

CAMERA

COORDINATION AND SUPPORT
ACTION FOR MOBILITY IN EUROPE
Research and Assessment

November 2017 - October 2021

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MOBILITY REPORT 2



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EXECUTIVE SUMMARY

This mobility report, second in a series of four planned for CAMERA, updates the insights first uncovered by the project. CAMERA is an EU-funded coordination and support action (CSA) that has focused on investigating the state of the mobility research in Europe from the FP7 programme in 2007 through the H2020 projects started in 2013. Additionally, a special focus has been given to air transport research, including its integration with other modes of transport and with passenger experience. The ultimate goal of CAMERA is to provide measurable and actionable insights into the state of mobility research in Europe that could be used by interested stakeholders and other decision-makers for their analytical needs and decision guidance. To provide these insights, the CAMERA team has relied on data mining and predictive modelling techniques to drive data-based analysis. More specifically, this means that the starting point in the analysis is the data. These were fed into different predictive models, allowing insights to be extracted based on the outputs of these models.

The CAMERA methodology has improved greatly since the first mobility report; the AI algorithms developed and the overall data mining methodology have been significantly improved for data gathering, data cleaning and pre-processing, language modelling, and validation. Details of these changes are given in section 5 of this report.

The European Commission's "Community Research and Development Information Service" (CORDIS) is the main database of results of projects funded through the different EU research and innovation framework programmes from FP1 to Horizon 2020. The CAMERA project uses a subset of this database to study initiatives from the FP7 and H2020 funding programmes. The data analysed are a textual description of the project and a number of important quantitative fields: the financial contribution received from the EC, the coordinating entity and its country, consortium information, etc.

Previous work described in CAMERA performance framework deliverables and in the first mobility report identified five mobility layers — mobility objectives with concrete measurable targets to be studied to achieve a sustainable, seamless and efficient transport system in Europe by 2050. Recent work has taken these data mining techniques to the next level of detail by applying topic modelling to the selected mobility projects to group them into thematic groups, thus enabling more granular analyses. These groups, referred to as "topic clouds", were defined using (mostly) unsupervised natural language processing (NLP) based methodologies applied to the text data in the database to select mobility-related projects. 926 such projects, funded under FP7 or H2020, were identified and included in the analysis. The topic clouds were automatically extracted using these projects, with the projects then assigned to clouds with different weights depending on the prevalence of the topics. Most projects pertain to more than one topic cloud.

Nine different clouds were found among the mobility projects identified. Results are provided across the defined project groups and a number of aggregated statistics giving analyses of consortia sizes, project sizes, financing, trend analysis, etc. by cloud are presented in Section 4. Results were analysed in relation to the five mobility layers defined in the previous work. This analysis is expected to help further detect gaps in the current EU research funding landscape. The main findings presented in Mobility Report 2 are:

- The European Commission has spent around €3.43b on mobility-related research activities since 2007. On average, H2020 funded projects received €1m more financial contribution than FP7 funded projects. No strong correlation was found between the project duration and the EC financial contribution. The financial needs of projects with smaller consortiums were more affected by the number of participating entities than projects with more consortium members, which might have a much wider range of influencing factors.
- On average, mobility projects take about 2.6 years to complete, with FP7 projects taking slightly longer on average. The average size of a consortium is around 10 partners.
- Germany, Spain, France, the United Kingdom, and Italy are the leading hubs in terms of mobility-research coordination, though clear differences can be found between funding programmes and the coordinating countries.
- Some of the topic clouds identified are well-established lines of research, consistently well-funded, and led by major entities and countries. Others are emerging and somewhat niche areas following the shifting trends in mobility; e.g., AI, with a few entities and countries emerging as new leaders of these more advanced and novel research areas.
- FP7 and H2020 projects differ in the topic clouds on which they predominantly focus. The focus on high-level strategies for transport innovation in FP7, for example, became less important with the transition to the H2020 programme. This is most likely because H2020 studied some research needs identified by research in FP7. Shifting trends in mobility areas, new emerging technologies, social reasons, etc. were likely factors that shifted the focus among different topic clouds over the years.
- Financial analysis performed on the topic clouds provides more detailed insights into how the financing is distributed among different research areas and can be linked to the mobility layers with their objectives and key performance indicators.
- The greatest number of research activities address the design and implementation of an integrated, intermodal transport system (layer 5).

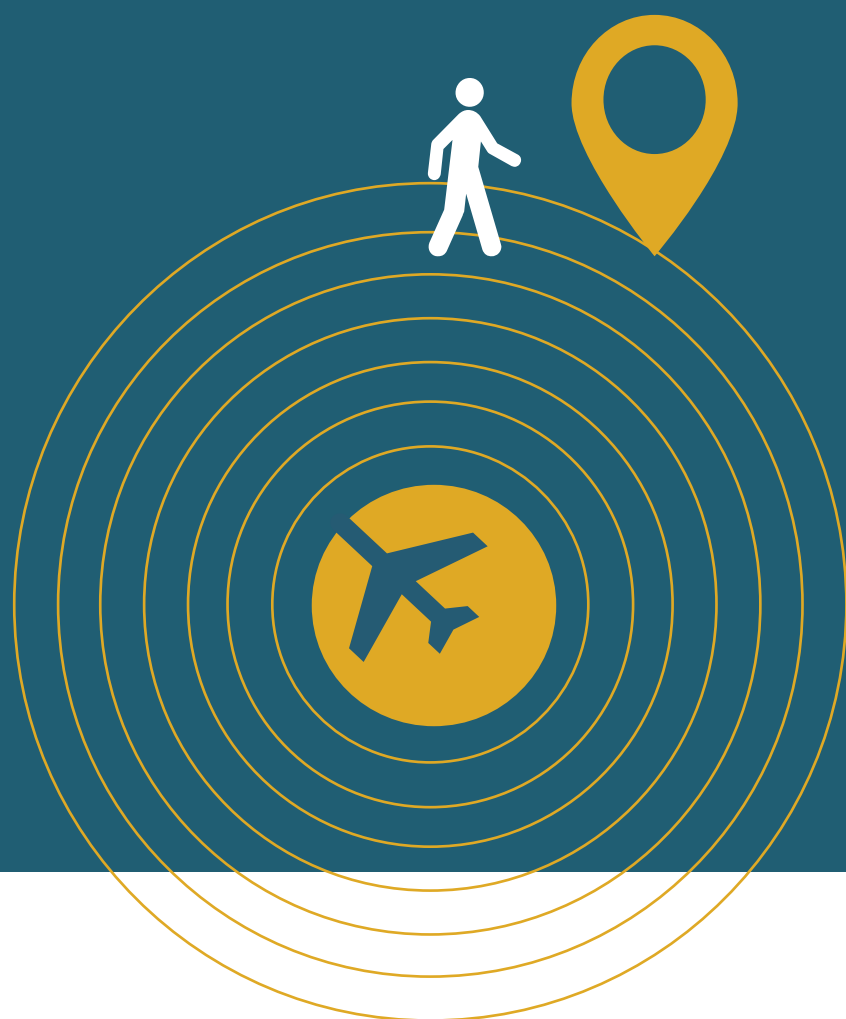
To improve our analysis, two areas of further research are planned in the upcoming months. First, further data collection needs to be performed and additional statistical analyses are needed to strengthen our understanding of the data and to obtain more insights. Second, based on additional analysis and insights, recommendations will be given for the future development of mobility research in Europe. Ultimately, we won't be able to answer all relevant questions and points of curiosity due to limitations such as lack of data or methodology limitations. However, these questions of interest will be documented as well. New findings will be discussed in the upcoming Mobility Report 3.



Number of scheduled passengers boarded by the global airline industry from 2004 to 2019 (in millions)
<https://bit.ly/2rNTzVm>

1

INTRODUCTION



What is CAMERA?

CAMERA (Coordination and Support Action for Mobility in Europe: Research and Assessment) is an EU-sponsored Coordination and Support Action. It is coordinated by The Innaxis Foundation and Research Institute (Spain), in partnership with the University of Westminster (UK), Bauhaus Luftfahrt (Germany), EUROCONTROL (France-Belgium) and DeepBlue (Italy). It was launched in November 2017 for a duration of 48 months. The project investigates research initiatives from 2007 into the European transport system, with a special focus on air travel, its integration with other transport modes, and the passenger experience.

Air travel is too often observed from the point of view of its mobility providers (airports, air navigation service providers, airlines, etc.), and not often enough from the passenger perspective, although these are the end customers of air transport. However, the digital transformation of the past years has changed passengers' expectations of air travel, which they increasingly consider to be just one part of a wider journey. Observing the whole door-to-door process, a typical air travel itinerary includes various segments such as getting to an airport by road or rail, and passing through different airport processes on the way to the aircraft gate. In many itineraries, the time spent in the air is one of the shortest, maybe even the shortest, parts of their trip.

To understand the complexity of the European air-travel system and address the mobility challenges it is facing, CAMERA's scope includes the whole door-to-door travel process and anything that has the potential to influence it. This holistic point of view is especially important in today's age of artificial intelligence, increased connectivity and personalised services. Moving towards a seamless and efficient door-to-door model, instead of focusing only on the gate-to-gate part of passenger itineraries, is becoming the norm for innovation in mobility.

Addressing essential European mobility strategies such as Flightpath 2050 [1], CAMERA started with summarising the challenges of the overall mobility system in Europe today into five major thematic groups, or "layers":

LAYER 1: Creating an individualised and seamless mobility system for everyone.

LAYER 2: Improving the overall performance of the mobility system.

LAYER 3: Improving the resilience and re-configuration of the mobility system.

LAYER 4: Providing safe and efficient air traffic management services.

LAYER 5: Designing and implementing an integrated, intermodal transport system.

These five layers are the foundation of the performance framework developed by CAMERA. Each layer presents a number of indicators, derived from high-level goals stated in various European strategic transport agendas, that enable progress towards tangible measurable goals for mobility research in Europe to be measured, and in turn allow the state, gaps and bottlenecks of latests research

initiatives towards achieving those goals to be assessed. An extensive discussion of the layers and the development of the performance framework is presented in the project's Deliverable 2.1. "Establishment of Performance Framework". [2]

Objectives of the CAMERA project

The CAMERA initiative aims to evaluate the impact of EU mobility-related projects in the context of the five above-mentioned mobility layers, e.g. for Layer 1 this means assessing the European research landscape in terms of individualised door-to-door passenger journeys. For this purpose, CAMERA focuses on developing an innovative and (semi-)automatic method that can:

Ingest data on European research projects funded by the FP7 and Horizon 2020 frameworks, and identify those that are most likely to be of interest to (air) transport and mobility.

Analyse the projects retained and cluster them according to the challenges they tackled.

Assess the extent to which each mobility research project addresses the identified challenges.

Provide a quantitative understanding of what challenges are being sufficiently investigated or, conversely, under-explored.

The automatised quantitative analysis obtained through state-of-the-art artificial intelligence algorithms is complemented by the qualitative analysis provided by human experts. Therefore, in working towards achieving its objectives, CAMERA combines a top-down (structured benchmark analysis of past and ongoing mobility-related activities) and bottom-up (separate consultations with stakeholders) approaches.

The Natural Language Processing (NLP) algorithms

Techniques developed in CAMERA provide tools for performing an automated assessment of research projects. Such tools are based on probabilistic clustering algorithms, which determine the most relevant topics in a document by inspecting the probability distributions of words in its text. CAMERA applies these tools to the textual data on the EU-funded projects available in the CORDIS database [3], the European Commission's primary public repository for project dissemination.

This approach enables the team to analyse large volumes of unlabelled text without prior knowledge of the content of the documents and the subjects they addressed. In principle, with this technique it is possible to process all textual data available on CORDIS, without having to specifically restrict the scope to transport-related programmes. One direct benefit of this method is that it makes it possible to identify mobility-relevant projects from other application domains (e.g., ICT - Information, Communication and Technology), or in other programmes such as the SME Instrument (one of the main funding programmes for emerging small and medium-size enterprises). Deploying artificial intelligence methods enhances our analytical capabilities for assessing and reviewing large datasets.

Work described in the previous mobility report (MR1)

CAMERA's first mobility report set the stage for the project by describing the challenges for European mobility in detail, and the methodology adopted to analyse the research. In addition, a preliminary study was presented, which analysed a sub-sample of 158 research projects to confirm the validity of the automatic approach and explore its limitations. For this primary data set, the geographical distribution, the leading coordinating entities, the historical evolution, and the overall project size were analysed. These findings provided the first valuable insights into applying an automatic approach in the CAMERA project. Furthermore, MR1 gave a first overview and comparison of how well the different layers and related topics were addressed. This showed the number of projects relevant for each of the five layers and derived topic clouds that particularly highlight the focal points of research over the past decade, and explored underlying content patterns within the textual data.

The specific objectives and focus of this mobility report (MR2)

As in the first mobility report, CAMERA applied an automatic filtering methodology based on natural language processing (NLP) to the full set of research initiatives in the CORDIS' database. The first objective of this approach was the selection of the projects relevant for mobility objectives as defined in CAMERA, and therefore relevant for analysis by the project. The time saved by using an automated approach instead of a manual selection process is immense since the CORDIS database contains around 50 000 entries* after the cleaning and preprocessing has been performed. However, in order to miss as few as possible mobility-relevant projects, and contrary to what was done in the first mobility report, this filter has now been redefined as a "weak filter". That means that the cost of a false positive is considered to be far less than the cost of a false negative. This filter currently relies on several algorithmic outputs passed through a system of majority voting, so that each project is labelled according to the majority vote of all the outputs (each output can be considered to be one voter).

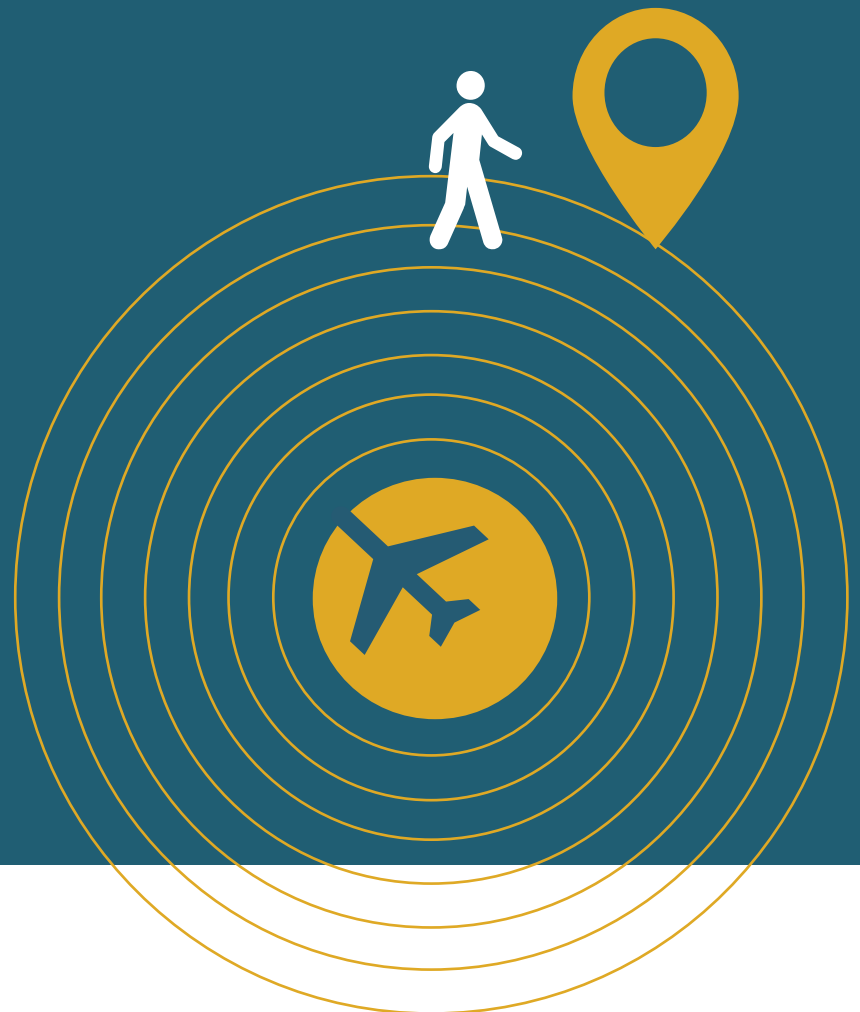
This filter yielded 1065 projects. These were reviewed by a team of experts, and the outliers were removed from the final selection, retaining the 926 projects that are analysed in this report.

Lastly, it should be remembered that the notion of mobility-relevance is not clear cut, as it is often difficult to assess the effect a research initiative might have on mobility in Europe, especially when trying to forecast its long-term impact. Due to this, CAMERA has decided to keep the scope of mobility relevance as broad as possible, while still obtaining insights that are pragmatic and, hopefully, useful for policy makers. The in-depth insights we present in this report are the result of a quantitative assessment of the impact of existing research initiatives into European mobility research, enriched by a qualitative analysis performed by CAMERA's team of experts.

**accessed and last updated in October 2019.*

2

MOBILITY CHALLENGES



European countries need to address the numerous and pressing challenges that obstruct the full realisation of the European vision for future mobility, that must be sustainable, digital, multimodal, highly efficient, and climate-neutral. Aviation plays a lead role in this vision, as growth in demand for air transport services is expected to increase further over the coming years.

Understanding the many challenges the European transport system faces today, and will face in the future, and turning these into measurable objectives is part of several transport research agendas.

In the CAMERA project these diverse challenges and their associated objectives are combined and translated into CAMERA mobility layer challenges: five different layers that are outlined in further detail below (and in [2] and [4]). While putting air transport at the heart of the mobility system, CAMERA adopts a broader passenger viewpoint by considering the entire door-to-door journey. To these passengers, air travel is only one leg of a journey that also includes the trips to and from the airports and navigating the processes within the terminals. Often these segments constitute the longest part of their trip. Since CAMERA does not just look at one single leg of the passenger journey, it pursues a wider mobility scope by considering the interaction between different transport modes, or the performance of the overall system. This approach is reflected in the definition of the CAMERA mobility layer challenges.

In order to make a statement about how well the European research landscape is meeting these challenges, the CAMERA project follows a data-driven approach using publicly available data from European research programmes. It investigates research initiatives from the past decade within the FP7 and H2020 funding programmes (cf. Table 1 on page 18) that focus on the European air transport system and its integration with other transport modes, with a special emphasis on the passengers' perspective and their experience as customers of the transport system as a whole.

The following section briefly reiterates the CAMERA mobility layer challenges, and outlines the database used for the analysis in the subsequent sections.



LAYER 1

Creating an individualised and seamless mobility system for everyone.

Since 21st century travellers differ in many ways, with diverse demands and requirements regarding the European mobility system, the future mobility system should be inclusive and provide intermodal solutions for all types of user. In the age of digitisation, artificial intelligence, and data literacy, customer demand will be even more diversified. Upcoming generations of travellers will be more empowered through technological advances and higher data availability. This imposes requirements on the air transport system such as various self-service facilities at airports, information on disruptions and delays along the entire journey, with the ability to proactively react to potential hiccoughs. Similarly, mobility providers also realise that they need to provide more options to allow travellers to manage and customise their travel arrangements. Personalised travel arrangements are one of the biggest drivers of customer demand in the age of big data. In the effort to create an easy and user-friendly transport system, single ticketing that incorporates all modes of transport could further increase service quality and seamlessness for passengers. All the improvements proposed above must also keep safety, security, and environment-friendliness in mind.

The realisation that each customer has unique travel needs has led to increased research into different customer profiles and their associated expectations, which include different aspects of the passenger experience. Mobility providers have realised that these have an impact on mobility choices that passengers make. In the end, their passengers are the users of the system and shape the demand for mobility.

