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Review

Research and Innovation Supporting the European Sustainable and Smart Mobility Strategy: A Technology Perspective from Recent European Union Projects

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Abstract: Many concepts and innovations aim to improve transport and mobility, while helping to decrease the externalities that transport imposes on society. Research and innovation monitoring tools are important to assess the current state of development so that research funding and policy making efforts can be aligned optimally. This paper presents a comprehensive approach which links technological developments in the transport sector in Europe to the objectives of the most recent policy developments, in particular, the 2020 European Sustainable and Smart Mobility Strategy. It does so by identifying and evaluating technologies from European Union-funded projects between 2007 and 2020, by means of a technology taxonomy. Information is provided at an aggregated level on funding characteristics of both projects and the technologies, while at the same time, the level of maturity of researched technologies in the most recent projects is identified. This study can aid policy makers to support the future development of transport technologies as part of pertinent policy strategies and identify research gaps.

Keywords: transport research and innovation; Sustainable and Smart Mobility; technology taxonomy; technology maturity

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1. Introduction

In the European Union (EU), transport is a key economic sector with an estimated EUR 599 billion in gross value added (GVA) for the transport and storage services or 5.0% of total EU GVA in the EU-27 in 2018 [1]. It represents 19.5% of the total greenhouse gas (GHG) emissions [2] and is the only sector that has not seen a decrease in GHG emissions between 1990 and 2018 [3]. In 2019, transport represented 30.9% of final energy consumption [4].

Transport systems include physical and organizational elements and are in general intrinsically complex. These elements influence each other directly and/or indirectly, linearly or nonlinearly, and may have feedback cycles [5]. As Sussman [6] argues, the transport system can be considered as a complex, large-scale, interconnected, open, socio-technical system, including elements from the built environment and the social-political domains. In this sense, any change in a transport subsystem, even if predictable separately, can be difficult to predict or even be counterintuitive, when considering the interactions, especially with the users. This is easy to comprehend considering that the nature and extension of the relationships in the interrelated elements of such a system are usually not easily identifiable in terms of their directionality, magnitude, and time scales [7]. In addition, any organizational innovation including new mobility concepts that do not require hardware modifications can be also regarded as a new technology since they aim to use hardware in a different manner [8].

In parallel, the technological applications across the various transport systems have been increasing in numbers and level of complexity along with the overall technological

development in related sectors (energy, information and communication technology, etc.). In fact, digital technologies, connectivity, and social media are transforming traditional concepts of mobility [9–11]. New mobility services and concepts are emerging, such as mobility as a service and cooperative, connected and automated mobility, and give rise to innovative mobility services [12–14]. Smartphone applications offer real-time analytics and data on traffic conditions [15]. Technology-driven eco-driving solutions can have a positive influence on fuel efficiency [16]. Smart parking solutions allow people to optimize time, and reduce fuel consumption and carbon dioxide emissions [17]. New forms of freight delivery appear as viable alternatives, with drones nowadays proposed for the (last-mile) delivery of goods [18]. Crowdsourcing and sensors in cars can be used in the future for monitoring the condition of the transport network [19]. Hyperloop technologies have the potential to revolutionize long distance trips [20].

At the same time, decarbonising transport will require an increase in the production and use of biofuels in all transport sectors, especially in aviation [21,22] and waterborne transport [23–25], together with a further diffusion of electric (light) road vehicles [26], with the role of current and future policies being crucial. Regarding sustainable alternative fuels, the role of biofuels and advanced biofuels (produced from feedstocks) between 2040 and 2050 will be very relevant [27]. However, transport sectors are characterized by different levels of innovation capacity, something that has to be taken into account in policies targeting innovation [28]. Another aspect of the challenge is that public policy priorities in the aftermath of the COVID-19 pandemic will need to adopt measures that stimulate innovation in transport technologies and services, supporting in particular active travel, public transport, railways, and aviation [29].

With this perspective, technological developments are fundamental in order for the transport sector to address current and future socio-economic challenges. These developments will be achieved through targeted research and innovation (R&I), which will lead to new quality standards in relation to the mobility of people and goods [30]. In particular, given the fundamental role of transport and its impact on the economy and quality of life, a need for the adoption of energy efficient innovations emerges, innovations that are inclusive of recent technological developments, together with a legislative framework that fosters both energy sustainability and economic growth [31].

From a policy perspective, in Europe, targeted policy actions over the last decade focus on the improvement of mobility and transport. Already in 2011, the European Commission's (EC) White Paper [32] identifies 40 concrete initiatives to build a competitive transport system over the next decade, aiming to increase mobility, remove major barriers in key areas, drive growth and employment, and, to reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050. An evaluation of the White Paper took place in 2020, aiming to examine all areas where it made policy proposals.

In May 2017, the EC adopted the Strategic Transport Research and Innovation Agenda (STRIA) as part of the 'Europe on the Move' package [33,34], which highlights main transport R&I areas and priorities for clean, connected and competitive mobility. Seven STRIA roadmaps have been developed covering various thematic areas, namely:

— Connected and automated transport (CAT);
— Transport electrification (ELT);
— Vehicle design and manufacturing (VDM);
— Low-emission alternative energy for transport (ALT);
— Network and traffic management systems (NTM);
— Smart mobility and services (SMO);
— Transport infrastructure (INF).

In May 2018, the EC published the third Mobility Package with the objective to allow citizens to benefit from safer traffic, less polluting vehicles, and more advanced technological solutions, while supporting the competitiveness of the EU industry [35].

The 2019 European Green Deal aims at a 90% reduction in emissions by 2050 [36]. Considering that transport currently accounts for a quarter of the EU's greenhouse gas

emissions, and this figure continues to rise as demand grows, considerably increasing the uptake of clean vehicles and alternative fuels and moving to more sustainable transport in general, will help meet this objective.

The EU 'Sustainable and Smart Mobility Strategy' (SSMS) presented in December 2020 and the accompanying action plan of 82 initiatives aims at achieving a modern, green, and more resilient EU transport system [37].

In July 2021, the EC adopted legislative proposals aiming to achieve climate neutrality in the EU by 2050, including the intermediate target of an at least 55% net reduction in GHG emissions by 2030 [38]. All transport modes—road, rail, aviation, and waterborne—will have to contribute to this aim.

Going back to STRIA and its roadmaps, they set out common priorities to support and speed up the research, innovation, and deployment process leading to technology changes in transport. Their implementation is supported by the Transport Research and Innovation Monitoring and Information System (TRIMIS), an effective monitoring and information mechanism developed by the authors at the EC's Joint Research Centre (JRC). TRIMIS, funded under the Horizon 2020 Work Programme 2016–2017 on Smart, Green, and Integrated transport [39] provides a holistic assessment of technology trends and transport R&I capacities, publishes information and data on transport R&I, and develops analytical tools on the European transport system.

Contrary to other transport policy-support tools, TRIMIS provides an integrated bidirectional monitoring and assessment of transport innovation approach [40], both backward looking using historical data, but also forward looking, through the development of an inventory on new and emerging technologies and trends in transport, complemented by the use of strategic foresight [41,42].

Building on the TRIMIS groundwork and analyses, this paper identifies and evaluates technologies in transport from European Union-funded projects. To this end, the TRIMIS technology taxonomy is used, which is built through a grounded theory approach, and comprises more than 850 technologies that fall under 45 technology themes. The top technologies in terms of funding in the period 2007–2020, are identified, belonging to the STRIA roadmaps on connected and automated transport, network and traffic management systems, and smart mobility and services. The technologies are then linked to the flagship ambitions of the 2020 European SSMS, which has set out an action plan for transport policy in Europe for the next four years. Focusing on the latest projects since 2014, a macro level technology maturity analysis is carried out, to identify those technologies that are at an early stage of research and those that can be pushed forward to demonstration and deployment. The principal merit of this study is linking technologies identified in a structured manner to transport policies, something that constitutes a rigorous and fair approach compared to the fragmented information usually provided in ad hoc technology analyses.

This study intends to help policy makers support the future development of transport technologies as part of relevant policy actions, while at the same time, helping researchers to forge collaborations and identify research gaps. The paper consists of the following parts: after the introduction, the next section discusses the materials and methods, including an overview of the methodology used in TRIMIS for transport R&I assessment and technology analysis. Following that, Section 3 provides some key metrics on EU transport R&I, including relevant identified technologies and their maturity phase. On this basis, Section 4 links the identified technologies to the EU "Sustainable and smart mobility strategy" ambitions and provides a discussion of the findings towards the development of these technologies. Section 5 provides the conclusions.

2. Materials and Methods

For this study, the TRIMIS database is used, which covers more than 8000 European or national transport-related R&I projects, including projects from Joint Undertakings and Joint Technology Initiative Programmes.

Figure 1 provides an overview of the TRIMIS transport R&I database structure [43]. It is characterized by four distinctive fields (A, B, C, D), with each field containing one or more different tables. The main part (field A) includes the project table, program table, technology table, and organization table. The projects in the database are labelled according to which STRIA roadmap their research is relevant to, with the possibility of being tagged with multiple roadmaps.

