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Contents

1	Executive summary	4
2	Introduction	6
2.1	Purpose of the document	6
2.2	Structure of the document	6
2.3	Delivery process and sequence of actions.....	7
2.4	Definitions and acronyms	7
3	Transition: possible future scenarios and trends.....	9
3.1	Capabilities of the transport infrastructure for 2030-2040	9
3.2	How to think about the future.....	10
3.3	Summary of different futures and trends	10
4	Human capital development	12
4.1	Organisation of work.....	12
4.1	Lifecycle of jobs	12
4.2	The evolving employee.....	13
4.3	Challenges of Human Capital Development	14
5	IFA support for professional competence building	15
5.1	Pool of experts.....	15
5.2	Toolkit	15
6	Recommendations for professional competence building.....	17
	References	19
	Annex 1 Different futures and trends.....	20
	Annex 2 Ideas for HCD toolkit content	29

1 Executive summary

This document provides an insight into the human capital development challenges and the proposition of the framework for the professional competence building in public sector, industry and research – for all stakeholders forming the eight Innovation Focus Area (IFA) ecosystems described in deliverable D1.2 “*Joint vision on transport infrastructure innovation until 2040*”.

The document builds on the input from the guidance from the three infra4Dfuture (i4Df) high level stakeholder conferences in the course of years 2018 and 2019, the input of experts participating in a i4Df expert workshop on 25-26 February 2019, IFA webinars in Summer 2020 and interviews conducted in the frame of this project in 2019 with key representatives of eight selected infrastructure related professional collaboration networks. Besides that, desk research has been conducted, analysing several respectable literature sources on future trends and scenarios.

Europe faces uncertainty about how mobility and infrastructure will develop in the next ten to twenty years. The European Green Deal, and ever increasing digitalisation, automation and aging of population are important drivers for future trends. It is very likely that the actual development will eventually be a mix of expected, possible scenarios (Green Recovery, Business As Usual, Rapid Technological Development, and Big Private Freedom). A few, to the team that compiled this deliverable most relevant ones, are described in this deliverable. The analysis of these future trends results in the following set of recommendations.

Recommendations

Include HCD as an important topic. People are the single most important drivers of change, and therefore stakeholders should pay significant attention to HCD in the innovation process. Consequently it is crucial that the IFAs include HCD as an important, generic component in all of their activities. Such HCD component should focus on the following topics:

- Spreading of the developed knowledge;
- Analysis of the required future professional competences according to the requirements identified in D1.2;
- Action plan to achieve the required activities in the field of HCD.

Human capital development support. Support the IFAs with experts in the field of HCD, to ensure it gets the proper attention.

Connect to existing activities and experiences. It is recommended to connect to existing activities and platforms that are dealing with and/or have already substantial experience and skills regarding the topic of HCD. It should be further investigated how to connect with the existing EU funding support programs like ‘Marie Skłodowska Curie’ and ‘Erasmus’, creating mutual interest in addressing the competence development challenges.

Monitor HCD over time. Create a mechanism to continually monitor and analyse the needed competences (created within and outside the IFAs), update training and education tools accordingly. Guidance for HCD and monitoring approach should be added to the i4Df IFA toolbox, so that IFAs can use it at will.

2 Introduction

2.1 Purpose of the document

This document provides a coherent view on the developments of the future demand for competences of professionals that coincide with the upcoming innovations related to future infrastructure capabilities. It is related to WP3 “Collaborative professional competence building”, Task 3.2 “Professional competences matching future infrastructure capabilities”. Task 3.2 is composed of two subtasks:

- **Professional competences matching future infrastructure capabilities.** The aim of this subtask is to determine the required professional competences for national transport infrastructure authorities (NTIA) matching the future infrastructure capabilities as defined under WP1 - specifically, in Deliverable 1.2. To complete the subtask it is needed to develop an understanding about the future trends in societal and technological domains, drawing different future scenarios from respectable sources. Knowing these trends, one shall be able to predict the demand for transport and respective mono and cross modal infrastructure and enabling sectors (environment, digitalisation and energy). Out of the demand for the infrastructure Capabilities and corresponding IFAs one will be able to determine the demand for training and education. A matrix, binding the three capabilities and main competences is created. Organisational Human Capital Development framework is presented, again – cast against the global trends of HCD.
- **Future framework for training and education.** The aim of this subtask is to develop a proposition for the future framework of training and education respective of the required professional competences for the modernization of infrastructure. Building on the findings of the first subtask, it should be possible to define the demand for training and educational needs (again, in the light of the future trends in training and education, including VR/AR training, Education 4.0 etc.).

2.2 Structure of the document

In Chapter 3, the document starts with the description and references to the findings at i4Df initiative stakeholder conferences and the expert workshop. It is continued by the desktop research with a broad view on the possible ways technology and society may develop in the future. Both domains will shape the society’s demand for transport and subsequently – demand for the transport infrastructure. Also, both will influence the human capital available for infrastructure managers.

Chapter 4 is dealing with Human Capital (HC) development issues, it broadly describes challenges and possibilities the NTIA managers have. A proposition for training framework and toolkit is developed and presented in Chapter 5. Recommendations for NTIAs and EC are drawn in Chapter 6. Annex of the report consists of two blocks – the first contains an analysis of five very different but respectable sources that deal with future scenario development, while the second describes future societal trends and their influence on competence building.

2.3 Delivery process and sequence of actions

Over a period of two years, the WP3 team gathered information by conduction of interviews, group sessions and desk research, to answer the questions posed by Task 3.2. The team has looked at trends and developments in the field of human research, knowledge development and training. The group has come up with the creation of a framework with the goal of enhancing the professional competence building in regard to the IFAs.

The following activities have contributed to the preparation of this deliverable:

- i) Three **Stakeholder conferences** contributed to the definition of future capabilities the NTIAs will have to deliver in the time periods until 2030 and 2040.
- ii) **1st i4Df Expert workshop**. This document builds on the results from the first i4Df expert workshop 25-26 February 2019. From this workshop the descriptions of challenge, scope and expected impacts for an original number of fourteen Innovation Focus Areas (IFAs) were drafted.
- iii) **Consultation of the i4Df consortium members**. Based on the comments of consortium members that were consulted on the second draft of this deliverable, this third and final version of the document was edited. This consultation resulted in minor amendments and edits, reinforcing the general support for this document.
- iv) **Interviews** with eight associations and networks of NTIAs, industry, and research providers gave an insight into the organisational structures and operationalisation of professional collaboration and knowledge sharing.
- v) **Desk research** provided the needed input for future scenarios and trends
- vi) Several (digital and physical) **meetings** and **telephone conferences** within the i4Df consortium members in task 3.2 were set up to discuss the contents and structure of this document.