With these developments in mind, the CAMERA project adopts a passenger-centred perspective. However, the passenger is not the only concern. The socio-political acceptance of mobility is another important aspect that must be considered, an example being the impact of transport projects on the environment and on ordinary citizens. Nor should the business aspect be forgotten; incentives for innovation in new technologies, mobility products, and services and hence the potential for market penetration, must be taken into account.

LAYER 2

Improving the overall performance of the mobility system.

The different steps of a passenger journey cannot be enhanced or optimised in isolation, a holistic approach that looks at the performance of the overall transport system is required. Flightpath 2050 targets or challenges explicitly address the target of 90% of intra-Europe journeys involving an air leg being potentially achievable in under 4 hours door-to-door (4HD2D) by 2050.

To describe the current state of the mobility system in Europe and its progress towards the targets envisaged in Flightpath 2050, it is necessary to capture crucial information on the door-to-door journey, including economic and environmental considerations, as performance indicators in a more fact-based discussion of the CAMERA project. This approach can help to drive innovation in transport and optimisation of overall mobility performance, including accessibility, interoperability, and punctuality, for example. These metrics are valuable to managing the travel process by monitoring and forecasting the flows within the system. This framework also provides benchmarks for the evaluation of the impact of new technologies and services.

LAYER 3

Improving the resilience and re-configuration of the mobility system.

Commercial aviation is subject to a number of events that can disrupt the air traffic management system such as bad weather, an external attack, a crisis, or an ATC strike. If the resilience of the air transport system falls short, this might significantly delay flights, resulting in cascading effects across the overall network.

The reaction of the overall system to these events determines the degree to which seamless and efficient operations can continue and what additional costs are incurred. Improving the resilience of the European transport system is an ambitious goal envisaged by Flightpath 2050, including the target that all flights should arrive "within 1 minute of the planned arrival time, regardless of weather conditions" [1]. Additionally, the transport system should be capable of automatically and dynamically re-configuring the journey within the network to meet the needs of the traveller.

The CAMERA project focuses on understanding and analysing the research initiatives that work towards meeting these goals, including minimising travel delay or re-configuring itineraries.



FLIGHTPATH 2050
Europe's vision for aviation
<https://bit.ly/2zQOp0z>

LAYER 4

Providing safe and efficient air traffic management services.

The increase in the number of flights over the years has put enormous pressure on the capacity of the air traffic system to handle them, which can thus result in delays to scheduled flights. Future challenges include the provision of services that enable the safe and efficient incorporation of "at least 25 million flights a year of all types of vehicles" [1] into the overall system while also reducing the environmental impact. Hence, reducing and handling congestion is one of the major challenges to be addressed.

CAMERA's analysis of the research landscape includes looking at progress towards reducing delays, the implementation of network congestion management and recovery mechanisms, and the establishment of a system that accommodates all vehicle missions and aerial applications.

LAYER 5

Designing and implementing an integrated, intermodal transport system.

The efficient integration of different transport modes and the provision of air transport interface nodes is crucial to ensuring progress towards a seamless European mobility system that meets both passenger needs and additional capacity requirements. As a result, European mobility goals, as outlined in Flightpath 2050, focus on the optimisation of services and processes within these nodes, and on the integration of air transport infrastructure with other modes.

The goal, therefore, is to achieve an intermodal network and related processes. This also includes the capability of integrating new (air) mobility concepts and technologies. CAMERA investigates the progress towards increased interoperability across transport modes. This is considered significant in reducing travel time as well as reducing unnecessary inconvenience for passengers. Another challenge aims to ensure access and equity for different user groups. This can include monitoring the availability of barrier-free access possibilities or the availability of different means for accomplishing a redundant presentation of essential information across all transport modes.

Database and funding programmes

Several EU-funding schemes have been established to tackle these mobility challenges and find possible solutions. Both the FP7 and H2020 framework programmes and the associated projects are considered within the scope of CAMERA. An overview of projects from these funding schemes is documented in the Community Research and Development Information Service (CORDIS).

TABLE 1:
CONSIDERED FUNDING SCHEMES (DATA SOURCES: [5], [6])



**45.5B €
Contribution**

2007-2013 | >130k ORGANIZATIONS

TRANSPORT
> 700 FUNDED
PROJECTS

TRANSPORT
3.5 BN EU
CONTRIBUTION

The 7th Framework Programme for Research and Technological Development (FP7) had a substantial increase in its overall budget compared with the previous framework programme, FP6 (41% at 2004 prices, 63% at current prices), a reflection of the high priority given to research in Europe.

In the scope of the EU framework programmes, there are many research programmes that are dedicated to specific sectors or fields, such as Clean Sky and Clean Sky 2 that focus on aeronautical research.



Funded by the European Union

**50B €
Contribution**

2004-2020 | >130k ORGANIZATIONS

TRANSPORT
> 1400 FUNDED
PROJECTS

TRANSPORT
4.5 BN EU
CONTRIBUTION

Horizon 2020 is the largest EU Research and Innovation programme so far. So far, more than 26,000 projects have been granted. One of the top priorities of the programme is to envisage and develop solutions for smart, green and integrated transport.



H2020 PROJECTS

EU research projects
under Horizon 2020
<https://bit.ly/2ckXLmz>



FP7 PROJECTS

EU research projects
under FP7
<https://bit.ly/2Dgtbcv>

CORDIS

CORDIS is the European Commission's primary public repository and portal for disseminating information on all projects funded by the EU's framework programmes for research and innovation (FP1 to Horizon 2020) and their outcomes. The objective of CORDIS is to bring research results to professionals in the field to foster open science, create innovative products and services, and stimulate growth across Europe. The repository includes all public information held by the Commission, such as project factsheets, participants, reports, deliverables, links to open-access publications, and editorial content to support communication and exploitation. CORDIS also produces its own range of publications and articles to make it easier for you to find relevant results that you can use in your domain [3].

This database builds the basis for the data analysis described in the following sections: identifying the geographical scope and dispersion of projects, the different entities involved, or the project size (Section 3); using the data to derive a range of topic clusters, thus identifying various focal areas for research, such as green urban mobility (Section 4). These topic clusters are matched with the CAMERA mobility layer challenges to identify those areas that are well represented by current research and those that are not.

3

PORTFOLIO OF MOBILITY-RELATED EU-FUNDED RESEARCH INITIATIVES

EU-funded mobility research activities involve consortium members from all over Europe. The assessment in this section provides an in-depth descriptive analysis of the geographical distribution, the leading coordinator, the historical evolution of the projects, the project size, and other information about the projects.

All the results are generated using state-of-the-art data mining and predictive modelling techniques. The dataset analysed is obtained by applying the automated text-mining approach developed within the CAMERA project. In total, 926 projects funded by FP7 and H2020* , and whose data was retrieved from the CORDIS database (see Section 2), were found to be in scope. These projects are either already completed or still in progress. The results show clear differences between the funding programmes and countries.

** As we will see below regarding Clean Sky 2 initiatives, Integrated Technology Demonstrators (ITDs) have co-leadership structures. For the sake of simplicity in reporting in this document, we will describe large, collective activities in Clean Sky 2 such as ITDs and Innovative Aircraft Demonstrator Platforms (IADPs), as 'projects'.*

Geographical distribution

A coordinating entity (coordinator) holds the coordinating function within a project. The main responsibilities of the coordinator are launching and overall leading of the project, monitoring project-related activities, acting as the intermediary for all consortium members and the European Commission, taking care of financial matters, and submitting deliverables and reports. Figure 1 shows the distribution of the countries coordinating each of the 926 projects analysed. The map reflects a fairly broad geographical range of institutes leading mobility research projects with several countries established as leading hubs of mobility research coordination. With 139 projects, Germany coordinates the greatest number of research activities, followed by Spain with 120 projects, France with 107, and United Kingdom and Italy with 106 projects each. As all of these countries are relatively strong European economies with large populations, these results were somewhat expected.

FIGURE 1:
NUMBER OF COORDINATED
PROJECTS PER COUNTRY
(BOTH COMPLETED AND
ONGOING PROJECTS)

TOTAL NUMBER
OF PROJECTS

926

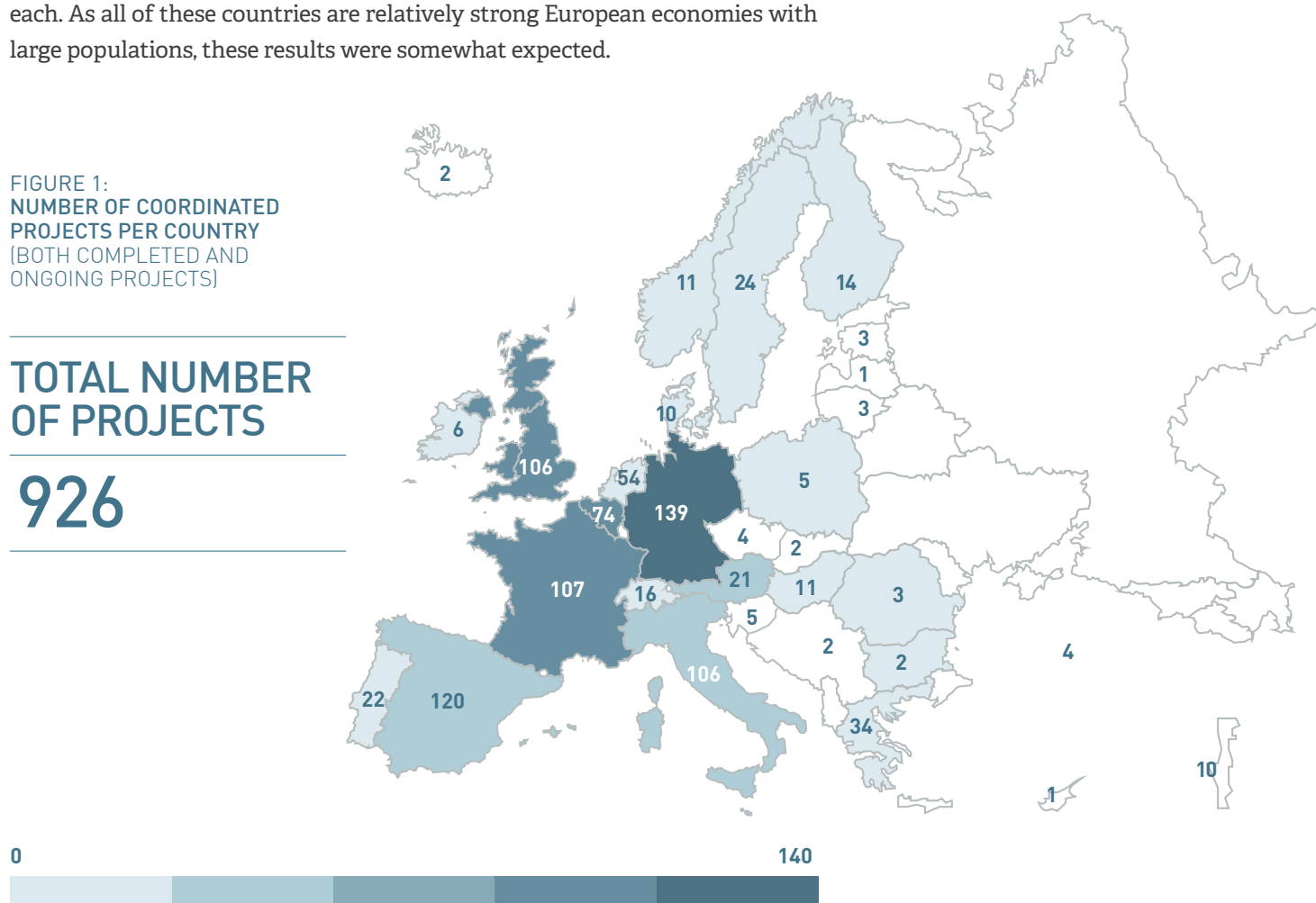
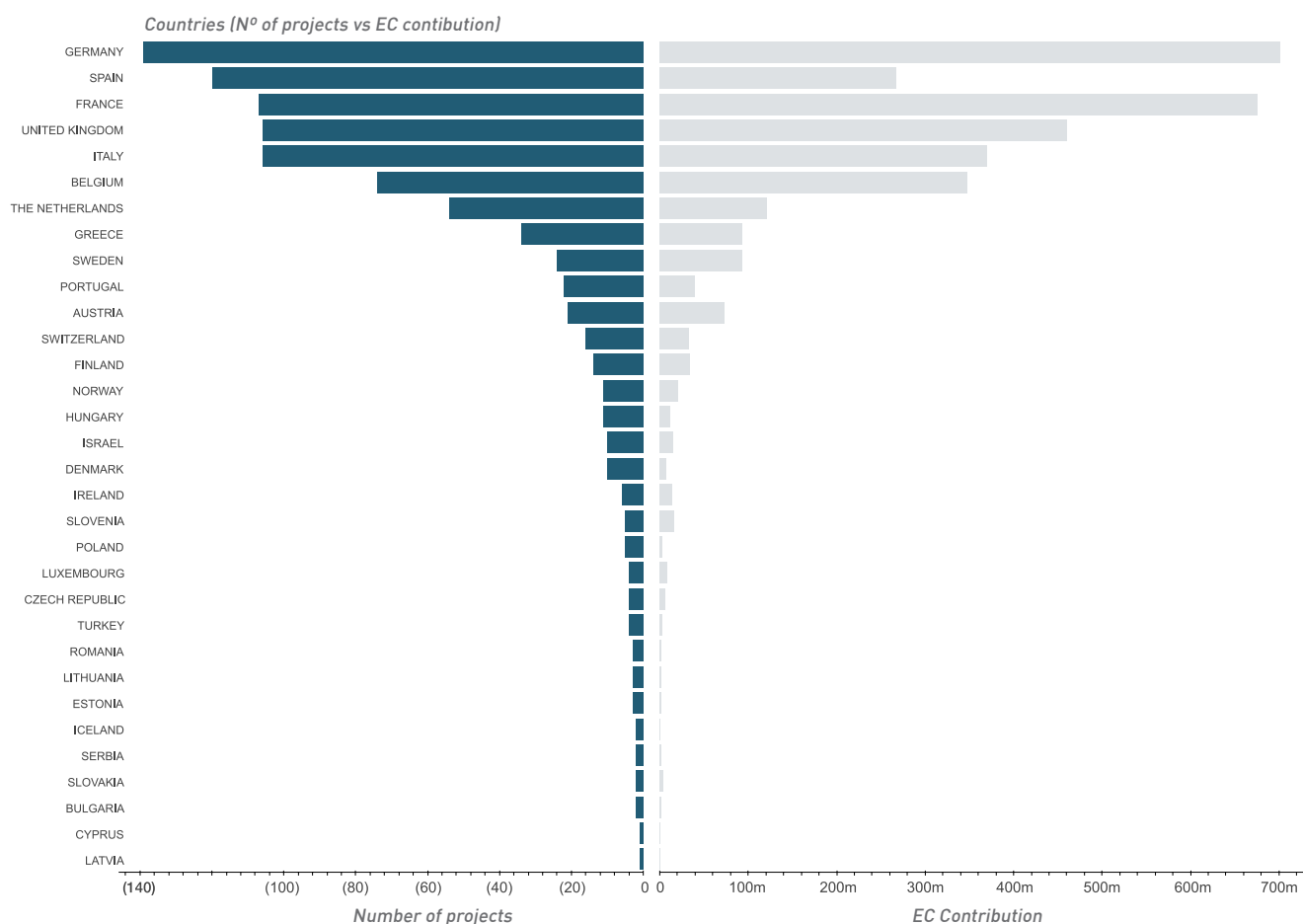


FIGURE 2:
COUNTRIES WITH TOTAL NUMBER OF PROJECT COORDINATIONS
AND EC CONTRIBUTION RECEIVED (IN €)



An overview of all the coordinating countries ordered by the total number of projects coordinated is shown in Figure 2, together with the total financial contribution from the EC for all of the projects coordinated for each country. There seems to be a fairly linear correlation between the total contribution received and the number of projects led. A few countries deviate from this trend, however.

For instance, Spain coordinates the second highest number of projects, the total contribution from the EC for these is fairly small. In addition, although France coordinates 32 projects fewer than Germany, the total EC contribution was almost the same in both cases. Such deviations could be explained by factors like the number of consortium members, project duration (shorter projects could receive a much smaller amount), and other specific project needs. More information on the project funding structure can be found in the next sections.

Leading coordinating entities

At the entity level, there is a similar distribution to that described above. For instance, the top two coordinating entities by total number of projects are both located in Germany. The Deutsches Zentrum fuer Luft- und Raumfahrt (DLR) coordinates 27 of the 926 projects. Other top coordinating entities are Fraunhofer, the European road transport telematics implementation coordination organisation, EUROCONTROL, and TU Delft. The list of the top ten coordinators, including the number of projects coordinated and the EC contribution managed, is given in Figure 3. The ten entities listed coordinate around 12% of all of the projects in scope. Becoming a leading coordinating entity can be influenced by various factors, such as the size of the organisation, previous experience as coordinator, the scope of work, networks, and internal project acquisition activities. Most of the entities in Figure 3 are large organisations with a strong mobility focus.

Filtering for the highest EC project contribution instead of the overall number of projects coordinated as explored above, the list of top entities changes, as can be seen in Figure 4. The bar chart shows that projects co-led by Airbus, MTU and Thales, all being corporate organisations working in the transport sector, and no research institutes, received the highest amounts of funding. DLR, the top coordinator regarding the overall number of projects coordinated, managed only the seventh highest total contribution overall. One could say that the number of projects in Figure 4 is somewhat inversely proportional to the overall project contribution managed. We will elaborate below on four projects within H2020. Three of them are (co)-led by Airbus, MTU, and Thales, which could explain the rather high contributions for these entities.

It should be borne in mind that the financing shown in this figure is the full contribution that a project received from the EC, assigned to, and managed by, its coordinating entity (or entities). Therefore, where Airbus is the leading entity on the infographic (cf. Figure 4), this should be interpreted as: 'The projects coordinated by Airbus received the highest total financing among the projects in the database'. The coordinator distributes payment among the other project partners. However, the data retrieved do not provide sufficient information to allow filtering for the contribution per project of each consortium member (or across co-leads).

