



HAL
open science

STAFFER: Skill Training Alliance for the Future European Rail System

Sebti Mouelhi, Alice Consilvio, Nicola Sacco, Angela Di Febbraro, Mirjana Bugarinovič, Eckhard Voss, Sabine Schneider, Mickaël Bregeon

► **To cite this version:**

Sebti Mouelhi, Alice Consilvio, Nicola Sacco, Angela Di Febbraro, Mirjana Bugarinovič, et al.. STAFFER: Skill Training Alliance for the Future European Rail System. ICEEL 2022: 2022 6th International Conference on Education and E-Learning, Nov 2022, Yamanashi, France. pp.247-254, 10.1145/3578837.3578886 . hal-04109019

HAL Id: hal-04109019

<https://hal.science/hal-04109019v1>

Submitted on 29 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

STAFFER: Skill Training Alliance for the Future European Rail System*

SEBTI MOUELHI, ESTACA, ISAE Group, France

ALICE CONSILVIO, NICOLA SACCO, and ANGELA DI FEBBRARO, DIME, University of Genoa, Italy

MIRJANA BUGARINOVIĆ, FTTE, University of Belgrade, Serbia

ECKHARD VOSS, WMP consult – Wilke Maack GmbH, Germany

SABINE SCHNEIDER, Siemens Mobility GmbH, Germany

MICKAËL BREGEON, CESI Ile-de-France, France

Rail is becoming the backbone of the European sustainable smart mobility. Nevertheless, Europe is experiencing a severe staff shortage for a rapidly developing but increasingly aging sector. In order to meet the rail development trends and to rejuvenate human resources, the STAFFER project aims to identify current and future skills requirements, and to support educational and training establishments in their efforts of curricula adaptation, and mobility programmes implementation. This paper presents the current achievements of the project namely, the identification of skills and competence needs from the perspectives of both operators and suppliers, the development of mobility and training programmes, and their validation for effectively increasing employability and career opportunities.

CCS Concepts: • **Social and professional topics** → **Governmental regulations**; • **General and reference** → **Empirical studies**; • **Applied computing** → **Transportation**; **Learning management systems**; **E-learning**.

Additional Key Words and Phrases: Europe, Rail, New technologies, Skills, Education, Training, Mobility.

ACM Reference Format:

Sebti Mouelhi, Alice Consilvio, Nicola Sacco, Angela Di Febbraro, Mirjana Bugarinović, Eckhard Voss, Sabine Schneider, and Mickaël Bregeon. 2022. STAFFER: Skill Training Alliance for the Future European Rail System. In . ACM, New York, NY, USA, 10 pages. <https://doi.org/10.1145/3578837.3578886>

1 INTRODUCTION

Rail plays a key role for Europe’s economy and societies, and is recognized as a major driver in pursuing the strategic vision of smart, green and sustainable growth. According to 2020 Sustainable and Smart Mobility Strategy [1], high-speed rail and freight traffic – currently using less than 2% of the final amount of transport energy in Europe – are expected to double by 2030 and 2050 respectively, and they are forecast to serve as backbone of the whole European transportation sector [2–4]. Late 2019, the European Commission’s (EC) expert group on competitiveness of the European rail supply industry identified skills development promotion and access safeguard to skilled labor as main action fields to ensure the European Union (EU) leadership in the sector, by noticing that availability of technical engineers may become a bottleneck in maintaining the European competitive position. They stated that “*combined with a decreasing youth workforce, an unattractive perception of the sector, and the mismatches between available and demanded skills due to the*


*STAFFER is co-funded by the Erasmus+ Programme of the European Union (<https://www.railstaffer.eu/>). Authors’ e-mails: sebti.mouelhi@estaca.fr, {alice.consilvio, nicola.sacco, angela.difebbraro}@unige.it (Angela Di Febbraro is the project’s coordinator), mirab@sf.bg.ac.rs, eckhard.voss@wilke-maack.de, sabine.s.schneider@siemens.com, staffer.mbg@protonmail.com.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

© 2022 Association for Computing Machinery.

Manuscript submitted to ACM

digital transformation and high-tech technologies extents, this (skills/staff) shortage is expected to steeply increase in the near future, and these concerns and mounting challenges necessitate action without further delay” [5].

The blueprint is an EU-funded framework for strategic cooperation between key businesses, trade unions, Vocational & Education Training (VET) [6] stakeholders and public authorities. The objective is to establish the overall sectoral skill development strategy and to launch concrete actions to meet short/medium-term skill needs. After several months of work, 32 partners submitted their proposal in February 2020. The EU Erasmus+ programme announced, during summer 2020, that the project – Skill Training Alliance For the Future European Rail system  [2] – had been approved to be the future plan to tackle the aforementioned major challenges. Coordinated by the University of Genoa, the alliance officially started on November 1st, 2020 and will last for four years. The consortium mission is to identify rail skills existing gaps and future needs, to assist VET stakeholders in their efforts of curricula adaptations, and training, educational and cross-European mobility programmes implementation.

