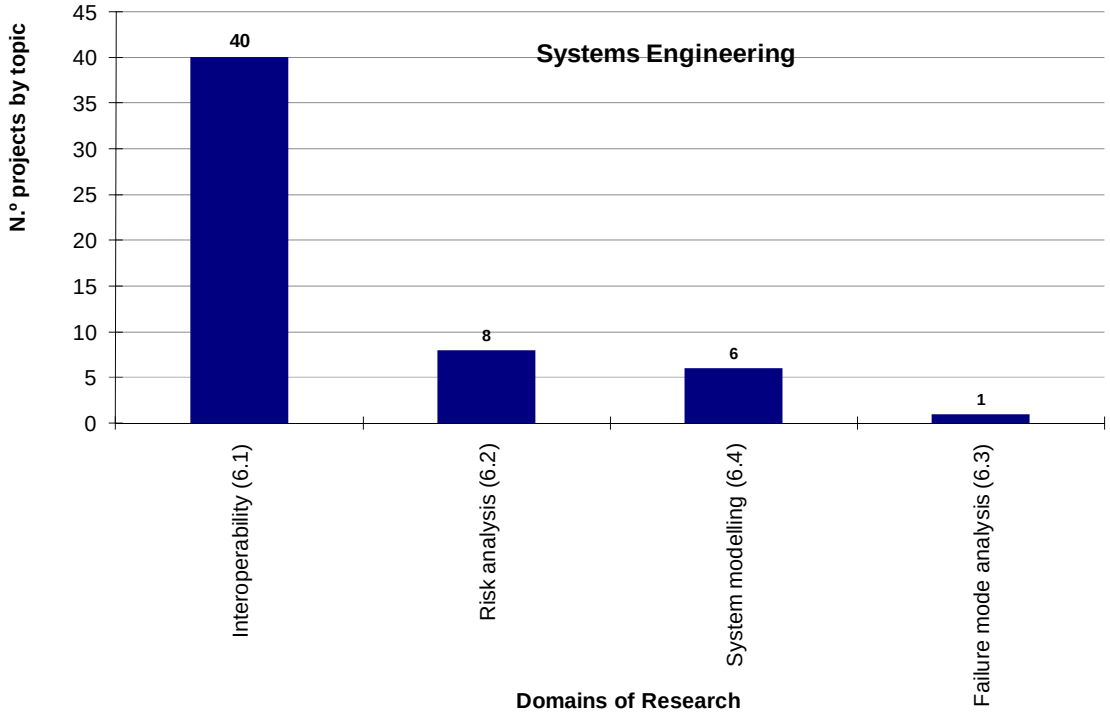


Figure 3.9 - Aggregation of projects per sub-topic in Systems Engineering

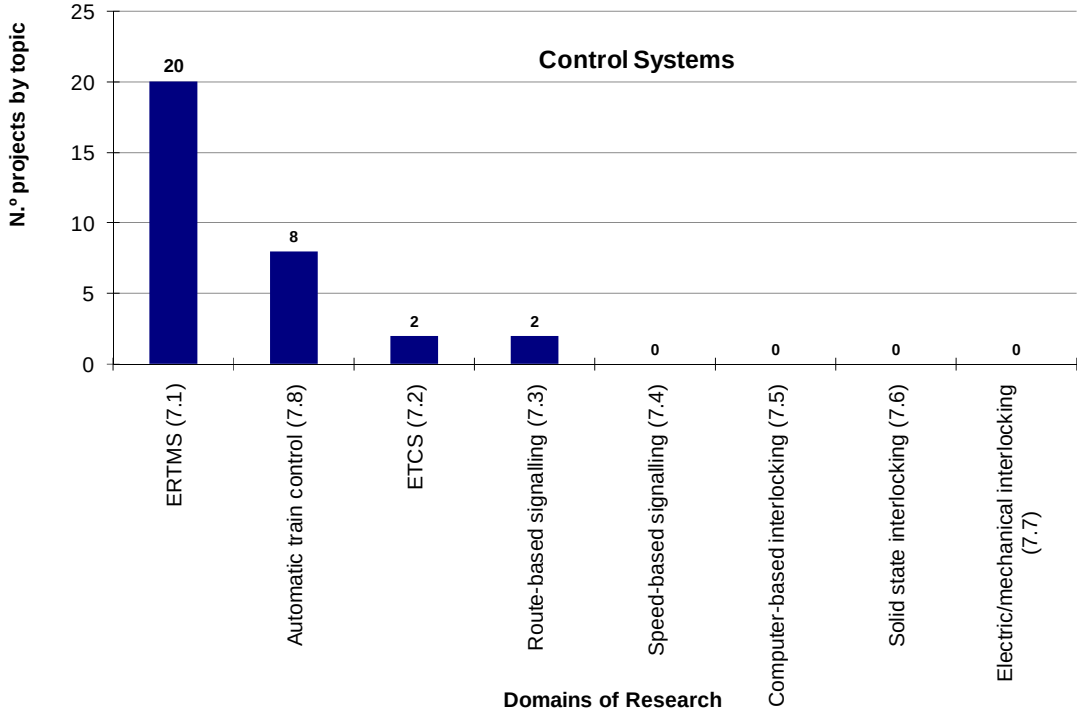


Figure 3.10 - Aggregation of projects per sub-topic in Control Systems

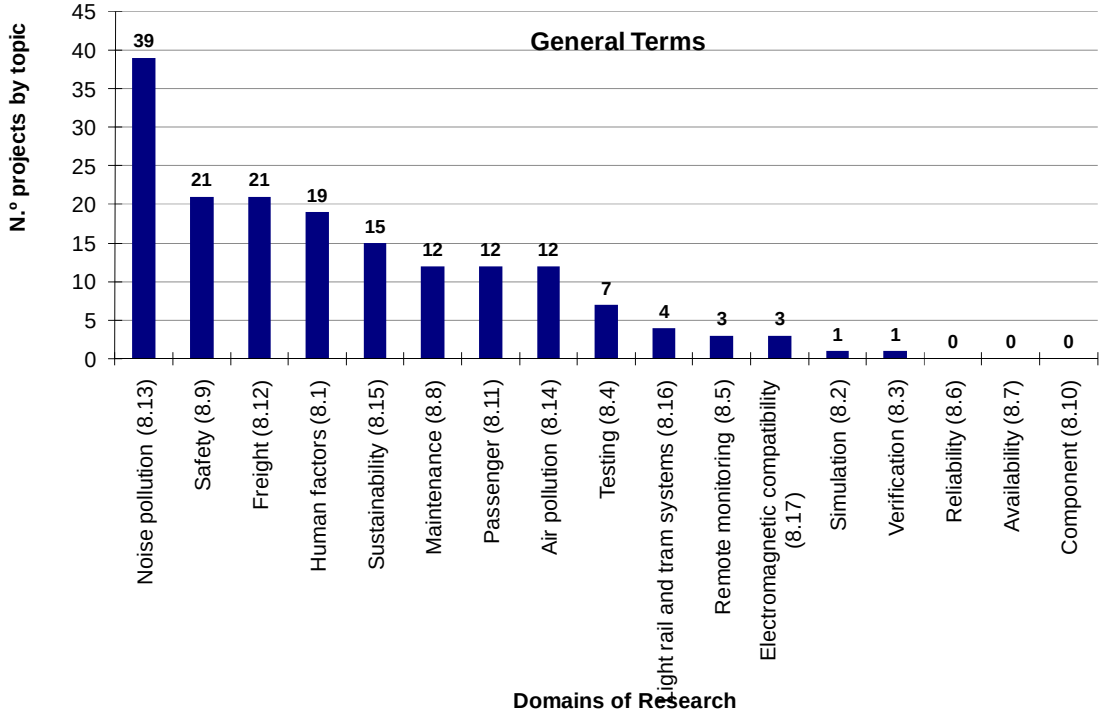


Figure 3.11 - Aggregation of projects per sub-topic in General Terms

In the research domain 'Systems Engineering' (Figure 3.9), 40 out of 57 research projects were tagged as related with interoperability issues, the remaining 15 projects are distributed in the remaining sub-topics 'Risk Analysis', 'System Modelling' and 'Failure Mode Analysis' with 8, 6 and 1 project, respectively. If for the first two sub-topics, we may expect enough available information; for the last one, with a single research project, we may expect some difficulties on the construction of the courses' contents.