FIGURE 3:
TOP TEN COORDINATING ENTITIES WITH RESPECT TO THE TOTAL NUMBER OF PROJECTS

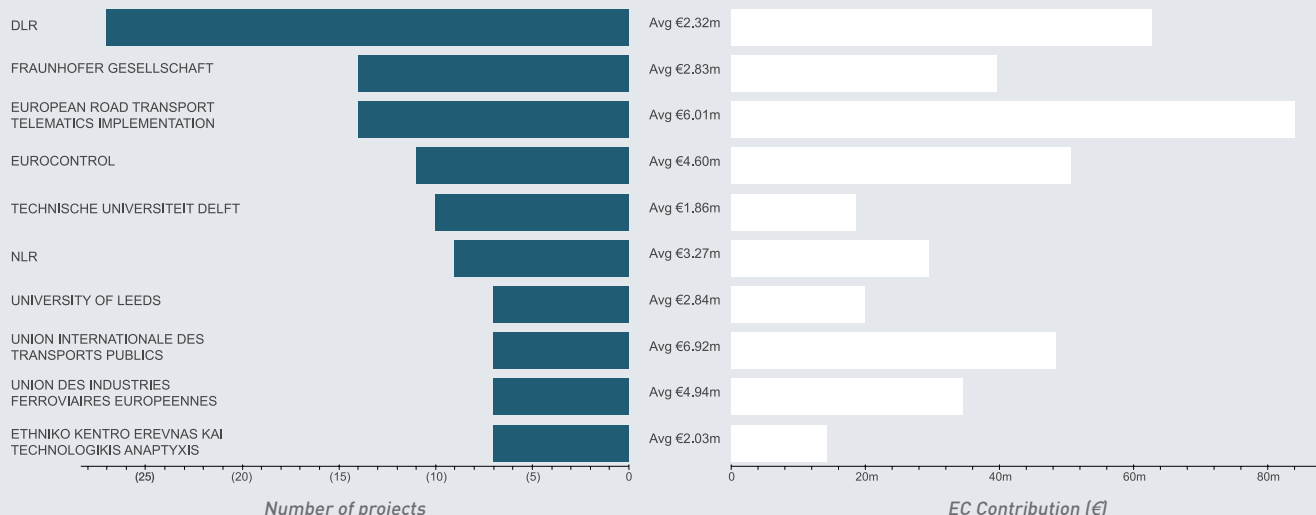
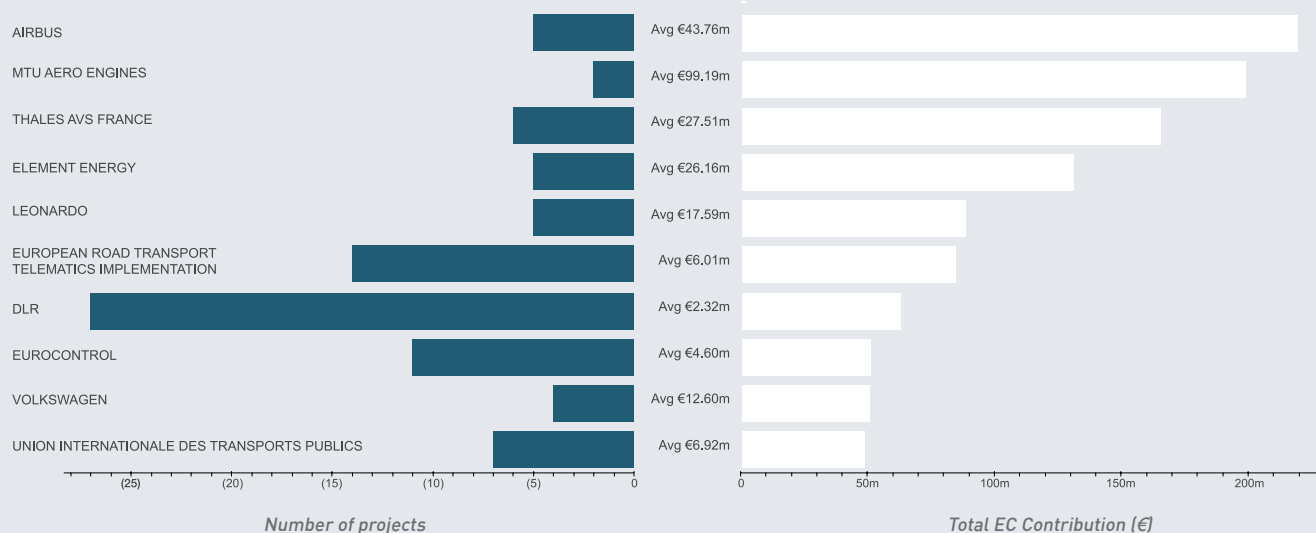


FIGURE 4:
TOP TEN COORDINATING ENTITIES WITH RESPECT TO THE TOTAL EC CONTRIBUTION RECEIVED (IN €, INCLUDING AVERAGE PROJECT COST)



Figures 3 and 4 show the average EC contribution per project coordinated between the bars of the total EC financing managed and the number of projects coordinated (sometimes (co-led) by each coordinator). Detailed information on financial contributions to individual consortium members is only available in an unstructured format on CORDIS. This would require web scraping to extract the fields of interest. This is not easy to implement and is generally a lengthy process. It is strongly recommended that detailed financial information in a structured format be added into the CORDIS database to increase transparency and enhance the insights achievable with automated procedures.

Project funding

The EC has spent around €3.4bn on mobility-related research activities since 2007. On average, FP7-funded mobility projects received smaller EC contributions than H2020-funded projects. FP7 projects received an average funding of €3.14m, compared with an average funding of €4.14m for H2020 projects. This is clearly seen on a per-country basis in Figure 6B. A notable example is France: H2020-funded projects received on average more than double the amount of funding from the EC than FP7-funded projects. This result is somewhat surprising as FP7 projects were longer in average (cf. Figure 10) and seem to have had larger consortiums (cf. Figure 11).

Other contributing factors could be the overall structure of FP7 projects, as more time could be given to preparing deliverables and reaching the overall project objectives. The greater average contribution per project-month for H2020 (Figure 6B) could be an indicator supporting this. FP7 projects also started much earlier in 2007, with the monetary value dropping over time due to inflation. We remind the reader that these figures are applicable to mobility-related projects only and not to the entire funding programme. In addition, our CAMERA analysis contains more H2020 projects than FP7 projects (519 vs. 407; cf. Figure 5A).

FIGURE 5:
A. NUMBER OF H2020 AND FP7 MOBILITY-RELATED PROJECTS ANALYSED
B. AVERAGE EC CONTRIBUTION PER PROJECT (IN €)

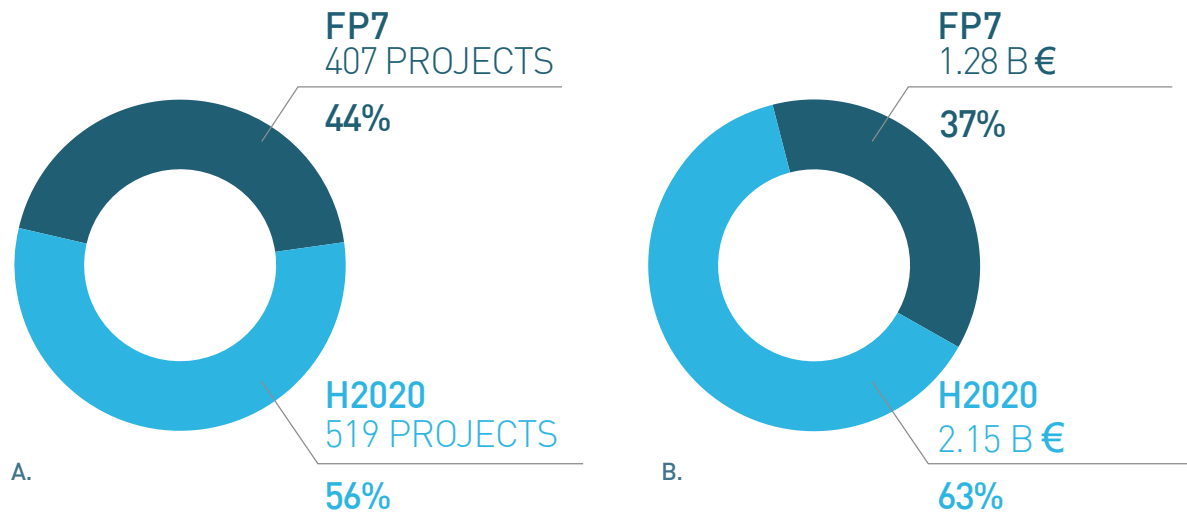
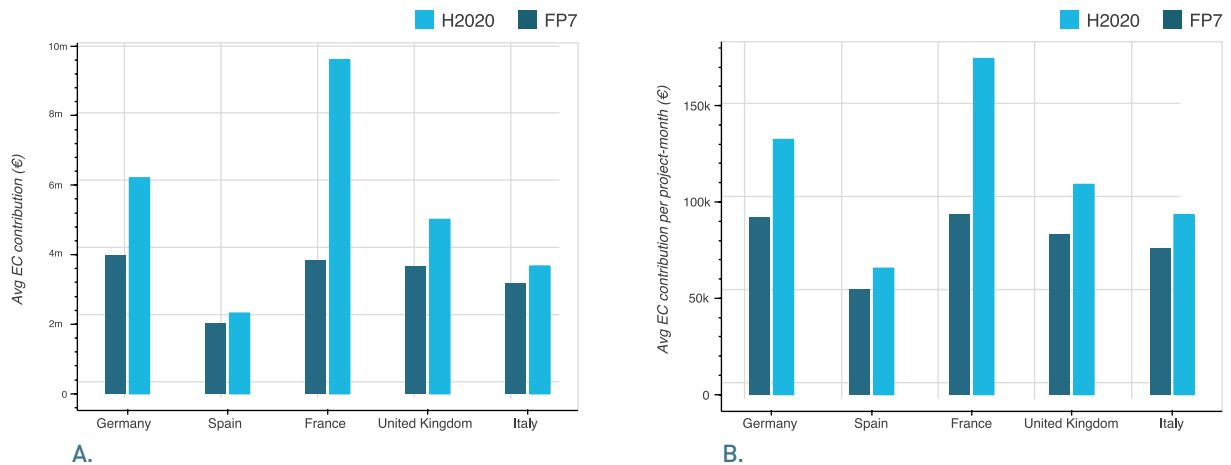


FIGURE 6:
A. AVERAGE EC CONTRIBUTION PER PROJECT (IN €) PER COORDINATING COUNTRY
B. AVERAGE EC CONTRIBUTION PER PROJECT-MONTH (IN €) PER COORDINATING COUNTRY



Historical evolution

Projects funded under FP7 started in 2007 and those under H2020 started in 2014. Figure 9a shows how the H2020 programme followed the FP7 programme in 2014. As (some) H2020 projects are still ongoing until the end of 2020, this cannot be considered the final curve; however, trends are clearly visible. Both funding schemes naturally have their project peaks in different years. Almost 80 FP7 projects were launched during the peak year (for start dates) in 2011. More than 120 H2020 projects represent the next peak of start dates five years later in 2016. Similarly, observing the curve that presents the number of active projects each year since 2007 (cf. Figure 7B), it can be seen that the peak of research activity in mobility research in FP7 was reached in years 2012 and 2013, with around 250 ongoing projects. On the other hand, the most active year for mobility research under H2020 was 2018, with around 350 projects ongoing at that time. A project trough can be observed in 2014, within the transition phase from FP7 to H2020.

The time-evolution curves of both funding schemes look normally distributed, more so the time-evolution of project activity shown in Figure 9b. This changes when looking closer at the curves showing the EC contribution received, in Figure 10. Whereas for FP7, the EC contribution and number of projects developed almost in parallel over time (cf. Figure 7A and Figure 8), H2020 shows a varying development. In terms of the EC contribution towards both programmes, Figure 8 shows that that for FP7 projects rose slowly, whereas H2020 projects received over €500m straight away in the launch year of 2014. By contrast, the peak of EC contribution for FP7 projects was reached in 2013, more towards the end of the programme.

FIGURE 7A:
TIME EVOLUTION OF PF7 PROJECTS AND H2020 PROJECTS STARTING FROM 2007

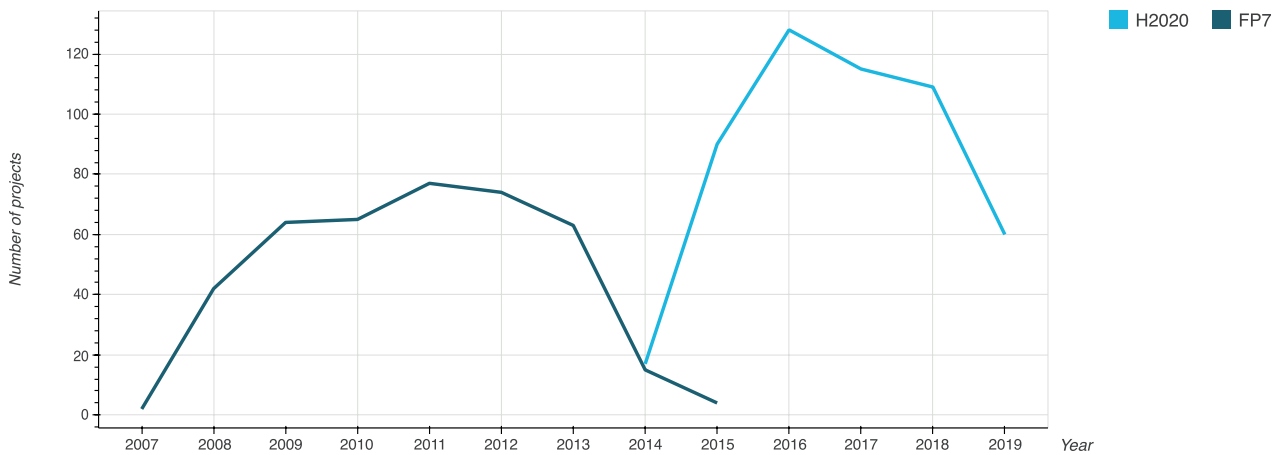


FIGURE 7B:
TIME EVOLUTION OF THE NUMBER OF ACTIVE FP7 AND H2020 PROJECTS

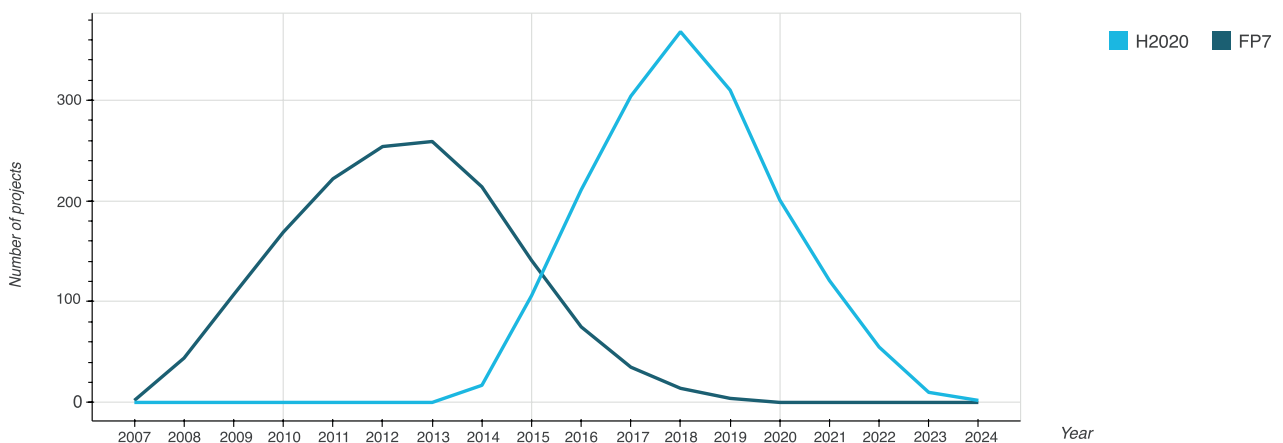
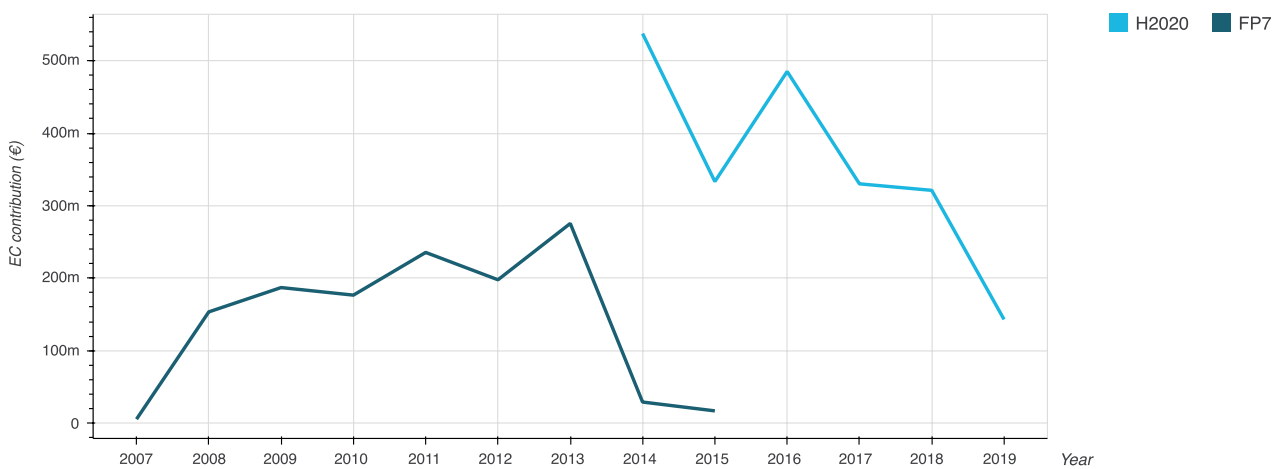


FIGURE 8:
TIME EVOLUTION OF EC CONTRIBUTION (IN €)



Project size

The average project duration and consortium size varies by coordinating country and funding programme. Figure 9 shows the lengths of both H2020 and FP7 projects. Most projects take 24, 36, or 48 months to complete, the average duration being about 2.6 years. Projects coordinated in Spain have the shortest duration, around 24 months, of those from the top five coordinating countries, which could explain the small EC contribution for that country's projects compared with the number of projects coordinated there.

Taking a closer look at these aggregated statistics by funding programme, FP7 projects seem to have a longer average lifespan than those of H2020. Likewise, the average consortium size of FP7 projects exceeds that of H2020 projects, as can be seen in Figure 9. For the top five coordinating countries, the average number of partners varies from a minimum of approximately six - H2020-projects coordinated in Spain - to a maximum of approximately thirteen - FP7-projects coordinated in Germany and France. This rather high number could be another explanatory factor for the large EC contribution received for projects coordinated in these latter two countries. The average size of a consortium for both H2020 and FP7 projects is around 10 partners. Very few project consortia have more than 30 partners, as shown in Figure 12.