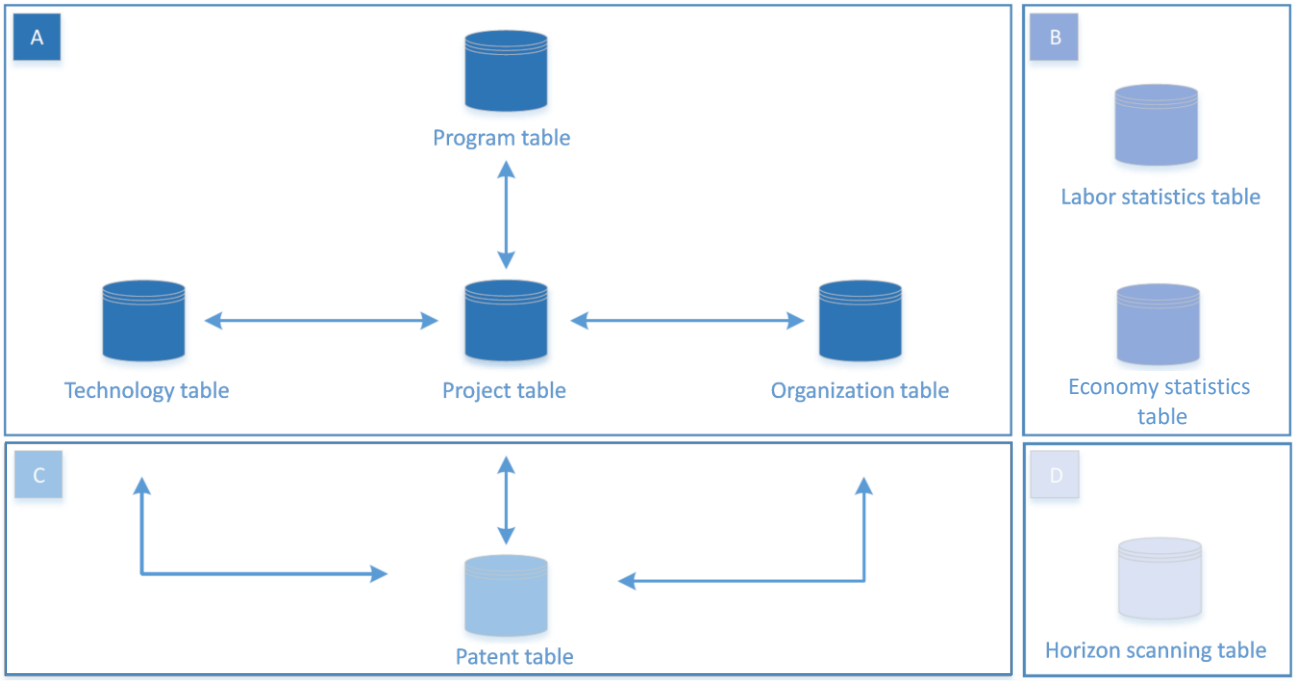

Figure 1. TRIMIS database structure (adapted from [43]).

The TRIMIS technology table derives from the TRIMIS project table. It focuses on technologies researched in European FPs, while, selected projects funded by member states (included in the TRIMIS project database) also are included in the analysis where relevant. The technologies are identified within technology themes through a grounded theory approach [44]. An iterative approach led to the development of a consistent taxonomy for transport technologies and technology themes. Figure 2 provides an overview of the methodology used for the technology assessment of the projects [45].

1. The results of a study that identified technologies within European transport research projects [46] were analysed. Based on this review, a standardized approach has been established on what constituted a distinct technology and how to label them.
2. All project descriptions were assessed and flagged when a technology was mentioned or hinted.
3. The full list of technologies was evaluated, and the labelling of similar technologies was aligned using also existing taxonomies as a basis.
4. When the technology list was established, a number of overarching technology themes was defined. An extensive list of themes was created and consequently reduced to the minimum number of themes under which all technologies could still be logically placed.
5. The funds associated with each technology were determined by linking them with the total project budget. If multiple technologies were researched in the project, the budget allocated to the technology of interest was determined by dividing the project budget by the number of associated technologies.
6. A set of metrics was established to assess the identified technologies. These metrics are intended to indicate the potential for the technology to be taken forward to

application through the level of support for its development. Three metrics are relevant to this study:

- The total value of all projects that have researched the technology (i.e., the total investment, by both the EU and industry, in the development of the technology);
- The number of projects that have researched the technology;
- The number of organizations that have been involved in projects that have researched the technology.

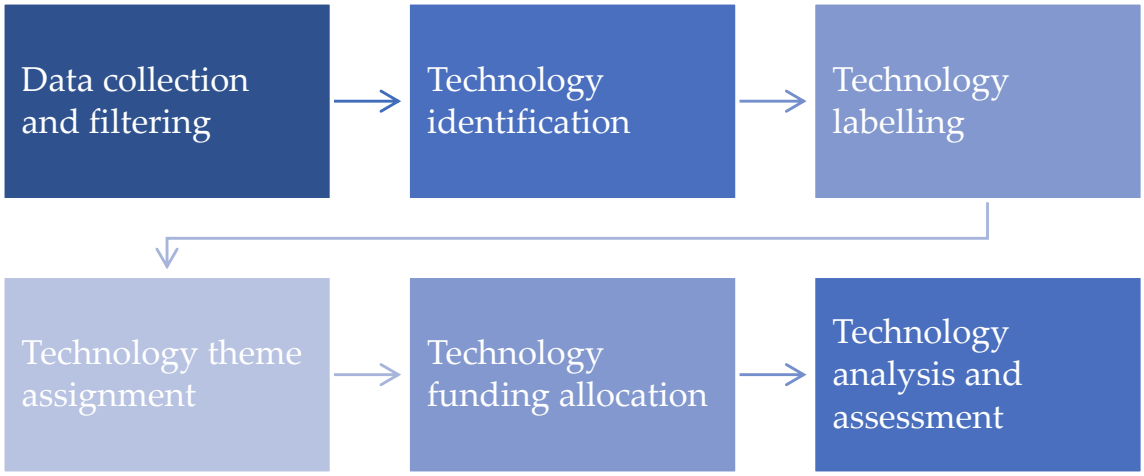

Figure 2. Technology assessment methodological steps (adapted from [45]).

Focusing on the metrics (point 6 above), the first two highlight the combined effort that has been put into researching the technology, while the third proxies the level of interest in the technology in industry and academia. Two points are worth highlighting:

- When identifying the (funding) value to use for a particular project for a particular technology, the total value for the project is divided by the number of technologies that the project has been identified as investigating in order to estimate the 'funding per technology'. Thus, the calculated total funding for the technology should rationally represent the funding for the individual technology. This parameter gives an indication of the total effort that has been employed to bring the technology to its current status and also indicates the level of interest and expectation there is in the potential of the technology. The nature of the funding schemes for the research under which the technologies have been developed is of key relevance to the use of this parameter. In most cases, the EU funding scheme will only pay 40–50% of the costs incurred by industry and other large organisations. Thus, a high level of funding for a technology indicates sufficient interest by industry to have invested considerable own resources in its development.
- A high number of projects and the number of organisations involved indicate a high level of interest and capability in developing the technologies further.

Finally, all technologies are assessed for their development phase as allocated in TRIMIS—from low (research or validation) to high (demonstration or implementation). These development phases were built on a similar concept to that of the National Aeronautics and Space Administration (NASA) Technology Readiness Level (TRL) [47]. In TRIMIS, the number of development phases is limited to four, reflecting the uncertainty that would be entailed in attempting to be o very precise with the allocation of a TRL, considering also the limited information that is usually available for the status of the technologies being researched by a project. Table 1 shows the TRIMIS development phases and their relationship to the NASA TRL scale.

Table 1. TRLs and corresponding TRIMIS development phases (adapted from [48]).

TRL	Description	TRIMIS Development Phase
1	Basic principles observed	Research
2	Technology concept formulated	
3	Experimental proof of concept	Validation
4	Technology validated in lab	
5	Technology validated in relevant environment	Demonstration/prototyping/pilot production
6	Technology demonstrated in relevant environment	
7	System prototype demonstration in operational environment	
8	System complete and qualified	Implementation
9	Actual system proven in operational environment	

3. Main Findings from the Project and Technology Analyses

In this study, the analysis focuses on the last two European Research Framework Programmes (FPs), the seventh FP (FP7) and the Horizon 2020 (H2020) FP. Figure 3 shows the project value evolution over the years globally and by roadmaps (in million EUR). The "Other" category refers to projects that are related to transport research and are overarching in relation to the STRIA roadmaps.

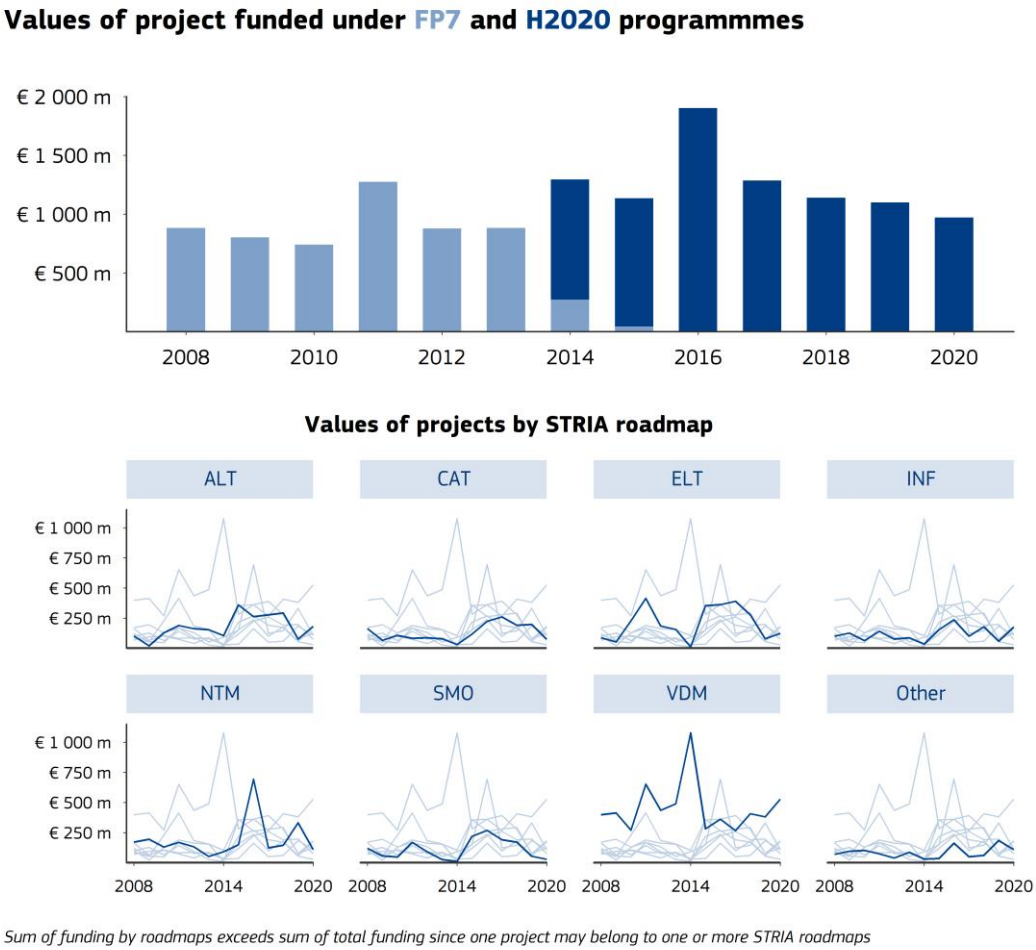

Figure 3. Project values (in million EUR) by starting year and STRIA roadmap.

