From AV Skills Identification to AV training:
The Drive2theFuture approach

Carlo Giro, IRU

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Introduction

- ➢ Automated vehicles
  - ❏ Vehicles of the future
  - ❏ Various systems and sensors
  - ❏ Driver assistance, partially or fully substitution

- ➢ Impact on the labor sector
  - ❏ Jobs alleviation and creation
  - ❏ Reskilled and upskilled needs
  - ❏ Additional skills and knowledge

- ➢ Impact on the driver's role
  - ❏ Abstain from the driving task
  - ❏ Remote vehicle control and operation
  - ❏ Additional skills and knowledge

- ➢ New skills and knowledge
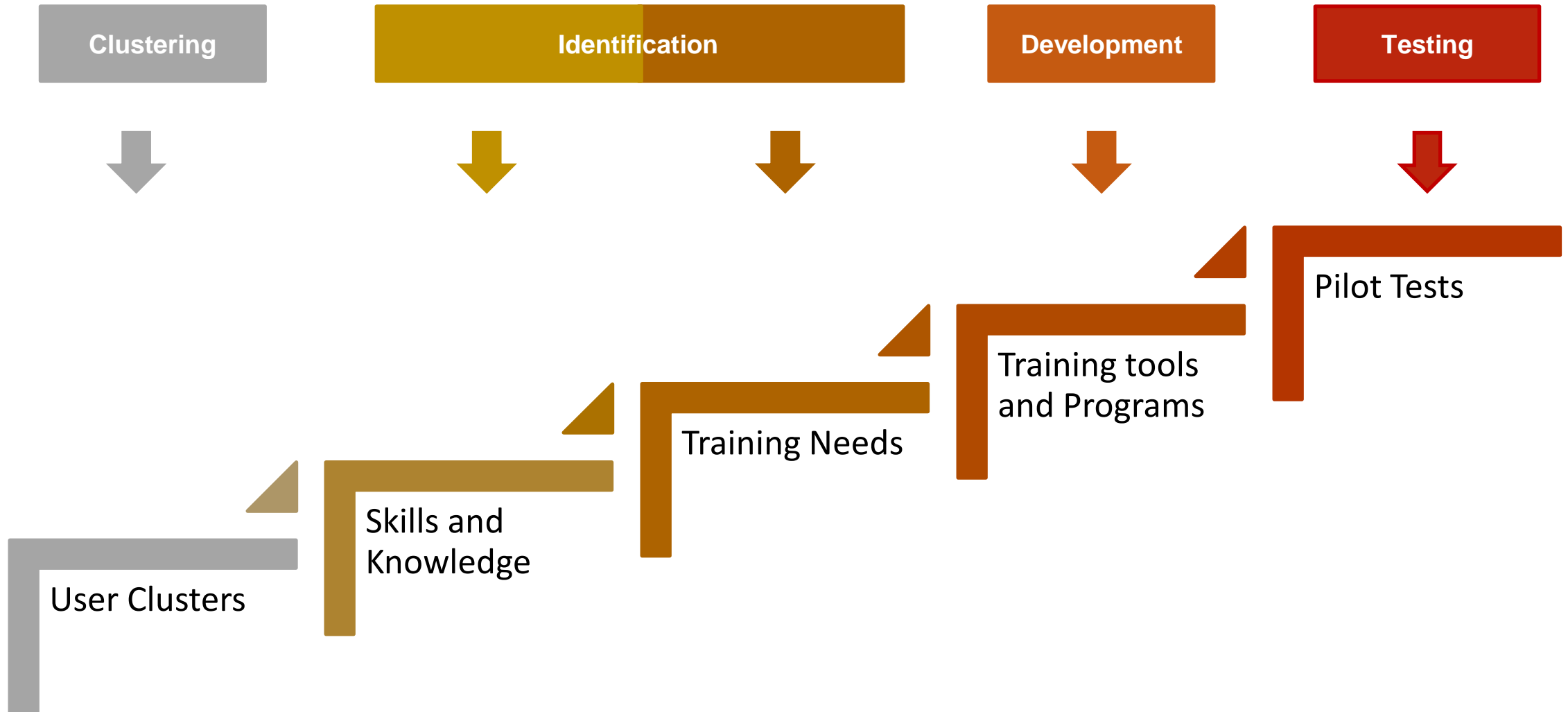 - ❏ New training needs, tools and programs
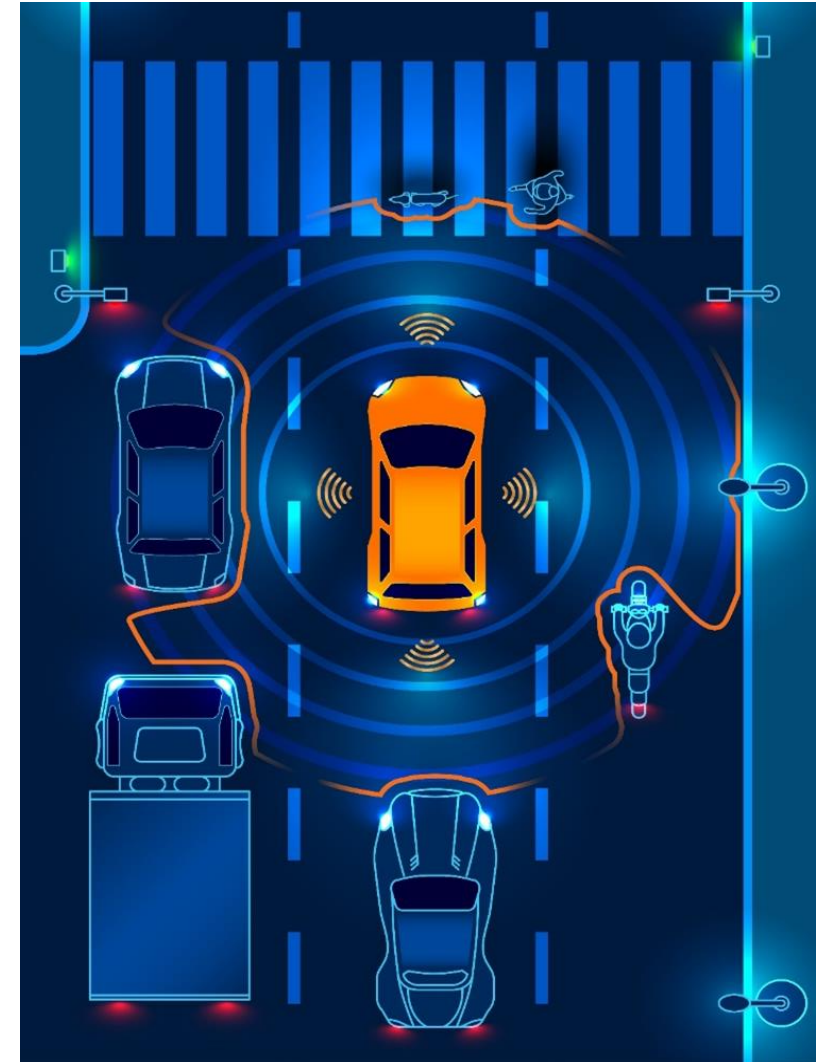
Objectives