FIGURE 9:
PROJECT DURATION HISTOGRAM (H2020 VS. FP7)

■ H2020 ■ FP7

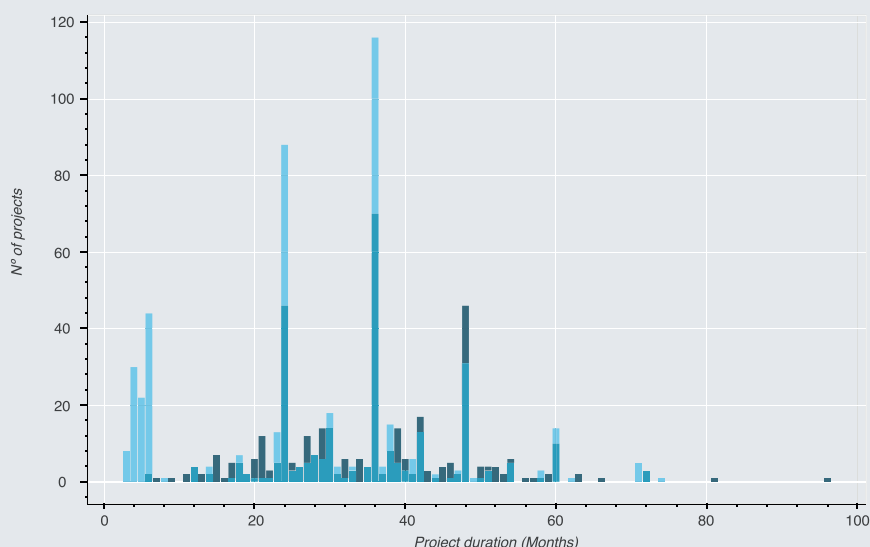


FIGURE 10:
AVERAGE PROJECT DURATION -TOP 5 COUNTRIES (H2020 VS. FP7)

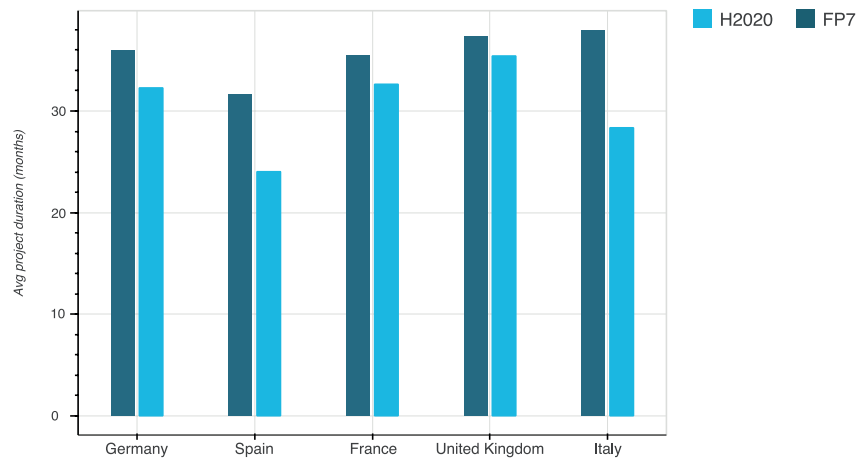


FIGURE 11:
AVERAGE CONSORTIUM SIZE FOR THE TOP FIVE COORDINATING COUNTRIES (H2020 VS. FP7)

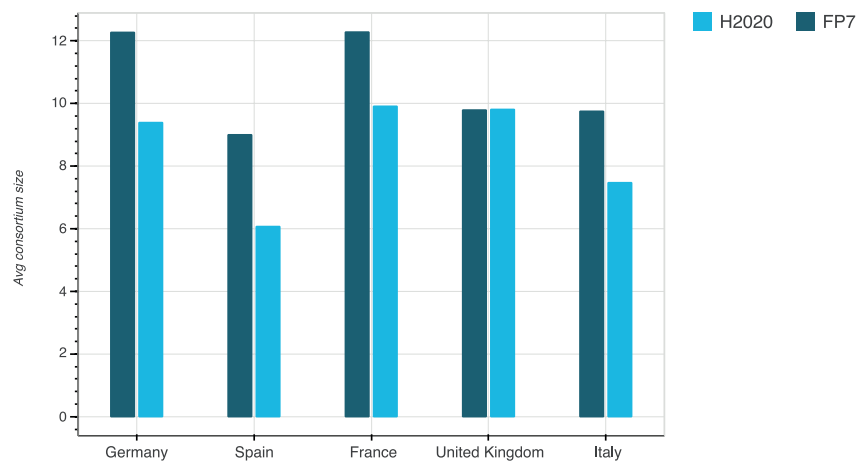
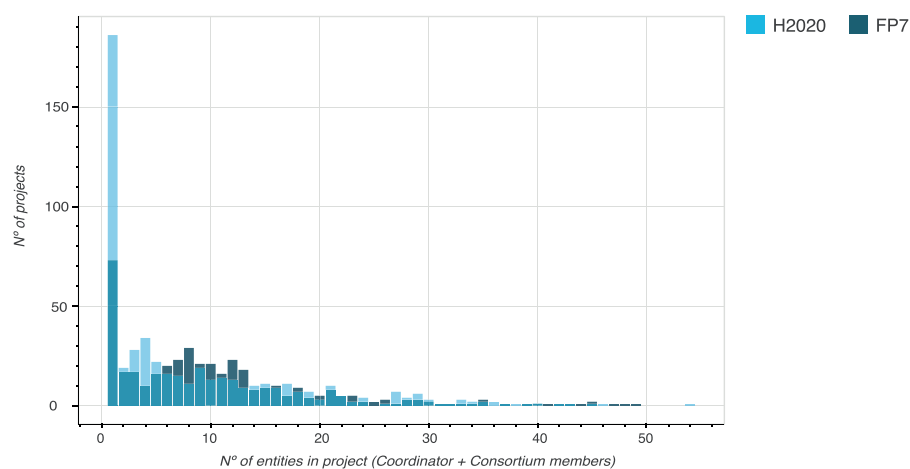


FIGURE 12:
NUMBER OF PROJECTS VS. PROJECT CONSORTIUM SIZE (COORDINATOR AND CONSORTIUM MEMBERS)



Exploring financing and project size

Correlation analysis provides additional descriptive insights and allows possible relationships to be detected. This is statistical technique to examine whether pairs of variables are related to each other, and if so how strongly. The resulting R^2 scores provide the strength of a linear relationship between two variables, ranking from 0 (very weak) up to 1 (very strong). In the scope of the CAMERA project, the results help us to evaluate the strength between financing that projects receive and other variables available in the dataset that might influence the financial contribution.

FIGURE 13A:
CORRELATION ANALYSIS OF
EC CONTRIBUTION VS. NUMBER
OF CONSORTIUM MEMBERS
LOGARITHMIC SCALE

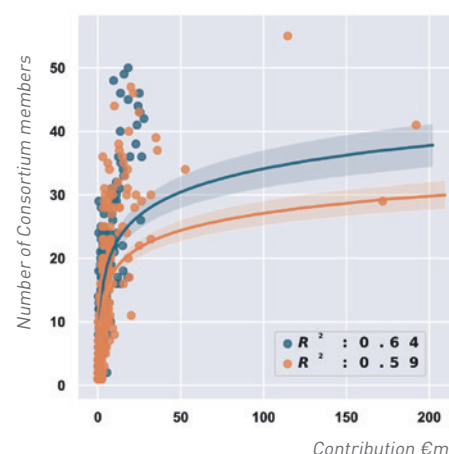
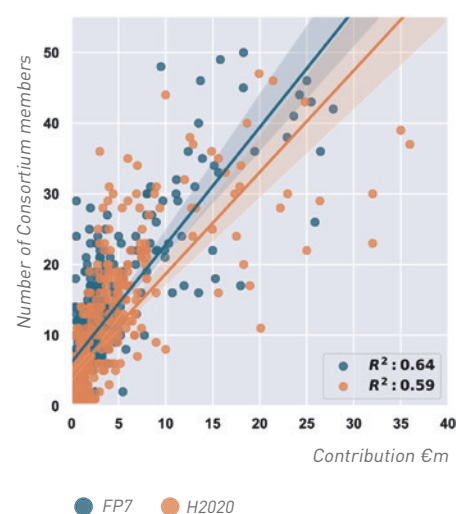


FIGURE 13B:
CORRELATION ANALYSIS OF
EC CONTRIBUTION VS. NUMBER
OF CONSORTIUM MEMBERS
AFTER REMOVING THE
FOUR OUTLIERS WITH
DISPROPORTIONATELY HIGH
FINANCING FROM H2020





In this section, the project size is expressed as a number of participating entities (also called the consortium members - the coordinator and the other consortium partners). Figures 13A and 13B were produced to investigate correlation characteristics between the project sizes (in terms of consortium size, and therefore their funding). Of the total 926 H2020 and FP7-funded projects in the database, only 65 outliers (i.e. 7%) received an EC contribution of more than €10m. These few projects with very large financing could distort the results of the correlation analysis and hence might hide relationships between variables we want to detect. For this reason, in addition to the analysis across the full distribution we decided to provide an analysis of two separate groups according to the financing received (Figures 14 A. - D.): projects with financing up to €10m, and those with financing equal to or above €10m. This threshold was chosen because different behaviour was noticed in the analysed variables for the projects below and above this amount.

Figure 13B shows a fairly linear, positive correlation between consortium size and financial contribution in the projects in the set when the outliers are excluded. In other words, in general, the more consortium partners work on a project, the more EC contribution the project receives. This behaviour is generally stronger for FP7 projects than it is for H2020 projects, as can be seen by looking at their coefficients of determination (the R2 scores): 0.64 for FP7 projects and 0.59 for H2020 projects.

The large funding areas (outliers) in the H2020 sample that were excluded from the general analysis slightly distort this result however (cf. Figure 13A), since their financing is much higher than average. The financial contribution given to these projects/areas is between 13 and 50 times higher than average of that for FP7 and H2020 projects of around €3.7m . These are discussed in more detail below.

There are some exceptions to these findings: projects with the largest consortia (over 30 partners) received financing ranging from €3m to around €40m, which is a significant range of values. This shows that the largest projects in terms of consortium size are not necessarily the ones that receive the highest financial contributions. This range of values is much smaller for projects with smaller consortia. The projects with the highest number of participating entities are usually those closer to market; typically those that include validation exercises, prototypes, etc. and have a higher cost (as was the case with CHIC, the project with the largest EC contribution in the analysis).

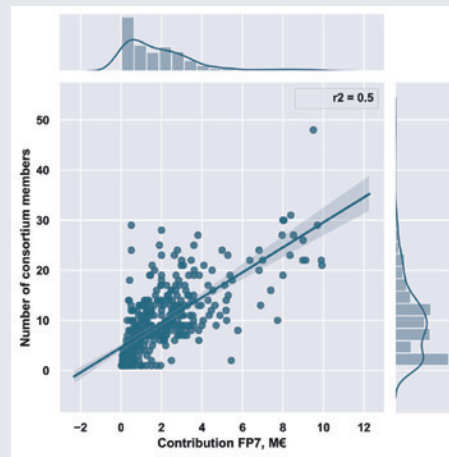
FIGURE 14: FINANCIAL CONTRIBUTION VS. PROJECT CONSORTIUM SIZE

A. FP7 PROJECTS WITH FINANCING UP TO €10 MILLION

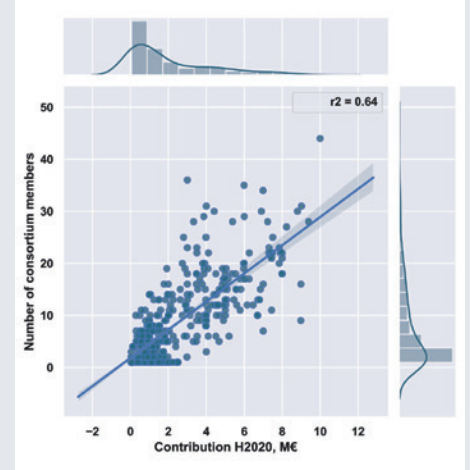
B. H2020 PROJECTS WITH FINANCING UP TO €10 MILLION

C. FP7 PROJECTS WITH FINANCING OVER €10 MILLION

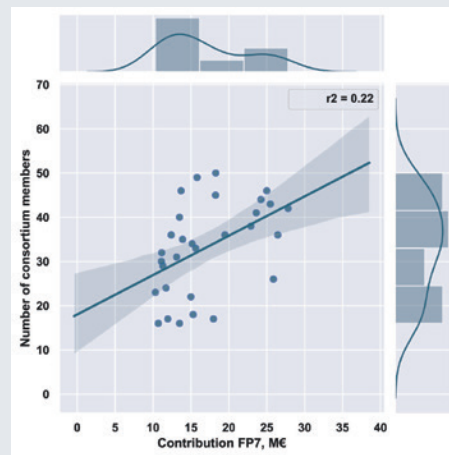
D. FP7 PROJECTS WITH FINANCING UP TO €10 MILLION WITHOUT OUTLIERS



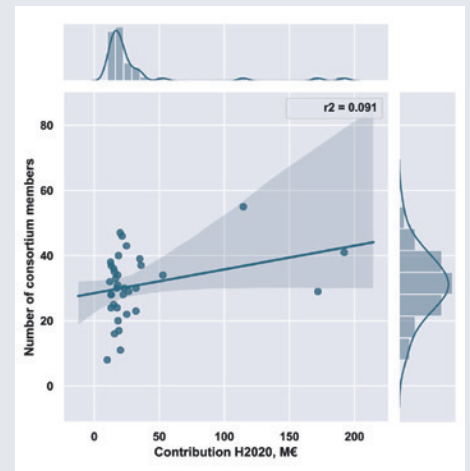
A.



B.



C.



D.

While there is no strong correlation between financial contribution and consortium size for large values of financial contribution, a stronger linear correlation can be established if we isolate the projects that received funding of up to €10m (see Figure 14A) and 14B). For these, we can see a fairly rapid linear 'growth' in financial contribution with each additional project member (more so in H2020 projects), whereas this relationship dissipates for projects with greater financing (see Figure 14C & 14D). The general conclusion is that larger projects do indeed have more variables that influence their financing, as explored further in the next section, whereas smaller projects' costs are mostly influenced by covering the costs of participating entities.

Larger funding activities

As mentioned above, there are four H2020 'projects' (see Figure 13A) that are particularly large in terms of their funding (over €50m) and/or duration (6 years) and number of participants (29 or more). Key details are summarised in the Table 2. They all belong to the Clean Sky 2 programme. We thus add a little context explaining the structure thereof. This programme comprises four elements: three ITDs (accommodating the main relevant technology streams for all air vehicle applications); three IADPs (involving demonstrations and simulations of several systems jointly at the full vehicle level); two Transverse Activities (integrating the knowledge of ITDs and IADPs for specific applications: Small Air Transport and Eco-Design); and the Technology Evaluator (assessing the environmental and societal impact of the technologies developed in the IADPs and ITDs). Each demonstrator or platform identified in our analyses (classified simply as a 'project' above) is coordinated by a large corporate organisation, rather than a research institute. In Clean Sky 2, as in Clean Sky 1, ITDs have co-leadership structures, and two of these are shown in the table.

TABLE 2.(NEXT PAGE)
LARGER CLEAN SKY 2 TECHNOLOGY DEMONSTRATORS
AND DEMONSTRATOR PLATFORMS IDENTIFIED

Clean Sky 2 programme activity	Technology Demonstrator/ Demonstrator Platform	Lead partner(s) (state(s))	Participants	Total budget (€m)	Summary details	Further information
Integrated Technology Demonstrators (ITDs)	System ('SYS')	Thales/AVS France (France), Liebherr (Germany, France)	55	114.6	This ITD includes most major aircraft systems: cockpit and avionics; environmental control systems; wing ice protection; electrical power generation, distribution and conversion; flight control systems and actuation. A joint focus is increasing electrification to enable the future more-electric or full-electric aircraft and creating environmentally friendly technologies, in particular for materials and processes.	www.cleansky.eu/systems
	Engine ('ENG')	Safran (France), Rolls-Royce (UK), MTU Aero Engines (Germany)	29	171.9	This ITD in Clean Sky 2 will build on the success of Clean Sky 1's Sustainable and Green Engines (SAGE), where the goals were to validate a 15% reduction in CO2 (compared to 2000 baseline), a 60% reduction in NOx and a 6dB noise reduction. This is roughly 75% of the ACARE objectives. The ITD will validate more radical engine architectures to a position where their market acceptability is not determined by technology readiness.	www.cleansky.eu/engines
	Regional Aircraft ('REG')	Leonardo Aircraft (Italy)	34	52.8	This IADP's objective is to integrate technologies for regional aircraft with respect to Clean Sky's Green Regional Aircraft ITD. Retaining these outcomes, advanced technologies for regional aircraft are being further developed and will be integrated and validated at the aircraft level, so as to de-risk their integration with future regional aircraft products.	www.cleansky.eu/regional-aircraft
Innovative Aircraft Demonstrator Platforms (IADPs)	Large Passenger Aircraft ('LPA')	Airbus (France)	41	192.2	This IADP is focussing on the large-scale demonstration of technologies integrated at the aircraft level, in three distinct 'platforms': [1] advanced engine and aircraft configurations; [2] innovative physical integration cabin – system – structure; [3] next generation aircraft systems, cockpit and avionics.	www.cleansky.eu/large-passenger-aircraft

Contribution vs. project duration

Figures 16A and 16B were produced to investigate correlation characteristics between the sizes of projects in terms of their funding and their duration. Here, project size is expressed as the overall duration in years, with an average duration of a project of around 2.6 years.

Figures 16A, 16B and 16C compare financial contribution with the duration of the project. We again observe different behaviour for the lower and higher values of both variables. For typical projects of up to 2 years, the growth in financial contribution with respect to the duration of the project is slower than for longer projects; a large number of shorter projects received contributions of up to around €2.5m. However, starting with a project duration of 3 years, the situation becomes more diverse. It is especially interesting to note the significant variance in funding received for projects of 3 and 4 years' duration, which indicates the existence of other variables dictating these differences. To detect further variables, additional in-depth analysis is necessary. The CAMERA project team will work further on this question over the rest of the project.

In general, the slopes of the H2020 and FP7 regression lines for the duration of the projects are more comparable than they were for the consortium size, but the correlation is weaker, as indicated by the determination coefficient, R^2 . In other words, at first glance, project duration does not seem to affect financing as much as consortium size.

FIGURE 16A:
PROJECT CONTRIBUTION VS.
ITS DURATION (EXPRESSED IN
YEARS), LOGARITHMIC SCALE
(ALL PROJECTS)

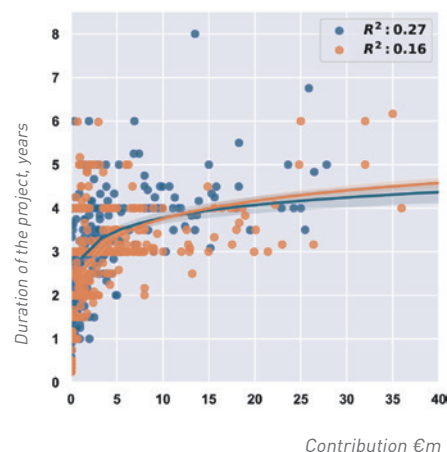


FIGURE 16B:
PROJECT CONTRIBUTION
VS. DURATION (EXPRESSED
IN YEARS), ABSOLUTE SCALE -
PROJECTS WITH FINANCING
UP TO €10M

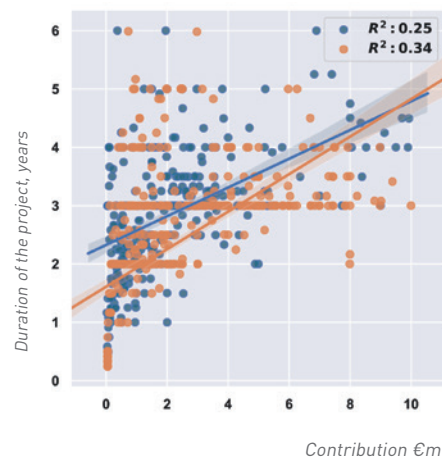
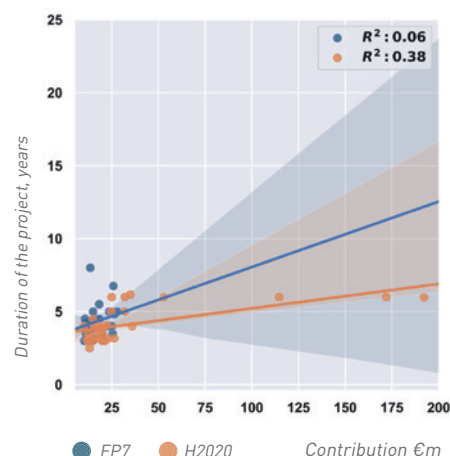


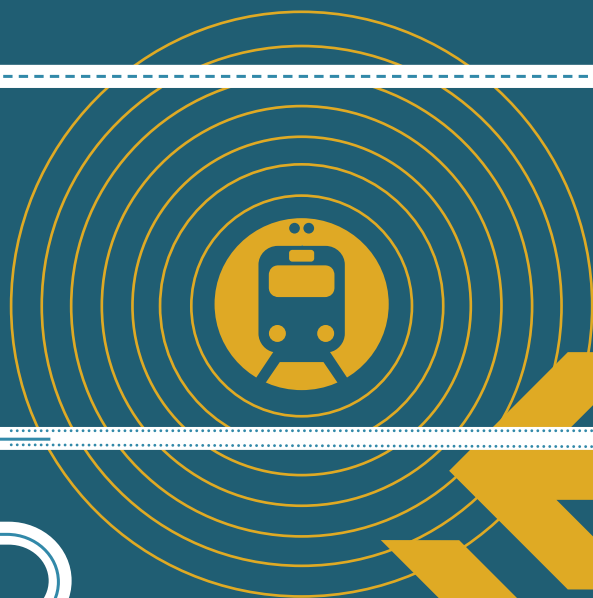
FIGURE 16C:
PROJECT CONTRIBUTION VS.
DURATION (EXPRESSED IN
YEARS), ABSOLUTE SCALE -
INCLUDING PROJECTS WITH
FINANCING OVER €10M





4

ANALYSIS: INSIGHTS AND EVIDENCE



Automatised unsupervised topic modelling: topic clouds

The set of 926 mobility-relevant projects has been modelled using an unsupervised AI method based on the latent Dirichlet allocation (LDA) topic modelling algorithm. This means, among other things, that we introduce no mobility preconceptions into our analysis and that the findings are purely data-driven. The model has the ability to automatically detect latent topics in a corpus of textual documents (926 projects in our case) without any human supervision. The following example better explains topic modelling and how it works:

Example: Topic modelling

Let us assume we have a very small corpus of 3 documents, each presented as a short vector of words, as in Table 3.