Note: Although the COVID-19 pandemic outbreak did interfere with the course of the development of this report, authors purposefully had not included any short term projections on how transport system might change after the pandemic. It is still too early to tell the impact of the COVID-19 pandemic on long term trends described in this paper. Only one clear trend is highly likely to stay – pandemic has proved to be a game changer accelerating the pace of the digitalisation of NTIAs.

2.4 Definitions and acronyms

Item	Definition
BIM	Building information modelling
CAV	Connected and automated vehicles
Competence	The set of demonstrable characteristics and skills that enable, and improve the efficiency or performance of a job.
FTE	Full-time equivalent

Item	Definition
Hard skills	Hard skills, also called technical skills, are any skills relating to a specific task or situation. It involves both understanding and proficiency in such specific activity that involves methods, processes, procedures, or techniques.
Human Capital Development (HCD)	The process of improving an organization's employee performance, capabilities and resources.
IFA	Innovation Focus Area
NTIA	National Transport Infrastructure Authority
Scenario	One of several possible situations that could exist in the future.
SH	Stakeholder
Skill	The ability to carry out a task with determined results often within a given amount of time, energy, or both.
Soft skills	Soft skills are a combination of people skills, social skills, communication skills, character or personality traits, attitudes, career attributes, social intelligence and emotional intelligence quotients, among others, that enable people to navigate their environment, work well with others, perform well, and achieve their goals with complementing hard skills.
Trend	A general development in a situation or in the way that people behave.

Table 1 Definitions and acronyms

3 Transition: possible future scenarios and trends

Europe faces uncertainty about how mobility and infrastructure will develop. The further into the future we look, the less certain we are. Given the innovative trends in physical and digital infrastructure, this is a time of change. Using standard planning tools, it is difficult to deal with high uncertainty. By contrast, using scenarios approaches can help policy-makers to make decisions that are more resilient in the future. These scenarios can help them to consider which outcomes are desired or undesired, and to identify the kind of future they hope for or rely on to steer the transport and mobility systems towards, or away from.

Note: It is not the purpose of this document to draw any definitive conclusions from different scenarios, it should be rather used as a tool to paint a holistic picture of possible competence development landscape and to give a material for thoughts.

3.1 Capabilities of the transport infrastructure for 2030-2040

The i4Df initiative has defined three capabilities for 2040, each encompassing several innovation focus areas. The human capital development recommendations in this document are set in that context.

Infrastructure optimally meeting end user needs: *The ability to provide optimal transport infrastructure network capacity in order to accommodate increasing transport needs, and balancing cost, performance, safety and risk to provide infrastructure as a high-quality service to end users.* Select keywords: [intelligent prediction](#), [digital twin](#), [smart infrastructure assessment](#), [non-destructive testing](#), [holistic examination](#), [smart design and construction](#), [risk analysis](#), [lifecycle costing](#), [circular economy](#), [procurement](#).

Infrastructure meeting environmental and social sustainability needs: *The ability to embed transport infrastructure networks in their immediate surroundings, optimally balancing interests from economy, society, and environment.*

Select keywords: [carbon footprint and decarbonisation](#), [energy neutrality and energy efficiency](#), [noise and vibration](#), [pollutant emissions](#), [spatial planning](#).

Infrastructure achieving added value from digitalisation: *The ability to harvest the benefits from digitalisation in internal processes of transport infrastructure management (e.g. planning, design, construction, operation, end-of-life) as well as in the relation between transport infrastructure management and its end user (smart mobility and logistical services, individual end users). Use digitalisation to support the achievement of sustainability targets and provide a better service to infrastructure end users.*

Select keywords: [smart mobility](#), [big and seamless data](#), [digital twins](#), [connected and automated vehicles](#), [artificial intelligence](#), [building information modelling](#), [decision making support](#), [robotization](#), [virtual and augmented reality](#).

The list of keywords gives a scope for the fields of competences needed to cover the capabilities set forth by SH. A corresponding matrix of the Fields of Competences and IFAs (Figure unterhalb) has been developed and is shown. Rankings are pictured in the scale from zero to five, depicting a possibility that the IFA collaboration group will need this

competence or will influence the field with the consequential impact on education/training/retraining needs during the innovation process.

Fields of Competences	IFA1.1c1.2	IFA1.3	IFA2.1	IFA2.2	IFA2.3	IFA3.1	IFA3.2
Human Resource management	5	5	5	5	5	5	5
General administration	5	5	5	5	5	5	5
Legal	3	5		2		3	5
Finance	1	5			5		1
Procurement	1	5	5	3	4		2
Design of infrastructure	5	3	5	5	4	3	5
Construction and materials	4	4		4			5
Maintenance of infrastructure	5	1		3	2		5
Road/rail/river vehicle development	1					5	
Traffic management	5		5	5	5	5	4
Logistics and mobility	5	1		3	5	3	
Safety	3	2		2		5	2
Spatial planning	4	2	2	3	5		4
Security	5	1	1	2		5	5
Risk management	5	4	3	2		5	2
Environment and climate	3	5	5	5	5	1	1
Energy distribution management	2	2	5	1			1
Communications and IT	4	1				4	5
Data analysis	5	1	2	4		5	5
Robotics	1						5
Artificial intelligence and VR	4	2		4		4	5

Figure 1 Matrix of the Fields of Competences and Innovation Focus Areas (Data source: i4Df Deliverable 1.2)

3.2 How to think about the future

To give a wider perspective rather than concentrating solely on human capital development, it is essential to understand the settings in which main resource of human capital (the human being itself) is built. With this aim in mind, in the following paragraphs different futures (also called scenarios) and trends in developments of **transport**, **society**, and **technology** are described. As already mentioned, during the early stages of the i4Df project, NTIA stakeholders did come up with three capabilities summarising the future needs for innovative research in cross-modal transport infrastructure. Efficient and data driven management, greening of transport systems, and digitalisation are the main trends that were identified and further described in the three capabilities (cf. D1.2 of the i4Df project). These closely match the EU policies, like the Green Deal, and expert outlooks from respected sources, like ENCORD foresight exercise, McKinsey insights, Skillful project and others.