➢Identification of skills and knowledge for AV operation

➢Identification of training needs to cope with the new challenges in AV operation

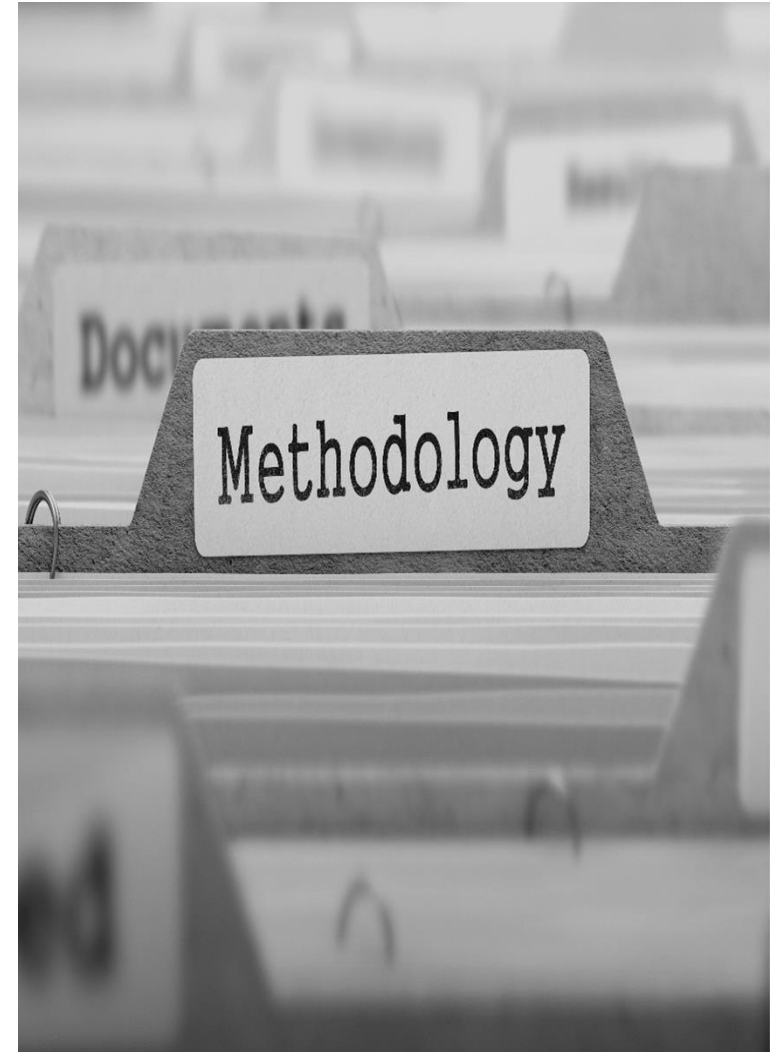➢Development of training programs fulfilling the training needs

Approach

DRIVE2
THE FUTURE

| Clustering | Identification | Development | Testing |

Pilot Tests

Training tools and Programs

Training Needs

Skills and Knowledge

User Clusters

Skills and Knowledge
Foteini Orfanou
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Skills and Knowledge - Methodology

➢ Projects Outputs/Deliverables

➢ Report

➢ Scientific Papers

➢ Studies

➢ Official Websites

➢ Experts interview

Skills and Knowledge - Methodology

Operator	User Type	Transport Mode	Level of Automation
• Professional • Private	• Driver • Passenger • Remote operator • AV Driver • Other (rail signaler, TMC operator, etc)	• Private Passenger Car • Taxi • Bus • Truck • Train • Tram • Ship • Drone	• Level 1 • Level 2 • Level 3 • Level 4 • Level 5