TABLE 3.
CORPUS OF DOCUMENTS,
EXAMPLE OF TOPIC MODELLING

Document Number	Word-vector representation of the document	Topic distribution
1	clothes, runway, show, fashion, model, Milan	$0.9 \cdot t_0 + 0.1 \cdot t_1$
2	premiere, drama, actor, cinema, release, show	$0.2 \cdot t_0 + 0.8 \cdot t_1$
3	drama, model, actor, premiere, fashion, world	$0.4 \cdot t_0 + 0.6 \cdot t_1$

The main premise of an LDA model is that the true topic of each document can be described as a distribution, or (linear) combination of other topics, or rather latent 'topic clouds' that the model will discover.

Imagine an LDA topic model that discovered 2 latent topic clouds, t_0 and t_1 , in this corpus. The last column in Table 3 presents a topic distribution for each document. This distribution describes the extent to which each of the revealed latent topic clouds contributes to the overall topic of a document.

However, the topic model does not produce labels for these topic clouds — they must be inferred by looking at the keywords with the greatest weight for each topic cloud and the documents most 'representative' of each cloud (where

the weight of that topic is greatest; e.g., from Table 3, document 1 would be topic t_0). By looking at the keywords extracted into each topic cloud, and an analysis showing that document 1 is about fashion and document 2 (the 'representative' document for topic cloud 2) about cinema, it can be deduced that topic cloud 0 is 'Fashion' and t_1 'Cinema'. Document number 3 can thus be seen to cover the two topics 'Fashion' and 'Cinema' almost equally well, with t_0 and t_1 having weights of 0.4 and 0.6, respectively.

In a real world setting, as is the case with the CAMERA project, things are not as simple. Real documents are much larger and more complicated; the topics revealed are not as clear-cut; the number of documents to be analysed is usually very high and many other problems arise that make building topic models quite a challenging task.

In order to obtain high quality topics, the topic model in CAMERA has been optimised for coherence among the defined topics. A coherent topic cloud of research projects can be understood as a set of projects that support each other. With the purpose of quantitatively assessing topic coherence, a topic coherence score [7] has been used as a metric, thus enabling the optimal number of topic clouds to be found. This measurement helps distinguish among topics that are semantically interpretable and those that are simply artifacts of statistical inference. In the example above, the topic coherence would be very high since the two topics are quite distinct and the third document supports the other two fairly well with its terms. (However, it should be understood that it is not very pragmatic to talk about a concrete topic coherence score on such small corpora of documents.)

Using the methodology described above, nine topic clouds were defined from the set of mobility-relevant projects. The following observations about the topic clouds should be borne in mind:

There may be some level of contextual similarity between the definition of the topic clouds — i.e., topics may overlap to some degree. However, when defining and describing the topic clouds, we tried to minimise that overlap. The model assigns each project a probability distribution over the defined topic clouds. This can be interpreted as a metric of how much each topic cloud contributes to the topic of a project (see Table 3).

In most cases, research projects cannot be fully assigned to one topic cloud. Due to the interdisciplinary nature of many mobility projects in the set, it can be expected that most are relevant to several topics, e.g. a topic of a concrete project lies at the intersection of several topic clouds (such as with document 3 in Table 3). One dominant cloud is assigned to each research project. A dominant cloud is the topic cloud with the highest weight for a certain project. However, the level of dominance can vary greatly: the dominant cloud of a highly interdisciplinary project is normally only marginally dominant over other topic clouds scoring highly for that project. In the example, document 3 in Table 3 would have Cinema as its dominant topic cloud, but with a fairly low level of dominance (over the other topic cloud in the example).



Topic Clouds

In this section, an overview of the identified topics is presented. In this report, each generated topic is referred to using the term 'topic cloud' to stress the fact that each topic can be represented as a word cloud. For each topic cloud, an umbrella title was chosen that will be used throughout this report together with a topic cloud number. Additionally, a short textual description is given to give the reader a little more understanding of the particularities of each topic cloud — for example, what kind of themes it covers.

Topic clouds are also presented, for ease of visualisation, using a list of key words in a word cloud. A word cloud for a topic contains the 12 most relevant terms that identify that topic. The important words, which have a much higher relative weight in this cloud than in other topic clouds are emphasised in blue and with a larger font. In addition to these keywords, to properly identify each cloud, the content of the projects that contribute most to each topic cloud and their distribution over all the identified topic clouds were analysed. For each topic cloud, the number of projects with this topic as their dominant topic was also determined — i.e. the number of projects best defined by this topic. This information is presented in a more easily digestible manner as a pie chart in Figure 21.

TOPIC CLOUD 1 GREEN AIRCRAFT TECHNOLOGIES OF THE FUTURE

emission industry design **new**
technology impact **engine** market
aircraft cost **fuel reduction**

SUMMARY DESCRIPTION

This topic cloud is characterised by the study and development of novel aircraft technology enhancements, with a strong focus on alternative fuels and greener technological solutions.

NUMBER OF PROJECTS 103

TOPIC CLOUD 2 NOVEL CONCEPTS IN MOBILITY

information data city user
traffic service transport urban
travel provide public mobility

SUMMARY DESCRIPTION

This topic focuses on the development of new mobility platforms and strategies for improving urban mobility. It also includes mobility as a service and similar mobility-related concepts.

NUMBER OF PROJECTS 147

TOPIC CLOUD 3 SECURITY SYSTEMS IN TRANSPORT AND MOBILITY

design architecture provide system
control solution security management
process technology service data

SUMMARY DESCRIPTION

The third topic cloud covers general security topics, from security of identification systems to physical security, with a strong data orientation.

NUMBER OF PROJECTS 152

TOPIC CLOUD 4 INTELLIGENT MACHINES AND AUTOMATION IN TRANSPORT

human accident system road
traffic infrastructure safety task
risk change automation data

SUMMARY DESCRIPTION

This topic cloud identified topics with a strong focus on automation in transport systems and their safety as aspects of great importance.

NUMBER OF PROJECTS 42

TOPIC CLOUD 5 GREEN URBAN MOBILITY TECHNOLOGIES

energy bus system hydrogen
urban demonstration vehicle
electric public fuel cell city

SUMMARY DESCRIPTION

The focus of this topic is green transport solutions and novel technologies for ground transport and urban mobility.

NUMBER OF PROJECTS 70

TOPIC CLOUD 6 AIR TRAFFIC MANAGEMENT (ATM)

pilot operation flight concept
airport air aircraft aviation
traffic ATM cockpit trajectory

SUMMARY DESCRIPTION

This cloud serves as an umbrella topic for the improvements of any of the subsystems or components of the air traffic management system, e.g. runway capacity, trajectory optimisation, navigation and surveillance, and many others.

NUMBER OF PROJECTS 114

TOPIC CLOUD 7 TRANSPORT MODELS HARNESSING THE POWER OF DATA

noise simulation design tool
develop model result test
analysis data method algorithm

SUMMARY DESCRIPTION

The main focus of this topic is developing projects or studying models of air transport systems. As such, this topic cloud has a strong data orientation and also includes studies of various emissions and noise models in transport.

NUMBER OF PROJECTS 81

TOPIC CLOUD 8 MULTIMODAL TRANSPORT NETWORKS FOR BOTH PASSENGERS AND FREIGHT

rail stakeholder infrastructure impact
network scenario mode transport
measure railway european freight

SUMMARY DESCRIPTION

This topic cloud predominantly focuses on the study of transport systems as networks, covering various multimodal networks, logistics and freight transport, as well as rail transport.

NUMBER OF PROJECTS 93

TOPIC CLOUD 9 HIGH-LEVEL STRATEGIES FOR TRANSPORT INNOVATION

innovation european partner transport
workshop future support Europe
development programme work activity

SUMMARY DESCRIPTION

This deals with high-level, strategic agendas addressing overall goals and challenges for future transport systems.

NUMBER OF PROJECTS 124

Distribution of projects over topic clouds

Distribution of research projects over dominant topic clouds

Figure 17 shows a dimension-reduced *uniform manifold approximation and projection for dimension reduction* (UMAP) representation. UMAP is a fairly novel technique for dimension reduction, often used to produce 2D figures that help in assessing and presenting the results of the topic modelling algorithms. This technique was used to visualise the distribution of projects over dominant topic clouds (nine dimensions) on a two-dimensional plane. The colours on the chart represent the dominant topic cloud each project was assigned to. The axes are the (artificial) principal component loadings, such that the graphic can be best described as showing a figurative proximity of the projects and their clustering within the topics.

From this figure, we can see that the LDA algorithm has created fairly compact clusters of projects that share the same dominant topic cloud. There are few exceptions to this rule — normally, these include projects with a very low dominance level.

We can observe that the clusters of projects belonging to topic clouds 1, 6 and 7 are close to each other since they are all heavily related to the air transport system and the aviation industry. Similarly, topic clouds 2 and 5 are close to each other as they both focus strongly on urban mobility and ground transport. Other interesting insights that can be gathered from this figure concern topic clouds 3 and 4. Topic cloud 3 seems to be the most transversal one, with its cluster being quite widely spread. Topic cloud 4, on the other hand, produced a somewhat isolated and compact cluster. This is to be expected since this topic cloud covers a very novel and niche research area that is still generally addressed at lower technology readiness levels. This might explain its proximity to the topic 9 cluster, which covers high-level strategies.

FIGURE 17:
VISUALISATION OF THE NINE
UNCOVERED TOPIC CLOUDS
(IN THE REDUCED 2D VECTOR SPACE)

- Topic Cloud 1: Green aircraft technologies of the future
- Topic Cloud 2: Novel concepts in mobility
- Topic Cloud 3: Security systems in transport and mobility
- Topic Cloud 4: Intelligent machines and automation in transport
- Topic Cloud 5: Green urban mobility technologies
- Topic Cloud 6: Air traffic management (ATM)
- Topic Cloud 7: Transport models harnessing the power of data
- Topic Cloud 8: Multimodal transport networks for both passengers and freight
- Topic Cloud 9: High-level strategies for transport innovation

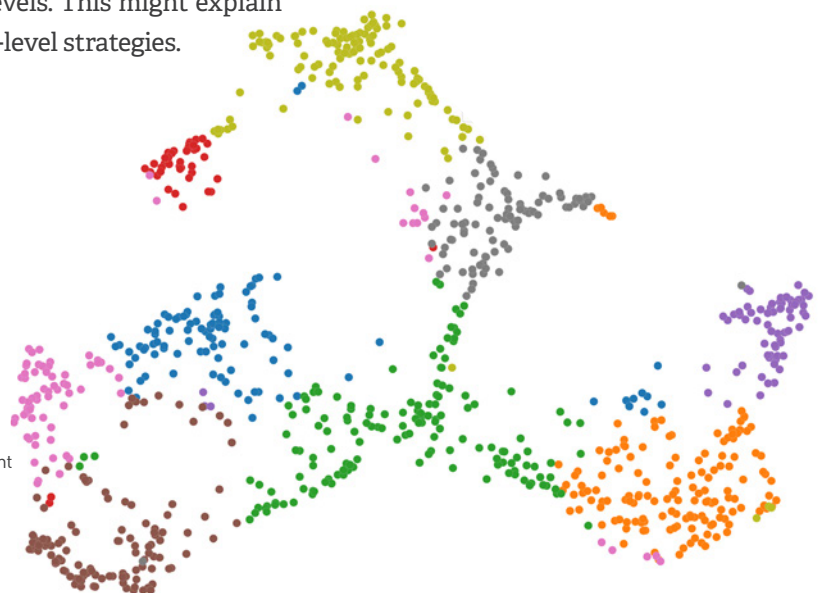


FIGURE 18:
NUMBER OF PROJECTS A
TOPIC CLOUD COVERS AS
THEIR DOMINANT TOPIC

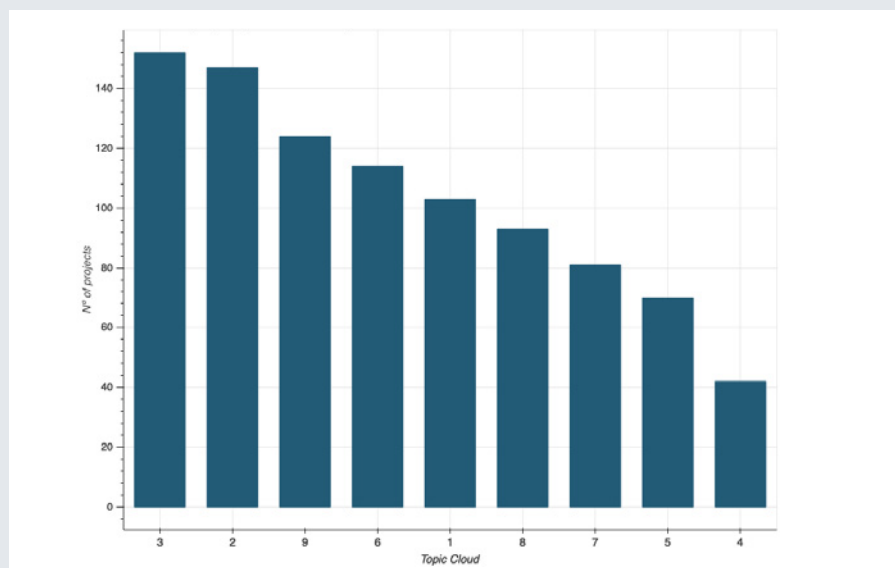
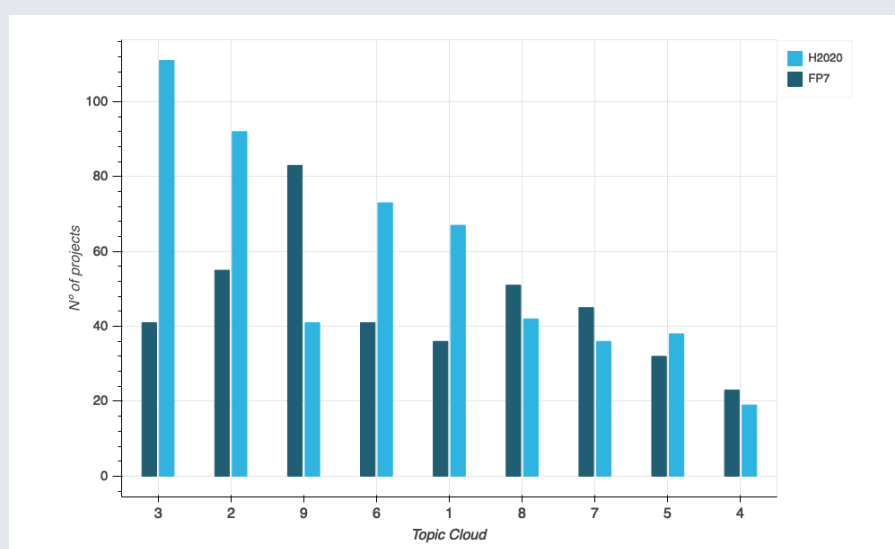


FIGURE 19:
NUMBER OF PROJECTS A
TOPIC CLOUD COVERS AS
THEIR DOMINANT TOPIC,
GROUPED BY FRAMEWORK
PROGRAMME
(FP7 VS. H2020)



Figures 18 and 19 shows the topic clouds ordered by the number of projects to which they are assigned as the dominant cloud. Intuitively, this shows how well represented each topic is among the mobility relevant projects analysed. In the first figure, where no distinction is made between H2020 and FP7 projects, topic clouds 3 (*Security systems*) and 2 (*Novel mobility*) can be noted as the most dominant topic clouds for projects in the data set. However, many projects are multidisciplinary with low levels of dominance and the dominant topic cloud assigned to them might not be as significant as could be expected.

Figure 19 shows the analysis of the same distribution but grouped by funding programme (H2020 vs. FP7). As expected, this distribution is similar to that in the combined analysis shown in Figure 18. An interesting observation is that topic 9, dealing with high-level strategies, is the dominant cloud of twice the number of FP7 projects than it is of H2020 projects. This could be explained by the fact that, since FP7 started before H2020, it carried most of the weight in defining overall goals, challenges, and milestones for transport research in the

coming decade and beyond. Topic clouds 3 (*Security systems*), 2 (*Novel mobility*), 6 (ATM), and 1 (*Green aircraft technology*) also contain significantly more H2020 projects than FP7 projects. This could be an indicator of a general shift in focus of more recent projects towards these research areas.

Figure 20 shows a set of nine probability distribution figures that depict the frequency with which a project is assigned a certain probability for a particular topic. For example, observing the distribution for topic 2, *Novel concepts in mobility*, and fixing a probability of 0.2, approximately 1% of the total of number of projects were assigned a weight of 0.2 for this cloud. The wider the probability distribution of a topic cloud, the more likely that projects will cover that topic.

On one hand, we can see that generally all topic clouds present a similar probability distribution near 0, meaning that most of projects are irrelevant for that topic cloud. On the other hand, small but significant differences between topic cloud distributions can be observed. For example, as we observed in Figure 17, we see that the topic 3 is the most transversal topic due to its wide distribution curve. This means that a large number of projects are relevant to or are related to this topic cloud. In contrast, topic cloud 4 presents a very narrow distribution. This means that only a few projects are related to this topic cloud. These insights fall in line with those extracted from the UMAP figure, below.