As can be seen, over the years, the majority of research focuses on vehicle design and manufacturing. This trend peaked with the end of FP7 (2014). Since then, projects related to connected and automated transport, network and traffic management systems and smart mobility and services have experienced growing interest from policy makers and the industry.

For the current technology assessment, the TRIMIS database January 2021 is used. The technology database includes 867 technologies, under 45 overarching technology themes, researched in 2936 EU-funded projects from FP7 and H2020. The majority of the technologies is found in the vehicle design and manufacturing roadmap (370 technologies).

The analyses are limited to three STRIA roadmaps: smart mobility and services; cooperative, connected, and automated transport; and network and traffic management systems. These roadmaps are selected due to their close relevance to the objectives of the EU 'Sustainable and Smart Mobility Strategy' and because they focus on digital technologies, which received the most interest during the last FP. The number of technologies researched in these roadmaps is 194, within 829 projects. A total of 93 are linked to the network and traffic management systems roadmap, 69 to the connected and automated transport roadmap and 32 to the smart mobility and services roadmap.

Figure 4 shows the top 20 technologies identified in terms of value (total budget invested) for the three STRIA roadmaps (smart mobility and services, connected, and automated transport, network and traffic management systems). The figure is developed using the Interactive Tree Of Life online tool [49].

As can be observed from the figure, the majority of funding has been provided to aviation technologies (three out of the top five); that can be explained by the presence of projects from the Clean Sky Joint Undertaking. At the same time, the top three technologies in terms of number of projects that research them (information and communication technologies support for multimodality, multimodal border management, collaborative logistics ecosystem) focus on multimodal integration for people and freight mobility.

Figure 5 shows the development phases of the top 20 technologies. The analyses are limited to the most recent projects, supported by H2020. The left point indicates the share of projects in the research phase: the more to the right this point is, the larger the share of projects in the research phase. The right point indicates the average maturity level of a technology excluding projects in the research phase. Technologies closer to the left are those with a higher share of projects in the validation phase, while those closer to the right are mainly or exclusively in the implementation phase. If only one dot is shown, it means that all projects are in the research phase. Finally, the length of line shows the average level of maturity including all four development phases, with longer lines indicating higher maturity level.

Some technologies clearly have many projects in the research phase. This is the case for advanced driver assistance systems (ADAS) platforms and connected and automated vehicles (CAV) controllers and sensor fusion; both of which, however, have a large number of projects in more mature development phases. Some other technologies (in particular the collaborative logistics ecosystem technologies) are researched by projects in more mature development phases. CAV controllers and sensor fusion technologies are researched only in the latest FP (H2020).

Some caution is necessary in interpreting the results, since they may reflect developments from a specific project that researches the technology from a certain perspective and not the technology as a whole. However, the aggregated outcome provides an indication on the overall development of the technology.

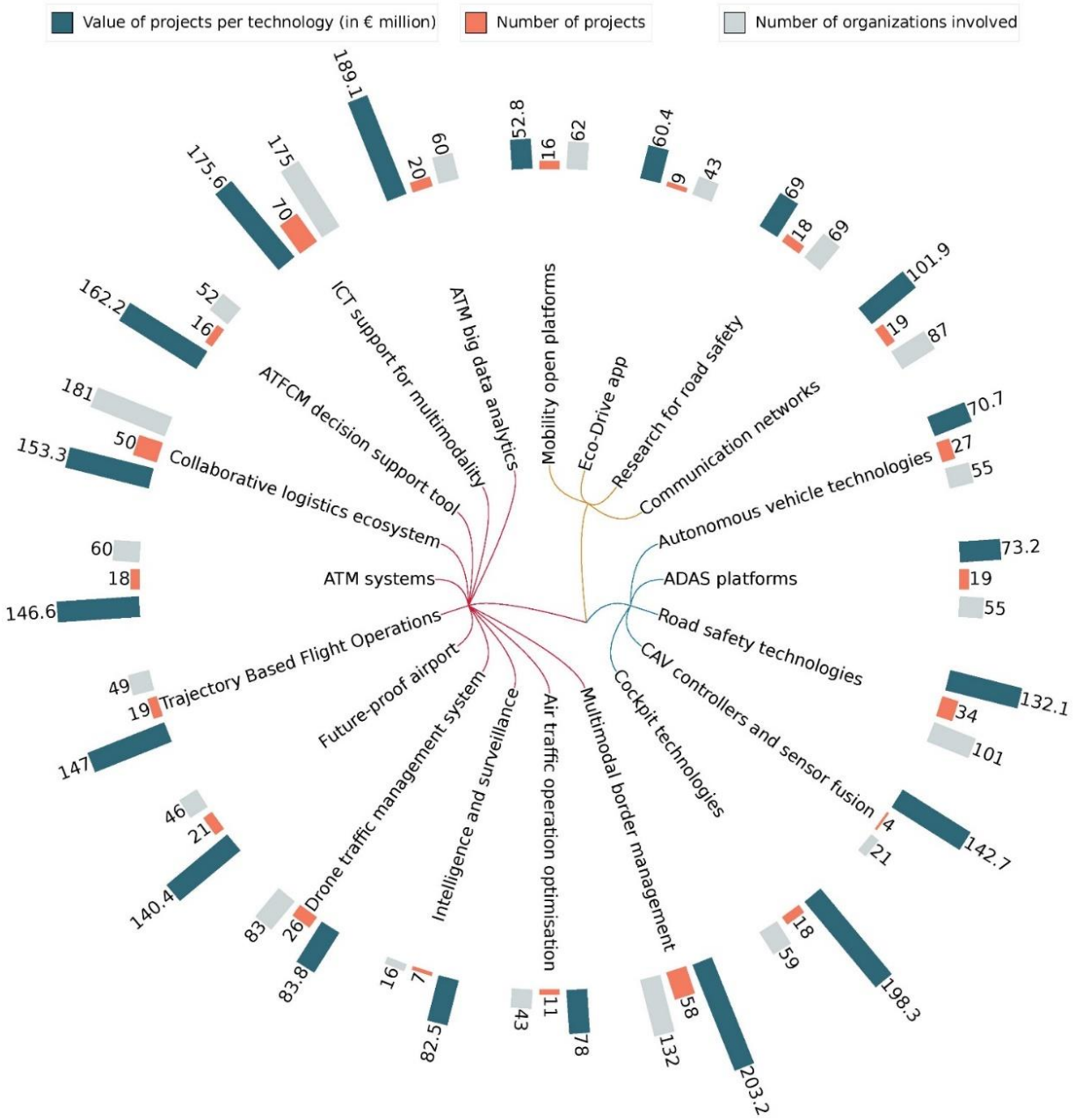

Figure 4. Top 20 technologies for the smart mobility and services (SMO), connected and automated transport (CAT), and network and traffic management systems (NTM) STRIA roadmaps. SMO-related technologies in yellow, CAT-related technologies in blue and NTM-related technologies in red. Abbreviations: ADAS: advanced driver assistance systems; CAV: connected and automated vehicles; ATM: air traffic management; ATFCM: air traffic flow and capacity management; ICT: information and communication technologies.

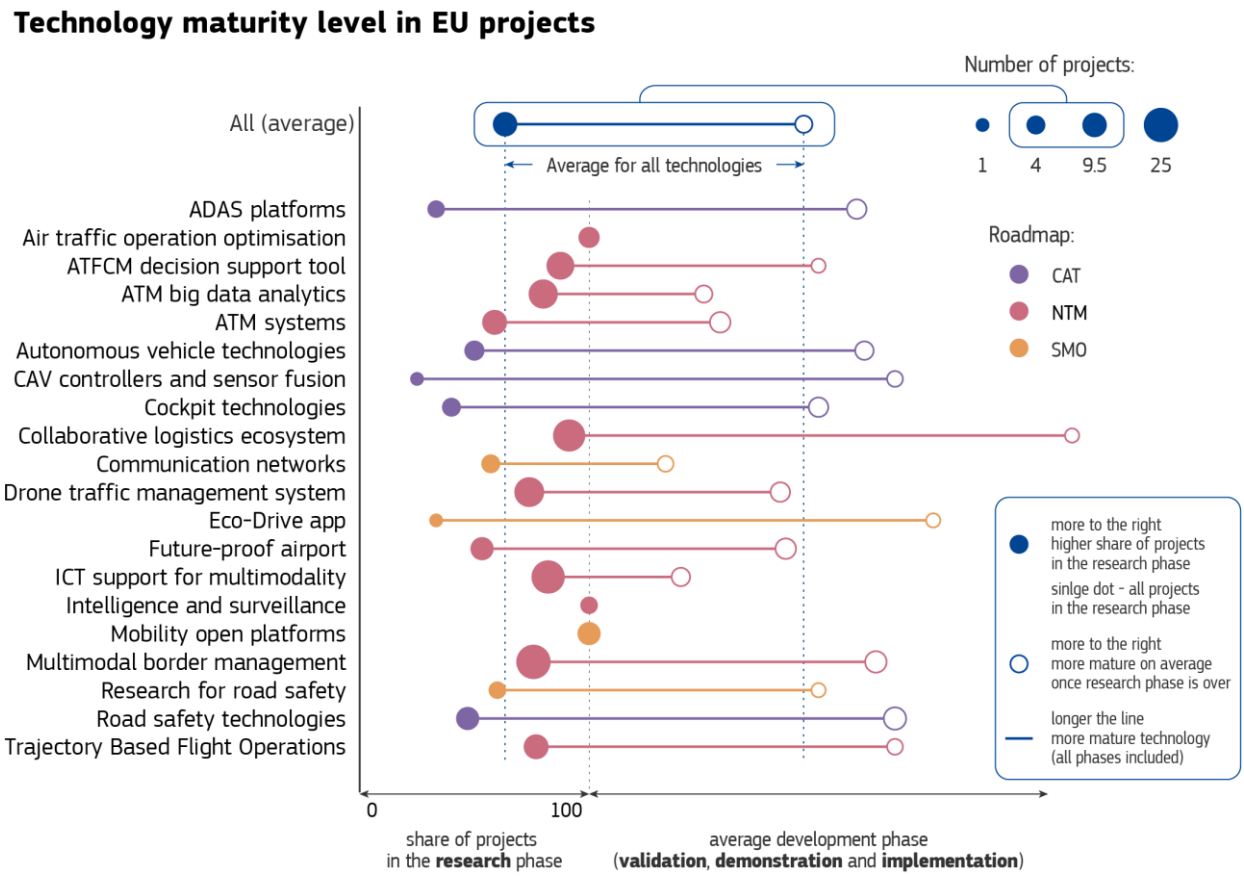

Figure 5. Development phases of the top 20 technologies.

