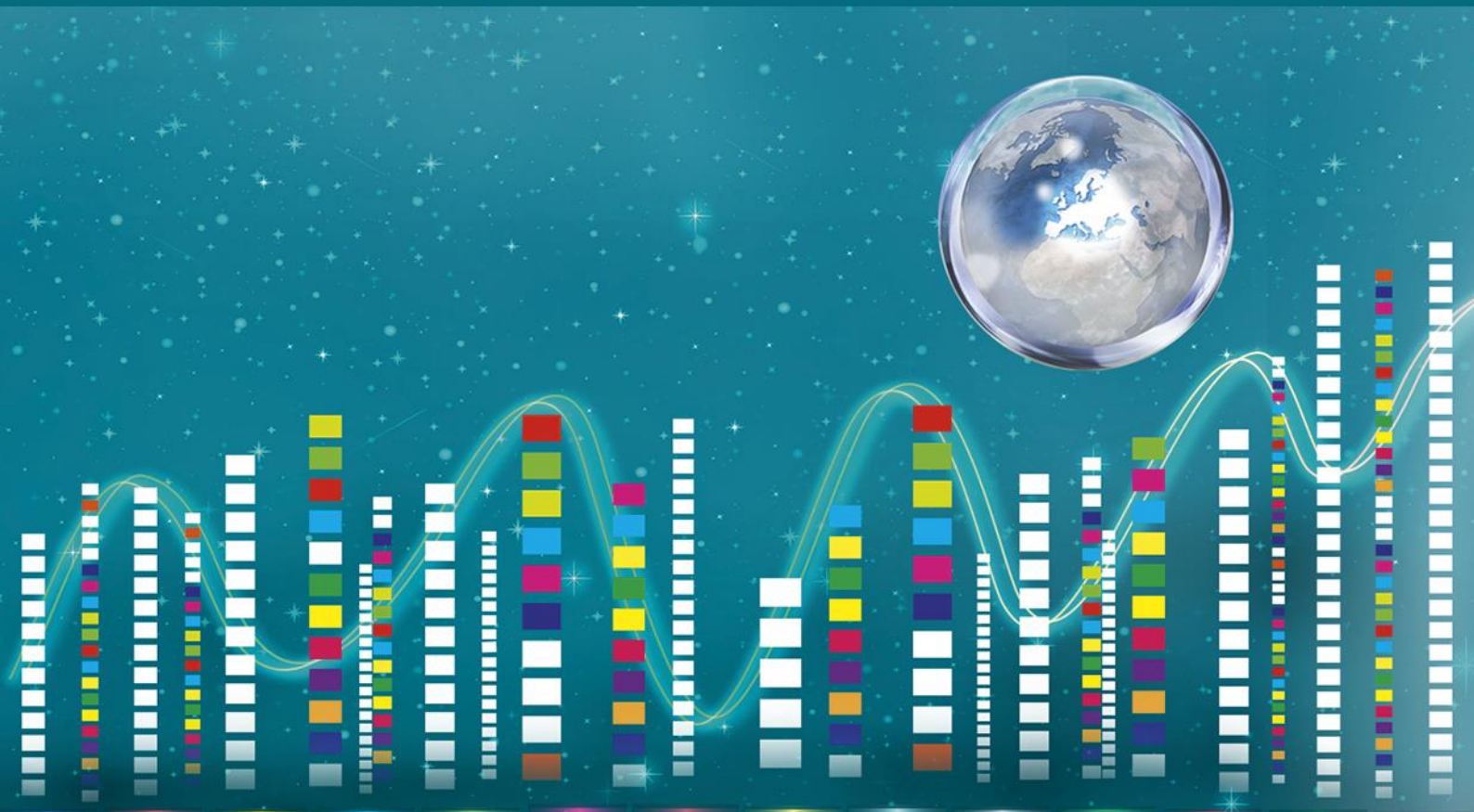
European Commission

Foresight

Smart Sustainable Mobility

Targeted scenario N°16

Glimpses of the future from the BOHEMIA study



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Research and Innovation

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***Smart Sustainable Mobility* - Targeted scenario N°16**

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EUROPEAN COMMISSION

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Targeted scenario N°16

Glimpses of the future

from the BOHEMIA study

Directorate-General for Research and Innovation

2018

About BOHEMIA

BOHEMIA is a foresight study (contract N° Contract PP-03021-2015) designed specifically to support the preparation of the next framework programme.