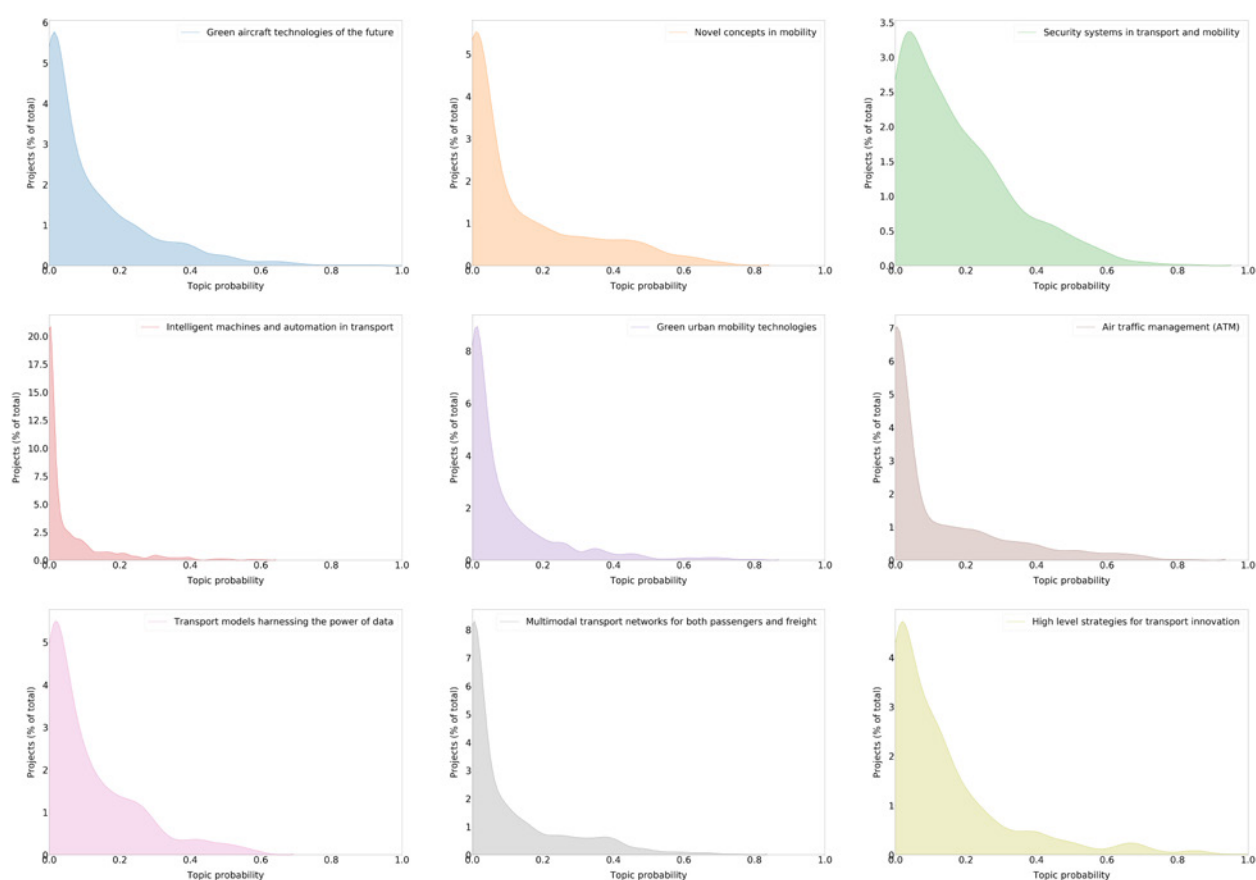


FIGURE 20:
PROBABILITY THAT A PROJECT COVERS A CERTAIN TOPIC,
GROUPED BY TOPIC CLOUDS

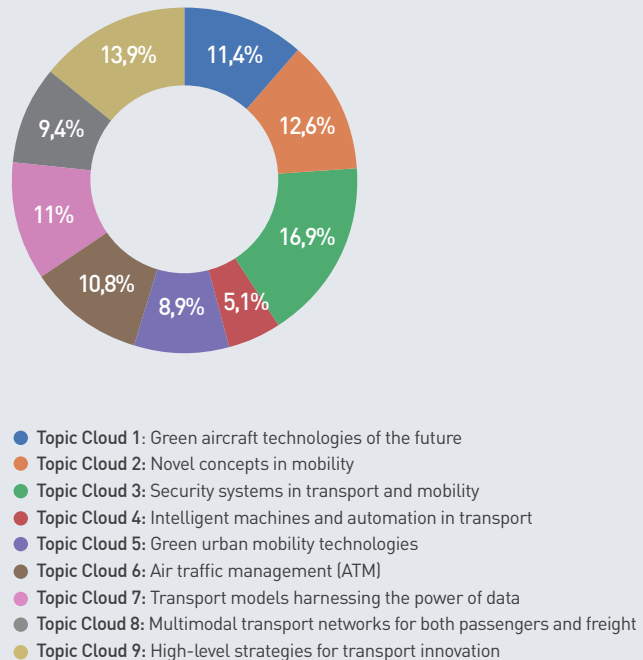
Topic representation in the data set

Figure 21 gives a representation of each topic in the set of all 926 projects analysed. The percentages in the pie chart can be interpreted as the likelihood that a random mobility project contributes to that topic, thus providing insights into how well each topic is covered in the set of research initiatives analysed.

Figure 21 shows that the topic with the highest coverage in the set of mobility projects is number 3, *Security systems in transport and mobility*. In other words, in a randomly selected project, the topic of security in transport is most likely to be studied. Once again, this confirms the insights gathered from Figures 1 and 4 and indicates that the importance of security in transport and mobility continues to be very high as it is one of the most discussed and researched aspects of transport.

Also of note, the majority of topic clouds are fairly uniformly represented. Indeed, if we combine topics 1 and 5, which generally address the theme of green mobility, their share even surpasses that of the security topic cloud. The least addressed topic cloud is Intelligent machines and automation in transport, which is not surprising since this a very novel technology and research area.

FIGURE 21:
REPRESENTATION OF TOPIC CLOUDS IN THE DATA SET
OF ANALYSED PROJECTS



Trend analysis: how did the focus shift over the duration of the framework programmes?

Figure 22a and 22b show how the focus of the projects has shifted over time in terms of different topic clouds. The weight of each topic cloud within the overall project dataset has been grouped by the start-year of a project. Project start-year is the only reference variable taken into account in this analysis, excluding other related variables, such as project duration, which are covered in the analyses below. While such variables would slightly change the graphs presented in Figures 22a and 22b, the start-year of a project is considered sufficient to provide a clear picture of how research trends evolved.

Notably, topic cloud 9, *High-level strategies for transport innovation*, had its peak at the beginning of the FP7 programme in 2007 and declined afterwards in annual share. On the other hand, some topic clouds have gained more visibility and research focus since the inception of FP7, such as topic cloud 3, *Security systems in transport and mobility*. Topic clouds 8 and 9 generally trended downward, and more so topic 9 (for reasons mentioned above, governed by the particular nature of this topic cloud). Topic clouds 1, 2 and 4 (see Figure 22b) have maintained a fairly stable focus. Topic clouds 1 and 2 are research areas that have been quite well established over the years, whereas topic 4 has a significantly lower representation due to its futuristic nature; however, a rise in its popularity is likely as these technologies become better understood, increasingly mature, and more widespread.

When it comes to topic clouds where an increasing focus (upward trend, topic clouds 3, 5, 6 and 7; see Figure 22a) is more prevalent, significant differences can be seen in the rate of growth in popularity among them. Topic 3, with its focus on security, maintains a strong presence over the years with its popularity continuously rising. This indicates that the importance of this topic is well established and is expected to grow further. A similar trend can be observed with topic 6, *ATM*, that was consistently researched throughout both FP7 and H2020 programmes. However, topic clouds 5, *Green urban mobility technologies*, and 7, *Transport models harnessing the power of data*, have experienced very accelerated growth since 2007. This can easily be attributed to a societal shift, as environmental aspects of transport and mobility grew in importance in the 2010s and the data revolution increased the need for data-driven applications and studies.

FIGURE 22A:
EVOLUTION OF THE DOMINANT TOPIC CLOUDS FROM 2007 UNTIL 2019
(PROJECTS SORTED BY THEIR START DATE) PREDOMINANTLY UPWARD TREND

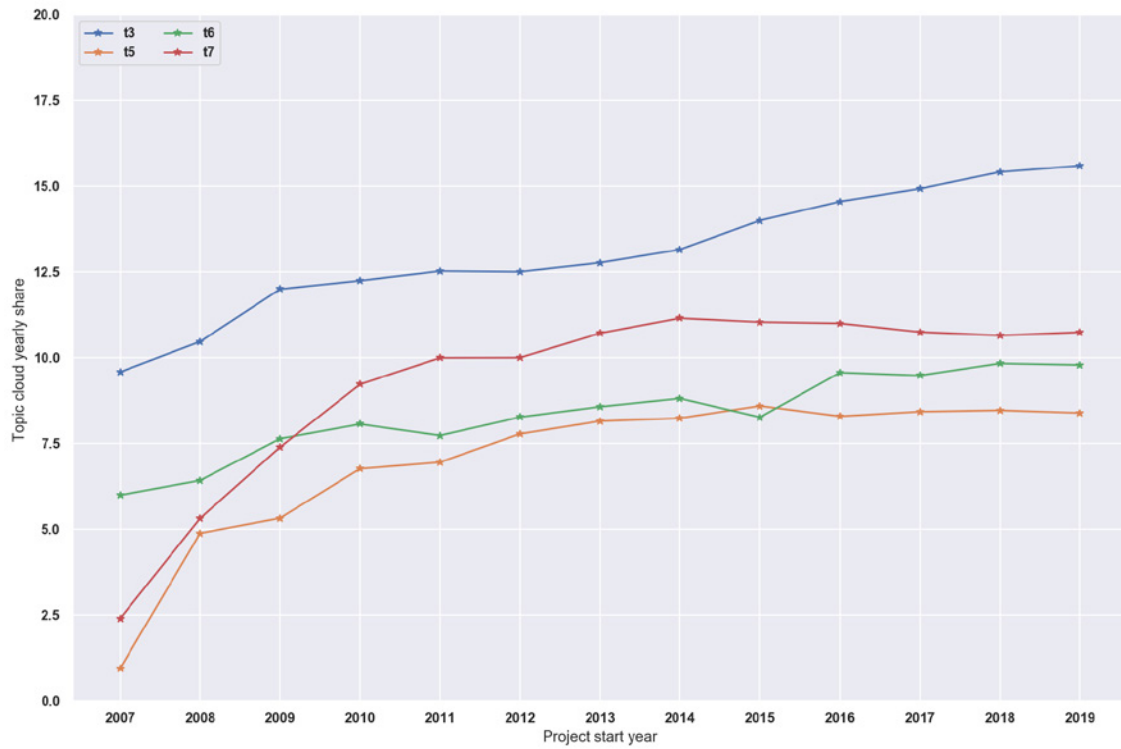
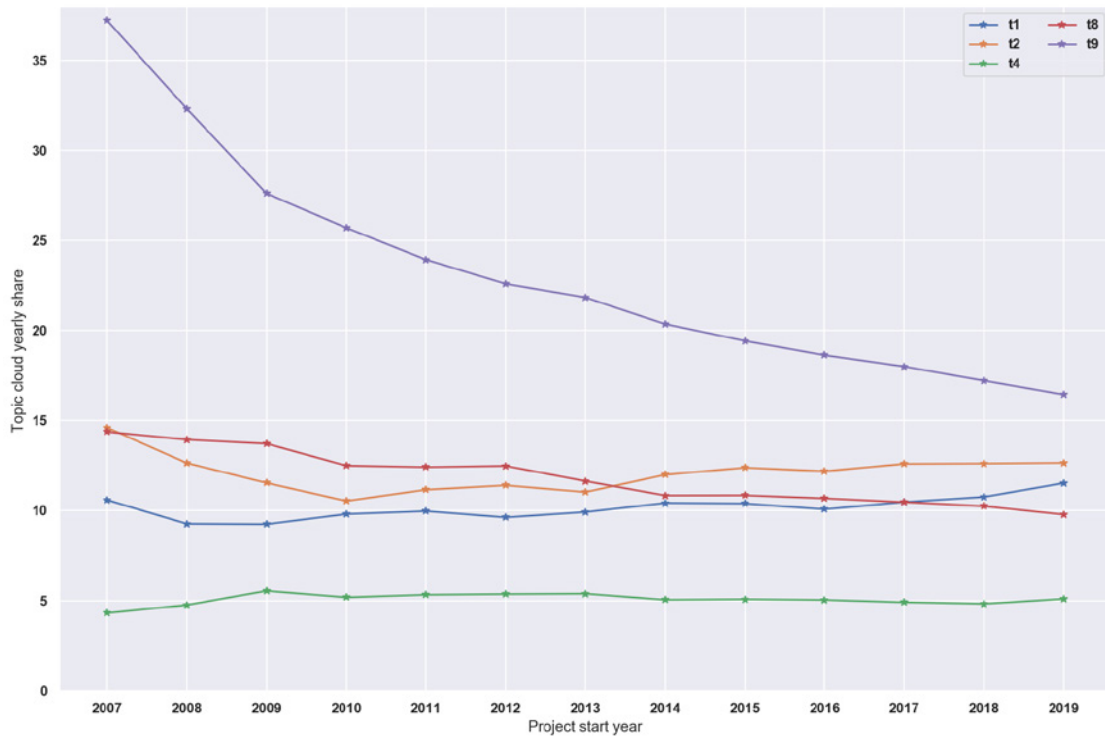


FIGURE 22B:
EVOLUTION OF THE DOMINANT TOPIC CLOUDS FROM 2007 UNTIL 2019
(PROJECTS SORTED BY THEIR START DATE) PREDOMINANTLY DOWNWARD OR STABLE TREND



Consortium size and other characteristics of topic clouds

This section provides a short analysis of project consortium size and duration, similar to in section 3 of this mobility report, but here with data aggregated by topic cloud.

The bar chart in Figure 23 shows that projects in topic cloud 4, *Intelligent machines and automation in transport*, have the longest average duration — over 3 years — as well as the second highest number of participating research entities (see Figure 24). This topic cloud turned out to be the smallest in terms of number of projects and financing. However, these numbers indicate that, while still a niche area, it is very thoroughly investigated, uniting a large number of entities in a smaller number of projects rather than spreading effort across a large number of research projects. Topic cloud 5, *Green urban mobility technologies*, follows closely with the second largest average duration and the largest consortium size. On the other hand, the topic clouds with highest numbers of different research projects (clouds 3 and 2) are the shortest in average project duration, with moderate consortium sizes. Further analysis and more data collection is required to fully understand the underlying reasons. One possible explanation might be that as topic clouds 4 and 5 cover more novel mobility research areas, with a very fast increase in popularity (see the trend analysis section below), they follow a commonly observed 'novel startup' pattern: accelerated growth and increase in popularity though less widespread than more established research areas.

Topic cloud 7, *Transport models harnessing the power of data*, has a noticeably lower average consortium size than other projects in the distribution (see Figure 8). This again might be driven by the fairly niche research area this cloud covers, or the financing that projects in this area typically receive. (This is on the lower side of the spectrum, especially when compared with the number of projects in this topic cloud and considering financial demands of data-intensive projects.) Once again, to come to a more definite conclusion, more data should be collected on these research initiatives and more in-depth analysis performed. This should be done in a continuation of the CAMERA study.

FIGURE 23:
AVERAGE DURATION OF
A PROJECT PER TOPIC CLOUD
(DOMINANT TOPIC CLOUDS ONLY)

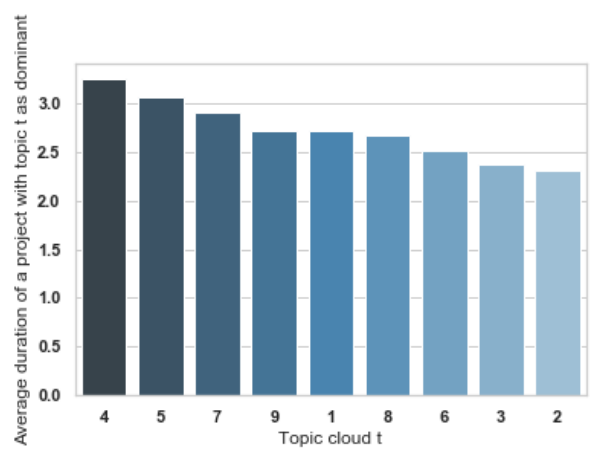
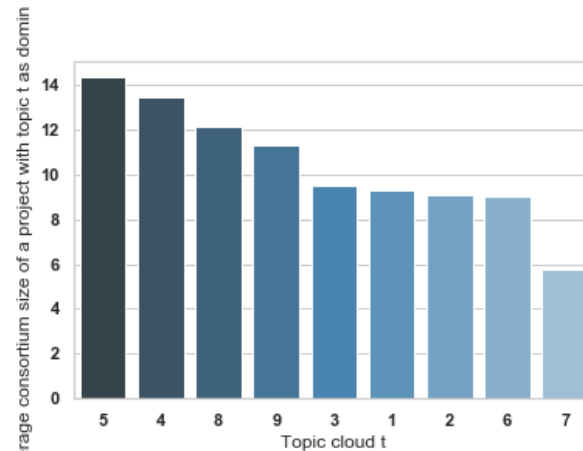


FIGURE 24:
AVERAGE CONSORTIUM SIZE OF
A PROJECT PER TOPIC CLOUD
(DOMINANT TOPIC CLOUDS ONLY)



Distribution of entities and countries over topic clouds

The bar charts shown in Figures 25 and 26 illustrate which entities and countries are prevalent in various topic clouds.

Figure 25 shows the top entity for each cloud, counting the number of projects that each entity coordinated. While this metric should be considered with some caution, since it only looks at dominant topic clouds and top entities, it gives a good overview of the leading research entities in Europe in different areas. Most of these are probably not very surprising, such as EUROCONTROL's being the leading entity in the topic of ATM research (cloud number 6). To a certain extent, this figure underscores the identity of various entities since the theme of each cloud often coincides with the main research focus of the entity dominant in that topic cloud.

Figure 26 shows countries by the frequency with which they are in the top three countries in terms of relative share in each topic cloud (again, taking into account only dominant topic clouds). This gives an overview of areas of research concentration around Europe. Moreover, it is fairly well aligned with the analysis of the geographical distribution presented in the section 3 of this report, with Germany, France, Italy, Spain and the UK being in top three countries for at least 4 topic clouds (Spain, UK and France) and up to even 7 topic clouds (Germany). Belgium is one of the countries with the highest representation in topic cloud 9, *High-level strategies*, which may not be coincidental since Brussels is often considered the *de facto* capital of the European Union. Sweden emerges as one of the leading countries in topic cloud 4, *Intelligent machines and automation in transport*. Considering that Sweden is well-known for its highly developed role in technical innovation in Europe, and that this topic covers very advanced and futuristic research initiatives, this result confirms their investments in, and higher focus on, innovative technologies.

FIGURE 25:
COORDINATOR WITH HIGHEST
NUMBER OF PROJECTS
PER TOPIC CLOUD

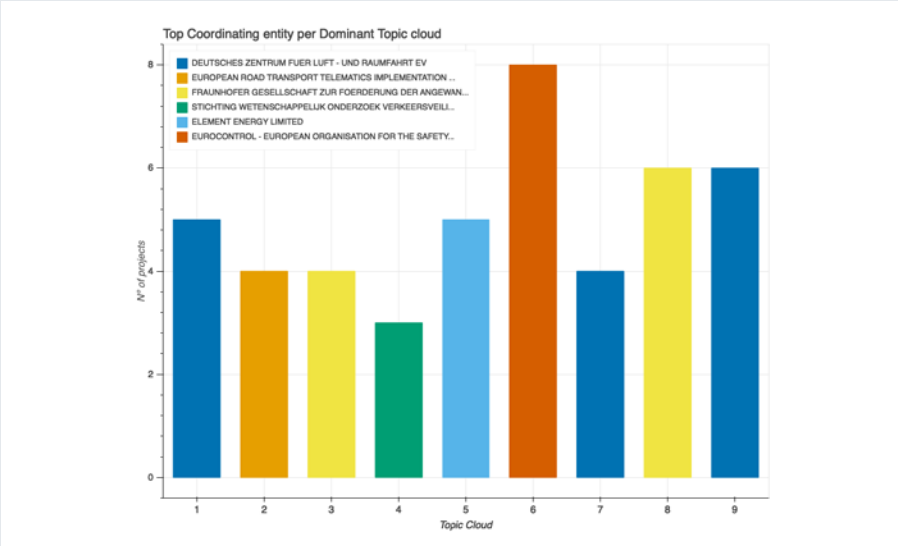
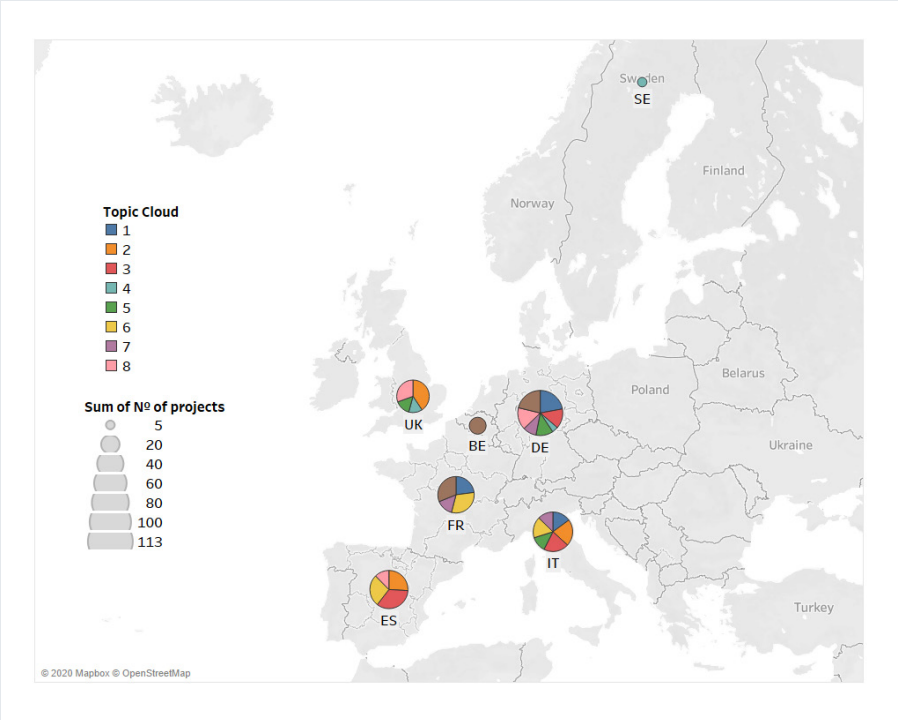


FIGURE 26:
THREE COUNTRIES WITH
THE HIGHEST NUMBER OF
COORDINATED PROJECTS
IN EACH TOPIC CLOUD
(GEOGRAPHICAL DISTRIBUTION)



Financial analysis: topic clouds

This section presents an analysis of the financial contribution that the projects received by topic cloud and yearly evolution.