STAFFER is composed of nine work packages (WPs). *wp1* (closed) covers the identification of current and future skill needs. *wp2* and *wp3* (both closed) rely on *wp1*'s methodology, the first addresses the point of view of railway operations and infrastructure management, and the second covers the suppliers' perspective. *wp4* (closed) exploits the outcomes of the first three WPs to develop mobility and training programmes. *wp5* (in progress) is about the validation of mobility and training programmes and strategies developed in *wp4*, *wp6* and *wp7* (see later in the paragraph) to guarantee effectively increasing employability and career opportunities. *wp6* (just started) is based on *wp4*'s outcomes and addresses training and mobility programmes implementation (continuous training monitoring methodology, cross-European students/apprentices/staff mobility, work-based internships, and course development and adaptation). *wp7* (not yet started) deals with the development of the long-term strategy and action plan (career path attractiveness, political and financial support, and filed execution). *wp8* and *wp9* (in progress) escort previous WPs' progress. The first covers the policy recommendations and dissemination (communication and exploitation plan/activities, and policy recommendations). The second covers the project's management and quality assurance (administrative, technical and financial management, meeting coordination, advisory/policy board, internal/external quality guarantees, continuous monitoring, risk assessment, and cooperation with other sectoral blueprint projects).

The core of this paper mainly presents the current achievements of the five first WPs, and ends up with a brief conclusion and upcoming actions in Section 4. In Section 2, the methodologies and main results of *wp1*, *wp2*, and *wp3* are presented and illustrated by their main surveys and assessment outcomes. Section 3 is articulated around mobility and training development approaches of *wp4*. The current first achievements of *wp5*, about employability and validation of career opportunities, are briefly presented at the end of this latter section.

2 IDENTIFICATION, ASSESSMENT AND EVALUATION OF SKILLS AND COMPETENCE NEEDS

The purpose of *wp1* is to identify (using *surveys* and relevant references) the trends in railway expected to impact the future staff profiles in all employment categories, and to define the assessment methodology for evaluating/identifying competences and skills. Two main steps were conducted: 1) a *state of the art* (task 1.1 or *wp1.1*) to analyze projects, studies, and initiatives aimed at evaluating the rail sector trends, and how they could be realized into new skills and/or adaptations of the current ones, and to gather the know-how of stakeholder companies regarding this analysis; 2) a *development of a methodology* (*wp1.2*) serving as a framework to assess and monitor skills and competence needs, occupational profiles (OPs), and workforce risk factors within the specific contexts of *wp2* and *wp3*. The leaders of *wp1.1* and *wp1.2* are resp. Siemens Mobility GmbH and Technische Universität Dresden (TUD).

The state of the art of rail future trends, conducted within *wp1.1*, was based on gathering several studies, projects, and initiatives ([7–10] among others). The findings are clear: demographic, behavioral, cultural, and socioeconomic factors will affect the railway sector in the coming years. The shortage of qualified staff is pointed out: many experts will retire in the coming years; the railway sector is actually perceived as unattractive; the share of women in total employment is small; the increasing system complexity requires newer, higher and trendy skills and qualification requirements due to digital transition and high-tech technologies, while working conditions and wages do not necessarily keep up with these needs. Traditional skills progressively lose their importance and values, and companies must take severe decisions either to invest or to exchange, expensively in both time and money. This shortage should be addressed by taking firstly concrete measures to ensure employment flexibility by reducing atypical working conditions, and improving job perception through a better balance of labor, social and private life, and secondly, by providing targeted training and education, and by recruiting talented/qualified employees. The following primordial strategic measures were emphasized: 1) modification of vocational training content; 2) bolstering transnational rail freight corridors; 3) boosting employment training to harmonize recruitment processes and staff management; 4) introductions of mandatory rail content in logistics training; 5) investment in (and additional support for) rail-related academic positions.



Fig. 1. Changes: economy and markets (left top), social (left bottom), and technical (right). Diagrams' x-axis: 1) extremely important, 2) very important, 3) quite important, 4) somewhat important, and 5) unimportant.

The large/increasing deployment of digital technologies in railway industry – almost present in (and required for) all occupations changes (expectations) of Figure 1 – is precursor of competitiveness, staff diversification, and human-machine interfaces improvement by making close interdependencies between both social, economic and technical changes. These new technologies enable seamless monitoring of cross-European railway facilities, allow the track capacities to be increased, guarantee behavioral correctness of safety-critical railway systems, and increase services availability. The federative European project – bringing all these transitions and challenges together – is the *European Rail Traffic Management System (ERTMS)* [11]. It is a set of standards hierarchies regulating the signaling interoperability of European railway systems, and aims at unifying the different national train control and command systems in Europe.