The last research domain 'Control Systems' (Figure 3.10) presents a distribution of projects rather similar to the previous one. There are some sub-topics with no project (namely: 'Speed based signalling', Computer based interlocking', 'Solid state interlocking' and 'Electric/mechanical interlocking'). Follows, two sub-topics with few research projects (being: 'ETCS' and 'Route-based signalling') that may pose some difficulties in the production of the courses' contents. The last two sub-topics (being, 'Automatic Control' and 'ERTMS') do have enough research projects to provide confidence on the availability of information, in particular, the former one, with a total of 20 projects.

Finally, the research domain 'General Terms' includes a total of 17 sub-topics. In three of them, no research project has been identified (being: 'Reliability', 'Availability', and 'Component'). On the other end, the sub-topic with more research projects was the 'Noise Pollution', with a total of 39 research projects, which provides a good background for the preparation of course's contents. Follows a set of seven sub-topics (being: 'Safety', 21 projects, 'Freight', 21 projects, Human Factors', 19 projects, 'Sustainability', 15 projects, 'Maintenance', 12 projects, 'Passenger', 12 projects, and 'Air Pollution', 12 projects) with a considerable amount of research projects. Finally, in the last six sub-topics (being: 'Testing', 7 projects, 'Light Rail and Tram Systems', 4 projects, 'Remote Monitoring' and ‘Electromagnetic compatibility’, 3 projects, 'Simulation' 1 project, and 'Verification', 1 project), few projects were identified, which may indicate insufficient information for the courses' contents.

3.3 Conclusions

The next table (Table 3.1) lists the number of research projects per sub-topic. The table is also shadowed accordingly the three classification clusters presented in the beginning of this chapter, being:

- Green shadow - Research domain with **enough research projects;**
- Light orange shadow - Research domain with **few research projects;**
- Pink shadow - Research doamin with **no research project**.

The table thus sheds light on the domains of research that could provide information to feed the production of the courses' contents.

The majority of the research domains do have research projects, which denotes that courses could be developed in most of them. The domains with most research projects, which certainly will contain enough information for the production of the courses' curricula are the following:

- Body Construction (3.7), with 94 projects,
- Resource management (5.1), with 54 projects,
- Track (4.1), with 45 projects,
- Noise pollution (8.13), with 39 projects,
- Whole life or life cycle cost (1.1), with 28 projects,
- Wheel / rail interface (3.3), with 27 projects,
- Safety (8.9) and Freight (8.12), with 21 projects,
- Business strategy (1.6) and ERTMS (7.1), with 20 projects,
- Human Factors (8.1), with 19 projects,
- Wheel (3.1), with 17 projects,
- Diesel (2.1) and Electric (including supply systems) (2.2), with 16 projects,
- Level Crossings (4.7) and Sustainability (8.15), with 15 projects,
-

Table 3.1 - Number of projects per sub-topic

Sub-topic	N. Projects	Sub-topic	N. Projects
Body construction (3.7)	94	System modelling (6.4)	6
Resource management (5.1)	54	Stations (4.2)	4
Track (4.1)	45	Freight management (5.5)	4
Interoperability (6.1)	40	Light rail and tram systems (8.16)	4
Noise pollution (8.13)	39	Gas turbine (2.5)	3
Whole life or life cycle cost (1.1)	28	Fuel Cells (2.8)	3
Wheel/rail interface (3.3)	27	Track capacity management (5.3)	3
Safety (8.9)	21	Remote monitoring (8.5)	3
Freight (8.12)	21	Electromagnetic compatibility (8.17)	3
Business strategy (1.6)	20	Revenue Forecasting (1.4)	2
ERTMS (7.1)	20	Earthworks (4.5)	2
Human factors (8.1)	19	Timetable management (5.2)	2
Wheel (3.1)	17	ETCS (7.2)	2
Diesel (2.1)	16	Route-based signalling (7.3)	2
Electric (including supply systems) (2.2)	16	Traction drives (2.3)	1
Level crossings (4.7)	15	Active steering (3.4)	1
Sustainability (8.15)	15	Suspension (passive) (3.5)	1
Government regulation (1.5)	14	Suspension (active) (3.6)	1
Demand forecasting (1.3)	12	Failure mode analysis (6.3)	1
Security (5.6)	12	Simulation (8.2)	1
Maintenance (8.8)	12	Verification (8.3)	1
Passenger (8.11)	12	Magnetic levitation (2.4)	0
Air pollution (8.14)	12	Distributed power (2.6)	0
Bridges (4.3)	11	Drainage (4.6)	0
Braking (2.7)	10	Heating and ventilation (4.8)	0
Train regulation (5.7)	10	Lighting (4.9)	0
Business cases (1.2)	9	Speed-based signalling (7.4)	0
Tunnels (4.4)	8	Computer-based interlocking (7.5)	0
Passenger management (5.4)	8	Solid state interlocking (7.6)	0
Risk analysis (6.2)	8	Electric/mechanical interlocking (7.7)	0
Automatic train control (7.8)	8	Reliability (8.6)	0
Wheel set (3.2)	7	Availability (8.7)	0
Testing (8.4)	7	Component (8.10)	0