Figures 27 and 28 show the relative financial share that each of the identified topic clouds received from the EC across all projects. The first is calculated without distinguishing between FP7 and H2020 projects and ordered by financial contribution, highest to lowest. The second shows this separately for FP7 and H2020-funded projects.

Note that the topic that received the overall highest financial contribution was *Security systems in transport and mobility*, which is also the most studied topic of the mobility projects that were analysed. However, the rest of the topics do not follow the order of the most studied topic clouds as shown in the pie chart in Figure 21. The topic with the second highest financial contribution is *Green aircraft technologies of the future*, while that topic is the fourth most studied. Topic 4, *Intelligent machines and automation in transport*, received the lowest financial investment.

Figure 28 shows how financial objectives shifted in the transition from FP7 to the H2020 framework. Topic 3 is the most financed in both framework programmes. While the topic with the second greatest investment in H2020 is *Green aircraft technologies of the future*, it received much less funding in FP7. However, the topic with the second highest investment in the FP7 programme was *Green urban mobility technologies*. This indicates that sustainability and emissions reduction have always been very important aspects of mobility and have always received sizeable investment, but that the focus has perhaps shifted more towards air transport in recent years; this aligns with current societal trends and burning issues in mobility and transport.

In general, observing the evolution of financial investments plotted start-year of a project in Figure 29, the topic clouds most studied and invested in are security and safety (topic cloud 3), emissions (topic clouds 1 and 5, with the upward trend towards cleaner air transport technologies), and air traffic management (topic cloud 6). Peak financing for topic cloud 1, *Green aircraft technologies of the future*, occurred in 2014, after which it decreased slowly. Topic cloud 3, *Security systems in transport and mobility*, has had fairly consistent year-on-year growth, as has had topic cloud 5, *Green urban mobility technologies*. Topic cloud 7, *Transport models harnessing the power of data*, had very rapid growth until 2014, after which stagnated. Notably, all topic clouds but the fourth, *Intelligent machines and automation in transport*, experienced a drop in 2019 in the graphs on Figure 29, most likely due to a data artifact (there are not many projects with 2019 as their start year).

Comparing figures 22 and 28, financing trends follow the general trends fairly well, with security (cloud 3) leading the way in both trend analyses.

FIGURE 27:
RELATIVE FINANCIAL CONTRIBUTION TO EACH TOPIC ACROSS
BOTH FRAMEWORK PROGRAMMES (H2020 AND FP7)

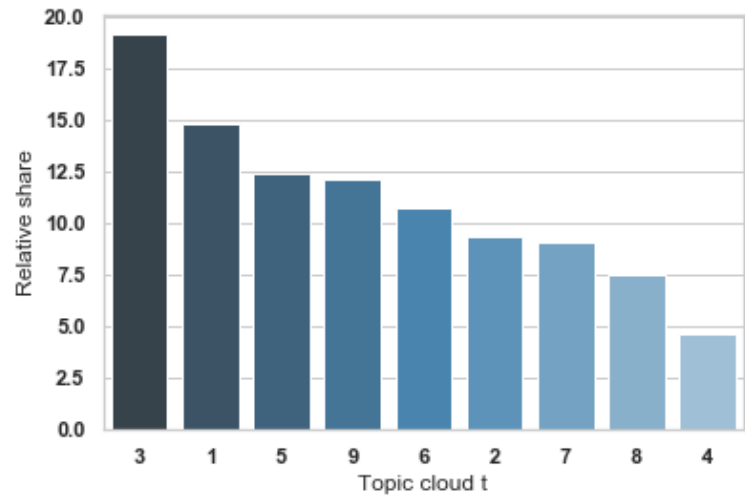


FIGURE 28:
RELATIVE FINANCIAL CONTRIBUTION TO EACH TOPIC:
H2020 VS. FP7 COMPARISON

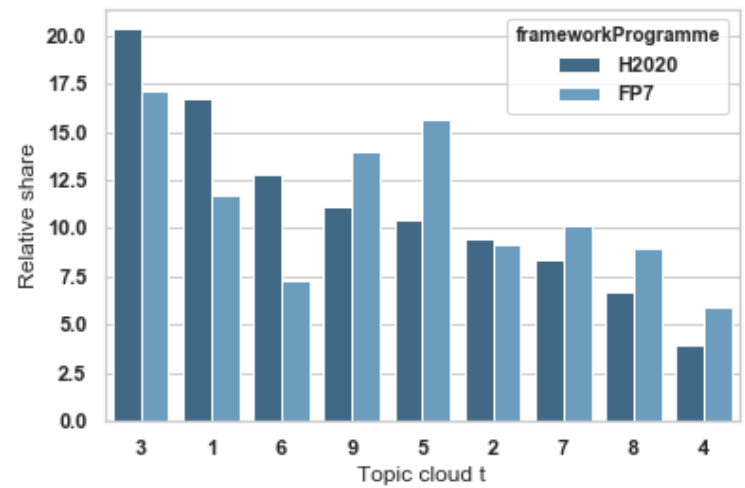
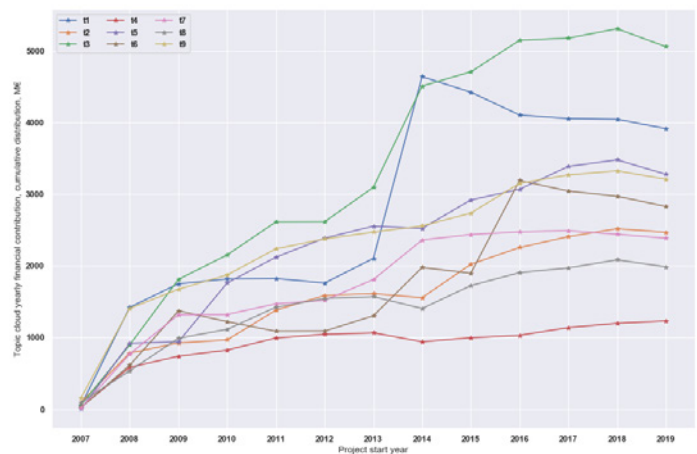


FIGURE 29:
FINANCIAL YEARLY TRENDS PER TOPIC CLOUDS,
RELATIVE GROWTH



Evaluation of mobility projects against mobility challenges: qualitative assessment

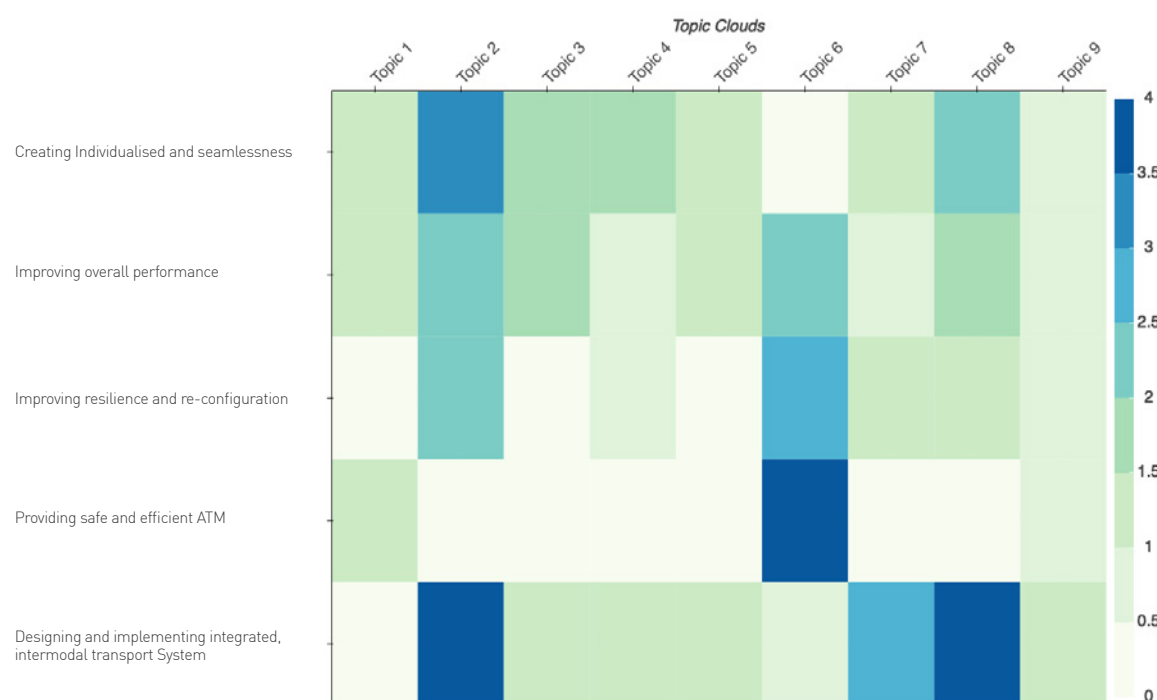
This section provides a high-level assessment of how well the nine topic clouds address mobility challenges as outlined by the five layers of the CAMERA Performance Framework. In this qualitative assessment, the CAMERA team compared the key performance indicator (KPI) of each layer with the characteristics of all of the topic clouds by examining their short descriptions, keywords, and project examples. A scale from 0 to 4 was developed and applied for this purpose. This evaluation metric is provided in Table 5. The scales given are represented by different colours in Figure 30, creating a heat map that depicts the findings at a glance. Dark blue shows that all KPIs are addressed within a topic cloud, equal to the score of 4 in Table 5. As an example, mobility challenges from layer 5, *Designing & implementing an integrated, intermodal transport system*, are very well researched in projects from topic cloud 2, *Novel concepts in mobility*. Likewise, a very light green stands for 'no research activities', equal to the score of '0' in Table 5.

TABLE 5:
METRIC USED IN
HIGH-LEVEL ASSESSMENT

SCALE	Number of KPI addressed in a topic cloud
0	None
1	A few
2	Several
3	Most
4	All

Adding up all individual evaluations per topic to a final score per layer (see Table 6, rightmost column), we can detect which layers are well-addressed across topic clouds and which are underrepresented. In other words, we can see which mobility challenges are already addressed in projects and which are less researched. Although the results are currently being developed, they already clearly indicate which of the five layers are well-addressed within

FIGURE 30:
LAYERS VS. TOPIC CLOUDS
(QUALITATIVE ANALYSIS)



European research activities (such as layers 5 and 1). Conversely, we can also identify layers that are less researched (such as layer 4). Cloud 2, *Novel concepts in mobility*, addresses most mobility challenges across all layers (with a total score of 11). Topic clouds 1, 5, and 9 address the smallest number of mobility challenges with their research activities.

As stated above, this first assessment is still in progress. Additional and more in-depth analyses need to be conducted to gain comprehensive insights and to detect gaps and bottlenecks within EU-funded, mobility-related research activities.

In Figure 31, a relationship is derived between the mobility relevant projects and the mobility layers and their KPIs. This relationship was derived through two assessments: first, a quantitative assessment obtained through a modelling

TABLE 6:
HIGH-LEVEL ASSESSMENT: TOPIC CLOUDS ADDRESSING MOBILITY CHALLENGES

LAYER* TOPIC CLOUD										
	(1) Green aircraft technologies of the future 	(2) Novel concepts in mobility 	(3) Security systems in transport and mobility 	(4) Intelligent machines and automation in transport 	(5) Green urban mobility technologies 	(6) Air traffic management (ATM) 	(7) Transport models harnessing the power of data 	(8) Multimodal transport networks for both passengers and freight 	(9) High-level strategies for transport innovation 	SUM (LEVEL OF RESEARCH FOR EACH LAYER)
<i>* layers are described and discussed in detail in the CAMERA Performance Framework[2]</i>										
(1) Creating individualised & seamless mobility systems	1	3	1.5	1.5	1	0	1	2	0,5	11,5
(2) Improving overall performance	1	2	1.5	0.5	1	2	0.5	1.5	0,5	10,5
(3) Improving resilience & re-configuration	0	2	0	0.5	0	2.5	1	1	0,5	7,5
(4) Providing safe & efficient ATM	1	0	0	0	0	4	0	0	0,5	5,5
(5) Designing & implementing integrated, intermodal transport system	0	4	1	1	1	0.5	2.5	3.5	1	14,5
SUM LEVEL OF ADDRESSING LAYERS	3	11	4	3.5	3	9	5	8	3	

* layers are described and discussed in detail in the CAMERA Performance Framework[2]

approach that detected and extracted nine topic clouds among the mobility relevant projects analysed; second, a qualitative, expert-based assessment presented above that relates these topic clouds to layers defined in the CAMERA Performance Framework. The heat map in this figure shows how well each project covers the indicators defined in each layer (the relationship is expressed using a Z-score, shown in the bar on the left). Each row of the heat map corresponds to a project. The idea is to gain overall insight of the layers' coverage as opposed to inspecting each project separately. A positive/negative Z-score indicates that the data point is above/below the mean value. Since, in this case, a higher score means that a project is more closely related to the indicators in the given layer, based on the qualitative analysis and the weight the project was assigned in particular topic clouds, the higher the Z-score, the better a project covers the objectives (indicators) defined in a layer.

The results obtained in this analysis are in accordance to those obtained in the first mobility report published in CAMERA. They are also similar to the results of the expert-based assessment above. The third layer, *Improving resilience and re-configuration*, is, in general, the least covered layer in the set of mobility projects analysed. On the other hand, layer 5, *Designing & implementing integrated, intermodal transport system*, contains objectives that have been researched to a much greater extent than average in the set of mobility projects analysed. The fourth layer, *Providing safe and efficient ATM*, is either well-covered or not covered at all in most projects, and there is a large subset of the projects that have this layer's objectives as the focus of their study. On the other hand, the second layer, *Improving overall performance*, is fairly well covered across almost all projects in the data set, with the majority of them having a Z-score close to 0 and a few with very high coverage of this layer. The first layer, *Creating individualised and seamless mobility systems*, seems to have wide coverage overall. However, almost no projects have a strong focus on the objectives of this layer such, as seen with layers 4 or 5.

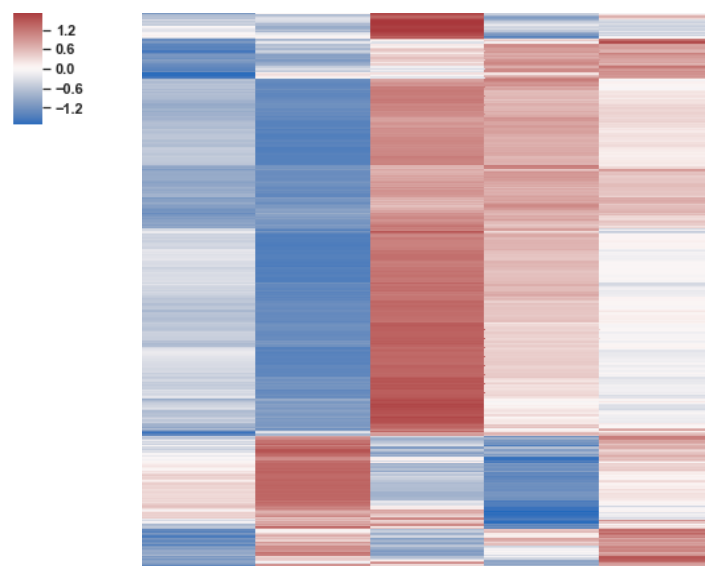


FIGURE 31:
HOW WELL DO PROJECTS
COVER PF LAYERS?
(BASED ON THE HYBRID
QUALITATIVE AND
QUANTITATIVE - ANALYSIS)

5

IMPROVEMENTS SINCE MOBILITY REPORT #1

The methodology used to automatically detect and filter out projects that concern mobility from the large CORDIS database, analyse them, and present the results, has significantly evolved since the first Mobility Report, published in Spring 2019. This methodology continues to evolve as CAMERA progresses. The workshop on the validation of the methodology held in Brussels in July 2019 helped gather feedback from many experts from different fields, and contributed to a better understanding of the mobility challenges and objectives that should be addressed in CAMERA. It also provided ideas for technological improvements, the most significant of which are outlined below.

Data base improvements

The database has been updated to the latest version (provided by CORDIS at the beginning of this study) to the version from October 2019. It now contains several new information fields such as description of the final results (for completed projects), more information on the participating entities, etc. This provided a better understanding of the data source and its structure, which helped to deliver the cleaner data used in further steps of the analysis pipeline, with a better selection of terms (words) that describe each project more succinctly.

Evolution of the data mining methodology

The methodology is still based on semi-supervised and unsupervised natural language processing (NLP) algorithms; however, it has significantly evolved since the first Mobility Report, and continues to evolve as CAMERA progresses. Significant improvements have been made in data gathering, data cleaning, language modelling, and validation. This is elaborated in more detail below.

Wider concept of mobility relevance

The concept of mobility relevance has been widened following consultation with various experts at the second CAMERA workshop. A single human expert (from a particular field of mobility research) is not able to give a full, detailed overview of the whole of the complex area of mobility, whereas a group of experts from various backgrounds can give a more accurate representation of mobility research needs and the impact a single project can have on innovation and development. In light of this, the selection criteria for retaining mobility relevant projects that had been followed in the MR1 were relaxed. Any project for which a mobility expert can see a potential impact on mobility or on their own particular area of expertise should be

taken into account in the analysis, and the ideas it presents should be explored and further nurtured. An ensemble approach was therefore applied to reflect this idea in our quantitative algorithmic approach, with democratic votes being taken on the different outputs of the algorithm.

More robust validation of the automated AI methodology

The validation phase has been made more robust, using several steps in the validation process. Labelled samples obtained at the second CAMERA workshop have been used to analyse the accuracy of the algorithm, the generated language model has been analysed using a number of validation metrics, and the filtered dataset has been revised for the purpose of outlier detection. An outlier is defined to be any project that a group of human experts would clearly label as not being mobility-relevant, but that the algorithm selected due to ambiguity inherent in the natural languages that humans use. Such projects have been detected using an expert-based assessment of the results of the automated project selection, and removed from the dataset. In further work, this methodology is planned to be automated as well, and the first step towards this is the collection of more relevant data.