Results - Road Sector (1/2)
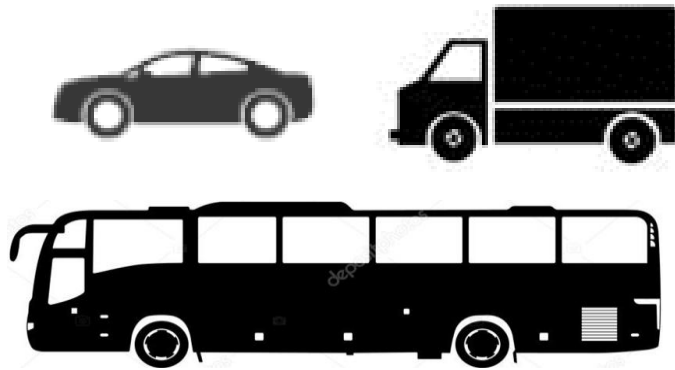
Social Skills

Programming/ Computer Skills

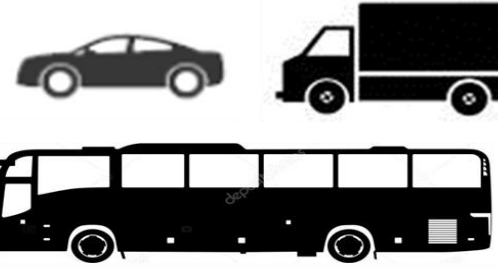Engineering/ Technical Skills

Driver Skills/ Knowledge

Remote Operator
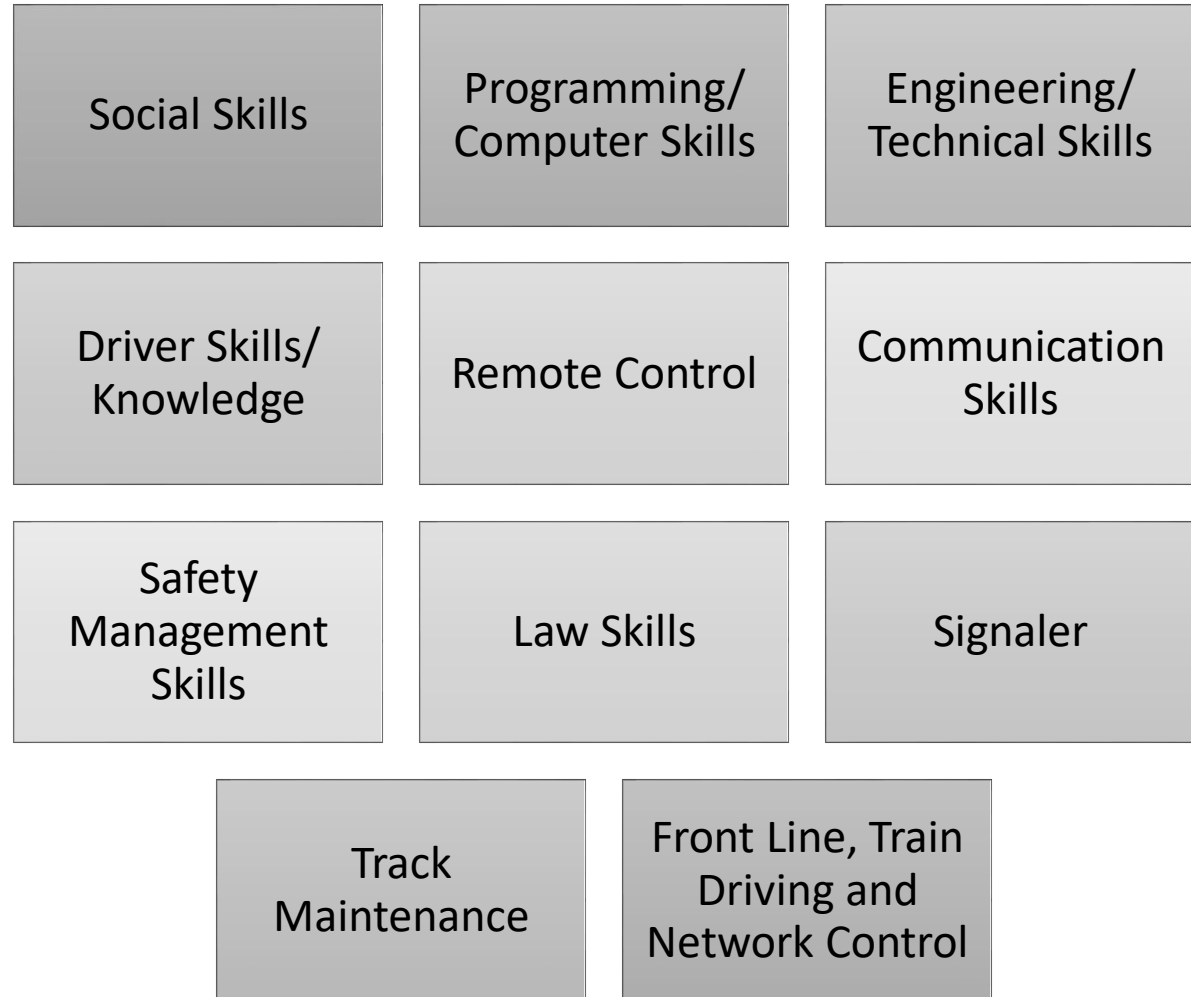
Communication Skills

Traffic Management Skills

Law Skills

Results – Road Sector (2/2)