In this context, the following main digital technologies were identified: 1) *specification, design, verification and maintenance tools* for complex and holistic railway system of systems (like ERTMS); 2) *Internet of Things (IoT) and cyber-physical systems (CPS) technologies* – embedded in smart objects (sensors and actuators deployed on rolling stock, infrastructures including stations, and operation control checkpoints) connected to remote controllers and *data analytics* cloud computing platforms – to improve automation, safety, security, and predictive maintenance; 3) *cybersecurity* approaches and techniques used to protect railway computer networks and data from outside malicious intrusions; 4) *artificial intelligence (AI)* to perform smart assistance tasks with high autonomy and optimal real-time conditions; 5) *big data* analytics to improve train operations and customers experience; 6) *5G (and beyond) cellular networks* to maximize CPSs connectivity and control reliability and robustness; 7) *Building Information Modeling (BIM) and digital twin* to improve (and reduce costs of) life-cycle design and manufacturing processes.

2.1 Assessment strategy

Numerous are the strategic studies that identify industrial trends effects, analyze cost impact, and recommend practices to reduce skills gap. All studies agree on the necessity of becoming proactive, adopting strategic approaches, and investing in *re-skilling* (as many OPs lose their relevance, workers learn completely new skills and roles in changing work environments), and *up-skilling* (learning additional skills to gain competence in specific fields more adapted to changing work environments). This implies courageous business decisions not yet taken. Many companies are underestimating the impact of the hybrid state in which traditional industries and new technologies coexist by progressively extending current portfolio of products and services instead of radically replacing them by technology-based new ones. Portfolios rather expand then change, and this affects skill capabilities in the same way to ensure manoeuvre flexibility by meeting business needs. Satisfying future skill needs is not a black-white decision, it should be marked by exploration, customer-centric approaches and targeted solution finding.

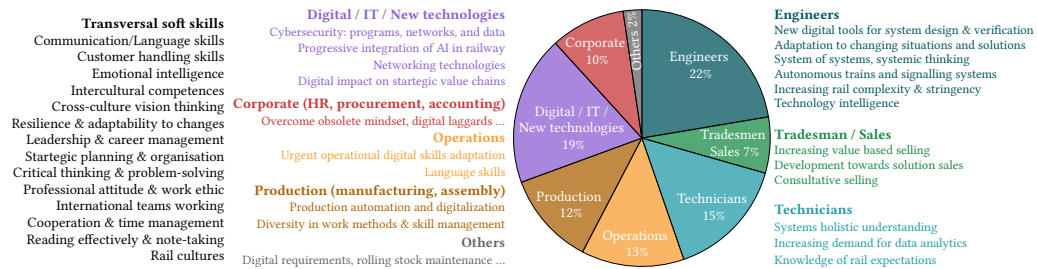


Fig. 2. Skill needs (mapped to their main rail occupations) given the economic, social, and technical changes shown in Figure 1.

The assessment strategy developed in *wp1.2* is based on these finding. It provides, for different stakeholder evaluators (particularly the leaders of *wp2* and *wp3*), two main inputs: 1) a set of relevant references providing interesting information and different examples about skills assessment and analysis [12–14]; 2) assessment methodologies for the evaluation/identification of skills and competences. Four general blocs of methodologies were identified: *face-to-face or online interviews*: (technical, professional, and annual) based on cross-functional hard and soft transversal skills; *aptitude tests* and *profile certifications*: exams, practical work proofs in certain roles, and practice observations with evaluation afterwards; *assessment and analysis*: of business needs, job management, competency enhancement, career development (knowledge and skills), staff-based interactions (management and company evaluations, self-appraisal, gap analysis, audits, etc.). The main output skill needs of *wp1.2* are shown in Figure 2.

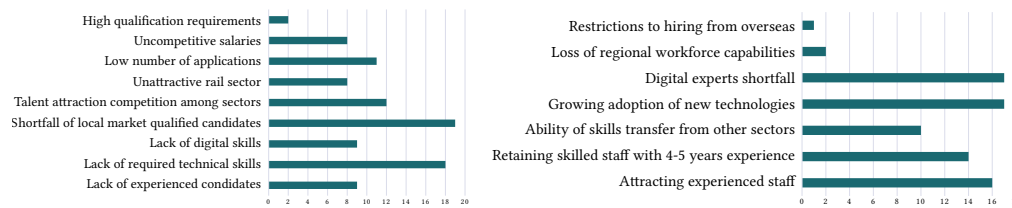


Fig. 3. Main difficulties in rail staff hiring (left); rail workforce key risk factors over the next 10 years (right). The diagrams' x-axis indicates the number of interviewees who identified a given item in the first three ranks of their choices.

Based on these possible assessment methodologies, the skills development approach should be conducted by following these six main steps: 1) analyze *micro* trends quickly rising in popularity and falls even faster within 3 to 5 years, and *macro* trends spanning decades; 2) identify and evaluate trends impact and risk factors (see Figure 3) on respective business products, services and processes; 3) break down the evaluated products, services and processes into transitional tasks, and evaluate the changes on each task level; 4) assign relevant OPs to each task level and assess the skills gap; 5) decide on workforce adaptations: re-skilling/up-skilling or layoff/transfer/hiring; 6) analyze individual/team levels, and transform workforce adaptations into skill development actions.