Note: Value in brackets denotes the topic (2nd level) and sub-topic (3rd level) of research. Refers from Figure 3.4 to Figure 3.11 for the classification of the topics and sub-topics.

- Government Regulations (1.5), with 14,
- Demand forecasting (1.3), with 12 projects,
- Security (5.6), Maintenance (8.8), Passenger (8.11), Air Pollution (8.14), with 12 projects,
- Bridges (4.3), with 11 projects,
- Braking (2.7), Train regulation (5.8), with 10 projects,
- Business Cases (1.2), with 9 projects,
- Tunnels (4.4), Passenger management (5.4), Risk analysis (6.2) and Automatic Train Control (7.8), with 8 projects,
- Wheel Set (3.2), Testing (8.4), with 7 projects,
- System modelling (6.4), with 6 projects.

Follows a set of domains with fewer research projects, which might raise some doubts on the availability of information. Thus, further analysis into the actual deliverables are required before we could state that there is enough information to feed the course's contents. The research domains are:

- Stations (4.2), Freight management (5.5), Light Rail and Tram Systems (8.16), with 4 projects,
- Gas turbine (2.5), Fuel Cells (2.5), Track Capacity Management (5.3), Electromagnetic Compatibility (8.17), with 3 projects,
- Earthworks (4.5), Timetable Management (5.2), ETCS (7.2), Route Based Signalling (7.3), with 2 projects,
- Traction Drivers (2.3), Active Steering (3.4), Suspension (passive (3.5), active (3.6)), Failure Mode Analysis (6.3), Simulation (8.2), Verification (8.3) , with 1 project.

Finally, there is a total of twelve sub-topics with no research project found, which preclude the elaboration of courses. The research domains are: . Magnetic levitation (2.4),

Distributed power (2.6), Drainage (4.6), Heating and ventilation (4.8), Lighting (4.9), Speed-based signalling (7.4), Computer-based interlocking (7.5), Solid state interlocking (7.6), Electric/mechanical interlocking (7.7), Reliability (8.6), Availability (8.7), Component (8.10)

4 Proposals for future courses

4.1 Brief review on the educational structure on the European Union

In this final chapter we propose a list of courses that could help to fill in the current competence needs (Chapter 3) and supported on the current available information (Chapter 2).

Before detailing the courses, it is relevant to discuss the current educational structure in the European Union, since it will define the type of the courses to propose. Indeed, the European Union is undergoing a profound restructuring of its higher education system. Over the last decade, the so-called Bologna Process has been progressively implemented, aiming to establish a common higher education degree structure in the European Higher Education Area[1]. The notion of higher education embraces three types of programmes:

- University programmes;
- Professional programmes;
- Vocational programmes.

So far, the main focus of attention in the Bologna process was the university programme. Firstly, countries have a clear academic structure made of universities, which eased the harmonisation process. Secondly, the understanding of professional and vocational is not the same in the various countries and, in some, the distinction between professional and university programme is blurred. As a consequence, the first years of the Bologna process were dedicated to the university programmes and, only recently, the other programmes were brought under into the process.