Skills	Description
Social Skills	Communication, Team working, organization, problem-solving
Programming and Computer Skills	Artificial Intelligence, Algorithms, software development, backend/frontend skills, machine learning, higher-order skills in big data analysis
	Cybersecurity and encryption protection, security systems for protecting external communication for AVs, data protection
Engineering/ Technical Skills	Sensors and systems development, hardware development, Robotics ,electrical engineering, automotive engineering, digital road map database access, firmware, Smart Traffic Light controller system, smart signs, advisory road marking, etc
	Simulation Skills
Driver Skills and Knowledge	Cooperation and collaboration with the vehicle, efficiently monitoring and supervising the system, concentration maintenance
	Familiarity with all electronic devices and sensors on and inside the vehicle, limitations and capabilities
	Awareness of the location of the sensors and the systems
	Awareness of the decisions taken by the systems, operational readiness of the system
	Understand the information and warnings from the systems based on the surroundings
	Knowledge of differences among different levels of automation
	Situational awareness and transition of control skills
	Capability of recognizing errors and malfunctions and act properly
Communication skills	V2I and V2V communication model
	Wireless communication, ad hoc network, DSRC Multi-Channel Test Tool
Traffic management center	Collection and processing skills from the data transmitted from the infrastructure and the vehicles
Law skills	Legal framework and standards for the autonomous vehicle operation, liability issues in case of incident occurrence, data generated by V2X infrastructures to be compliant with national or international law

11/03/2021

Results – Rail Sector (1/2)

Social Skills	Programming/ Computer Skills	Engineering/ Technical Skills
Driver Skills/ Knowledge	Remote Control	Communication Skills
Safety Management Skills	Law Skills	Signaler
	Track Maintenance	Front Line, Train Driving and Network Control

Main Results – Rail Sector (2/2)

Skills	Description
Social Skills	Communication, Team working, organization, skills in timetable management, problem-solving, slit-second decision making, Knowledge in human factors for passengers and workers safety
Programming and Computer Skills	Artificial Intelligence, Algorithms, software development, backend/frontend skills, machine learning, higher-order skills in big data analysis Cybersecurity and encryption protection, security systems for protecting external communication for AVs, data protection
Engineering Skills	Sensors and systems development, hardware development, electrical engineering, systems for driverless and unattended train operation, automatic train protection and automatic train operation, **train operation in event in disruption, obstacle, people and animal detection for collision avoidance, existence of other trains on the route or lineside signaling observation, diagnostics,** Signaling technologies, Simulation Skills
Technical Knowledge	Knowledge in new signaling and position technologies, Knowledge of the European Train Control System (ETCS) and wireless delivery of mission-critical rail communications, digital interlocking system
Driver/Crew Skills and Knowledge	Same as in road sector **Maintenance of on route driving skills, knowledge of new on board systems** **Monitoring of the the passenger exchange, detection and accomplishment of emergency conditions, supervision of the train's state**.
Communication Skills	Wireless interface/connection and components, data transmission systems
Law skills	Legal framework and standards for the autonomous vehicle operation, liability issues in case of incident occurrence, data generated by V2X infrastructures to be compliant with national or international law
Skills for workers in front line control, train driving and network control	**Rail vehicle setup and deconstruction skills and knowledge for a safe and efficient pre-journey, in journey and post journey autonomous train operation, Skilled rail network controllers**
Safety management skills	Preparing for emergencies related to both safety and environmental protection, fatigue management
Remote Control Skills	Off site and remote fault support skills, skills and knowledge for Incident recovery procedures for autonomous trains and rail vehicles, including fault identification and rectification, remote operations

Social Skills

Programming/ Computer Skills

Engineering/ Technical Skills

Driver/Crew Skills/ Knowledge

Remote Control

Communication Skills

Safety Management Skills

Law Skills

Results - Maritime Sector (2/2)

Skills	Description
Social Skills	Communication, Team working, organization, **onboard and shore-based personnel**, problem-solving
Programming and Computer Skills	Artificial Intelligence, Algorithms, software development, backend/frontend skills, machine learning, higher-order skills in big data analysis, augmented and virtual reality skills and knowledge Cybersecurity and encryption protection, security systems for protecting external communication for AVs, data protection
Engineering/ Technical Skills	Sensors and systems development , hardware development, Robotics (able of performing maintenance work that cannot be handled by humans), electrical engineering, automotive engineering, obstacle detection, surroundings mapping, **mooring and unmooring systems, HD Maps of the relevant port transport infrastructure, naval engineer.** Modelling and Simulation Skills Airborne or **underwater drones can perform potentially hazardous inspection and maintenance tasks, either by remote control** or autonomously (in cooperation with programming and computer skills).
Driver/Crew Skills and Knowledge	Same as road sector Interoperability Skills, Docking skills, **Coast water crews inner-port navigation the mooring skills**
Law skills	Legal framework and standards for the autonomous vehicle operation, liability issues in case of incident occurrence, data generated by V2X infrastructures to be compliant with national or international law
Remote control and assistance skills	**Understand and interpret the pertinent data transmitted from the vessel to the shore-based facility in case of a machinery/equipment/hull damage event and any other case concerning safety** **Distinguish the different principles governing each type -Interoperability skills** **Mooring and unmooring operation skills** **Complex engines and machinery aboard monitoring**
Communication Skills	**Satellite communication capacity and the bandwidth, advanced data transmission technology systems, communication network**
Safety management skills	**Preparing for emergencies** related to both safety and environmental protection

Main Results – Aviation (1/2)

|			
Social Skills	Programming/ Computer Skills	Engineering/ Technical Skills	Driver/Crew Skills/ Knowledge
Remote Control	Communication Skills	Safety Management Skills	Law Skills
	Personal Resilience and Critical Thinking	Urban Environment Operation	

Results – Aviation (2/2)