3.3 Summary of different futures and trends

When looking at the offers for different future scenarios in general and specifically in transport (see annex for more detailed overview), one can see that there are a number of common features, both in the characterizations of the scenarios themselves and in certain trends. It can be seen that technological development, environmental and sustainability considerations, human cooperation and the use of shared transport are very important topics. Scenarios differ and put more emphasis either on the central role of private or public sectors, and the importance of local communities and commuter distances – with all the consequences affecting the transport system and human capital development. Terms for describing different “futures” are used interchangeably across the reviewed literature to

describe the same predictions and tendencies. Based on the findings of the literature review, four leading scenarios can be defined.

- **Business As Usual** – no big changes from the course of the things as they are now. Gradual technological development but with little cross-modal fertilisation.
- **Green Recovery** – green thinking and actions are very pronounced, research and innovation resources are devoted to build a sustainable (in all ways – environmental, technological, social) society.
- **Big Private Freedom** – there's a shift towards more privacy, technologies are restricted to meet this aim. Data collection, AI is controlled by strict rules.
- **Rapid Technological Development** – as title says – technology over other fields. Corporations are given freedoms to develop and build new products, society is giving up its privacy, sustainability is an issue.

It is clear that none of these “futures” will prevail. Most likely, there will be a mix of scenarios – question remains – what proportion of each scenario will make the future. As for today, it is most likely that Green Recovery is prevailing the European agenda, with Business As Usual in the second place, followed by Rapid Technological Development, with least likely that Big Private Freedom is coming into the equation at a large scale $(50+30+15+5)\% = 100\%$. These different “futures” are of course not cast in stone and are fluidly changing, thus the reader of this document should consult the latest trends (beyond 2020, the time of writing of this report) in order to better understand what competences there are and will be needed in the future.

Various sources on future trends (see annex) agree on few common megatrends: future will be **green** (decarbonisation, energy efficiency, sustainability etc.) and **digital** (CAV, artificial intelligence, BIM, robotization, smart mobility etc). The importance and credibility of these trends are reinforced by the delegates of i4Df SH conferences.

In the human capital development context, the **ageing population** is a dominant assumption and one that shapes the challenges faced by the infrastructure managers, service providers and education/research community.

4 Human capital development

Human capital development (HCD) is the process of improving an organization's employee performance, capabilities and resources as human capital represents the sum of abilities, skills, knowledge, experience and talent that employees possess.

4.1 Organisation of work

In the current situation, a lot of NTIAs are organised more or less on the same principle. People are working in monodisciplinary teams, organised by their speciality. From the first SH conference and the various interviews and expert meetings the core message was that there is a development towards multidisciplinary teams. This transition requires competences that go beyond the actual basic set of required vocational skills.

Besides the move to multidisciplinary, also the change from supply to demand driven work is mentioned several times. These changes in the organisation of work requires employees with additional skills and competences compared to the current situation.

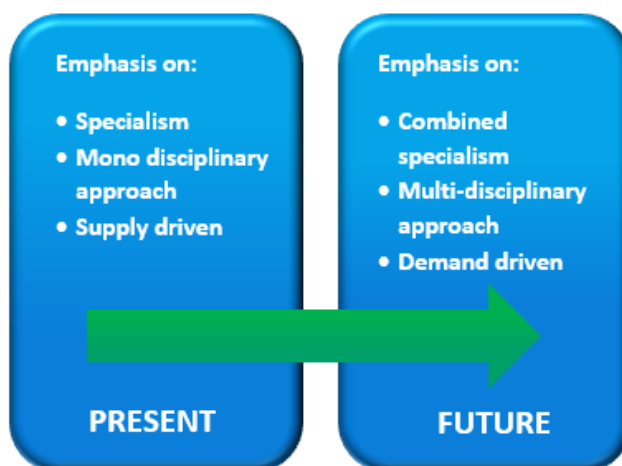


Figure 2 Organisation of work

4.1 Lifecycle of jobs

Change is the only constant factor. This also applies to the jobs. It is not easy to draw a hard line between near-future and current, as well as between current and fading jobs, as the dynamics are changing the landscape at a fast pace. The prediction is that 70% of young people start jobs that will be radically affected by digitalisation and automation (Table 2).

Timescale	Types of jobs	Description
Future	Blue-sky [future] jobs	Blue sky, yet to be found. For these jobs one has to look really into the future. Even quantum computing is closer to emerging than to the blue sky jobs.
Future and present	Emerging and near-future jobs	One can already start to design curriculum. These jobs already are around but some might be at the early stages, still residing mainly in research institutions. Examples: artificial intelligence, deep learning, data science, robotics, internet of things, 3D printing etc.
Present	Active or current jobs	All jobs that are active now, in 2020. Automated, semiautomated or totally manual. Taxi drivers, asphalt paver operators, BIM engineers etc.
Past and present	Fading jobs	Fading jobs are those that are still somewhat in the active sector but already giving way to automation. With technological progress also taxi driver will give way to a driverless car.
Past	Fossil [extinct] jobs	Jobs that are no longer needed. Lampposts are long ago lit up by electronic switches, no one is attending an individual post to light up the gas burner or a candle.

Table 2 Lifecycle of Jobs

Emerging trend in labour market is the transformation of jobs from standard jobs that require performing repeatable tasks using limited and specified skill set to hybrid jobs that demand a combination of soft and hard skills and finally developing into superjobs that combine competences from various traditional jobs and use technology to achieve higher productivity and efficiency.

4.2 The evolving employee

Changing employers during careers from a minority behaviour in the 20th century is becoming a norm in the 21st century. Changes in work and residence follow and accompany each other. Working conditions vary from cabinet and conveyer to joint working arrangements, non-binding and free relationships, to zero-hours contracts. People change the jobs a number of times, on average having at least twelve different jobs in a lifetime. Human careers don't form solid vertical growth curves, but gain the character of a more variable curve, with rises and falls.

The professional skills of young people are changing throughout their lives. In addition to formal secondary and higher education, new skills are being acquired by life and in labour market (lifelong learning). Therefore, the focus on 'learning on the job' and 'corporate learning centres' will increase. The instruments to 'build' competences will change during the different stages in an employee's career (see also figure on next page).