4. Technologies and the EU "Sustainable and Smart Mobility Strategy" Ambitions

The Annex to the EU Sustainable and Smart Mobility Strategy identifies an action plan of 82 actions under 10 overarching flagship ambitions (24). These are:

1. Boosting uptake of zero-emission vehicles, renewable and low-carbon fuels and related infrastructure
2. Creating zero-emission airports and ports
3. Making interurban and urban mobility more sustainable and healthy
4. Greening freight transport
5. Pricing carbon and providing better incentives for users
6. Making connected and automated multimodal mobility a reality
7. Innovation, data and AI (artificial intelligence) for smart mobility
8. Reinforcing the single market
9. Making mobility fair and just for all
10. Enhancing transport safety and security

Focusing on the three previously pointed out STRIA roadmaps, Tables 2–4 report the top 20 technologies identified, the description of the technologies, the projects that research them and the link to the principal flagship ambitions of the SSMS. Only the most recent projects (from H2020) are included, while, all the projects (266 in total) are reported in Appendix A and can be retrieved from the TRIMIS website [39].

Table 2. Connected and automated transport technologies, research projects and pertinent SSMS Flagships (FS).

Technology	Description	Projects	FS
Cockpit technologies	Technologies for aircraft cockpits to enhance efficiency, reduce pilot workload and reduce the potential for human errors.	ALC, ASCENT, AS-DISCO, BrainWorkloadReader, EFAICTS, E-PILOTS, GALAHD, HiLICo, HIPNOSIS, LPA GAM 2018	10
CAV controllers and sensor fusion	Development of systems for fusing data from a wide array of sensors.	L3Pilot, NewControl, PRYSTINE, TrustVehicle	6, 10
Road safety technologies	Range of technologies to reduce the prevalence of road traffic accidents, and the dangers to drivers, passengers, pedestrians and other vulnerable road users.	4SBLOCK, Blinkers, COSAFE, ECOMARK, HyTunnel-CS, I-VALVE, MEDIATOR, PREVENT, ROADART, SafetyCube, SAFE-UP, SimuSafe, SOX2-Cloud, SSBUMP, Tangi0, WOOLF	10
ADAS platforms	Systems to support the development of algorithms for ADAS.	ADASANDME, AutoMate, BRAVE, CarNet, MAVEN, MeBeSafe, SMARTCARS, SMARTCARS 2, STS	6, 10
Autonomous vehicle technologies	Self-driving cars require a high number of sensors; with multiple LiDAR sensors, camera and radar sensors.	ALBORA, AutoPro, CELSO, CoEXist, Hailo-8, ICT4CART, INFRAMIX, interACT, Levitate, SAS	6

Table 3. Smart mobility and services technologies, research projects and pertinent SSMS Flagships (FS).

Technology	Description	Projects	FS
Communication networks	Communications networks (through dedicated infrastructure or 4G/5G networks) to support the development of ITS and C-ITS for improved traffic efficiency and safety and to support the implementation of new transport concepts.	5G-CARMEN, 5G-DRIVE, 5G-MOBIX, CREATE, IMOVE, MUV, SocialCar	10
Research for road safety	Monitoring of road traffic events and collection of traffic data to provide inputs to the development of traffic models to improve safety.	i-DREAMS, OSCCAR, PIONEERS, SENIORS, VIRTUAL	10
Eco-Drive app	Mobile phone-based app, which supports the vehicle driver to drive safely and economically, by monitoring parameters such as acceleration and braking.	Cloud Your Car UBI, ELVITEN, GlobalBLED	1
Mobility open platforms	An integrated open data mobility platform gathers information from all transportation modes and provides information to the user.	DIGNITY, FreeWheel, INDIMO, MW-R, SELECT for Cities, TRANSIT, Translate4Rail, TT	3

On the STRIA connected and automated transport roadmap, as can be observed, most technologies are related to the Flagship Areas 6 (making connected and automated multimodal mobility a reality) and 10 (enhancing transport safety and security). Four out of five technologies focus on road transport, while the fifth (on cockpit technologies for increased efficiency) on aviation. All the technologies are researched over a wide spectrum of development, considering also that basic research and validation for some of them were pivotal during the first phase of H2020.

On the STRIA Smart mobility and services roadmap, the technologies that received most funding focus on the SSMS flagship ambitions 1 (boosting uptake of zero-emission vehicles, renewable and low-carbon fuels and related infrastructure), 3 (making interurban and urban mobility more sustainable and healthy) and 10 (enhancing transport safety and security). All technologies focus on road and multimodal transport. Most of them started from basic research, with the "Communication network technologies" focusing on the fifth generation of cellular networks (5G) being a notable example, while others such as "Eco-drive app" advanced further with one project at a close to deployment phase.

Table 4. Network and traffic management systems technologies, research projects and pertinent SSMS Flagships (FS).

Technology	Description	Projects	FS
Multimodal border management	Systems for efficiently managing border controls between countries that may need to deal with travellers using a multitude of transport modes.	AFRIGOS, BODEGA, CANGOPAL, Cargo Beacon, CB Container SpeedUp, C-BORD, CITADEL, City.Risks, CLEV, COLLOGISTICS, DAM Component, ETNA 2020, HiperTURB, iCROSS, IMPROVER, IntelServBus, KB plus, MDC, MESMERISE, MIDRAULICS, MIDRAULICS (2), MoTiV, NEC14, OTR, p-DRIVE, ReVibe, SCORE, SINSIN, SKILLFUL, TriboGlide, TWIMP, TWIMP 2, Wimper	6
ATM big data analytics	The integration of very large quantities of data from various sources to enhance the performance of air traffic management systems.	AISA, BEACON, BigData4ATM, COCTA, FIVER, FMPMet, ITACA, Modus, NOSTROMO, PJ05 Remote Tower, PJ09-W2 DNMS, PJ13-W2 ERICA, PJ14-W2 I-CNSS, PJ19-W2 CI, PJ20-W2 AMPLE, PJ24 NCM, PJ27 IOPVLD, PJ28 IAO, START, Track and Know	2
ICT support for multimodality	Information and Communication Technology systems, including smartphone "apps", to assist passengers in integrating multi-modal transport options when planning travel, when travelling and/or changing between transport modes at intersections.	ALLEGRO, ATENA, ELEONE, EVA, FLAMINGO, Gait Biometrics 3, GlobILS, GOEASY, ICT 4 CART, INCLUSION, INTRANSYS 2, ISO-COLD, ITS OBSERVATORY, LowCostTracking, MASAI, METRO-HAUL, MiniMo-Logistics, MUGICLOUD, PRIVACY FLAG, PROTECT, PROXITRAK, RapeedTest, RESILENS, SHIELD, Shift2MaaS, SIADE SaaS, SISSDEN, SPRINT	6
ATFCM decision support tool	Software tool to reduce the workload of air traffic controllers, by providing guidance on decisions related to directing aircraft trajectories, to improve the efficiency of the system and increase safety.	APACHE, BEACON, Domino, ENVISION, EVOAtm, IMHOTEP, ISOBAR, MOTO, PARTAKE, PJ02-W2 AART, PJ10 PROSA, PJ14 EECNS, PJ17 SWIM-TI, PJ25 XSTREAM, SINOPTICA, TaCo	2
Collaborative logistics ecosystem	Urban fright logistics systems that exploit the power of collaborative intelligent transport systems (C-ITS) to provide efficient collaboration between different transport systems (rail, long-distance road, trucks, local delivery vehicles) to deliver freight quicker, more cheaply and with reduced environmental impact.	AEOLIX, CAPTOR, CLUSTERS 2.0, COG-LO, COLDTRACK, CWT, ECOLUP, FOX, Mega-Inliner, My-TRAC, NIRWOOD, NOESIS, PrEDICTS, RAGTIME, SELIS, SENATOR, SENSE, shippiesbags, SUNRISE, SYNCHRO-NET, TAKEDOWN, TRANSAFELOAD, ULaaDS	4
ATM systems	Technologies to enhance the performance of the European air traffic management (ATM) system, through improved forecasting of network capacity and flexibility, integration of multiple national ATM systems and enhanced interfaces.	ADAPT, Airline Team NCM, Engage, FARO, GAUSS, Modus, PJ03b SAFE, PJ04 TAM, PJ07 OAUO, PJ08 AAM, PJ15 COSER, PJ16 CWP HMI, PJ19 CI, SafeClouds.eu, SAFELAND, TAPAS, X-TEAM D2D	2, 7
Trajectory Based Flight Operations	Implementation of 4D (three spatial dimensions plus time) management of aircraft flight profiles to improve efficiency (more direct routes), reduce delays (controlling the flight so that the aircraft arrives at the airport when a slot is available rather than being held at altitude) without compromising safety.	CADENZA, COTTON, DART, Dispatcher3, OptiFrame, PJ06 ToBeFREE, PJ07-W2 OAUO, PJ09 DCB, PJ18-W2 4D Skyways, PJ31 DIGITS, PNOWWA, SafeNcy, TERRA	2, 7