Skills	Description
Social Skills	Communication, Team working, organization, problem-solving
Programming and Computer Skills	Artificial Intelligence, Algorithms, software development, backend/frontend skills, machine learning, higher-order skills in big data analysis Cybersecurity and encryption protection, security systems for protecting external communication for AVs, data protection
Engineering/ Technical Skills	Sensors and systems development, hardware development, **Robotics (able of performing maintenance work that cannot be handled by humans),** electrical engineering, **aeronautics**, automotive engineering, safe navigation systems development Modelling and Simulation Skills **Airborne or underwater drones can perform potentially hazardous inspection and maintenance tasks, either by remote control or autonomously (in cooperation with programming and computer skills).**
Driver Skills and Knowledge	Same as road sector Interoperability Skills
Law skills	Legal framework, regulation and operational rules, standards for the autonomous vehicle operation, liability issues in case of incident occurrence
Remote control and assistance skills and knowledge	More difficult and demanding than the on board control and supervision **Detection of suspicious activities or abnormal behavior of the plane** **Simultaneously monitoring and supervision of more than one unmanned airplanes** **Knowledge of characteristics of different types of aircraft, the routes they follow** **Preflight Check**
Safety management skills	**Preparing for emergencies** related to both safety and environmental protection
Communication skills	Data transmission system
Urban Environment Operation	Engineering/Technical/Programming Skills (**Landing and take off without a runway, obstacle detection and avoidance**)

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AV Training Needs
Zoe Agiasophiti, WEGEMT

Training needs- Scope of the Task
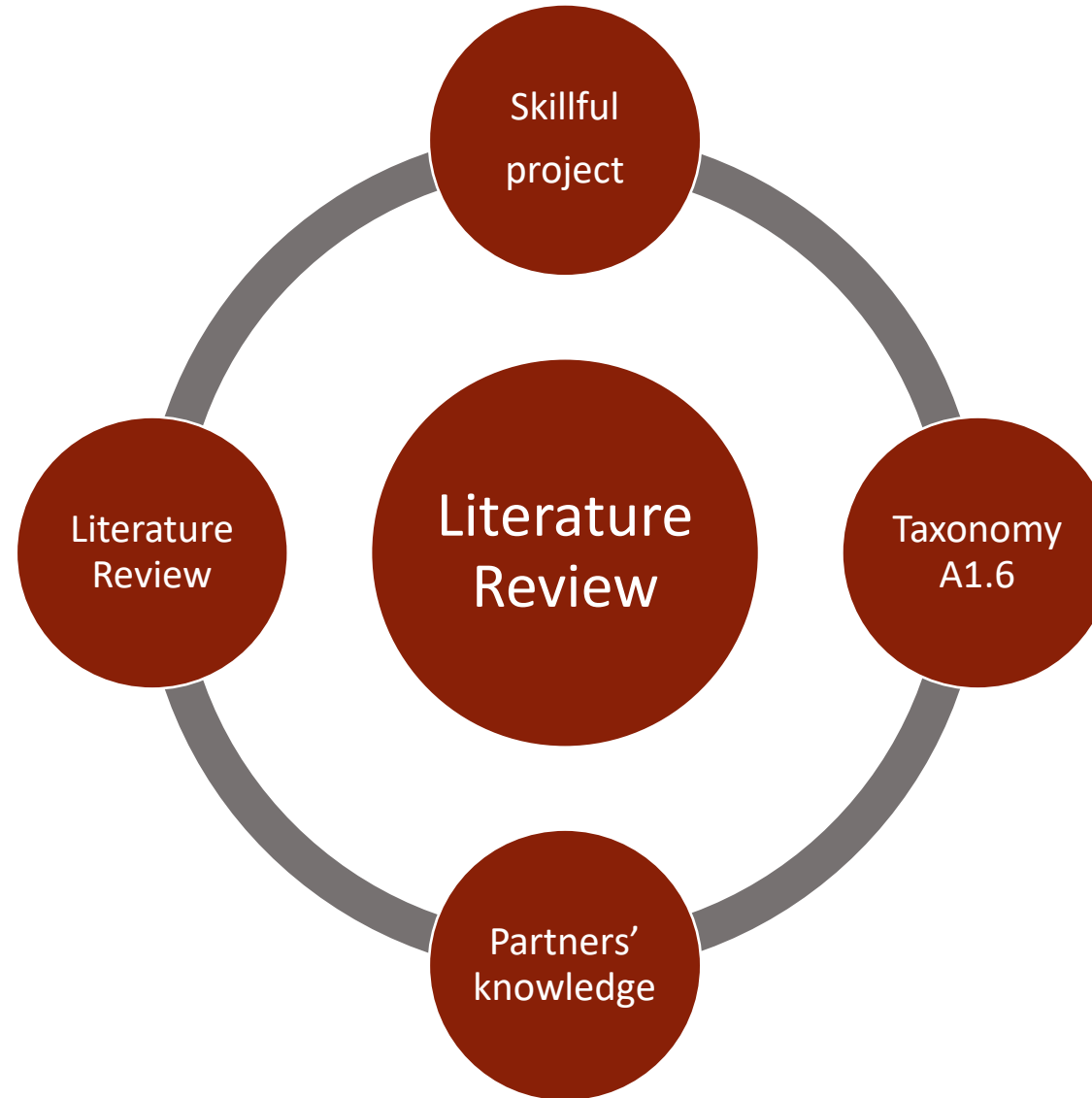
Training needs- Literature Review

➢ Projects Outputs/Deliverables

  e.g. SKILLFUL, FutureDRV, AIMESC Projects etc

➢ Reports, incl. conferences and roundtable reports

➢ Papers

➢ Studies

➢ Official Websites from Universities, vocational Training Institutes and Institutional Bodies programms, such as NOVIA University; Maritime UK; JAA – Training Organisation etc.

