5th Conference on Sustainable Urban Mobility
Virtual CSUM2020

17-19 June 2020

A taxonomy of skills and knowledge for efficient autonomous vehicle operation

Presenter: Foteini Orfanou

Authors: Foteini Orfanou, Eleni Vlahogianni, George Yannis

Introduction

- Automated vehicles
  - 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

Scope

- Identification of skills and knowledge for AV operation
  - All transportation sectors
  - All automation levels
  - Professional and private drivers
  - Various categories of the labor sector and professions
- Contribution in HMI development
  - Anticipated operator skills and training needs

Methodology

- Projects Outputs/Deliverables
- Report
- Scientific Papers
- Studies
- Official Websites
- Experts interview
  - Classification of skills/knowledge
  - Operator – User Type – Transport mode – LoA

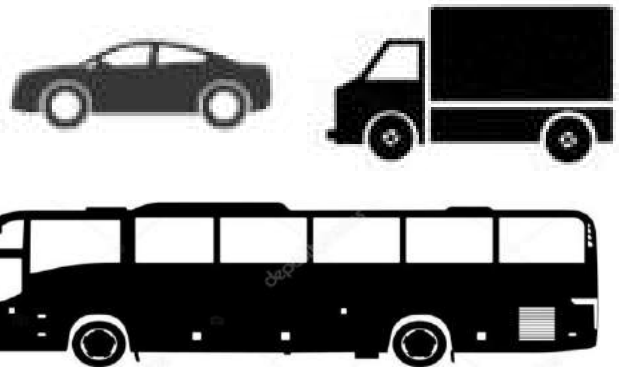
Results – Road Sector

Social Skills

Programming /Computer Skills

Engineering/ Technical Skills

Law Skills

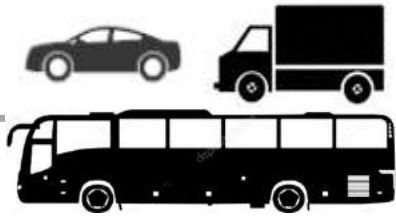


Driver Skills Knowledge

Traffic Management Center

Communication Skills

Remote Operation



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 analytics 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 Testing and 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, Understanding of 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
Remote operation	Skills and knowledge for efficient remote monitoring of the PT and freight and logistics transport operations in confined areas
Communication skills	V2I and V2V communication model, Wireless communication, ad hoc network, DSRC Multi-Channel Test Tool
Traffic Management Centre	Collection and processing skills from the data transmitted from the infrastructure and the vehicles
Legal knowledge	Legal framework and standards for the autonomous vehicle operation Social legislation and its adaptation to autonomous vehicle operations (driving and rest time rules) Liability issues in case of incident occurrence Data generated by V2X infrastructures to be compliant with national or international law

Results – Rail Sector

Social Skills

Programming /Computer Skills

Engineering/ Technical Skills/Knowledge

Legal Knowledge

Driver/Crew Skills Knowledge

Track Maintenance

Communication Skills

Front line, train driving and network control Skills

Remote Control Skills

Safety management skills

Signaler

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/ Technical Skills/Knowledge	Sensors and systems development, hardware development, Robotics, electrical engineering, automotive engineering, systems for driverless and unattended train operation, automatic train protection and automatic train operation, train operation in event of disruption, obstacle, people and animal detection for collision avoidance, existence of other trains on the route or lineside signalling observation, diagnostics, Signaling technologies, Testing and Simulation Skills Knowledge in new signalling 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 for road sector (Table 1) Maintenance of on route driving skills, knowledge of new on board systems Monitoring of the passenger exchange, detection and accomplishment of emergency conditions, supervision of the train's state.
Communication skills	V2I communication model Wireless communication, ad hoc network, Wireless interface/connection and components, data transmission systems
Legal 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 train driving, front line 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 safety and environmental protection, fatigue management, safe management of door closures
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, processing of large amount of data
Signaler	Knowledge of all new signalling technologies and systems, ready to intervene efficiently any time
Track Maintenance	Knowledge of replacing the components