In conclusion, the technological and business evolution will reinforce the importance of human capital development.

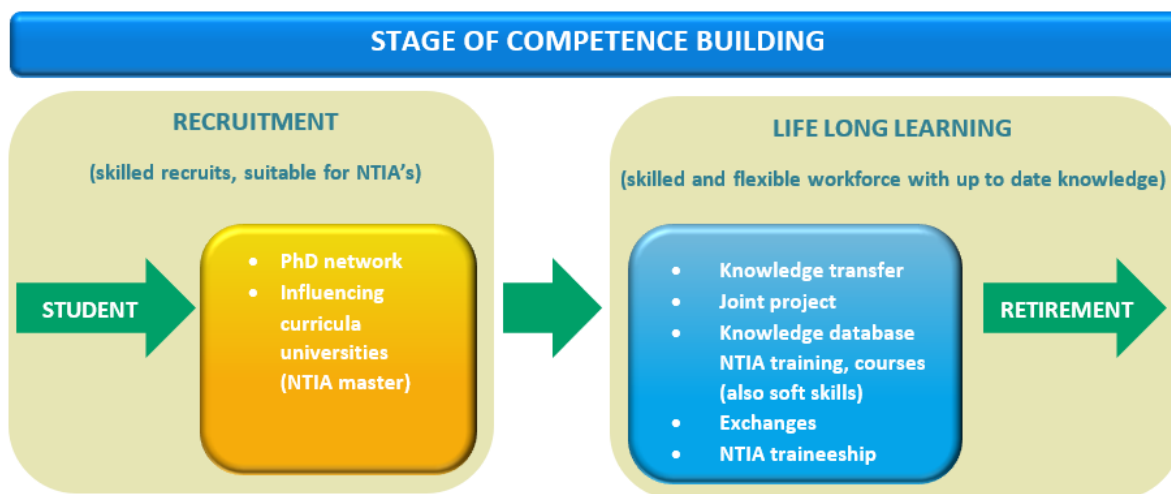


Figure 3 Competence building stages

4.3 Challenges of Human Capital Development

Human capital developments faces big challenges in the near future. Expert consultation has identified the following key challenges:

- **Replenishing lost and developing new expertise.** The loss of valuable expertise on one hand (due to an aging workforce). But also the need of new expertise and competences on the other hand, to meet the needs of the changing landscape.
- **Management development.** New ways of organisation of work, other jobs and the development of employees ask for another form of management. From hierarchical leadership, towards a coaching way of working together.
- **Enabling technologies.** Digitalisation (in the broad sense) helps people to communicate more effectively, organize work more productively and have significantly reshaped day-to-day practices. Progressive organizations must take advantage of digital technology to maintain employee engagement.
- **Diversification of workforce.** The structure of the workforce has reshaped as employees represent four distinct generations and have different cultural background – the work environment becomes more multicultural in which contrasting work habits come across.
- **Flexible Work Arrangements.** Even more employees emphasize on working in flexible set-ups because of balancing the demands of work with personal responsibilities and interests. Adjustments trough organization policies and procedures has to be made to ensure productivity.

5 IFA support for professional competence building

In their coordination of national and European programs and initiatives, the IFA ecosystems (cf. deliverable D1.2) in essence also define the need for new knowledge and competences. A recurring question is how to transfer the developed knowledge and thereby contribute to professional competence building. This is not a question exclusively for the NTIAs, but a larger recognized issue in the industry, research and education community. How will it be possible to transfer new knowledge and competences to the workforce? The fact that the IFA knowledge is produced on a European level from multiple countries (and therefore less specific to the needs of a single organization) makes the deployment of knowledge and competences even more challenging.

5.1 Pool of experts

It is recommended to deploy a pool of experts to support the IFAs in HCD. Such pool of experts should exist of dedicated experts from different countries on the fields of expertise of HR, Learning and Development, Innovation and Organizational advise. These experts work on a voluntary basis and are assigned to the project for at least one day a week, for the minimum period of a year. This is to ensure continuity. The HCD coordinator has a contract and therefore has an accountability for the deliverables and an active role to the IFAs.

These experts can be 'hired' by the IFAs for a period of time to develop and implement a tailored approach how to spread the knowledge and to develop competences. Knowledge sharing and competence development is in the end the responsibility of the IFAs.

It is advised to explore how the HCD support through a pool of experts could best be accommodated in the light background structure, the common facilitating services that will support the coordination mechanism and which is detailedly described in deliverable D1.4.

5.2 Toolkit

During the i4Df initiative the team has gathered a lot of different instruments that contribute to professional competence building and can be added to the i4Df toolbox. Here some of the more promising instruments are listed. Recommendation is to further develop and tailor the toolkit for supporting HCD activities.

- Training or education. NTIA/IFA courses, workshops, focusing on a specific field of expertise. Develop a syllabus.
- Training on social skills (NTIA courses):
 - European networking (focusing among others on international cooperation)
 - Enhancing innovation and change skills on a European level
- Knowledge database (webinars, publications, courses etc.). Enliven it by making the database accessible for a broader audience.

- NTIA traineeship. A traineeship focusing on young people with a focus on the future workforce.
- Exchanges, internships. Exchange of employees between NTIAs, in order to learn from best practices, exchange knowledge and developing networks.
- Joint (implementation) projects.
- Overview PhD's studying transport infrastructure. Visualise the network, make it accessible for participating countries.
- Advise to stakeholders on how to gain budget from the European support programmes (like Erasmus and Marie Skłodowska Curie).

Further ideas for toolkit content concerning HCD can be found in Annex 2.

6 Recommendations for professional competence building

Recommendations on human capital development are drawn to advise all participating stakeholders of IFAs.

Include HCD as an important topic. As described previously, the deliverable 3.2 has been build up from the findings in the deliverables D3.1 and D1.2. In these deliverables the main future mid-term and long-term challenges for NTIAs are identified and described. People are the single most important drivers of change, and one must not forget to make them a crucial part of the innovation process. Therefore we recommend to include a mandatory HCD component in all IFAs. This HCD component should focus on the following topics:

- Spreading of the developed knowledge;
- Analysis of the required future professional competences according to the requirements identified in D1.2;
- Action plan to achieve the required tasks.