➢ Training courses provided by Institutions such as UITP, VTI, Easy Mile and VEDECOM

➢ Experts' interview

➢ Taxonomy A1.6

➢ User clusters D1.1

Training needs- Literature Review

➢Overall, 24 sources provided 30 cases.

MODE	CASES	SOURCES
Road	7	7
Rail	6	5
Maritime	7	7
Air (Drones)	6	3
Cross-modal	4	2
Total	30	24

Training needs for operators

- Familiarization of drivers with automation levels and operational functions of each vehicle.

- Training regarding the hardware and software of the vehicle.
- Training in trouble-shooting, in having enhanced decision making and problem solving skills.
- HMI adaptation: vigilance, driver-readiness in transitions between manual and automated driving, reaction, in-vehicle HMI strategies
- Training on the take-over behavior after a take-over request or after a critical event taking place, requiring the driver to intervene in order to avoid an accident.
- Hands-on training for operators using an automated vehicle in order to gain experience is essential. the interaction between av and other users will lead towards acceptance and HMI adaptation.

Bus drivers and passengers

● Training with multi-platform tools for VR simulation to increase acceptance, safety, improve performance, HMI adaptation, enhance users' perception of the AV's operation.

Results - Road Sector (3/4)

TMC operators

● Training to increase acceptance after hands-on experience of all levels of automation in urban, rural, highway and specific applications, such as tunnels, constructions and bridges, and environmental conditions (i.e. co-pilot for adverse weather, unknown environments, unknown type of vehicle, etc.).

● Training for behaviour adaptation ("mimicking", "flocking") of non-equipped vehicles.

● Training for the impact of mixed and automated flows to traffic flow (micro/macro) simulation, incl. big data analytics for scaling.

● Training to understand liability and operational issues per automation level and user cluster.

Results - Road Sector (4/4)

All users

● The basic technical characteristics of automation, i.e. levels of automation; architecture.

● AV driving skills and knowledge remote operation skills

● Customized training considering age, gender, IT literacy, socioeconomic factors and understanding of automation in order to increase levels of acceptance and capacity.

● Understanding new mobility services and business models arising with automated transport.

● Recognizing the implications for mobility in cities that autonomous and connected vehicles will bring.

● Social skills: communication, team-working, organisation, problem-solving

● Legislation and Liability training

● Life-long learning schemes.

Train drivers

➢ Training with of Regina type simulators that will lead to a better understanding, enhance performance, increase safety and HMI adaptation.

➢ Training that will enhance their awareness, performance and acceptance; ensure safety in automated operations supervision, incl. operator's HMI & strategies for rail transport.

➢ Continuous monitoring, operational skills, as well as assessing risks and decision making.

➢ HMI adaptation

➢ European Rail Traffic Management System (ERTMS)

➢ European Train Control System (ETCS)

Traffic controllers operators

- European Rail Traffic Management System (ERTMS)

- Upskilling and to a point re-composition of their profession that will resemble that of air traffic controllers, in terms of task complexity, autonomy, managing operative procedures, decision making, cognitive and communication skills (for ERTMS).

- European Train Control System (ETCS)

- HMI intervention in case of failure with focus on the take-over procedure, to ensure safety.

- Reaction time response training (incl. vigilance and attention) for managing circulation.

Train maintenance staff

- European Rail Traffic Management System (ERTMS)

- focus on acquiring technical knowledge and e-skills, emphasizing in interdisciplinary abilities.

- Specialization in equipment's design and technological content with appropriate training when new equipment arrives is essential.

- Team-working and communication skills require a careful and extensive training curriculum that will equip staff accordingly.

Rolling stock inspection staff

- ➤ European Train Control System (ETCS)

- ➤ Existing staff will need updated knowledge of the different modules and the interaction between old systems and ETCS, as well as acquire knowledge on the related software. As harmonization is a long and complex process, the different versions of the systems' application should be considered in the training process.

Results - Rail Sector (5/5)

All
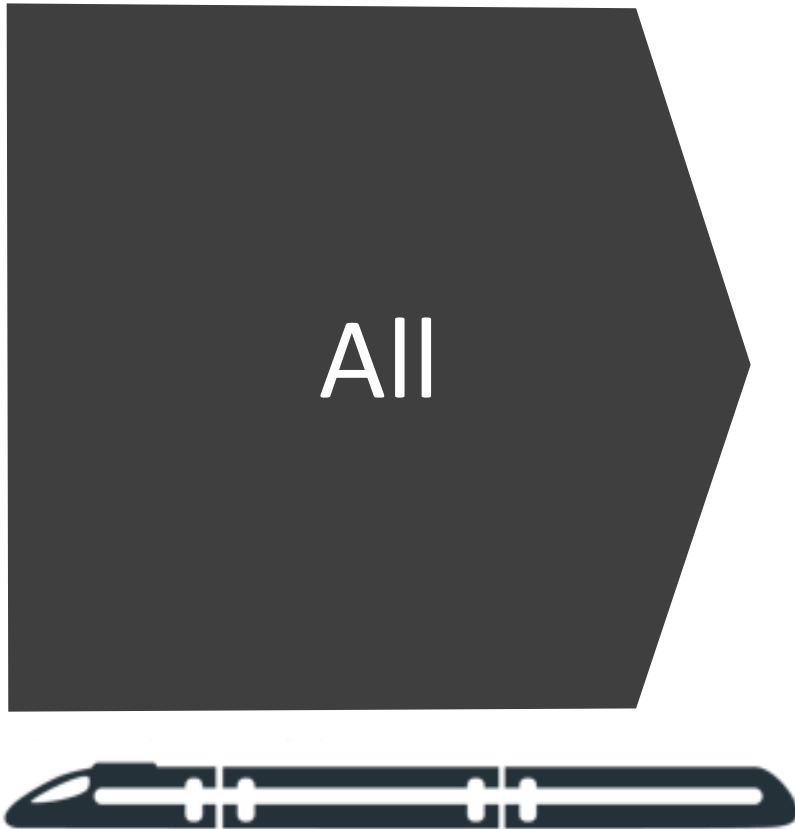
- Technical and engineering skills
- Global System for Mobile Communication-Railway (GSM-R) training
- Artificial intelligence, Satellite Based Augmentation Systems (SBAS), Galileo GNSS satellite navigation system
- ICT skills, handling big data, Cybersecurity.
- Training in legislation
- Communication skills incl. problem-solving and decision-making skills
- Perceptual and cognitive skills, such as selective attention and situational awareness.
- Lifelong training