2.2 Operational and suppliers perspectives

The *wp2* provides a deep look of *wp1* outcomes from the perspective of Railway Operations and Infrastructure Management (ROIM) by applying, enriching, and customizing the *wp1*'s assessment methodologies. It consists of two sub-tasks: 1) *wp2.1* addresses the future visions (trends and challenges) from ROIM perspective; 2) *wp2.2* is intended to identify specific ROIM skill needs and OPs, at the different EQF (*European Qualifications Framework*) levels [15] with reference to *European Skills, Competencies, Qualifications and Occupations* (ESCO) [16] classification. The leaders of *wp2.1* and *wp2.2* are resp. Wilke Maack GmbH and Deutsche Bahn AG.

Beyond the general assessment evidence, *wp2* focuses on further issues: 1) cross-border rail traffic with special references to EU rail freight corridors; 2) cross-border traffic language and communication; 3) staff skills requirements, focusing on three groups of OPs: train drivers, staff in traffic control and management, and staff in rail engineering and maintenance (of both rolling stock and infrastructure) with a focus on all the measures required to implement European new policies and recommendations related to digital transition, alternative energy, ecology and environment.

These issues were addressed by research activities and layered large online survey with the support of the *European Community of Railways* (CER) addressing ROIM and VET, railway related research institutions, company practitioners, and other experts. The survey logic was founded on the following basics: 1) addressing future challenges and needs from the perspective of HR (*Human Resources*) ROIM requirements and strategies; 2) assessment of challenges, needs, and hindering factors of cross-border railway from HR perspectives, and different measures and specific suggestions on rail freight corridors; 3) assessment of different measures to promote transnational mobility and skills development thanks to the co-leaders experience in transnational cooperation on staff mobility/exchange, education and training; 4) development of new OPs, and identification of new skill needs/shifts based on the ESCO classification.

Task *wp3* focuses on *wp1*'s outcomes from the railway suppliers' viewpoint again by applying, enriching, and customizing *wp1*'s assessment and information gathering methodologies. The objectives of the sub-tasks *wp3.1* and *wp3.2* are the same as their corresponding sub-tasks of *wp2*. By the way, the two WPs' co-leaders cooperated by setting up joint working groups. The leaders of *wp3.1* and *wp3.2* are resp. MAFEX and Siemens Mobility GmbH.

The *wp3* provides the definition of one or more possible future scenarios with reference to both Rail 2030 and Rail 2050 visions [17, 18] published by ERRAC (*European Rail Research Advisory Council*). According to these strategic outlooks, the rail transport in Europe aims at being the backbone of intermodal MaaS (*Mobility as a Service*) within cities and beyond, for both passengers and goods, meeting the needs of customers, and EU citizens/society. Future scenarios in this document also include requirements in the field of education, vocational training, and human resource development. Quantitative complex data collection and skills gap modeling was undertaken via a range of sources including stakeholders' requirements, industrial surveys, access to skills data, labor statistics, as well as education and training data. The key objectives of this exercise was to estimate the size of workforce gaps by analyzing the difference between existing workforce and labor demand. In addition to estimating labor supply, the introduced model predicts the future demand for occupations (by referring to ESCO as in *wp2.2*) across rail manufacturing, operations and maintenance based on new technologies drivers, being considered among other factors.

3 MOBILITY AND TRAINING DEVELOPMENT

Mobility and training programmes development is currently undertaken within *wp4* by exploiting the outcomes of *wp1*, *wp2* and *wp3* in terms of future visions, OPs, and skill needs of the rail sector. It is broken down into five sub-tasks. Task *wp4.1* gathers information about existing VET in secondary and tertiary education institutions providing European recognized certifications and/or diplomas. The output database maps all the VET and higher-education institutions to their certifiable graduate mobility and training programmes in the rail sector with their EQF levels associated. It is a relevant benchmark of the existing programmes, and constitutes the basis for the development/integration of new ones. A public version [19] of the database is already published, and includes all initiatives started during and after the project life-time. This task was co-led by ESTACA, University of Genoa, and CESI Ile-de-France.

Task *wp4.2* (led by CESI Ile-de-France) aims at identifying common qualification standards and the relevant measurement procedures to evaluate the existing/designed training programmes. The agreed upon approach was then to establish a methodology in regard to *wp4* entirely. While mapping the existing VET providers and programmes (outputs of *wp4.1*) is definitely a useful precondition in order to know what of the qualification standards can be deemed applicable to the rail sector, it is also worth noting that this map is key to *wp4.3* as benchmark. The method applied is broken down into three steps: 1) the data recollection of existing VET offers, 2) the analysis of these data, and 3) the qualification building method. Data analysis was mainly based on these interrogations: How many skills and/or profiles do we want to map? How many can we map in the time-frame of this task? Which skills to prioritize over others?