Table 4. *Cont.*

Technology	Description	Projects	FS
Future-proof airport	Design of airports with improved operations and monitoring of passenger movements to provide an enhanced passenger experience, improved security and greater efficiency, while having sufficient flexibility to accommodate changes in travel demand without adverse impacts on the operation.	AERFOR, AERFOR, Aerowash II, A-FOD, AIRMES, Airport IQ, AUDIO, CLAIRPORT, DEMETER, e-Airport, FLYSEC, IBiS, PJ01 EAD, PJ02 EARTH, PJ04-W2 TAM	2, 7
Drone traffic management system	Air traffic management systems that can accommodate both manned and unmanned aerial vehicles without compromising safety.	5D-AeroSafe, ADS Project, AIRPASS, AW-Drones, CLASS, COMP4DRONES, DACUS, DAPS, DREAMS, DroC2om, Drones4Safety, EXTREMDRON, ICARUS, IMPETUS, INAS, LABYRINTH, MoNIfly, PercEvite, PJ05-W2 DTT, PODIUM, SAFEDRONE, SECOPS, SURVEIRON	7
Intelligence and surveillance	Innovative approaches to gathering intelligence, such as the use of autonomous vehicles (e.g., drones) and surveillance systems.	GATEMAN, PJ18 4DTM, URClearED	7, 10
Air traffic operation optimisation	Use of ATM systems to manage European airspace in such a way as to reduce environmental impacts (noise, air quality and climate) through changes to aircraft altitudes and trajectories.	ACACIA, ATM4E, ClimOP, GREAT, PJ01-W2 EAD, PJ10-W2 PROSA	7

Finally, as discussed previously, network and traffic management systems technologies seems to dominate the funding. Eleven technologies make it into the top 20, focusing on several flagship ambitions. With the exception of three technologies ("Multimodal border management", "ICT support for multimodality", and "Collaborative logistics ecosystem") which concentrate on road and multimodal transport, all the other technologies focus on aviation. This was to be expected since much of the funding derives from the SESAR Joint Undertaking, which received an EU contribution of 585 M € under H2020 for the period 2016–2024 [50]. The high interest in using drones for freight (and passenger) transport in the past years explains the high number of projects related to this topic.

Some relevant outcomes and outlook from the analysis of links to the flagship ambitions of the EU SSMS is reported below:

- FS 6 ("Making connected and automated multimodal mobility a reality") and FS 10 ("Enhancing transport safety and security") include most of the connected and automated transport technologies such as cockpit technologies, CAV controllers and sensor fusion technologies, road safety technologies, and ADAS platforms. These technologies thrived in H2020 research at a lower development phase (research and validation) and it is expected that they will be researched in higher development phases in the Horizon Europe FP.
- FS 2 ("Creating zero-emission airports and ports") and FS 7 ("Innovation, data and AI for smart mobility") gather many network and traffic management systems technologies on air traffic management and operations optimisation. These technologies have been researched mainly on a low development phase, using also AI for traffic flow optimisation. As an outlook on FS 2, four projects that commenced in the fourth quarter of 2021 will focus on green airports and ports, as multimodal hubs in the post COVID-19 era [51]. Likewise, it is expected that projects focusing on drones will scale up, focusing for example on the further development and testing of drone last-mile solutions in the urban and sub-urban environment using automated drone fleet operations.

- Collaborative logistics ecosystem technologies can help achieve the ambitions of FS 4 "Greening freight transport". Although this technology is researched at a low development phase (research), projects NOESIS [52] focusing on the use of big data, and SUNRISE, focusing on collaborative ways to address mobility challenges at the neighborhood level have achieved higher maturity towards deployment.
- The Eco-Drive app technologies can help towards the goal of "Boosting uptake of zero-emission vehicles, renewable & low-carbon fuels and related infrastructure" envisioned by FS 1. This technology is researched at low maturity, with the exception of the GlobalBLED project specific to the professional fleet market focusing on deployment.
- Finally, mobility open platform technologies can contribute towards "Making interurban and urban mobility more sustainable and healthy" of FS 3. All projects researching this technology are at a low development phase. These include user-centric projects such as DIGNITY and INDIMO focusing on digital mobility solutions, and TRANSIT, focusing on the evaluation of the impact of innovative intermodal transport solutions. These projects pave the way for the demonstration and implementation of the technology in the near future.

Beyond these high-level findings, the performed technology and maturity mapping provides a rapid indication of past and ongoing R&I development providing valuable insights on the progress of particular technologies.

5. Conclusions

This study provides a comprehensive assessment of technologies from European research projects relevant to the most recent EU 'Sustainable and Smart Mobility Strategy', making use of the technology-monitoring methodology developed by the authors for TRIMIS. The exercise of linking the technologies to the most recent policies provides useful information to policy makers in further specifying policy documents. It also helps them to specify future transport R&I needs, while at the same time, prioritising technology funding and avoiding funding overlapping. It can also contribute to the work of transport researchers who aim at gaining a better understanding on the evolution of transport technology. On a practical level, researchers can understand the historic evolution of a technology within the context of FPs, and identify areas for future development, something that can be helpful in preparing research proposals when applying for funding.

Principal findings focus on the technology maturity of the technologies: mapping the various technologies and their development phases allows a clear view on the technological developments that can support the SSMS and future policies. This is important since technologies and policies are part of a cyclic process, with the former contributing to the timely adoption of the latter.

Nevertheless, there are some limitations to this study. Most importantly, the technology assessment focuses on EU-funded projects, and consequently, not all conducted research is covered. In this sense, it would be valuable to complement the assessment with information on private R&D investments or data from intellectual property offices. Another limitation is that funds associated with each technology were determined by linking them with the total project budget. If multiple technologies were researched in the project, the budget allocated to the technology of interest was determined by dividing the project budget by the number of associated technologies. Despite the limitations, this approach is considered as appropriate and transparent in absence of specific technology-budget reports in EU funded R&I projects.

Finally, in this exercise focus is given to selected technologies, in particular those that received most funding. Extending the analyses to the entire technology database goes beyond the scope of this academic paper.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of H2020 Projects Considered for this Research.

Acronym	Title	Funding Programme *	Start/End Year	
4SBLOCK	Pavement Building System based on Detachable and Embedded Blocks	H2020-EU.3.4.	2016	2017
5D-AeroSafe	5 services of Drones for increased airports and waterways safety and security.	H2020-EU.3.4.	2020	2023
5G-CARMEN	5G for Connected and Automated Road Mobility in the European UnioN	H2020-EU.2.1.	2018	2021
5G-DRIVE	5G HarmoniseD Research and TrIals for serVice Evolution between EU and China	H2020-EU.2.1.	2018	2021
5G-MOBIX	5G for cooperative & connected automated MOBIility on X-border corridors	H2020-EU.2.1.	2018	2021
ACACIA	Advancing the Science for Aviation and ClimAte	H2020-EU.3.4.	2020	2023
ADAPT	Advanced prediction models for flexible trajectory-based operations	H2020-EU.3.4.	2018	2019
ADASANDME	Adaptive ADAS to support incapacitated drivers Mitigate Effectively risks through tailor made HMI under automation	H2020-EU.3.4.	2016	2020
ADS Project	Autonomous Dronistics for Security (ADS): optimized services with fleets of flying robots	H2020-EU.2.1.	2015	2015
AEOLIX	Architecture for EurOpean Logistics Information eXchange	H2020-EU.3.4.	2016	2019
AERFOR	Proactive Passenger Flow Management for Airports with an Advanced Forecasting System	H2020-EU.3.4.	2016	2019

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
AERFOR	Advanced Forecasting System for Proactive Airport Passenger Flow Management	H2020-EU.3.4.	2014	2015
Aerowash II	InnovAtive automatic battERy pOwered WASHing robot for the aviation industry	H2020-EU.3.4.	2015	2015
A-FOD	SAFER and TIMELY FLIGHTS with Automated Foreign Object Detection System	H2020-EU.3.4.	2017	2018
AFRIGOS	African Governance and Space: Transport Corridors, Border Towns and Port Cities in Transition	H2020-EU.1.1.	2016	2020
Airline Team NCM	Airspace User support to the development of Network Collaborative Management	H2020-EU.3.4.	2018	2020
AIRMES	Airline Maintenance Operations implementation of an E2E Maintenance Service Architecture and its enablers	H2020-EU.3.4.	2015	2019
AIRPASS	Advanced Integrated RPAS Avionics Safety Suite	H2020-EU.3.4.	2017	2020
Airport IQ	Situation-Aware Mobile Platform for Airport Collaborative Decision-Making	H2020-EU.3.4.	2015	2017
AISA	AI Situational Awareness Foundation for Advancing Automation	H2020-EU.3.4.	2020	2022
ALBORA	Next-generation navigation technologies for autonomous vehicles	H2020-EU.2.1.-H2020-EU.2.3.	2018	2018
ALC	Aircraft Light Communication	H2020-EU.3.4.	2017	2021
ALLEGRO	unrAvelLing sLow modE travelinG and tRaffic: with innOvative data to a new transportation and traffic theory for pedestrians and bicycles	H2020-EU.1.1.	2015	2020
APACHE	Assessment of Performance in current ATM operations and of new Concepts of operations for its Holistic Enhancement	H2020-EU.3.4.	2016	2018
ASCENT	Active Simulator Cockpit Enhancement	H2020-EU.3.4.	2017	2019
AS-DISCO	AS-DISCO—Audio Suite for Disruptive Cockpit Demonstrator	H2020-EU.3.4.	2019	2023
ATENA	Advanced Tools to assEss and mitigate the criticality of ICT compoNents and their dependencies over Critical InfrAstructures	H2020-EU.3.7.	2016	2019
ATM4E	Air Traffic Management for environment	H2020-EU.3.4.	2016	2018
AUDIO	Airspace User supporting Demonstrations of Integrated Airport Operations	H2020-EU.3.4.	2019	2021
AutoMate	Automation as accepted and trustful teamMate to enhance traffic safety and efficiency	H2020-EU.3.4.	2016	2019
AutoPro	An adaptive system for modular automotive production to boost efficiency and reduce manufacturing cost.	H2020-EU.3.4.	2017	2017
AW-Drones	Contributing to a well-reasoned set of Airworthiness Standards for mass-market drones	H2020-EU.3.4.	2019	2021
BEACON	Behavioural Economics for ATM Concepts	H2020-EU.3.4.	2020	2022
BigData4ATM	Passenger-centric Big Data Sources for Socio-economic and Behavioural Research in ATM	H2020-EU.3.4.	2016	2018
Blinkers	Next generation bicycle lights. Be visible, understood and expected by other vehicles, whatever the weather, angle and situation.	H2020-EU.2.1.-H2020-EU.2.3.	2018	2018
BODEGA	BOrdDErGuArd—Proactive Enhancement of Human Performance in Border Control	H2020-EU.3.7.	2015	2018