Passengers, pilots and operators

- Training to increase awareness and acceptance by passengers, pilots, and operators.

- Training to increase the users understanding of systems operation and deskilling issues.

- Increase of vigilance, perception and situation awareness in transition from operator to systems monitor.

- Cost efficiency of automated vs non-automated operation.

Training needs for AV-operators

- Technical and Engineering training needs specifically adapted for on- and off-board personnel

- Operational training needs

- HMI (incl. AI)

- Interoperability training

- Cybersecurity

- Data analysis skills and data handling.

- Training on efficient planning, watchkeeping, scheduling, equipment dispatching, monitoring and remote control of ship handling for the shore control center.

Training needs for AV-operators

- Development of cognitive abilities is essential in order to ensure safety with the enforcement of decision making, and risk-assessment skills.

- Training tailored according to qualifications and experience.

Results – Maritime Sector (3/4)

Port workers, i.e. crane operators, gate entrance controllers, dockers

- Upskilling and further training and/or retraining is necessary, such as quay cranes operators, gate entrance controllers and dockers.

- In the case of dockers, training would have to be customized according to the subject port or terminal and the operational processes used.
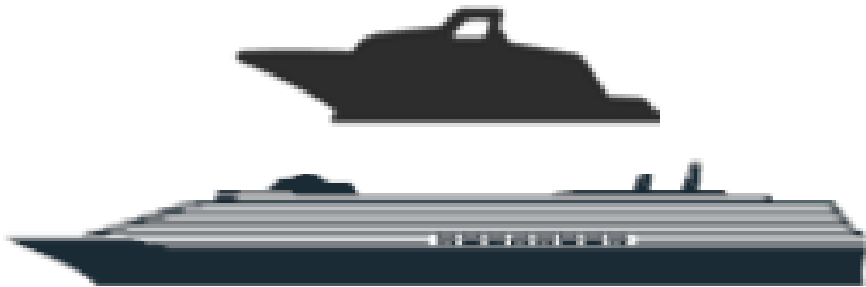
Results – Maritime Sector (4/4)

All users

- Programming/ Computer Skills

- Social Skills

- Training in Legislation and Liability issues.

- Safety Management

- Customised Training

- Lifelong Learning Training

Results – Aviation Sector (1/2)
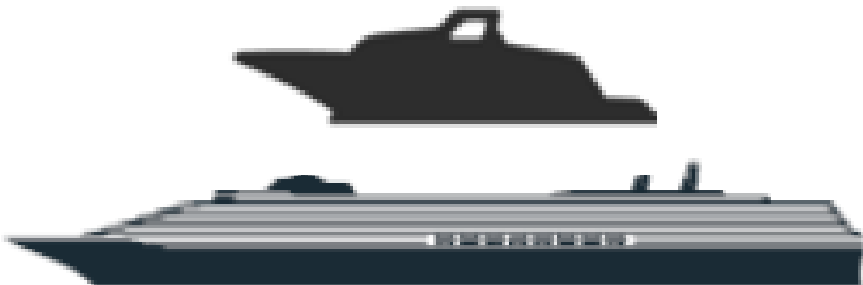
Pilots and operators

- Training on operators HMI and strategies for air transport

- Simulated behaviour training in non-standard situations.

- Impact of adaptive HMI on drone flight planning and execution.

- Drone purpose of use correlation to its HMI.

- Risk of drone accidents.

- Situational awareness for the drone operator and the supervising controllers.

- Liability and operational issues, incl. safety, security and cybersecurity

Pilots and operators

- Training on the regulatory framework that will establish categories based on the taxonomy, operations and technical aspects of each system, as it is provided by different international authorities (e.g. ICAO, JARUS, EASA) to date.

- Training for operator's certification

- Training for UAS airworthiness

- Social skills, i.e. communication, team working, problem solving skills.

- ICT training on AI, algorithms, AV and AR skills, data protection

Findings-Training Needs

➢Automation is not achieved in the same levels across all modes.

➢Some training needs or approaches seem to be horizontal across modes:

❑ need for a lifelong strategy, because of continuous developments and evolution of the systems.

❑ constant level of awareness and functionality of the HMI

❑ understanding and handling big amount of data, e.g. of data transmitted from the sensors.

❑ awareness of new mobility services, business models and implications arising through automation.

❑ cybersecurity and emergency management

❑acquire skills in transport legislation, in order to ensure safety.

Training Tools

- Combine traditional learning with e-learning, self-paced learning etc.

- Use case scenarios

- Hands-on training

- Customized training (i.e. targeted to age group).