The verdict was to select some relevant soft skills and some other new technical rail skills identified in the OPs database developed in *wp2.2* and *wp3.2*. Regarding the qualification building, the choice was to use a workshop-approach. The participants to these workshops were members of the original stakeholders' circle. Thanks to their inputs, two tools were established: 1) a *skill recollection form* which is a document giving relevant information on one specific skill (EQF level, assessment modalities, short description, learning outcomes, etc.), and 2) a *OPs-to-skills recollection form* which is a database sheet whose purpose is to gather inputs from *wp2.2* and *wp3.2*, and to allow tracing the whole dependency path from the OPs to skills while identifying if said profiles and/or skills were *emerging* (new), *changing* (already existing but evolving), or only *existing*.

Task *wp4.3* (led by MAFEX) summarizes the existing railway sector VET paths, curricula and courses identified in *wp4.1*. It identifies new and emerging innovative teaching/training approaches and best practices with respect to skill needs identified in *wp2* and *wp3*. The followings were identified as relevant to railway: *e-learning*, *e-training*, *blended* and *collaborative learning*, *mobile learning*, *gamified learning*, *instructor-led individualized training*, *peer-led learning*

and mentoring, *networked learning*, *smart personalized learning* based on smart technologies, *authentic contextualized real-world learning*, *scenario/story based learning*, *informal learning*, *work-based learning*, *cross-European/cross-industry internships*, etc. Finally, the task was concluded by outlining some key mobility and programmes development considerations, and how these new approaches and best practices could be scaled up to support the European rail sector.

According to the analysis carried out in *wp3.1*, 70% of learning in the sector is related to problem-solving within challenging tasks, in which employees learn from their own experiences. 20% of learning is from colleagues and workmates through exchange with more experienced experts. And the remaining 10% would be formal training to learn new skills. In order to prepare professionals in the sector, it is important to adapt educational methods and to apply the emerging ones. Before choosing the programme to be used, different factors are to be taken into account [20]: 1) the geographical area in which the learner resides; 2) the type of organization or institution in which he works (in the case he is an employee); 3) his prior knowledge and experience; 4) the time available for study/training; 5) the location from which the training will be conducted (at home, in the office, in front of a computer, etc.).

Task *wp4.5* (co-led by University of Genoa) is broken down into the following sub-tasks: 1) assign the proper EQF levels to the specific skills of some selected training curricula and fields from the outputs of *wp1*, *wp2* and *wp3*; 2) design/complement existing and new training curricula; 3) develop the programmes accordingly to the *European Credit System for Vocational Education and Training (ECVET)* [21] and the *European Quality Assurance in Vocational Education and Training (EQAVET)* [22] framework; 4) include soft skills, STEM (Science, Technology, Engineering, and Math) skills, job specific skills, and mobility plans of work-based learning; 5) focus on new and possible (joint) training contents and modules for physical and virtual training. The first sub-task was the foundation of the others (started up in parallel), and has required a consolidated approach to carry out it. And the first faced issue was *purely fundamental*: it is about *concepts' definitions* representing the *criteria* according to which skills are assigned to EQF levels.

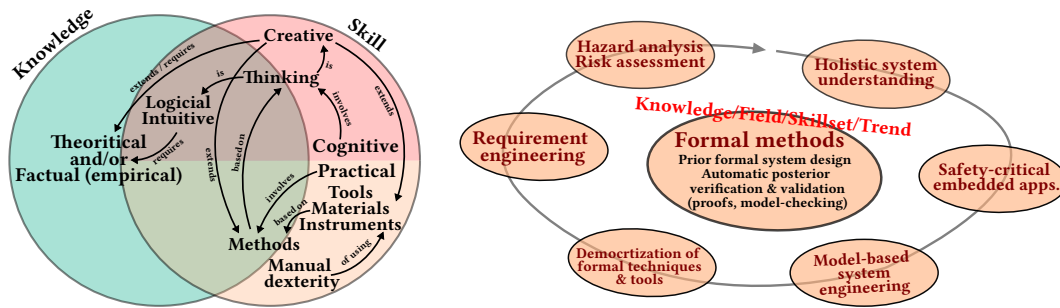


Fig. 4. Skill and knowledge: EQF definitions overlaps [15] (left). The case-study field “Formal Methods” and its related skills (right).

At a given EQF level, a *knowledge* is theoretical and/or factual (empirical) built up on sense experience or experimental procedures. A *skill* is however a learning outcome described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments) [15]. Figure 4 (left) depicts an intersection *ontology* between the two concepts. Another considered aspect, related to these definitions, was to sort out all the terms already used (in the previous WPs): *skill*, *knowledge*, *topic*, *sub-skill*, *field*, *trend*, and *skill-set*. The last three terms join the same concept space. Some of the fields are too specific *skill-sets* (like norms, standards & certifications, and soft skills sub-categories), some others are *trending big fields* (like cybersecurity and AI) and the remaining ones are more *traditional* (like transportation systems, and safety, dependability & security).