[1] The European Higher Education Area embraces EU27 plus Croatia, Georgia, Iceland, Liechtenstein, Moldava, Montenegro, Former Yugoslav Republic of Macedonia, Norway, Serbia, Russia, Turkey, Ukraine and Holy See.

The Bologna process is comprised by a series of high level meetings of the Education Ministers. The following figure (Figure 4.1) presents a timeline of the meetings and respective decisions taken.

The Bologna process was based on two main pillars, being: the European Credit Transfer and Accumulation System (ECTS) and the Diploma Supplement (DS). The European Credit is the basic unit for measuring the competences transmitted to the students. The ECTS is a mechanism whereby degrees are established and recognised between countries. The DS is a standardised template containing a description of the nature, level, context, content and status of the studies completed by the individual noted on the original diploma. The goal of the DS is to increase transparency of education acquired for the purposes of securing employment and facilitating academic recognition for further studies.

Also central to the Bologna process was the commitment of countries to establish a three cycle degree in higher education, being: graduation, master and doctorate. Typically, first cycle qualifications comprise 180-240 ECTS credits while second cycle qualifications comprise 60-120 ECTS credit. No harmonisation has yet been achieved for the third cycle.

However, the Bologna process is not limited to the three cycle period. Indeed, the Lifelong Learning (LLL) has gained relevancy in the Bologna process agenda. In 2009, the ministers emphasised that "widening participation shall be achieved through lifelong learning as an integral part of our educational systems" (EC, 2010, pp 34). So, far there is no widely accepted European or international definition of the concept of LLL in the higher education. Indeed, the term LLL has multiple interpretations, for example (EC, 2010, pp 35):

- In Malta, LLL refers to adult learning;
- In the Netherlands, United Kingdom, LLL refers to the non-traditional student whether in a formal or informal environment;
- In Czech Republic or Slovakia, LLL refers to supplementary (non-degree courses) study programmes.