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
BrainWorkloadReader	Generation of a business plan for the production of a compact and reliable device able to measure in real-time the cerebral workload state of high responsibility operators in the transport domain	H2020-EU.3.4.	2015	2015
BRAVE	BRidging gaps for the adoption of Automated VEhicles	H2020-EU.3.4.	2017	2021
CADENZA	Advanced Capacity and Demand Management for European Network Performance Optimization	H2020-EU.3.4.	2020	2022
CANGOPAL	Next generation of Carrier Open SaaS for boosting e-Commerce economy	H2020-EU.3.4.	2016	2017
CAPTOR	cAPTor captures Advanced System Threats	H2020-EU.3.7.	2014	2015
Cargo Beacon	Cargo Beacons—no unexpected delays or losses in shipments of valuable cargo	H2020-EU.3.4.	2016	2017
CarNet	Rapid Data Communication Network for Connected Cars	H2020-EU.3.4.	2015	2018
CB Container SpeedUp	Conexbird Wind speed up containers and prevent damages	H2020-EU.3.4.	2015	2016
C-BORD	effective Container inspection at BORDer control points	H2020-EU.3.7.	2015	2018
CELSO	Low-cost and high-performance pocket Automated Vehicle Monitoring system for Public Transport	H2020-EU.3.4.	2016	2016
CITADEL	Critical Infrastructure Protection using Adaptive MILS	H2020-EU.3.7.	2016	2019
City.Risks	Avoiding and mitigating safety risks in urban environments	H2020-EU.3.7.	2015	2018
CLAIRPORT	Clean Sky 2—Airport Environmental Impact Assessments for Fixed-wing Aircraft	H2020-EU.3.4.	2017	2021
CLASS	CLear Air Situation for uaS: Maturing ground based technologies for a real-time Unmanned Aerial System Traffic Management System (UTMS) to monitor and separate Unmanned Aerial System (UAS) traffic	H2020-EU.3.4.	2017	2019
CLEV	Most cost and time efficient EU-wide cross-border automated parcel delivery solution	H2020-EU.3.4.	2015	2015
ClimOP	CLIMATE ASSESSMENT OF INNOVATIVE MITIGATION STRATEGIES TOWARDS OPERATIONAL IMPROVEMENTS IN AVIATION	H2020-EU.3.4.	2020	2023
Cloud Your Car UBI	Establishing new eco-driving methods to score drivers and to enhance good driving habits based on advanced analytical B2B software platform for Connected Cars.	H2020-EU.3.4.	2016	2016
CLUSTERS 2.0	Open network of hyper connected logistics clusters towards Physical Internet	H2020-EU.3.4.	2017	2020
COCTA	Coordinated capacity ordering and trajectory pricing for better-performing ATM	H2020-EU.3.4.	2016	2018
CoEXist	'AV-Ready' transport models and road infrastructure for the coexistence of automated and conventional vehicles	H2020-EU.3.4.	2017	2020
COG-LO	COGnitive Logistics Operations through secure, dynamic and ad-hoc collaborative networks	H2020-EU.3.4.	2018	2021
COLDTRACK	New cloud-base SW for ensuring the Cold Chain during Food Transportation	H2020-EU.3.4.	2017	2017
COLLOGISTICS	Express Delivery end-to-end Management System through collaborative intelligence.	H2020-EU.3.4.	2015	2016
COMP4DRONES	Framework of key enabling technologies for safe and autonomous drones' applications	H2020-EU.2.1.	2019	2022

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
COSAFE	Cooperative Connected Intelligent Vehicles for Safe and Efficient Road Transport	H2020-EU.1.3.	2018	2022
COTTON	Capacity Optimisation in TrajecTory-based OperatioNs	H2020-EU.3.4.	2018	2019
CREATE	Congestion Reduction in Europe: Advancing Transport Efficiency	H2020-EU.3.4.	2015	2018
CWT	Clearview Trade—Cloud based collaborative custom system	H2020-EU.3.4.	2015	2016
DACUS	Demand and Capacity Optimisation in U-space	H2020-EU.3.4.	2020	2022
DAM Component	Dual Active Mode Component	H2020-EU.3.4.	2015	2015
DAPS	Drone Alarm and Protection System	H2020-EU.3.7.	2016	2016
DART	Data-driven AiRcraft Trajectory prediction research	H2020-EU.3.4.	2016	2018
DEMETER	Development of E2E Maintenance architecture process and methods enabling a reliable and economic air transport system	H2020-EU.3.4.	2015	2019
DIGNITY	DIGital traNsport In and for socieTY	H2020-EU.3.4.	2020	2022
Dispatcher3	Innovative processing for flight practices	H2020-EU.3.4.	2020	2022
Domino	Novel tools to evaluate ATM systems coupling under future deployment scenarios	H2020-EU.3.4.	2018	2019
DREAMS	DRone European AIM Study	H2020-EU.3.4.	2017	2019
DroC2om	Drone Critical Communications	H2020-EU.3.4.	2017	2019
Drones4Safety	Inspection Drones for Ensuring Safety in Transport Infrastructures	H2020-EU.3.4.	2020	2023
e-Airport	Increase airport capacity, safety and security using European GNSS	H2020-EU.2.1.	2015	2017
ECOLUP	Smart collect points as an innovative logistic solution to shorten fruit and vegetables supply chain	H2020-EU.3.4.	2017	2017
ECOMARK	An ecological road striping system	H2020-EU.3.4.	2016	2016
EFAICTS	Ergonomic impact and new Functions induced by Active Inceptor integration in CockpiTS	H2020-EU.3.4.	2018	2021
ELEONE	New advanced sensor for automated metrology	H2020-EU.3.4.	2016	2017
ELVITEN	Electrified L-category Vehicles Integrated into Transport and Electricity Networks	H2020-EU.3.4.	2017	2020
Engage	Knowledge Transfer Network proposed in response to the SESAR-ER3-01-2016 Call	H2020-EU.3.4.	2018	2021
ENVISION	Enhanced Situational Awareness through Video Integration with ADS-B Surveillance Infrastructure on Airports	H2020-EU.3.4.	2018	2019
E-PILOTS	Evolution of cockPIt operations Levering on cOgnitive compuTing Services	H2020-EU.3.4.	2019	2021
ETNA 2020	European Transport Network Alliance 2020	H2020-EU.3.4.	2016	2020
EVA	SMART CITY NAVIGATION TOOL FOR THE VISUALLY IMPAIRED	H2020-EU.3.4.	2017	2017
EVOAtm	Evolutionary ATM. A modelling framework to assess the impact of ATM evolutions	H2020-EU.3.4.	2018	2019
EXTREMDRON	Unmanned aerial vehicle for vigilance, control and critical urban infrastructure protection	H2020-EU.3.7.	2016	2016
FARO	saFety And Resilience guidelines for aviatiOn	H2020-EU.3.4.	2020	2022

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
FIVER	Innovative solution for FMS computed trajectories validation by means of pilot actions emulation, comparison with PANS-OPS criteria and data mining techniques.	H2020-EU.3.4.	2018	2020
FLAMINGO	Fulfilling enhanced Location Accuracy in the Mass-market through Initial GalileO services	H2020-EU.3.4.	2017	2020
FLYSEC	Optimising time-to-FLY and enhancing airport SECurity	H2020-EU.3.7.	2015	2018
FMPMet	Meteorological uncertainty management for Flow Management Positions	H2020-EU.3.4.	2020	2022
FOX	Forever Open infrastructure across (X) all transport modes	H2020-EU.3.4.	2015	2017
FreeWheel	Lifecycle-reconfigurable Smart Mobility Platform to enable autonomous and cost-effective personalized solutions for social inclusion of disabled and elderly while leveraging AM technologies	H2020-EU.2.1.	2017	2020
Gait Biometrics 3	Main goal of the project is to create a prototype of the software, which will be able to identify people just based on the way how they walk.	H2020-EU.2.1.	2015	2015
GALAHD	General and Light Aviation Head-up Display	H2020-EU.3.4.	2016	2016
GATEMAN	GNSS NAVIGATION THREATS MANAGEMENT	H2020-EU.3.4.	2018	2019
GAUSS	Galileo-EGNOS as an Asset for UTM Safety and Security	H2020-EU.2.1.-H2020-EU.3.4.	2018	2021
GlobalBLED	Ecosystem of Advanced ICT-based Services Personalised Training for Efficient Secure Driving	H2020-EU.3.4.	2017	2019
GlobILS	Global Platform for Indoor Location Services	H2020-EU.3.4.	2016	2018
GOEASY	GalileO-based trustEd Applications for health and SustainabilitY	H2020-EU.3.4.	2017	2020
GREAT	Greener Air Traffic Operations	H2020-EU.3.4.	2020	2023
Hailo-8	End-to-end hardware implementation of Artificial Neural Networks for Edge Computing in Autonomous Vehicles	H2020-EU.2.3.-H2020-EU.2.1.	2019	2020
HiLICo	High Luminescence In Cockpit	H2020-EU.3.4.	2017	2020
HiperTURB	Development of investment casting process of nickel superalloys with enhanced weldability.	H2020-EU.3.4.	2017	2020
HIPNOSIS	Hardware Implementation of Pilot-Non-intrusive cOgnitive States Identification System	H2020-EU.3.4.	2018	2021
HyTunnel-CS	PNR for safety of hydrogen driven vehicles and transport through tunnels and similar confined spaces	H2020-EU.3.4.	2019	2022
IBiS	Full scale demonstration of an Innovative solution for Baggage Handling Systems at airports (IBiS)	H2020-EU.3.4.	2017	2017
ICARUS	INTEGRATED COMMON ALTITUDE REFERENCE SYSTEM FOR U-SPACE	H2020-EU.3.4.	2020	2022
iCROSS	Intelligent Portable ContROl SyStem	H2020-EU.3.7.	2016	2019
ICT4CART	ICT Infrastructure for Connected and Automated Road Transport	H2020-EU.3.4.	2018	2021
i-DREAMS	Safety tolerance zone calculation and interventions for driver-vehicle-environment interactions under challenging conditions	H2020-EU.3.4.	2019	2022
IMHOTEP	Integrated Multimodal Airport Operations for Efficient Passenger Flow Management	H2020-EU.3.4.	2020	2022