EQF	Keywords	Meanings	EU VET
3	Keywords of general, well-known & well-mastered topics/skills, in a field of study or work, transversal ...	Understand, general well-known topics, concepts, facts, processes and principles #31, apply basic methods & tools #32 ...	Secondary levels
4	Keywords of well-mastered & common topics/skills, in a field of study or work, transversal ...	Well-mastered/common #41, medium-skilled staff #42, (creatively) find solutions to specific problems, predictable & changing contexts #43	Upper-secondary levels
5	Foundations, tools, system, level 1, transversal ...	Abstract problems #51, cornerstone general required for specialized #52 topics & skills, (creatively) solve (develop) problems (solutions), specialized unpredictable & changing contexts #53	Initial bachelor programmes
6	Advanced, complex, design, model, analysis, optimization, architecture, complexity, theory, smart, methods, approaches, strategies, levels 2, 3, transversal ...	Cornerstone specific advanced topics/skills #61, methods & procedure critic #62, (creatively) solve (develop) complex, specialized & unpredictable problems (solutions) #63	Final bachelor programmes
7	(new) Approaches, keywords of specific highly specialized topics/skills keywords ...	Highly complex #71, specialized, holistic #72, and trending #73 fields/topics, mastery of complex #74, unpredictable innovative & contemporaneous contexts #75, renewed strategic approaches #76	Master programmes & Post master mid-career training
8	Special keywords in a specific research domain, in the political & administrative strategies, philosophy ...	At the most advanced frontier of a field #81, most advanced & specialized skills/techniques #82, solve (develop) critical (innovative) problems (solutions) #83, extend/redefine existing knowledge #84, substantial authority & autonomy #85, scholarly and professional integrity and sustained commitment #86 ...	PhD ...

Mathematics	#31	Algorithmic and programs 1	#5(1,2,3)	Algorithmic and programs 2/3	#6(1,2)
Introductions to algorithms	#31	Logical and digital systems	#5(1,2)	Computer architectures	#6(1,2)
Python programming	#32, #4(2,3)	Mathematical foundations & tools	#5(1,2)	Program compilation	#6(1,2,3)
Electronics	#4(2,3)	Formal languages, discrete maths & logic	#5(1,2), #61	Program complexity	#6(1,2,3)
				Program optimization	#6(1,2,3)
Component-based software design approaches	#7(1,2,3,4,5,6)	Specific research ...	#8...	Accelerated programmes as needed:	
Concurrent, real-time and parallel apps.	#7(1,2,3,4,5)			- Norms & standards: ERTMS, CBTC, ...	#7(1,2,4,5,6)
Distributed apps. / cyber-physical systems	#7(1,2,3,4,5,6)			- Risk assessment & hazard analysis ...	#7(1,2,4,5,6)
Non-classical logics	#71			- Requirement engineering	#7(1,2,4,5,6)
Logic and computation models	#71			- Strategic planning	#7(1,6)
Programming language semantics	#7(1,3,4,5,6)				
Computer (embedded) systems modeling	#7(1,2,3,4,5,6)				
Model-based system engineering (SysML)	#7(1,2,3,4,5,6)				
Certification of safety-critical software	#7(1,2,3,4,5,6)				
Formal design (abstraction & refinement)	#7(1,2,3,4,5,6)				
Verification decision procedures & tools	#7(1,2,3,4,5,6)				

Fig. 5. The top table classifies the EQF levels definitions' keywords and tagged meanings (#-suffixed). The bottom table shows the Skills/EQF mapping approach applied to the case study field "Formal Methods" (see Figure 4, right). Background colors: secondary level (yellow); tertiary level (light violet), post-master mid-career training (light blue). Font colors: topics (orange); skills and sub-skills (red); keywords (green); meanings tags (dark violet). The tags #x1 ... #xn are written as #x(1,...,n) where x is an EQF level (see the top table). The two table was captured from the project's work sheets.

A *sub-skill* is an intermediate skill (see the bottom table of Figure 4: *algorithmic & programs* is a sub-skill, *formal design by abstraction and refinement* is a skill). A *topic* could be considered as knowledge with a slight nuance between the two concepts: a topic is specific, but knowledge tends to be more generic (*mathematical foundations & tools* is a knowledge, *discrete maths & logics* is a topic), because of that we opted for the term *topic* (instead of knowledge) in harmony with the customization aspects dominating the task. Hence, by definition, fields, trends, and skill-sets (FTSs) encompass skills, sub-skills and topics (SSTs).