Provide HCD support. As described in chapter 5, there is a need for a HCD support, to ensure it gets enough attention. It is not the primary focus of researchers or experts, HCD is a field of expertise that must be added to the IFAs to ensure it gets necessary attention. It is recommended the HCD support is hosted by an already existing NTIA entity, preferably in a EU context. This way of work has to be regularly updated and supervised by all participating NTIAs and supported by the stakeholders to consider their point of view. In order to make the HCD support reliable, it is also recommended that there must be funding for a small supporting staff but the exact size and duration of HCD support depends on coordinating mechanism arrangement.

Part of the HCD support is to develop and execute 'HCD workshops' for IFA members. Helping them to understand the importance of HCD and figure out in what way a IFA can contribute to HCD.

Connect to existing activities and experiences. There are already a lot of excellent organizations and platforms surrounding the IFAs and knowledge development on a European stage. It is recommended not to organize new platforms, but to connect to the activities and platforms that already proved their right to existence on a EU level. It is also recommended to further investigate the connection with the existing funding support programs like 'Marie Skłodowska Curie' and 'Erasmus' because of the overlapping goals, and to figure out how to reinforce one another by funding opportunities for knowledge exchange.

Some examples to consider:

- Collaboration with the 'Marie Skłodowska Curie' and 'Erasmus' programmes to implement the needs for human development considering the needs of NTIAs and all stakeholders (industry, innovation programme owners, research providers) to boost future innovations in this research field.

- Strengthening the infrastructure part of EU macro-regional strategies through coordination programmes or mechanisms might add a visibility to the hot topics identified and developed in IFAs.
- Promoting the open science with projects like openaire.eu and implementing it in IFA practices to gain from open access of data and innovations.

Monitor HCD over time. Create a mechanism to continually monitor and analyse the needed competences (created within and outside the IFAs and Capabilities). With this input training and education tools can be updated accordingly.

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Label	Reference
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ANNEX 1 Different futures and trends

ENCORD Foresight Report

The European Network of Construction Companies for Research and Development (ENCORD) conducted a Foresighting conference and created a report on future trends in construction sector. Driving forces cards were used to heat-map, on two scales – certainty and relevance, the number of predefined global and industry related trends. All in all, the project gathered response from 250 high level participants (construction companies, different EU wide associations) during three sessions. Top five most certain and relevant drivers came out to be: Data and intelligent systems, Artificial Intelligence, Renewable energy, Talent wars, and Customisation and flexibility. As can be seen, all these drivers are also part of i4Df project findings, either found in Capabilities 2040 or expert discussions. On the other hand, as most divergent drivers or trends came out to be Platform business, Ethical consumer, Threat of cyber-attacks, Divestment, and Limited resources.

This document deals with the human resources issues, and the reader might be interested in *Talent wars*. The findings of ENCORD say that considerations for Talent Wars are following: competition to attract and retain the workers one needs in a very competitive market; the implications of the rising salary costs on project pricing; the company's ability to manage the supply chain with or without these costly workers; how to attract workers, making the construction a sector of choice; are companies efficiently using the workforce they have; pace of adaptation of modern methods of construction e.g. offsite, automation, to counteract the impact of a falling number of skilled trades people.

The approach of the foresight itself is worth mentioning and could be included in the toolkit for the HCD.

An integrated perspective on the future of mobility (McKinsey)

The McKinsey company develops its vision for future transportation prospects and offers three distinct scenarios in the view of seamless mobility in 2030. These are based on rapidly growing changes in the lifestyle, technology, demography, transport vehicles and transport systems in recent years. The development of scenarios took place on the basis of the modelling of short, medium and long trips. The first scenario is Business-as-usual urbanization, scenario 2 is Unconstrained autonomy, but scenario 3 is Seamless mobility. According to the first scenario Business as usual, population mostly deal with transport system, as it is at present. The number of means of transport has increased by 15%, and carbon pollution has increased proportionally. Private vehicles provide about 35% of the passenger per kilometre ratio. Travel time is also rising by 15% and only a few very large cities are developing more sustainable travel alternatives. The second scenario involves a very rapid deployment of automatic means of transport for which public policy is not taking place. Expenses on robot taxis are falling significantly and people switch from personal cars. Carbon emissions are declining, along with waiting times, which on average would fall by as much as 15% compared to present times. Finally, as part of the third scenario, public policy is active and able to influence people's choices to align the use of both trains and automatic means of transport with a rise of up to 30% in passenger/kilometre terms, a 10% reduction in

the time spent and a third of the spent funds being matched by the current role of private cars. “Intelligent traffic systems, advanced rail signalling, and connectivity-enabled predictive maintenance all boost network reliability”.

Four qualitative scenarios demonstrating divergent possible futures (UK)

The four scenarios were developed using insights from the evidence collected in the UK and presented in a paper on the future of mobility. This work was aimed to identify the critical uncertainties that will influence mobility between now and 2030, focussing on those areas that are most important in shaping the future and which of these have the greatest level of uncertainty. Building on these, future timelines and policy decisions were constructed for each scenario. Rather than a 2x2 grid, a central scenario (Trends Unmodified) was built with three different futures diverging from it. The critical uncertainties used were transport users’ willingness to share data and adopt new technologies, and the extent to which transport will be shared or used exclusively [individually]. Other important uncertainties built into the scenarios included: future levels of automation; future rates of electrification; the extent to which physical mobility will be replaced by online alternatives; future use of active transport (biking and walking); the relative roles of public and private actors; future levels of social inequality; and the trade-offs between individual choices and overall social and environmental values.

The qualitative scenarios that were developed demonstrate four diverging possible futures: ***Trends Unmodified***, ***Individual Freedoms***, ***Greener Communities***, and ***Technology Unleashed***. Subsequently, an overview of these scenarios and the implications of each for government, including the important choices that it could make to shape future patterns in transport and mobility is provided.

Trends Unmodified: Government is reactive to changes in mobility and a directed approach to reaping the benefits of new technologies in transport is limited.

Individual Freedoms: The public demand freedom, independence and control over their transport and are concerned about the data privacy.

Greener Communities: Society is less materialistic and prioritises the social and environmental aspects of mobility over new technology and individual choice. Car sharing vs ownership, is an example for this scenario.

Technology Unleashed: Transport deregulation, rapid technological progress, private sector dominated. As one of the consequences, technology increases efficiency in freight, but jobs are lost, and employees lack the skills required to move to newly created jobs.