Results – Maritime Sector

Social Skills

Programming /Computer Skills

Engineering/ Technical Skills

Legal Knowledge

Driver/Crew Skills/ Knowledge

Remote Control Skills

Safety management skills

Communication Skills

Skills	Description
Social Skills	Communication, Team working, organization, skills in timetable management, problem-solving, slit-second decision making, onboard and shore-based personnel 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, 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, electrical engineering, automotive engineering, obstacle detection, surroundings mapping, mooring and unmooring systems, HD Maps of the relevant port transport infrastructure, naval engineer Testing 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 for road sector (Table 1) Knowledge of new on board systems, Interoperability Skills, Docking skills, Coast water crews inner-port navigation the mooring skills Monitoring of the passenger exchange, detection and accomplishment of emergency conditions, supervision of the vessel's state.
Communication skills	Satellite communication capacity and the bandwidth, advanced data transmission technology systems, communication network, V2V and V2I communication
Legal 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
Safety management skills	Preparing for emergencies related to both safety and environmental protection
Remote Control 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 of vessel-Interoperability skills Mooring and unmooring operation skills Complex engines and machinery aboard monitoring Data analytic experts and system controllers

Results – Aviation Sector

Social Skills

Personal resilience and critical thinking

Programming /Computer Skills

Legal Knowledge

Engineering/ Technical Skills

Remote Control Skills

Driver/Crew Skill/ Knowledge

Safety Management Skills

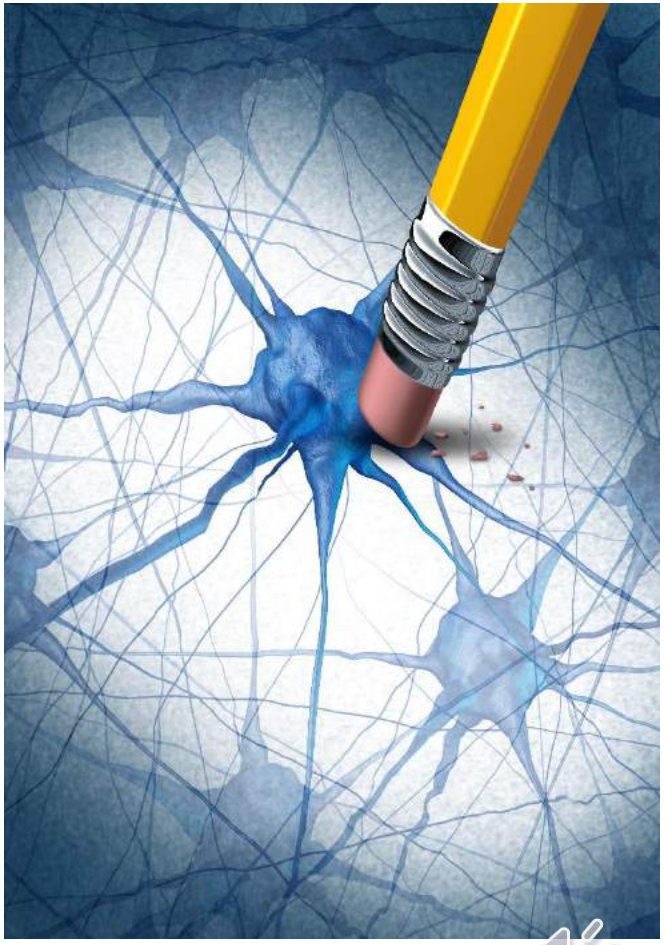
Communication Skills

Urban Environment operation Skills

Skills	Description
Interpersonal Skills	Teamwork skills, conflict management skills, stress management skills, organization, leadership, skills in timetable management, slit-second decision making
Personal resilience and critical thinking	Identify and manage risks effectively, ability to cope with complex and stressful situations, problem solving, workload management skills
Programming and Computer Skills	Artificial Intelligence, Algorithms, software development, backend/frontend skills, machine learning, higher-order skills in big data analytics, 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, aeronautics, automotive engineering, safe navigation systems development Testing 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 for road sector (Table 1) Knowledge of new on board systems, Interoperability Skills, Monitoring of the passenger exchange, detection and accomplishment of emergency conditions.
Communication skills	Satellite communication capacity and the bandwidth, advanced data transmission technology systems, communication network, effective communication skills, emergency communication skills
Legal 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
Safety management skills	Emergency Plan preparation, risk assessment, emergency management, application of procedures, effectively monitors aircraft using automation
Remote Control Skills	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
Urban Environment Operation	Engineering/Technical/Programming Skills (Landing and take-off without a runway, obstacle detection and avoidance)

Conclusions

- Significant impact of automation
  - Driver's role
  - Labor sector
  - All stages of AV operation
- Similarities among all sectors
  - Social, programming, engineering, communication and legal skills
- Differences among all sectors
  - Individual systems requirements
  - Remote control needs



Thank you very much for your attention

Foteini Orfanou, Eleni Vlahogianni, George Yannis

National Technical University of Athens

forfanou;elenivl;geyannis@central.ntua.gr