The second issue was *technically dependent* to the current achievements of the project, especially the OPs database of *wp2.2* and *wp3.2*. Nearly 57% of profiles are exclusively assigned to EQF 7 with the unique focus on their output main skills and competences, which is an unfair distribution of EQF levels throughout the database. The key questions were: How to use relevant information about skills to make it fairer? How EQF levels could be gradually distributed on the SSTs of a specific OP? How the chronological dependencies between SSTs could be established? And which skills should be decomposed to sub-skills and topics and how? According to these interrogations, this activity could not be naively tackled with a simple raw Skills/EQFs mapping. It should be carried out according to a sound approach.

EQF levels definitions are decomposed to groups of keywords and meanings (see the top table of Figure 5). Then, the following steps are applied. Firstly, each involved partner selects a relevant FTS, and identifies the SSTs for that selected FTS with their specific keywords and headings. SSTs are then chronologically distributed based on their gradual complexities. This distribution is to be refined/adjusted later during the next steps (EQF levels should not be involved in this first one). Secondly, the headings of SSTs are keyword-decomposed and meanings-tagged. Thirdly, EQF levels could then be assigned according to the keywords identified and the meaning tags.

A *keyword* is any qualifier appearing in the heading of a SST, most of them are specific for that SST, and some of them are generic like those included in the table shown in the top of Figure 5 (*advanced, approaches, design, etc.*). A *meaning* is any qualification descriptive feature not appearing in the heading of a SST. The presence of several keywords of a given EQF level x in the heading of a SST, and the cumulative tagging of that SST by several meanings related to EQF x affirms beyond any doubt that this SST is assignable to EQF x (see the example shown in the bottom of Figure 5).

Task *wp4.4* (led by Deutsche Bahn and being finalized) is dedicated to develop new training contents and modules reflecting new needs in cross-border railway, communication and language emerging from the *Single European Rail Area* initiative [23] and the EU energy, environmental and digitalization new policies. The content basis of *wp4.4* was carried out in the first three WPs, and its framework conditions got established in the first three tasks of *wp4*. The specific aim of this task is to bundle ideas, to make universal templates, and to hand over structured results to subsequent WPs. A lot of action fields were selected from the output databases of *wp2*, *wp3* and *wp4.1*. After discussions with partners, 48 topics were rated as important and a total of 140 measures to develop new training contents and modules related to the selected topics. Results were classified according to different criteria (goals, target groups, topics, formats, etc.) and clustered into four categories under each class: training and mobility programmes, academic modules, and cross-border railway conferences and symposiums.

Employability and assessment of career opportunities. On the road to validate Employability and Career Opportunities (ECO) of rail related education and training programmes within a consolidated progressive approach, *wp5* includes four tasks: 1) a methodological umbrella is developed in order to identify the criteria and measurable indicators to evaluate ECO (*wp5.1*). Then, in parallel, the assessment of ECO is performed by ROIM in *wp5.2*, and by rail suppliers in *wp5.3*. Task *wp5.4* provides the outputs of *wp5* as a feedback mechanism to better tune the mobility and training programmes developed in *wp4*. At the time of writing this paper, *wp5.1* (led by the Faculty of Transport and Traffic Engineering FTTE, University of Belgrade) has been completed and *wp5.2* and *wp5.3* are ongoing.

The methodology of task *wp5.1* has two phases: conceptualization and operationalization. The first one is about what is being measured and the second is about how it is going to be measured. Both phases entail several steps with similar underlying idea: assemble state-of-the-art knowledge body about the different views on employability concepts and indicators (unemployment rate, percentage of trainers and teachers with a prior professional experience, etc.), enrich it with insights from rail perspective, and finally nest it in the STAFFER's objectives. Initial set contains 30 indicators. Every indicator is described by its name, definition, source, type, criteria, and dimension. The rationale behind indicators is that employability is a complex concept that strongly depends on the context in which it is immersed. The aim is not to embrace every aspect of employability but those that are in line with STAFFER.

4 CONCLUSION AND PERSPECTIVES

This paper presented the current progress of the STAFFER project: the identification of skills and competence needs from the perspectives of operators and suppliers, mobility and training programmes design, and the first stages of their validation for effectively increasing employability and career opportunities. *wp6*, covering training and mobility programmes implementation, has just been started. *wp7*, covering the development of long-term strategy and action plan, is planned soon. The STAFFER project is actually a real think tank shaping the future of the European rail sector labor forces, training and mobility. Other dissemination papers are planned for publication in the near future to update the interested communities on the project's progress.

ACKNOWLEDGMENTS

The following project members are directly or indirectly involved in this work: Elena Queeck (Technische Universität Dresden), Garazi Carranza (MAFEX), Matthias Rohrmann, Reymund Weitzel (Deutsche Bahn AG), Marijana Petrović, Nikola Stojadinović, Branislav Bošković (FTTE, University of Belgrade), Anastasia Lobanova (Alstom Transport Deutschland GmbH), Michael Lehmann (Institut Verkehr und Raum, Fachhochschule Erfurt), Cherif Larouci, Toufik Azib, and Anne de Cagny (ESTACA). We would like to thank them all for their valuable contributions, monitoring and support.