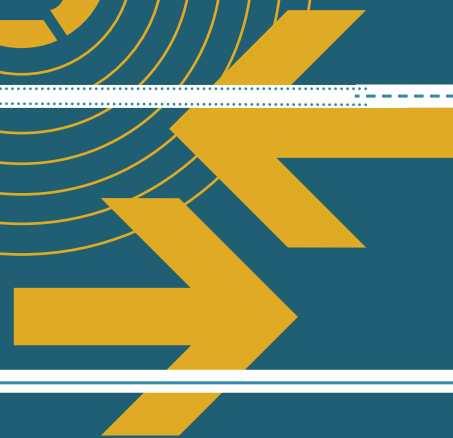
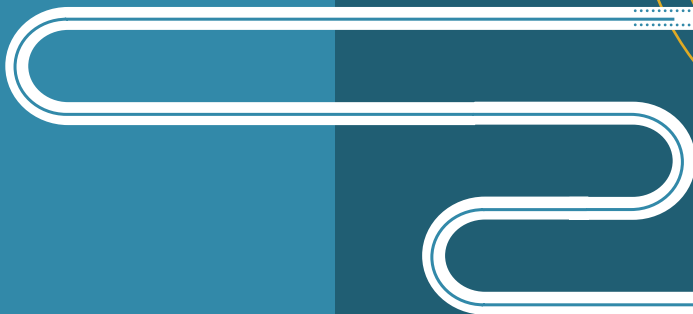
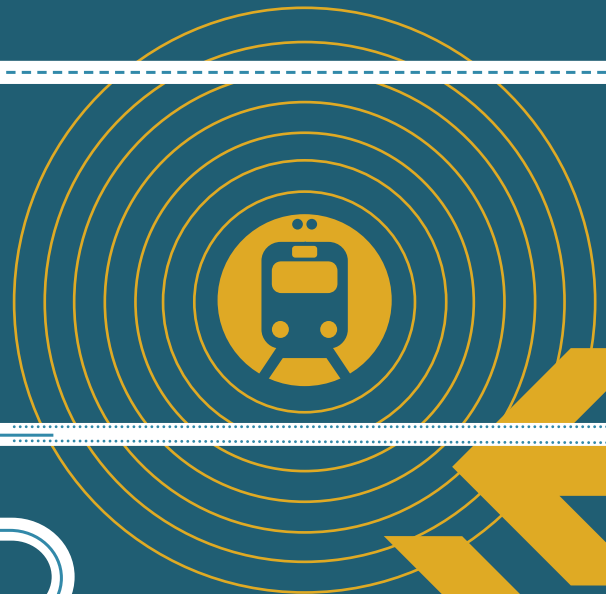
More in-depth analysis of projects relevant to mobility

Overall, 926 relevant projects were identified for this Mobility Report, allowing more in-depth insights into such aspects as the geographical distribution for coordinators and the EC contributions managed. This has enabled interesting outliers such as Spain's coordinating many projects, but with a rather small total contribution from the EC, to be spotted. Four projects from H2020 were also detected as receiving a significantly larger financial contribution compared with the other projects in the sample, and have been analysed separately. We believe that these, and many other interesting cases described in this Mobility Report, can add to our understanding of mobility research in Europe, supply useful insights as to where mobility research is headed, and inspire certain actions in the future.



6

CONCLUSION AND RECOMMENDATIONS



This mobility report has presented a framework for analysing the current state of mobility research in Europe and its path towards achieving the goals outlined in Flightpath 2050 and other high-level strategies. As such, it has presented two categorisation methods for extracting and systematising mobility-relevant research projects from the body of projects funded under FP7 and H2020.

The first consists of five 'mobility layers' that identified essential research areas and defined concrete measurable targets (KPIs) that should be achieved to create a sustainable, seamless, and efficient transport system in Europe. These layers are presented in detail in the Performance Framework published by CAMERA [2].

The second categorisation, which detected mobility-relevant research projects, identified nine 'topic clouds'. These were defined using state-of-the-art natural language processing-based methods that: modelled the textual descriptions of all of the projects in the CORDIS database; selected projects relevant for analysis; extracted topic clouds; and evaluated selected projects against these topics.

A summary of the main findings given in this mobility report is shown herby.



926

MOBILITY RELATED PROJECTS



32

COORDINATING COUNTRIES



555

COORDINATING ENTITIES



3,43B

EC CONTRIBUTION



9

IDENTIFIED TOPIC CLOUDS

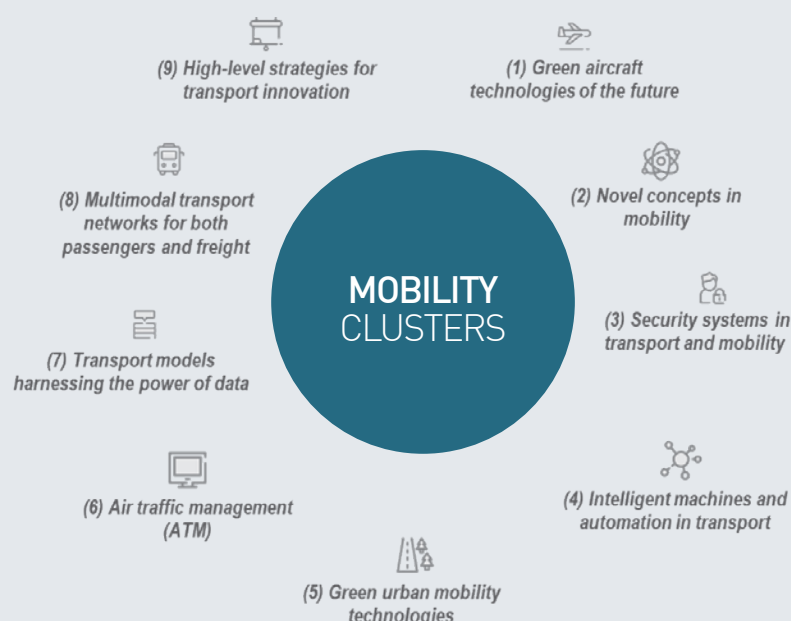
In total, 926 mobility-related research projects were extracted from CORDIS. An analysis of the geographical distribution of all projects in scope produced fairly expected results, with the majority of research efforts concentrated in the largest European economies (Germany, Spain, the United Kingdom, France, and Italy). Entities from these countries coordinated 51% of all of the identified projects and managed 72% of the total EC contribution.

The mobility projects funded by the FP7 framework programme lasted, on average, several months longer than H2020 funded projects. On the other hand, an H2020-funded project received on average €1m greater financial contribution than an FP7-funded project. This is probably linked to the creation of different Public-Private Partnerships (in form of Joint Technology Initiatives or Joint Undertakings) driving the research in several strategic areas through (very) large 'projects'* with strong industrial leadership. However, looking at the full set of projects analysed, no strong correlation could be found between a project's duration and the financial contribution it received from the EC. In further research, more data should be collected and mined to investigate contributing factors and characteristics of H2020 and FP7 projects. Such in-depth analyses enhance our understanding of how research focus, needs, and requirements shifted between these two framework programmes.

Figure 32 below shows the nine topic clouds identified for the set of 926 mobility-relevant projects. They differ in regard to themes covered and in research project distribution over the dominant topic clouds. However, there may be some level of contextual similarity between the definitions of these topic clouds. For instance, there is a proximity between clusters of projects belonging to topic clouds 1, 6 and 7 as they are all related to aviation research.

FIGURE 32

NINE IDENTIFIED TOPIC CLOUDS OF MOBILITY-RELEVANT RESEARCH PROJECTS



*cf. footnote at pag. 21 and Section 3 for a discussion of these 'projects'.

The topic cloud with the overall greatest financial contribution received is cloud 3 on *Security systems in transport and mobility*. This topic cloud and cloud 2 *Novel concepts in mobility* were the two dominant topic clouds for most projects in the data set. Topic cloud 3 has also been identified as the most common cloud, in the sense that its themes (security and safety of various systems) are studied in the largest number of research projects and year-on-year financial contributions and incidence of this topic across various projects is on the rise. This indicates that, throughout the duration of FP7 and H2020, safety and security have been one of the most focused on topics in mobility and transport, with steadily increasing investment being made in this area.

By contrast, topic cloud 4, *Intelligent machines and automation in transport*, is still rather a niche area of research, though one that has seen accelerated growth in recent years. Since it is a research area that is just emerging and becoming more mainstream, there are very few research institutes and companies in Europe dedicated to it. It is thus characterised by the lowest overall financial contribution, though it has very large consortium sizes and durations. Sweden is becoming one of the leading European economies in this area. Analysis of its financial trends showed a financial breakthrough a few years ago; since then, contributions to this area have grown slowly. This should change this as these technological trends start to become more widespread in the community of mobility and transport researchers.

From analysis of the topic clouds, it can be seen that FP7 and H2020-funded projects differ in the topics they focus on. For example, FP7 projects significantly focus more on high-level strategies for transport innovation (topic cloud 9), a topic whose importance decreased quite significantly in the transition to the H2020 programme in 2014. This topic cloud peaked in popularity in 2007, followed by constant decline (both in financial contributions and overall focus on its topics). The most likely reason for this is that a number of research initiatives in FP7 identified further research needs that were developed to a higher level in H2020.

A large amount of research effort was dedicated to the field of environmental impact of transport, predominantly represented in topic clouds 1 and 5, from the beginning of the FP7 programme. This indicates that the topics of sustainable mobility and greener transport have always been of great importance to the European Commission. In fact, the two topic clouds, when combined, cover the largest number of projects of all dominant topics. Overall, they are the second most financed topics after topic cloud 3. The focus at the beginning of FP7 was indeed more on topic cloud 5 *Green urban mobility technologies*; however, in the beginning of H2020, topic cloud 1 *Green aircraft technologies of the future* overtook cloud 5 in financial contribution and overall focus of various research initiatives. This might not be surprising given the immense focus and increased effort on emission reduction in aviation in recent years. Topic cloud 1 focused specifically on this, whereas topic cloud 5 covers a wider spectrum of themes regarding greener transport in other areas, particularly focusing on urban mobility. Nevertheless, the trend analysis showed a rapid growth in topic cloud 5 as well.

Another topic cloud with a very rapid growth in research effort allocated to it is cloud 7, *Transport models harnessing the power of data*. It has significantly lower financing than other research topics, but the consortium size is also smaller on average. Despite this, its incidence across projects is rapidly rising and is now comparable with other, consistent clouds. This can be explained through the popularity of applying data and artificial intelligence methods to all walks of life, including in mobility research. This research area could grow even faster in the future as data becomes one of the most valuable resources for better decision-making and planning.

Finally, topic cloud 6, which focuses on more fundamental ATM research, is consistently well-represented and financed in the set of projects analysed. This could be a natural consequence of the criteria by which the projects were selected for analysis in CAMERA, and as such may not be very surprising. This level of activity is most certainly due to the presence of a dedicated Joint Undertaking — the SESAR JU - managing research in this area. There was a noticeably upwards financial trend. Similar conclusions can be made from observing topic clouds 2 and 8. Topic cloud 2, *Novel concepts in mobility*, shows that a consistently large number of research entities are focusing on this research area. However, its overall financing is significantly lower than that of many other topic clouds. Topic cloud 8, *Multimodal transport networks for both passengers and freight*, covers somewhat less represented research areas, with lower financing, consortium sizes, etc.

A fairly strong positive correlation can be seen between the size of consortium in mobility projects and financing received, with a correlation factor above 0.5 in all cases, excluding larger projects — see Section 3. Furthermore, this correlation was much stronger for smaller projects (lower financing and fewer participating entities). In fact, isolating projects that received financial contributions over €10m, the correlation weakened (although still positive). This indicates that for projects with smaller consortium sizes, financing needs are more affected by the number of participating entities and the costs needed to cover participation. In contrast, projects with larger numbers of consortium members might have a much wider range of influencing factors. It could be useful and insightful to look into this in more detail and to collect more data that would help shed some light on this correlation analysis.

In addition to the quantitative analysis based on artificial intelligence methods, a high-level qualitative assessment was carried out to examine how well the nine topic clouds address the mobility challenges outlined in the CAMERA Performance Framework. The CAMERA team compared KPIs of each layer in the Performance Framework with the characteristics of all topic clouds by examining their short descriptions, keywords, and project examples. The results revealed clear trends: layer 5 *Designing and implementing integrated, intermodal transport system* and layer 1 *Creating individualised and seamless mobility systems* seem to be well-addressed by European research activities. Conversely, layer 4 *Providing safe and efficient ATM* is the least researched layer. Further analysis needs to be conducted to gain comprehensive insights into this and to detect gaps and bottlenecks within mobility-related research activities.

Further research

The CAMERA project will continue until October 2021. To improve our analysis, two major areas of work are planned in the upcoming months.

Firstly, additional data collection will be undertaken and more statistical analysis performed to strengthen our understanding of the data and to obtain further insight. The following open questions and possible research activities will be considered:

More granular financial analysis, e.g. drilling down into the individual project consortium membership data.

More in-depth correlation analysis, e.g. looking into potential confounding variables that could act as drivers of the observed characteristics of H2020 and FP7 projects.

Expanding the data base to include project deliverables currently unavailable to the CAMERA team, as this could improve the accuracy of the predictive models developed.

Producing social media analytics at a topic cloud, mobility layer, or even project level. However, large amounts of social media data (e.g. Twitter) are not easily obtainable.

Further detection of gaps and bottlenecks in mobility-related research activities, relying on topic clouds and layer categorisations.

More detailed analysis of mobility projects with a particular focus on aviation, to identify emerging areas of research, trends and, if the necessary data are available, various research tools and methodologies used (e.g. simulation, data analytics, modelling, etc). Considering the growing importance of aviation's environmental impact, specific analysis will be performed on this topic.

Secondly, based on this additional analysis and insight, recommendations will be made for the future development of mobility research in Europe. Ultimately, it will not be possible to answer all relevant questions and points of curiosity due to lack of data or methodological limitations. However, these questions of interest will be documented and new findings will be discussed in Mobility Report 3.

ANNEXES

ANNEX 1

Mobility-relevant projects selected for the analysis

Due to the very large number of analysed projects in this Mobility Report, here we present just the preview of the first 21 projects sorted alphabetically by their acronym, and with their basic data fields: acronym, project title, coordinating entity and country, received financial contribution, pertaining framework programme (FP7 or H2020), and start and end date of the project.

The full list of the projects included in the analysis performed in this Mobility Report can be found at:

https://innaxis-comm.s3.eu-central-1.amazonaws.com/CAMERA/Annex_7.1_v2.pdf



Acronym	Project title	Coordinator	Coordinating country	EC financial contribution	Framework programme	Start date	End date
2-BE-SAFE	2-WHEELER BEHAVIOUR AND SAFETY	EUROPE RECHERCHE TRANSPORT	FR	5282341,21	FP7	2009-01-01	2011-12-31
2050AP	The 2050+ Airport	STICHTING NATIONAAL LUCHT- EN RUIMTEVAARTLABORATORIUM	NL	2678340	FP7	2011-09-01	2014-02-28
2DECIDE	Toolkit for sustainable decision making in ITS deployment	AUSTRIATECH - GESELLSCHAFT DES BUNDES FÜR TECHNOLOGIEPOLITISCHE MASSNAHMEN GMBH	AT	2748429	FP7	2009-10-01	2011-09-30
2MOVE2	New forms of sustainable urban transport and mobility	LANDESHAUPTSTADT STUTTGART	DE	8976338,87	FP7	2012-12-01	2016-11-30
321NOW	321NOW: The Now Booking Channel	NOW BOOKING CHANNEL SL	ES	71429.0	H2020	2019-06-01	2019-11-30
3EMOTION	Environmentally Friendly, Efficient Electric Motion	VAN HOOL N.V.	BE	39232162,6	FP7	2015-01-01	2019-12-31
3IBS	The Intelligent, Innovative, Integrated Bus Systems	UNION INTERNATIONALE DES TRANSPORTS PUBLICS	BE	3360088,2	FP7	2012-10-01	2015-03-31
4DCO-GC	4 Dimension Contracts - Guidance and Control	OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES	FR	5472611	FP7	2010-11-01	2013-10-31
4SBLOCK	Pavement Building System based on Detachable and Embedded Blocks	INVEPAT GO SL	ES	71429.0	H2020	2016-12-01	2017-04-30
5G-CARMEN	5G for Connected and Automated Road Mobility in the European Union	FONDAZIONE BRUNO KESSLER	IT	18566123.75	H2020	2018-11-01	2021-10-31
5G-MOBIX	5G for cooperative & connected automated MOBility on X-border corridors	EUROPEAN ROAD TRANSPORT TELEMATICS IMPLEMENTATION COORDINATION ORGANISATION - INTELLIGENT TRANSPORT SYSTEMS & SERVICES EUROPE	BE	26711677.75	H2020	2018-11-01	2021-10-31
5GCAR	Fifth Generation Communication Automotive Research and innovation	ERICSSON AB	SE	7995413.75	H2020	2017-06-01	2019-07-31
5GCroCo	Fifth Generation Cross-Border Control	CENTRE TECNOLÓGIC DE TELECOMUNICACIONS DE CATALUNYA	ES	17159937.25	H2020	2018-11-01	2021-10-31
A-FOD	SAFER and TIMELY FLIGHTS with Automated Foreign Object Detection System	ARGOSAI TEKNOLOJİ ANONİM ŞİRKETİ	TR	71429.0	H2020	2017-08-01	2018-01-31
A-PIMOD	Applying Pilot Models for Safer Aircraft	DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV	DE	4772266,4	FP7	2013-09-01	2016-08-31
A3R	Air To Air Automatic Refuelling	MESUREX AERONAUTICS DIVISION SL	ES	71429.0	H2020	2016-02-01	2016-06-30
AAASP	Advanced Avionic Applications Simulation Platform	SYNOPSYS GMBH	DE	496000	FP7	2013-08-28	2015-08-27
AAL2	Augmented Approaches to Land 2	HONEYWELL INTERNATIONAL SRO	CZ	2963438.51	H2020	2018-02-01	2020-01-31
AAS	Integrated Airport Apron Safety Fleet Management	TSB Innovationsagentur Berlin GmbH	DE	3543313	FP7	2008-05-01	2011-04-30
ACC_EXT	The Accident Externality from Driving: Evidence from Shabbat Exit and Entry	THE HEBREW UNIVERSITY OF JERUSALEM	IL	100000	FP7	2012-09-01	2016-08-31
ACCEPT A	ACcelerating EGNOS adOPtion in Aviation	INGENIERIA Y ECONOMIA DEL TRANSPORTE SME MP SA	ES	4544346,33	FP7	2010-04-15	2014-12-14

PREVIEW OF THE FULL LIST OF MOBILITY RELEVANT PROJECTS ANALYSED IN MR2, SORTED ALPHABETICALLY BY ACRONYM, FIRST 21 ENTRIES.

ANNEX 2

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ANNEX 3

Abbreviations

4HD2D = 4 hours door-to-door

ACARE = Advisory Council for Aeronautics Research in Europe

AI = artificial intelligence

ATC = air traffic control

ATM = air traffic management

b = billion

CAMERA = Coordination and Support Action for Mobility in Europe: Research and Assessment

CORDIS = Community Research and Development Information Service

CSA = Coordination and Support Action

DLR = Deutsches Zentrum fuer Luft- und Raumfahrt

EC = European Commission

ENG = Engine

EU = European Union

FP7 = 7th Framework Programme for Research and Technological Development

H2020 = Horizon 2020

IADP = Innovative Aircraft Demonstrator Platform

ICT = Information, Communication and Technology

ITD = Integrated Technology Demonstrator

k = thousand

KPA = key performance area

KPI = key performance indicator

LDA = latent Dirichlet allocation

LPA = Large Passenger Aircraft

MR1 = Mobility Report 1

MR2 = Mobility Report 2

MR3 = Mobility Report 3

m = million

NLP = natural language processing

REG = Regional Aircraft

SAGE = Sustainable and Green Engines

SME = Small and Medium-size Enterprise

SYS = System

UMAP = uniform manifold approximation and projection for dimension reduction

w/o = without

YOY = year-on-year



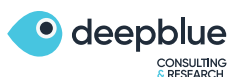
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COORDINATION AND SUPPORT
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