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
IMOVE	Unlocking Large-Scale Access to Combined Mobility through a European MaaS Network	H2020-EU.3.4.	2017	2019
IMPETUS	Information Management Portal to Enable the inTegration of Unmanned Systems	H2020-EU.3.4.	2017	2019
IMPROVER	Improved risk evaluation and implementation of resilience concepts to critical infrastructure	H2020-EU.3.7.	2015	2018
INAS	Integra A/S—Service provider of drones for civil use	H2020-EU.3.4.	2015	2015
INCLUSION	Towards more accessIble and iNCLUSIve mObility solutions for EuropeaN prioritised areas	H2020-EU.3.4.	2017	2020
INDIMO	Inclusive digital mobility solutions	H2020-EU.3.4.	2020	2022
INFRAMIX	Road Infrastructure ready for mixed vehicle traffic flows	H2020-EU.3.4.	2017	2020
IntelServBus	Intelligent Hydraulic Systems Enabling Service Business in Heavy Transport	H2020-EU.3.4.	2015	2017
interACT	Designing cooperative interaction of automated vehicles with other road users in mixed traffic environments	H2020-EU.3.4.	2017	2020
INTRANSYS 2	Delivering next generation Transport Management System to European transport SMEs (2)	H2020-EU.3.4.	2016	2018
ISOBAR	Artificial Intelligence Solutions to Meteo-Based DCB Imbalances for Network Operations Planning	H2020-EU.3.4.	2020	2022
ISO-COLD	Integrated SOlution to enhance COLD chain and logistic tracking	H2020-EU.3.4.	2015	2015
ITACA	Incentivising Technology Adoption for Accelerating Change in ATM	H2020-EU.3.4.	2020	2022
ITS OBSERVATORY	ITS Observatory	H2020-EU.3.4.	2015	2017
I-VALVE	INTELLIGENT VALVE FOR PERSONALIZED SAFETY AIRBAG	H2020-EU.3.4.	2017	2017
KB plus	Ultra Compact and Highly Eco-efficient Heating System	H2020-EU.3.4.	2017	2018
L3Pilot	Piloting Automated Driving on European Roads	H2020-EU.3.4.	2017	2021
LABYRINTH	UNMANNED TRAFFIC MANAGEMENT 4D PATH PLANNING TECHNOLOGIES FOR DRONE SWARM TO ENHANCE SAFETY AND SECURITY IN TRANSPORT	H2020-EU.3.4.	2020	2023
Levitate	Societal Level Impacts of Connected and Automated Vehicles	H2020-EU.3.4.	2018	2021
LowCostTracking	Low cost tracking and data management solution for biopharma cold chain logistics	H2020-EU.3.4.	2016	2016
LPA GAM 2018	Large Passenger Aircraft	H2020-EU.3.4.	2018	2019
MASAI	Mobility Based on Aggregation of Services and Applications Integration	H2020-EU.3.4.	2015	2018
MAVEN	Managing Automated Vehicles Enhances Network	H2020-EU.3.4.	2016	2019
MDC	CNG Fuels- Mother and Daughter CNG Station Concept	H2020-EU.3.4.	2016	2016
MeBeSafe	Measures for behaving safely in traffic	H2020-EU.3.4.	2017	2020
MEDIATOR	MEdiating between Driver and Intelligent Automated Transport systems on Our Roads	H2020-EU.3.4.	2019	2023
Mega-Inliner	High tech Inliner for ISO tank containers	H2020-EU.3.4.	2018	2018
MESMERISE	Multi-Energy High Resolution Modular Scan System for Internal and External Concealed Commodities	H2020-EU.3.7.	2016	2019

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
METRO-HAUL	METRO High bandwidth, 5G Application-aware optical network, with edge storage, compUte and low Latency	H2020-EU.2.1.	2017	2020
MIDRAULICS	Modular Intelligent hyDRAULICS	H2020-EU.3.4.	2016	2016
MIDRAULICS (2)	Modular Intelligent Hydraulics (2)	H2020-EU.3.4.	2017	2020
MiniMo-Logistics	MiniMo-Logistics application	H2020-EU.3.4.	2016	2016
Modus	Modelling and assessing the role of air transport in an integrated, intermodal transport system	H2020-EU.3.4.	2020	2022
MoNIfly	Mobile-Network Infrastructure for Cooperative Surveillance of low flying drones	H2020-EU.3.4.	2017	2020
MoTiV	Mobility and Time Value	H2020-EU.3.4.	2017	2020
MOTO	the embodied reMOte Tower	H2020-EU.3.4.	2016	2018
MUGICLOUD	PLUG AND PLAY intelligent transport system for bus and coach sector	H2020-EU.3.4.	2017	2018
MUV	Mobility Urban Values	H2020-EU.3.4.	2017	2020
MW-R	MoveWise-Research project	H2020-EU.2.3.	2017	2018
My-TRAC	My TRAvel Companion	S2R	2017	2020
NEC14	New Electric Vehicle Chassis-Cab 10–14 for urban logistic	H2020-EU.3.4.	2015	2017
NewControl	Integrated, Fail-Operational, Cognitive Perception, Planning and Control Systems for Highly Automated Vehicles	H2020-EU.2.1.	2019	2022
NIRWOOD	Fast, Accurate, Low Cost and Hand Held NIR Technology to Ascertain Wood Origin and Quality during Logistic Operations	H2020-EU.3.4.	2016	2016
NOESIS	NOvel Decision Support tool for Evaluating Strategic Big Data investments in Transport and Intelligent Mobility Services	H2020-EU.3.4.	2017	2019
NOSTROMO	Next-Generation Open-Source Tools for ATM Performance Modelling and Optimisation	H2020-EU.3.4.	2020	2022
OptiFrame	An Optimization Framework for Trajectory Based Operations	H2020-EU.3.4.	2016	2018
OSCCAR	Future Occupant Safety for Crashes in Cars	H2020-EU.3.4.	2018	2021
OTR	Off The Rails	H2020-EU.3.4.	2014	2015
PARTAKE	cooPerative depArtuRes for a compeTitive ATM networK sErvice.	H2020-EU.3.4.	2016	2018
p-DRIVE	Pyrolysis of Derived Residues of waste, providing Improved gas for Vehicle Engines	H2020-EU.3.4.	2015	2016
PercEvite	PercEvite—Sense and avoid technology for small drones	H2020-EU.3.4.	2017	2020
PIONEERS	PROTECTIVE INNOVATIONS OF NEW EQUIPMENT FOR ENHANCED RIDER SAFETY	H2020-EU.3.4.	2018	2021
PJ01 EAD	Enhanced Arrivals and Departures	H2020-EU.3.4.	2016	2019
PJ01-W2 EAD	PJ01 Wave 2 Enhanced Arrivals and Departures	H2020-EU.3.4.	2019	2022
PJ02 EARTH	Increased Runway and Airport Throughput	H2020-EU.3.4.	2016	2020
PJ02-W2 AART	Airport airside and runway throughput	H2020-EU.3.4.	2019	2022
PJ03b SAFE	Airport Safety Nets	H2020-EU.3.4.	2016	2019
PJ04 TAM	Total Airport Management	H2020-EU.3.4.	2016	2019
PJ04-W2 TAM	PJ04 W2 Total Airport Management	H2020-EU.3.4.	2019	2022

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
PJ05 Remote Tower	Remote Tower for Multiple Airports	H2020-EU.3.4.	2016	2019
PJ05-W2 DTT	PJ05-W2 Digital Technologies for Tower	H2020-EU.3.4.	2019	2022
PJ06 ToBeFREE	Trajectory based Free Routing	H2020-EU.3.4.	2016	2019
PJ07 OAUO	PJ07 Optimised Airspace Users Operations	H2020-EU.3.4.	2016	2019
PJ07-W2 OAUO	SESAR2020 PJ07-W2 OAUO Optimised Airspace Users Operations	H2020-EU.3.4.	2019	2022
PJ08 AAM	Advanced Airspace Management	H2020-EU.3.4.	2016	2019
PJ09 DCB	Advanced DCB	H2020-EU.3.4.	2016	2019
PJ09-W2 DNMS	Digital Network Management Services	H2020-EU.3.4.	2019	2022
PJ10 PROSA	Controller Tools and Team Organisation for the Provision of Separation in Air Traffic Management	H2020-EU.3.4.	2016	2019
PJ10-W2 PROSA	Separation Management and Controller Tools	H2020-EU.3.4.	2019	2022
PJ13-W2 ERICA	Enable RPAS Insertion in Controlled Airspace	H2020-EU.3.4.	2019	2022
PJ14 EECNS	Essential and Efficient Communication Navigation and Surveillance Integrated System	H2020-EU.3.4.	2016	2019
PJ14-W2 I-CNSS	Integrated Communication, Navigation and Surveillance System	H2020-EU.3.4.	2019	2022
PJ15 COSER	Common Services	H2020-EU.3.4.	2016	2019
PJ16 CWP HMI	Controller Working Position / Human Machine Interface-CWP/HMI	H2020-EU.3.4.	2016	2019
PJ17 SWIM-TI	SWIM Technical Infrastructure	H2020-EU.3.4.	2016	2020
PJ18 4DTM	4D Trajectory Management	H2020-EU.3.4.	2016	2020
PJ18-W2 4D Skyways	4D Skyways	H2020-EU.3.4.	2019	2022
PJ19 CI	Content Integration	H2020-EU.3.4.	2016	2019
PJ19-W2 CI	PJ.19 W2 Content Integration, Performance Management and Business Case Development	H2020-EU.3.4.	2019	2022
PJ20-W2 AMPLE	PJ.20 W2 Master Planning	H2020-EU.3.4.	2019	2022
PJ24 NCM	PJ24 VLD Network Collaborative Management	H2020-EU.3.4.	2016	2019
PJ25 XSTREAM	Cross Border SESAR Trials for Enhanced Arrival Management	H2020-EU.3.4.	2017	2019
PJ27 IOPVLD	Flight Object Interoperability VLD Demonstration	H2020-EU.3.4.	2016	2019
PJ28 IAO	Integrated Airport Operations	H2020-EU.3.4.	2016	2020
PJ31 DIGITS	Initial Trajectory Information Sharing	H2020-EU.3.4.	2016	2020
PNOWWA	Probabilistic Nowcasting of Winter Weather for Airports	H2020-EU.3.4.	2016	2018
PODIUM	Proving Operations of Drones with Initial UTM Management	H2020-EU.3.4.	2018	2019
PrEDICTS	Optimizing Container Load for Parcel and Pallet Transport Networks	H2020-EU.2.3.- H2020-EU.2.1.	2018	2018
PREVENT	"Alcohol-impaired driving PREVENTion and personal authentication by a vehicle ignition interlock system"	H2020-EU.3.4.	2017	2017
PRIVACY FLAG	Enabling Crowd-sourcing based privacy protection for smartphone applications, websites and Internet of Things deployments	H2020-EU.3.7.	2015	2018
PROTECT	Pervasive and UseR Focused BiomeTrics BordEr ProjeCT	H2020-EU.3.7.	2016	2019