Trends predict that rural transport provision in particular may struggle to meet the demands of an ageing population. Left to the market, new mobility services will tend to operate in more densely populated areas. This could leave some people underserved or priced out and may exacerbate problems with accessibility in rural areas and small towns.

These trends will occur within a changing global picture. Climate change will place increasing pressure on the natural environment. The EU will become a lower-carbon economy, with a target to reduce greenhouse gas emissions by at least 80% by 2050, relative to 1990 levels.

There will also be a shift in global economic power and trading relations. [Emerging economies such as Brazil, China, India, Indonesia, Russia and South Africa are growing rapidly, decreasing the dominance of today's developed nations.]

Many of these trends will affect the transport sector. The growing and ageing population, combined with current capacity constraints and the expected shift to electric vehicles, could increase congestion and escalate its associated costs. Rapid changes caused by new business models or changing transport provision may mean government has to respond quickly to ensure beneficial outcomes are realised.

Key points Triple win of INHERIT project (EU)

The Reaching of Triple Win report of the INHERIT project describes future European scenarios by 2040. The project aims at identifying interdisciplinary policies, strategic interventions and innovation to enable a 'triple-win': reduce environmental impacts, improve health, and increase health equity. There is also a vision for the direction of transport. The first scenario is ***My life between realities*** or private sector driven individualistic scenario. The transport and mobility area is based on the systemic and multi-faceted use of several mobile and digital devices. The main supply on the market are personalized services available from early childhood. There are practically no available means of transport based on fossil fuels due to regulation. Automatically operating vehicles (CAVs) have significantly reduced the need for car ownership. People get benefits from insurers and employers for distances travelled on bikes or by walking.

The second scenario is influenced by ***Less is more to me*** by the public sector. The use of private means of transport is rather seriously affected and regulated, and public transport is very widely used and integrated, starting in cities and then outside cities. Countries and local governments have transformed formerly used roads into green and pedestrian-friendly streets. Human mobility behaviour has changed. Companies are in-depth following and reducing their carbon footprint.

The third scenario is ***One for all, all for one***, where the public sector also plays a key role. In the field of transport, in this case, local communities that have been active in the creation of living spaces at a relatively short distance are central to each other. Work, school, kindergarten, shopping and recreational areas are close to each other, thereby reducing the need for a major use of motorized transport. There is very well-developed public infrastructure, including bicycle-sharing systems. The use of cars is only permitted in peripheral areas.

Finally, the fourth scenario is ***Our circular community***, where the private sector also plays an important role. Companies are very active in supporting their employees' choice to go on foot or ride bikes with offers of financial rewards. Mobility is made smart by employing technology, teamwork is encouraged through the use of group games.

Criticism of the scenarios of INHERIT. Most projections revolve around society, production and transport of goods is left out. If one wants to have a holistic view on the future, the production and distribution of physical goods should be considered along with societal and technological developments (transforming roads into green paths sounds very

environmentally positive but at the same time it does not provide an alternative for logistics. Unless one assumes that everything will be produced outside Europe. Concentrating on urban areas and assuming that almost everyone will live in the urban area is describing a very small part of Europe, i.e. – the Western Europe with high population density and vast resources to rebuild everything in a very short time period. The Northern, Eastern and Southern part of Europe and their respective transport needs are not taken into regard in this model.

Takeaways for i4Df. Although, INHERIT does not address the HCD or transport infrastructure issues directly, it is clear that less physical travels (less national and international face to face meetings) are envisaged to help protect the environment. That would also mean less face to face training and networking for IFA ecosystems. Less networking is feasible when concentrating on already established networks. To form a trust in new networks, physical meetings are of high importance.

SKILLFUL output linked to i4df capabilities

It can be seen that many professions that will be affected, eliminated or even developed, converge in the various categories are linked to Guiding Objectives for 2040 of i4Df project. For example, professional drivers are going to undergo various and dramatic changes in all aspects of the profession (i.e. taxi/ metro/ bus drivers, truck drivers, logistics drivers, urban rail drivers, etc.). Many positions characterized by manual labour (i.e. stevedores, road workers, crane operators, loader and unloaders, etc.), customer services (i.e. ticket issuers, booking agents, customer service personnel, customers' suppliers, etc.), which are going to be affected and maybe disappear due to the outbreak of IT solutions, other technological developments, the development of retail and e-commerce services are linked to Guiding Objectives for 2040 as well. Occupations that are related to fuels are also expected to change and maybe to be completely different in the future (i.e. fuel station operators, fuel distributors and retailers, fuel quality control personnel, etc.) due to the transportation greening and deployment of alternative fuels.

Additionally, several professions and new jobs are also expected to emerge in the future, which will either be completely new or holistically altered. A broader and more comprehensive feature that most new jobs are expected to have is the need for more upgraded software and technological competences. For example, experts on artificial intelligence (AI), digital transformation and big data are going to be needed (i.e. for new transport/travel software development to customize people's travel, applying machine learning algorithms to improve efficiency by implementing autonomous data interpretation and control, etc.), as well as IoT developers, IoE Engineers, 3D Printing personnel Automation and Robotics experts, Security (& cyber security) experts, legal services personnel and privacy protection specialists to handle issues related to data privacy, e-Vehicles and automation vehicles and infrastructure maintenance, etc.

The results presented in SKILLFUL project, which includes the identification of future trends and the impact on jobs that are likely to affect the European Transportation system, as well as the identification of existing and/or emerging relevant training methodologies and approaches, add noteworthy value on i4Df's strategic goals per IFA/Capability.

To sum up, inevitably some jobs that exist today will become less significant, while some may vanish altogether. It is therefore imperative that the EU prepares itself for this challenge by providing new training and skills that adapt to the emerging employment landscape. A robust framework for further and ongoing research for the development where all relevant stakeholders are included should be taken place in the future. There is need to develop a set of harmonized standards for courses for low/middle and high skilled workers in Europe in order to improve mobility of skilled human capital.

Findings of the *Skillful* project suggests four significant future developments affected by increased use of technology in transport industry that will require new jobs and competencies. Similar keywords are found in capabilities and corresponding IFAs defined during stakeholder workshops and conferences of the i4Df initiative.