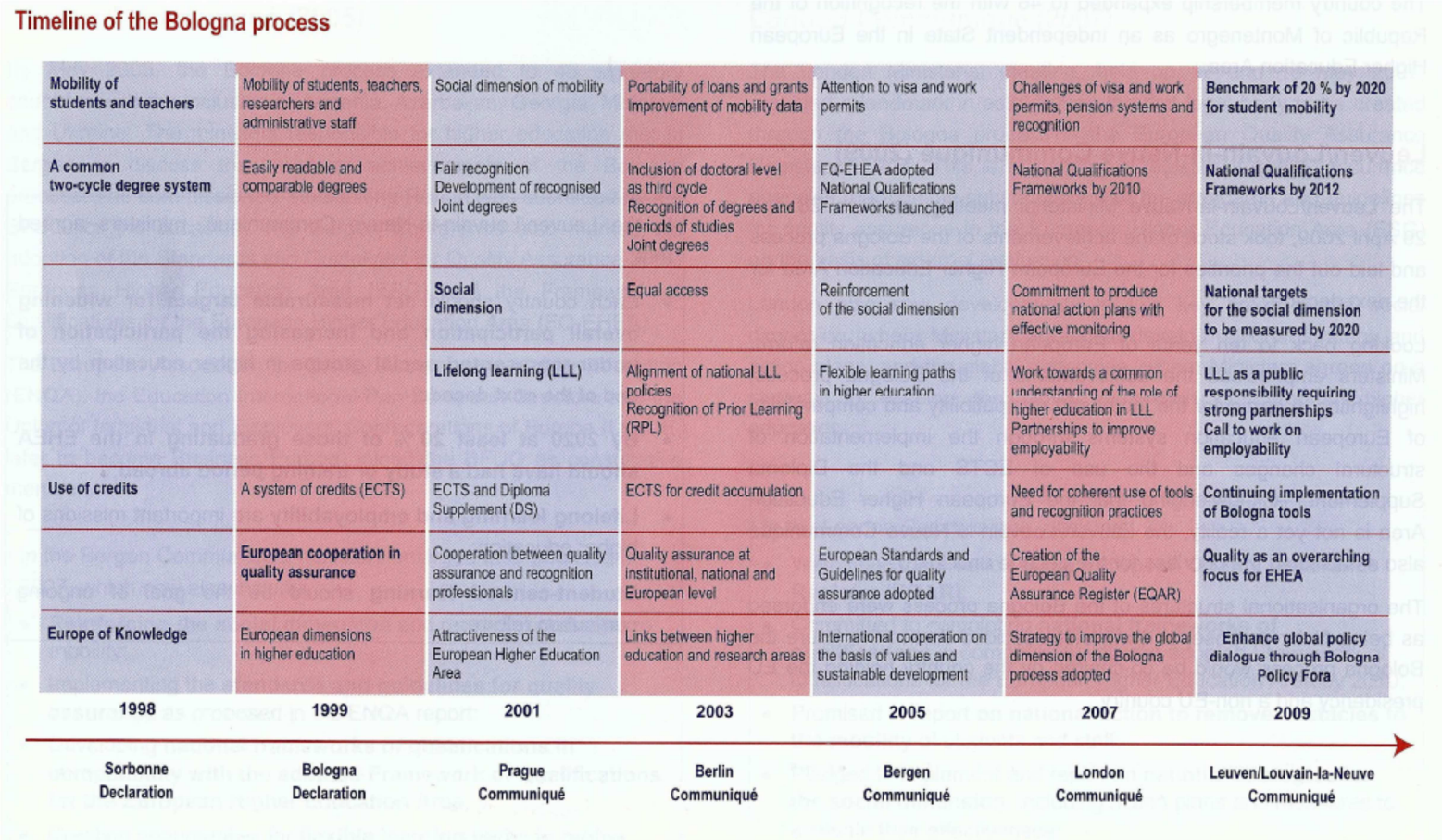


Figure 4.1 - Timeline of the Bologna Process

The momentum of the LLL is the outcome of major dynamics that the economic markets underwent over the past few decades, which rendered obsolete the employees' initial competences acquired in their university, professional or vocational programmes, and resulted in a continuous need for recycling competences.

Indeed, we are herein presenting Life Long courses, since with the courses we aim to recycle or update the current knowledge of the current or prospective employees in the railway industry.

4.2 Proposals of courses

The underlying reasoning to define the list of courses is depicted in Figure 1.4, and it essentially consists in a filtering process that uses the available information to pinpoint from the universe of competence needs (Chapter 2) which ones can be addressed through educational courses. The final list of courses was then defined based on the list of competences (based on Table 2.1, and supported on Table 2.2, Table 2.3 and Table 2.4) and filtered by the information available (on Table 3.1).

In the definition of the courses, we have taken into consideration the likely target audience. Naturally, the courses must be tailored to the audience's job's specificities, so that they could be relevant (for example: a course on safety for an operational employee must naturally have a different structure and contents than for a member of the administration board). We considered two types of business functions, being:

- **Senior staff** – oriented for management oriented jobs, it includes employees in high level positions, typically involved in managing teams, units or related with business activities;
- **Technical staff** – oriented for operational oriented jobs, it includes employees in low or medium positions, typically involved in production and operations activities.

In addition, we have also considered different time length, namely:

- **Short duration course** – courses with a maximum of 20 hours of duration (up to 5 days). These are meant to be courses with high intensife and focussed on very specific topics. They target employees that cannot spend long periods of time away.

- **Long duration** – courses above 20 hours (but, typically, above 50 hours). These courses are meant to be incorporated in longer educational programmes such as master and doctoral programmes. They targett those empliyees that undergo lober recycling programmes.

We have then concluded on a total of 12 courses. Follows a tentative list of the courses:

- **Course 1**: Assessment and evaluation of risk , availability, maintenance and safety assessment and evaluation in railways systems;
- **Course 2**: Techniques for risk and failure mode analysis in railways systems;
- **Course 3**: Testing and verification applied to railways systems;
- **Course 4**: Project of tracks;
- **Course 5**: Implementation of signalling systems;
- **Course 6**: Advancements in the monitoring process;
- **Course 7**: Integration of railways systems;
- **Course 8**: New challenges in safety and security in railways;
- **Course 9**: Solutions to reduce noise in railways;
- **Course 10**: Current advancements in human factors.
- **Course 11**: New developments in level crossings,
- **Course 12**: Systems for automatic train control.