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
PROXITRAK	PROXITRAK—next generation IoT tracking solution for a connected logistics—collect, analyse and visualise big data in a true real time	H2020-EU.3.4.	2017	2017
PRYSTINE	Programmable Systems for Intelligence in Automobiles	H2020-EU.2.1.	2018	2021
RAGTIME	Risk based approaches for Asset inteGrity multimodal Transport Infrastructure ManagEment	H2020-EU.3.4.	2016	2019
RapeedTest	IntegRAted control technology for unparalleled high sPEED data acquisition, storage and analysis for TEST rigs	H2020-EU.3.4.	2016	2016
RESILENS	RESILENS: Realising European ReSiliencE for CritIcaL INfraStructure	H2020-EU.3.7.	2015	2018
ReVibe	Vibration energy harvesters to power the IoT revolution	H2020-EU.3.4.	2016	2016
ROADART	Research On Alternative Diversity Aspects foR Trucks	H2020-EU.3.4.	2015	2018
SafeClouds.eu	Data-driven research addressing aviation safety intelligence	H2020-EU.3.4.	2016	2019
SAFEDRONE	Activities on drone integration and demonstration in VLL operations	H2020-EU.3.4.	2018	2020
SAFELAND	SAFE LANDing through enhanced ground support	H2020-EU.3.4.	2020	2022
SafeNcy	SafeNcy—the safe emergency trajectory generator	H2020-EU.3.4.	2019	2022
SafetyCube	Safety CaUsation, Benefits and Efficiency	H2020-EU.3.4.	2015	2018
SAFE-UP	proactive SAFEty systems and tools for a constantly UPgrading road environment	H2020-EU.3.4.	2020	2023
SAS	Safer Autonomous Systems	H2020-EU.1.3.	2018	2022
SCORE	Score board of competitiveness of European transport manufacturing industries	H2020-EU.3.4.	2016	2018
SECOPS	An Integrated Security Concept for Drone Operations	H2020-EU.3.4.	2017	2019
SELECT for Cities	SELECT for Cities (Standardized, opEn, data-driven, service-oriented user-centric pLatform Enabling large-scale Co-creation, Testing validation of IoE services for Cities)	H2020-EU.2.1.	2015	2019
SELIS	Towards a Shared European Logistics Intelligent Information Space	H2020-EU.3.4.	2016	2019
SENATOR	Smart Network Operator Platform enabling Shared, Integrated and more Sustainable Urban Freight Logistics	H2020-EU.3.4.	2020	2024
SENIORS	Safety-ENhancing Innovations for Older Road userS	H2020-EU.3.4.	2015	2018
SENSE	Accelerating the Path Towards Physical Internet	H2020-EU.3.4.	2017	2020
SHIELD	Securing against intruders and other threats through a NFV-enabled environment	H2020-EU.3.7.	2016	2019
Shift2MaaS	Shift2Rail IP4 enabling Mobility as a Service and seamless passenger experience	S2R	2018	2020
shippiesbags	Hamburg Airport Feasibility Pilot for Seamless Bagshuttle Service	H2020-EU.3.4.	2016	2016
SIADE SaaS	SIADE SaaS: Spatial Decision Support System for Transportation Planning	H2020-EU.3.4.	2017	2019
SimuSafe	SIMULATOR OF BEHAVIOURAL ASPECTS FOR SAFER TRANSPORT	H2020-EU.3.4.	2017	2020
SINOPTICA	Satellite-borne and IN-situ Observations to Predict The Initiation of Convection for ATM	H2020-EU.3.4.	2020	2022

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
SINSIN	Enhanced PLB, EGNSS receiver, and MEOLUT, according but beyond the standard, significantly improving the localization in difficult conditions, paving the way to a mass market SAR/Galileo service	H2020-EU.3.4.	2017	2020
SISSDEN	Secure Information Sharing Sensor Delivery event Network	H2020-EU.3.7.	2016	2019
SKILLFUL	Skills and competences development of future transportation professionals at all levels	H2020-EU.3.4.	2016	2019
SMARTCARS	Low cost Advanced Driver Assistance Systems (ADAS): A cost affordable solution for improved road safety	H2020-EU.3.4.	2016	2016
SMARTCARS 2	Low Cost Advanced Driver Assistance Systems (ADAS): A cost affordable solution for improved road safety (2)	H2020-EU.3.4.	2017	2020
SocialCar	Open social transport network for urban approach to carpooling	H2020-EU.3.4.	2015	2018
SOX2-Cloud	Integrated Safety Engineering Platform for electrical and electronic systems for transportation	H2020-EU.3.4.	2016	2017
SPRINT	Semantics for PerfoRmant and scalable INteroperability of multimodal Transport	S2R	2018	2020
SSBUMP	SMART SPEED BUMP	H2020-EU.3.4.	2017	2017
START	A Stable and resilient ATM by integrating Robust airline operations into the network	H2020-EU.3.4.	2020	2022
STS	MOTORCYCLE ALL-IN-ONE SMART TOUR INTEGRATED ROAD SECURITY SYSTEM	H2020-EU.3.4.	2017	2018
SUNRISE	Sustainable Urban Neighbourhoods—Research and Implementation Support in Europe	H2020-EU.3.4.	2017	2021
SURVEIRON	SURVEIRON: Advanced surveillance system for the protection of urban soft targets and urban critical infrastructures	H2020-EU.3.7.	2016	2018
SYNCHRO-NET	Synchro-modal Supply Chain Eco-Net	H2020-EU.3.4.	2015	2018
TaCo	Take Control	H2020-EU.3.4.	2016	2018
TAKEDOWN	Understand the Dimensions of Organised Crime and Terrorist Networks for Developing Effective and Efficient Security Solutions for First-line-practitioners and Professionals	H2020-EU.3.7.	2016	2019
Tangi0	Touch and pressure sensitive material without electronic sensors for intuitive and eyes-free control of a car's features while driving	H2020-EU.3.4.	2018	2018
TAPAS	Towards an Automated and exPlainable ATM System	H2020-EU.3.4.	2020	2022
TERRA	Technological European Research for RPAS in ATM	H2020-EU.3.4.	2017	2020
Track and Know	Big Data for Mobility Tracking Knowledge Extraction in Urban Areas	H2020-EU.2.1.	2018	2020
TRANSAFELOAD	TRANSAFELOAD: Testing the real behaviour of packaged loads during transport	H2020-EU.3.4.	2016	2016
TRANSIT	Travel Information Management for Seamless Intermodal Transport	H2020-EU.3.4.	2020	2022
Translate4Rail	Translation for breaking language barriers in the railway field	H2020-EU.3.4.	2019	2021
TriboGlide	Development of an innovative and cost-efficient friction and wear reduction solution (TriboGlide)	H2020-EU.3.4.	2016	2016

Table A1. *Cont.*

Acronym	Title	Funding Programme *	Start/End Year	
TrustVehicle	Improved trustworthiness and weather-independence of conditional automated vehicles in mixed traffic scenarios	H2020-EU.3.4.	2017	2020
TT	Transforming Transport	H2020-EU.2.1.	2017	2019
TWIMP	Innovative Laser Solution for Cutting Welding TWIP steel with Improved Performance	H2020-EU.3.4.	2014	2015
TWIMP 2	Innovative Laser Solution for Cutting Welding TWIP steel with Improved Performance (2)	H2020-EU.3.4.	2015	2017
ULaaDS	Urban Logistics as an on Demand Service	H2020-EU.3.4.	2020	2023
URClearED	A Unified Integrated Remain Well Clear Concept in Airspace D-G Class	H2020-EU.3.4.	2020	2022
VIRTUAL	Open access virtual testing protocols for enhanced road users safety	H2020-EU.3.4.	2018	2022
Wimper	Windshield with improved bird-strike, erosion, de-fogging, de-icing and IR performance	H2020-EU.3.4.	2017	2021
WOOLF	An advanced and wearable solution to increase motorcyclists' safety	H2020-EU.3.4.	2017	2018
X-TEAM D2D	eXTEnded AtM for Door2Door travel	H2020-EU.3.4.	2020	2022

*: H2020-EU.1.3.—EXCELLENT SCIENCE—Marie Sklodowska-Curie Actions; H2020-EU.2.1.—Horizon 2020: INDUSTRIAL LEADERSHIP—Leadership in enabling and industrial technologies; H2020-EU.2.3.—Horizon 2020: INDUSTRIAL LEADERSHIP—Innovation In SMEs; H2020-EU.3.4.—Horizon 2020: Smart, Green and Integrated Transport; S2R: Shift2Rail Joint Undertaking; H2020-EU.3.7.—Horizon 2020: Secure societies—protecting freedom and security of Europe and its citizens; H2020-EU.1.1.—EXCELLENT SCIENCE—European Research Council (ERC).

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