- Automation and artificial intelligence – increased usage of digital solution will lead to creation of new jobs within industry.
- Data analysis – Digitalization will generate a large quantity of data that will be necessary to interpret to aid the decision-making process of organizations.
- Cybersecurity – With progress of technology and involvement in industry comes increased vulnerability of virtual threats as transport infrastructure needs to have protection against such risks.
- Green technologies – Alternative energy sources will become one of the tools to solve environmental problems with an orientation towards sustainable development at all levels.

Conclusions from this project propose multiple training tools or methodologies that can be used to gain new skills and reinforce existing competencies.

What can go wrong

After projecting models, some common features shall be drawn and used to develop the next step - identification of key future trends that should affect the utilisation of transport and mobility systems as well as trends of social environment that will affect competence retention and creation.

Although, all different futures are based on expert surveys and opinions, there is always a chance that these scenarios will not come even close to projections in reality.

Politics – extreme wings (left or right) might put the country into instability, shifting the focus and channelling research and innovation resources to different causes, rather than general or mobility related technological advancements. As a rule of thumb, social issues are coming first on the agenda for the populist governments.

Weather - climate change happens too fast to be contained effectively by research community, resources are needed for reactive repairs of infrastructure to provide society with basic logistics and mobility.

Cyber security - developments in AI, ML and quantum computing threatens the existing cyber security paradigm. Cybercriminals might cripple some technological developments to the point that these have to be abandoned or slowed down.

Health – major [virus] outbreak of pandemic scale (COVID-19, for example) might put the delivery chains in turmoil, disrupting business-as-usual. Mobility is put at high risk as governments try to contain the outbreak. Networking events are postponed or cancelled. At the same time, it is an opportunity to filter out the jobs that are suitable for remote working, and which are not, to design more resilient contingency plans for extreme situations.

Future trends and impact on required competences

In order to grasp and understand the possible changes that the near future may bring, it is essential not only to look and analyse the broader different futures but also to closer investigate the trends that already are shaping the social and technological landscape.

General trends

Europeans witness changes and developing trends in various fields. The changes shall shape and determine both, everyday work and consumption experiences and affect the way we use transport and mobility services. Consumption habits, compared with 20-30 years ago, have changed. A growing share of search, acquisition and use [of products and services] is being implemented in a digital, interactive environment. Purchase transactions are carried out using different forms of settlement, with a significantly higher proportion of acquisitions and further use being carried out regionally and globally, compared to past, where it was contained within national boundaries. The goods purchased are not thrown out but repaired, further used or passed on to those who need them more. There has been a transition from cassettes, compact discs and storage repositories to immediate [real time] online consumption. People communicate through new forms of social networks.

Demographics

Great demographic changes have occurred and shall continue. At the beginning of the 1980s, very rarely could anyone predict that, after 35 years, China's population growth would start to freeze and shrink. That population growth will no longer double as between the 1960s and the 2000s but will rapidly start to slow down. The rise of birth rates in Europe will dramatically decrease, population age groups trapeze will turn more into a rectangle, with an average age rising by nearly 10 years over the next 30 years. Population cohabitation and relations is and will become more variable. The forms of establishing human relationships have changed dramatically, including huge pathways in mobile communications and spatial movement. There has been a huge population migration which is likely to continue in the next ten and twenty years. In parallel, there is an increase in ageing population and a number of single adult households. "Urban space has become very dominant in the European geography. Growing and extending cities lead to the emerging concept of city-regions, which combines several spatial scales and imposes different transport modes." Urban agglomerations have become and will stay key to the development.

Education

The education process has witnessed a major transformation. The forms of training for pupils and students have changed, the format of data and records has been radically digitised, evaluation and process registration have changed. Parents and children can share their success digitally. Learning opportunities are increasingly available in a digital and Internet-linked format, with wide variety of topics. The need to acquire new skills, to change professional abilities, become a matter of life. The ability of ordinary, diverse social actors to implement part of the learning process in another country and the education system is becoming an expected, widely used opportunity.

Training

Over the last 20-30 years, there have been very significant changes in education and training. People learn virtually during all of their active lives. The professional skills of young people are changing throughout their lives. In addition to formal secondary and higher education, new skills are being acquired by life and in labour market. People learn skills, take tests and receive certification digitally. Training takes place anywhere. Migration - both physically and digitally - for skills acquisition takes place in an escalating pattern.

Professions of the coming years are, for example: data analysts and scientists, experts in artificial intelligence and machine learning, experts in big data and digital transformation. 70% of young people start jobs that will be radically affected by automation.

Differences in scenario projections are significant and also have an impact on skills requirements that are more demanding. There are a number of common skills and educational trends that will take place in any case. Higher education will be important, but job specific skills will also be important. In particular, only some of the professions will be able to live without higher education.

HCD practitioners will, in the meantime, call for online training platforms to work more closely with entrepreneurs to develop courses for which there is a real demand. The need to learn new knowledge and skills fairly quickly will encourage a regular return to a more formal learning process. The willingness of people to gather for the co-employment of larger and smaller groups - workshops, presentations, working groups, co-working - will continue and will not be replaced by digital means. The use of artificial intelligence in large supply of different work and security processes will grow very rapidly, which will release or make much less important the use of human mind and skills in similar tasks and demand the development of new areas of acquisition. The use of Big data in modelling and design will allow more accurate planning of logistics and mobility processes.

In different scenarios knowledge and skills will develop differently. Let us remind which factors and alternatives determine the differences between scenarios. Divergent expectations of people to share their movement data with mobility and logistics systems, differences in future transport automation and electrification, differences in digital and physical mobility, different involvement of public and private service providers, individual freedoms, social and environmental balances and levels of equality or inequality.

At the same time, there are more and more complaints about educational institutions - that they are not preparing sufficiently their students for work in industry as enormous demand for new skills and capabilities are created by increasing use of AI, robotics and automation in work process. Therefore, most of the professions we know today will change even more as the jobs of the future are more multidisciplinary and more digital compared to what they used to be in the past. Nevertheless, technological and business evolution will reinforce the importance of the human dimension in the transportation sector.

Emerging trend in labour market according to the research done by Deloitte is transformation of jobs from standard jobs that require performing repeatable tasks using limited and specified skill set to hybrid jobs that demand combination of soft and hard skills and finally developing into superjobs that combine competences from various traditional jobs and use technology to achieve higher productivity and efficiency.