REFERENCES

- [1] European Commission. Sustainable and Smart Mobility Strategy: putting european transport on track for the future, 2020. Communication COM/2020/789, URL: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789>.
- [2] University of Genoa (Applicant organization of STAFFER consortium). STAFFER: Skill Training Alliance For the Future European Rail System, 2020. Application Form, Call for proposals EAC/A02/2019, EU Erasmus+ programme.
- [3] European Rail Research Advisory Council (ERRAC). Rail Strategic Research & Innovation Agenda, 2020. Report, URL: https://rail-research.europa.eu/wp-content/uploads/2020/12/RAIL-Strategic-Research-and-Innovation-Agenda-2020_FINAL_dec2020.pdf.
- [4] European Commission, European Partnership under Horizon Europe. Transforming Europe's Rail System, 2020. Report, URL: https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_he-partnerships-transforming-europes-rail-system.pdf.
- [5] European Commission. Report of the expert group on competitiveness of the european rail supply industry, 2019.
- [6] European Centre for the Development of Vocational Training (CEDEFOP), agency of the European Commission. Vocational education and training in Europe, 2019. Reports, URL: <https://www.cedefop.europa.eu/en/tools/vet-in-europe/systems/france-2019>.
- [7] European Commission. Horizon 2020: Skills and competences development of future transportation professionals at all levels, 2016-2019. Project, URLs: <https://cordis.europa.eu/project/id/723989>, <https://skillfulproject.eu/>.
- [8] European Commission. Horizon 2020: Roadmaps for A.I. integration in the rail Sector, 2019-2023. Project, URLs: <https://cordis.europa.eu/project/id/881782>, <https://rails-project.eu/research-areas/taxonomy-of-ai-state-of-the-art-review/>.
- [9] European Commission, Erasmus+ programme. Cybersecurity Skills Alliance - A New Vision for Europe, 2020-2024. Project, URL: <https://erasmus-plus.ec.europa.eu/projects/search/details/621701-EPP-1-2020-1-LT-EPPKA2-SSA-B>.
- [10] Chloe Cannon, Marin Marinov, and Mark Robinson. Data analysis of current and emerging skills development and training schemes in the rail transport sector. *J. Edu. Res. Rev.*, 7(3):57–75, 2019.
- [11] European Union Agency for Railways (ERA). European Rail Traffic Management System (ERTMS), 2019-2020. Standards, URLs: <https://www.era.europa.eu/content/ertms>, <https://www.ertms.net/>.
- [12] Steven Dhondt, Frans A. van der Zee, Peter Oeij, Ming Chen, and Dewan Islam. Bridging the skills gap for the rail sector: analysis of six measures and recommendations, 2019. Publications Office of EU, Shift2Rail Joint Undertaking.
- [13] Steven Dhondt, Ming Chen, Frans A. van der Zee, and Peter Oeij. Building blocks for a new skills ecosystem in the rail sector: assessment of the state of play in employment in the railway sector, 2019. Publications Office of EU, Shift2Rail Joint Undertaking.
- [14] Steven Dhondt, Ming Chen, Frans A. van der Zee, and Mark Robinson. Employment and skills in the rail sector: impact analysis of shift2rail's innovation programmes, 2019. Publications Office of EU, Shift2Rail Joint Undertaking.
- [15] Directorate General for Education and Culture (Europass), initiative of the European Commission. European Qualifications Framework, 2019. Standard, URL: <https://europa.eu/europass/fr/description-eight-efq-levels>.
- [16] European Commission. European skills, competences, qualifications and occupations, 2017-2022. Database, URL: <https://esco.ec.europa.eu/en>.
- [17] European Rail Research Advisory Council (ERRAC). Rail 2030 – Research & Innovation Priorities, 2019. Report, URL: <https://errac.org/publications/rail-2030-research-and-innovation-priorities-2/>.
- [18] European Rail Research Advisory Council (ERRAC). Rail 2050 – Research & Innovation Priorities, 2017. Report, URL: <https://errac.org/publications/rail-2050-vision-document/>.
- [19] STAFFER consortium. Existing training initiatives, 2021. Database, URLs: <https://www.railstaffer.eu/existing-rail-training-initiatives/>.
- [20] Food and Agriculture Organization of the United Nations. *E-learning methodologies and good practices: A guide for designing and delivering e-learning solutions*. FAO eLearning Academy, Rome, Italy, 2nd edition, 2021.
- [21] European Parliament. European Credit System for Vocational Education and Training, 2009. Recommendation reports, URLs: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009H0708%2802%29>.
- [22] European Parliament. European Quality Assurance Reference Framework for Vocational Education and Training, 2009. Recommendation reports, URLs: [https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009H0708\(01\)&qid=1611571795661](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009H0708(01)&qid=1611571795661).
- [23] European Economic and Social Committee. The Single European Railway area, 2020. Reports, URLs: <https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/single-european-railway-area-0>.