- Wizard of Oz

- Interactive training programs: Use of on-board video tutorials, Virtual Reality (VR) simulators and Augmented Reality (AR).

AV Training Programmes
Carlo Giro, IRU

Modes covered

Road

Rail

Maritime

Air

Users targeted

Road	Rail	Maritime	Air
• AV bus drivers • AV truck drivers • Hired car/taxi drivers	• Rail drivers, signallers and dispatchers	• Automated workboat pilots	• Drone operators

Types of tools used

- ➢ VR/AR
- ➢ Curricula
  - ❑ Classroom teaching
- ➢ Movies
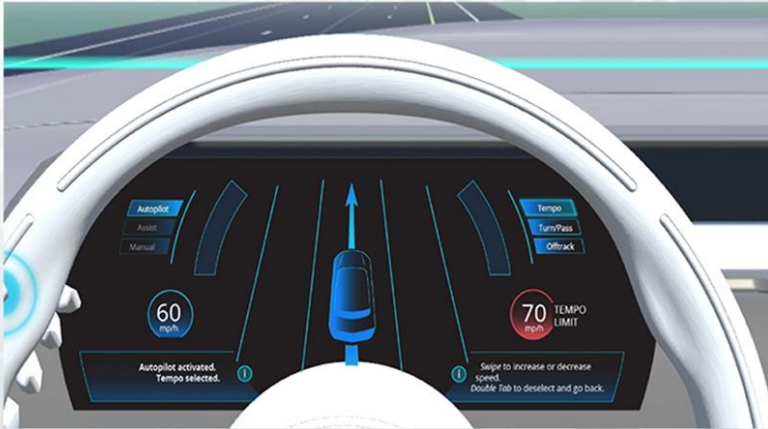
Automation at docking at bus stop. Hand/Take over in amber, automation mode in blue

Mode of transportation	Role	Scenario - benefit of using	Tool to use
Passenger car	Driver	Safe operation and awareness of how to interact with an automated car	VR / playback movie
Passenger car	Pedestrian	Safe behavior at zebra crossings	VR / playback movie
Partly AV bus	Driver	Safe and efficient docking at bus stop	VR / playback movie
Partly AV bus	Pedestrians	Safe and efficient interactions while waiting at bus stop	VR / playback movie
AV shuttle	Pedestrian	Safe interaction with shuttles when passing its path	Movie – real world
AV shuttle	Cyclist	Safe interaction with shuttles when passing its path	Movie – real world
AV shuttle	Passenger	Awareness of how to use and behave in an autonomous shuttle	VR / playback movie
Drone	Pilot	Safe operation and awareness of how to interact in an efficient way with a drone	VR / playback movie

E-learning

Titles of training programmes (1/2)

➢ Development of AV training programmes is ongoing:

❑ Road:
- ✓ Introduction to Autonomous Trucks
- ✓ Introduction to Autonomous Public Transport
- ✓ Evolution of Traffic Management towards CCAM
- ✓ Driving a highly automated car of the future
- ✓ Riding in a future autonomous shuttle
- ✓ How to safely overtake an autonomous shuttle
- ✓ Pedestrian interaction with an autonomous shuttle
- ✓ Train pedestrians regarding automated vehicles on the road

Information during the ride

More examples

Choose your destination

- On the screen, you can choose your destination
- You are always up-to-date during the ride:
  - ❑ You see the route of the vehicle on the screen,
  - ❑ your destination,
  - ❑ the remaining time until you reach your destination,
  - ❑ and the current speed.

Please help us by **keeping distance** when passing the bus.

Titles of training programmes (2/2)

❑ Rail:
    ✓ Train drivers and signalers as remote operators
    ✓ Train driving exercise for train dispatchers

❑ Maritime:
    ✓ Introduction to Autonomous Workboats

❑ Air
    ✓ Introduction to Autonomous Drones

The first facing turnout is to the right direction,

Training programme template

➢ For the analysis and description of the different training programmes that will be used in the project, a dedicated template has been developed:

❑ Introducing the trainings and describing its main objectives and expected learning outcomes.

❑ Correlating each training to the project's:

✓ target **users and stakeholders** groups;

✓ **use cases**;

✓ identified **training needs and training tools and methodologies**.

Course "Introduction to Connected and Automated Freight Vehicles"

Proposed by – IRU

Course description/introduction – Connected and Automated Driving will impact the commercial road transport sector. For this reason, this introductory course gives an overview of the state of the art concerning freight vehicles and automation. The course explains the difference between SAE automation levels, outlines the use cases applicable to road freight transport and provides examples of relevant legislation. The course also highlights EU research and innovation activities which look into different aspects of automated driving related to freight vehicles.

Objectives - The course aims to raise awareness about initiatives and developments regarding the commercial road freight transport sector and automated driving.

Learning outcomes (LO) - At the end of the course, trainees should be able to gain knowledge on: different SAE automation levels in road transport and which responsibility they have as a driver; general understanding of specific definitions; relevant legislation; etc.

Duration – 1 hour

Correlation to WP1 Use cases

- Training for road transport

Correlation to WP4 training needs:

- Familiarization of drivers with automation levels and operational functions of each vehicle, since there are differences.
- Training that will have an impact on driver's behaviour.
- Legislation and Liability training: Transport Legislation should be adapted to the new needs that will arise through automation. When available, operators must be trained in order to acquire necessary knowledge and skills in transport legislation, so as to ensure safety.

Use of WP4 identified training tools & methodologies:

- Traditional lecture

Correlation to WP1 target user/stakeholder clusters:

- Truck drivers/operators
- Remote operators
- Truck passengers
- Other road users when relevant

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