Future of work in EU trends

The last 10 years have shown an increasing trend in employment rate in all socio-demographic groups. In the future a larger proportion of population will still work at the age that is currently a retirement age. A significantly greater proportion will do so in services and they will be working in the form of less traditional or non-standard employment relationships. Those who are in a non-standard employment relationship do not currently enjoy full social protection, and this, in turn, affects a wide range of aspects in social and personal life. As the nature of the work changes, more opportunities are available for companies that are “putting in place more agile, digital-based, customer-oriented, and networked business models, as well as more sustainable and carbon-neutral practices (such as clean tech, waste management or sustainable banking)”.

As employment grows, wages are still stagnating and the gap between high and low-income people is not significantly reduced. This, in turn, contributes to brain-drain and talent flowing from low-paid to higher-paid jobs and countries. The educational changes highlight their challenges for graduates who cannot find work so easily in their chosen profession. Job shifts are becoming more frequent and learning and training extend throughout life. “43% of adult employees in Europe report having recently experienced changes in the technologies they use at work, with 1 in 5 considering it likely that their skills will become outdated in the next five years”.

Digital skills have become and will continue to be the new part of basic skills. However, in 2017 “35% of the EU's active labour force (employed and unemployed) still lacked such basic digital skills.” Unfortunately, it is increasingly difficult for people of older age, lower incomes and education to keep up with them. “With the rise of e-government, online shopping, banking and smart mobility, lack of basic digital skills may lock individuals not only out of work, but also out of society.” Up to 70% of companies' slower acquisition of digital skills limits productive investment strategies.

The working and leisure environments are rapidly changing and the borders between the two are dissolving. The proliferation of mobile and digital technologies only contributes to the disappearance of these borders and, at the same time, develops many and different new business competencies and offers opportunities to re-organise work processes. “As the link

between workplace and working time has eroded, it has also blurred the line between work and leisure, with consequences for private and family life, and also mental health, leading to efforts to grant workers' the right to disconnect”.

Artificial intelligence, automation and robotization: 6 out of 10 current jobs contain up to 30% components that are interchangeable with automation and artificial intelligence. Artificial intelligence will affect the work process in the near future. “The deployment of machines and robots in the work place is gradually freeing the human workforce from ‘dull, dirty, dangerous work – be it routine, tedious, physically-strenuous, or safety-critical tasks”.

EU’s workforce is gradually growing older, people stay active even after they reach the retirement age, many countries have adapted longer activity periods. This trend may bridge the gap that is forming between the needed workforce and the available resources.

Skilled migrants is yet another possible source for reducing the labour shortages. Training and education should encourage the integration process for those who are in EU on family reunion visas. Talent attraction via immigration rules (e.g. Blue Card) is welcome.

Although, the paper claims that the movement of talent within the EU is a positive trend, authors of this report would argue that this is potential threat to less developed countries as a cause of talent drain.

ANNEX 2 Ideas for HCD toolkit content

An outline for creation of new competences - Mixed teams

Creation of new competences and problem solving abilities in mono-sectoral or cross-sectoral context, based on cooperation and collaboration between different generations, organisations and institutions, and international networking. How to:

1. Build awareness about the advantages and disadvantages of various generations of experts - combined workshops, webinars, or any other form of remote collaboration. Create environment of mutual respect and understanding while working in mixed age/experience level groups.
2. Mentoring programmes - make a selection of mentors within the organisation - employees with experience, some special expertise, with teacher's talent. Develop very specific skills, working 1:1 or 1:many. Mentors should be given special role within organisation and their work load adjusted accordingly. International cooperation is possible (remotely).
3. Coaching - to help in guiding an individual expert in her/his development or transfer of knowledge to other colleagues.
4. Develop/buy/rent online/remote learning systems to facilitate learning skills needed for specific projects/jobs/positions. Motivation is needed to get individuals involved in online learning, gradually creating environment where everyone is responsible for her/his training while organisation is providing support.
5. Creating a mixed teams approach - where project teams consist of experts from different national organisations and authorities optionally - inviting international experts.

Prerequisites: language skills, skills in communication and collaboration, development of emotional intelligence and co-working in teams.

An outline for the generation of curriculum/syllabus

Demand side Competence building.

In IFA ecosystem, NTIAs will always be a thought leader. IFA ecosystem will serve as a designer of the curricula for training or education. NTIA may have abilities to define curricula but only training or education provider is able to develop a specific course syllabus. For reference – syllabus is a specific course or part of a course, curriculum is a training program, that includes specific syllabus(es).

Curriculum/syllabus generation steps:

1. Identify the new job within research/innovation area.
2. For which IFAs the new job is relevant? – Are there special requirements dedicated to only some IFAs? – Is a combination of the educational requirements possible?

3. Can this job (position) be covered with existing competences/skills?
4. If not – to what extent training for needed competences/skills is available in training/education market?
5. How wide is the gap (needed/available scope for learning)? Can it be covered with simple means (new or adjusted syllabus) or do we need to develop a new curriculum?
6. Can we borrow the needed knowledge from other sectors – IT, energy, economics etc.)?
7. Can we borrow knowledge or training from international partners?
8. How urgently we need the new skills to be available (time domain)?
9. What is the character of training activities – new staff or retraining of existing personnel (human domain)?
10. What is the breadth of the demand? Is it narrow and needed only in NTIA/research/industry or for all three stakeholders? What about policy makers?
11. Who can provide training or education? Do we need to train our trainers?
12. How can we develop syllabus? Simple steps and general knowledge of the topic or very specific knowledge and highly knowledgeable expert(s).
13. Steps to develop new curriculum:
 - a. Pair with (known) training provider;
 - b. Discuss the general topic, break it down into graspable specific topics;
 - c. For each specific topic search for existing syllabus, assign if found;
 - d. For new specific topics assign (IFA ecosystem) team members who are experts in the area. If not present in the discussion group, find and invite to the next (round of) meeting(s); it is advisable that for these next steps a professional in syllabus generation is available to the group;
 - e. A template of syllabus shall be provided to the group members who are writing the actual specific syllabus; training the group members in writing the syllabus is seen as beneficial;
 - f. Develop a specific syllabus and merge it into the new or modified existing curricula;
 - g. Test run the new curricula, get needed certifications (this step will depend on regulations of education system);
 - h. Introduce the new/modified curricula and syllabus to students/trainees.