Table 4.1 presents for each course the respective competence needs and the project category and subcategory, which will serve to feed the courses' contents. Categories in bold denote categories with few research projects (recall Chapter 3.1), which require a deeper analysis into the projects before launching the course.

Table 4.1 - List of courses

Course Number and Designation	Competence needs	Project Category and Subcategory
1. Assessment and evaluation of risk , availability, maintenance and safety assessment and evaluation in railways systems	- Risk , availability, maintenance and safety *(multidisciplinary issues)*	- Maintenance (8.8) - Safety (8.9)
2. Techniques for risk and failure mode analysis in railways systems	- Risk analysis and failure mode analysis *(multidisciplinary issues)*	- Risk analysis (6.2) **- Failure mode analysis (6.3)**
3. Testing and verification applied to railways systems	- Testing, verification and qualification *(systems engineering)*	**- Verification (8.3)** - Testing (8.4)
4. Project of tracks	- Tracks, switches and crossings *(civil engineering and infrastructure)*	- Track (4.1) - Wheel/rail interface (3.3)
5. Implementation of signalling systems	- Signalling, control-command and interlocking *(control systems)*	**- Route based signalling (7.3)**
6. Advancements in the monitoring process	- Train control, positioning and communication *(control systems)*	**- Remote monitoring (8.5)**
7. Integration of railways systems	- System integration and engineering interfaces *(systems engineering)*	- Interoperability (6.1) **- Simulation (8.2)** - System modelling (6.4)
8. New challenges in safety and security in railways	- Safety and Security *(multidisciplinary issues)*	- Safety (8.9) - Security (5.6)
9. Solutions to reduce noise in railways	- Noise and vibrations *(environment)*	- Noise pollution (8.13)
10. Current advancements in human factors	- Testing, verification and qualification *(systems engineering)*	- Human factors (8.1)
11. New developments in level crossings	- Switches and crossings *(civil engineering and infrastructure)*	- Level Crossings (4.7)
12. Systems for automatic train control	- Train control (*control systems*)	- Automatic train control (7.8)

Note: Value in brackets in "Project Category and Subcategory" represent the project subcategory as presented in Table 3.1

The Table 4.2 presents the expected target audience for each course. Most of the courses are design to the technical staff, which is somewhat expected since the topic are quite specialised and with a strong practical nature.

Table 4.2 – Courses' target audience

Target Audience	Course Number and Designation
Technical Staff	1. Assessment and evaluation of risk , availability, maintenance and safety assessment and evaluation in railways systems
	2. Techniques for risk and failure mode analysis in railways systems
	4. Project of tracks
	5. Implementation of signalling systems
	9. Solutions to reduce noise in railways
	11. New developments in level crossings
	12. Systems for automatic train control
Senior Staff and Technical Staff	6. Advancements in the monitoring process
	8. New challenges in safety and security in railways
Senior Staff	3. Testing and verification applied to railways systems
	7. Integration of railways systems
	10. Current advancements in human factors

Finally, Table 4.3 proposes a time length for each course. This however is a tentative classification, which will necessarily have to be reviewed.

Table 4.3 – Courses' expected duration

Expected Duration	Course Number and Designation
Short Duration	3. Testing and verification applied to railways systems
	6. Advancements in the monitoring process
	7. Integration of railways systems
	8. New challenges in safety and security in railways
	9. Solutions to reduce noise in railways
	10. Current advancements in human factors
	11. New developments in level crossings
Long Duration	1. Assessment and evaluation of risk , availability, maintenance and safety assessment and evaluation in railways systems
	2. Techniques for risk and failure mode analysis in railways systems
	4. Project of tracks
	5. Implementation of signalling systems
	12. Systems for automatic train control

However, not all competence needs were addressed either because no suitable research domain was found or because no project was found in the respective research domain. So, the competence needs for which no suitable research domain was found include:

- Computer technology and networking (multidisciplinary issues);
- Control command (control systems);
- Quality management (mustidisciplinary issues);

The competences for which no research project was found include:

- Interlocking (control systems) - the related project category and subcategories are:
    - Solid state interlocking (subcategory 7.6);
    - Electric and mechanical interlocking (subcategory 7.7);
    - Computer based interlocking (subcategory 7.5)

5 ANNEX – List of Projects