The study put forward policy recommendations for the next framework programme, based on a foresight processes involving scenario development, a Delphi survey and an online consultation.

As part of its recommendations, the study identified 19 likely future scenarios with disruptive implications and associated priority directions for EU research and innovation.

The full range of the results of the study is available at https://ec.europa.eu/research/foresight

Targeted scenario N° 16

Smart Sustainable Mobility

Summary

It is now 2040. A new cultural and business model has emerged: half of EU citizens do not own a car but rely on seamless intermodal mobility services. Passenger vehicles are increasingly automated and run on electricity, while freight transport also benefits from automation, with a massive use of drones for last-mile delivery, and high-performance power storage systems for trucks.

UN Sustainable Development Goals (SDGs) most relevant to this scenario:

The scenario

It is now 2040. For most people access to mobility services is more important than car ownership. New business models ensure the provision of a broad range of reliable and seamless intermodal mobility services. Providing access to diverse, sustainable mobility solutions remains a key policy for attractive, competitive cities and regions. The extended public transport network, the diffusion of remote working and the new life-style and mobility patterns halve the number of people that actually own or desire to own a car.

Public transport safety, efficiency and reliability have increased also thanks to the use automated vehicles. Half of passenger transport is fully automated and more and more cities have dedicated lanes for driverless cars and their inner centre reserved for small, shared, fully automated, electric mobility cells. One in two vehicles on EU roads is electric (fuel cells, solar cars).

Automated and electric freight transport is also on the rise, and drone traffic logistics is as an important economic sector employing an increasing share of the total EU workforce. Electric energy storage systems for trucks - allowing transport over distances of more 500 km with one charge - are available in every country. Trucks cover mostly regional distances as 3D printing and local circular economy loops reduce the need for transport and a large part of the long distance distribution is shifted to rail.

Relevance for Europe

New mobility-as-a-service concepts have the potential to provide for personal freedom of movement, avoid the need for individual car ownership, avoid congestion through multi-modal as well as single-mode trip optimisation, and guarantee reliable travel times. Several EU Member States have defined ambitious road safety targets and visions, and their achievement could benefit from the introduction of automated and electric road transport solutions.

The economic implications of the shift towards mobility-as-a-service concepts are likely to be important. Car manufacturers still rely on a model of individual ownership and may see their business models threatened, but on the other hand personalised mobility services will continue to rely on cars. With congestion, pollution, emission and safety agendas growing in importance globally, alternative models of ensuring the mobility of people are likely to be in great demand. European industry could position itself as a global frontrunner in the supply of integrated mobility and logistics solutions.

Contribution towards the UN Sustainable Development Goals (SDGs)

Smart cities, innovation in infrastructure and integration of services can contribute to reach SDG target 11.2: “By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons” as well as SDG target 9.1 “Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all”. The shift towards new mobility service concepts is also of relevance to the achievement of other SDGs, in particular Climate Action (SDGs 13) and Reduced Inequalities (SDG 10). The electrification of transport, and the expansion of public transport and the integration of services can make a crucial difference on cities’ air quality, contribute to mitigate climate change and ensure equitable access to all.

Implications for EU policy

The scenario is directly relevant to the EU Transport Policy. The development of low cost, ubiquitous, environmental sustainable mobility opportunities calls for the regulation of the market and the harmonisation, interoperability and integration of the IT system architectures[1]. To be attractive, the new services need to be promoted through a standardised interface for data management, exchange and protection. The risk exists that technologies, solutions and applications deepen the urban/social divide if not included in comprehensive policy packages that take into consideration economic, environmental and social goals, and the diversity of local contexts and users' needs.

Future Directions for EU R&I policy recommended by the public consultation

- **Research on battery efficiency, energy storage and recovery technologies**
- **Testing new mobility service solutions in pilot areas**
- **Research on new traffic management systems developments**
- **Research on methods, practices and policies for achieving behavioural change (ownership models, mode choices, location decisions)**
- **Agreements on interoperability standards for multi-modal transport systems**
- **Rules for autonomous transport by road and water**
- **Research on human-automated vehicles interfaces**
- **Research on smart grid management and on the opportunities for cross-domain solutions (Smart Mobility, Smart City and Smart Grids)**
- **Regulation of data security and liability in the context of automated transport**
- **Research on automated transport applications in the freight sector**
- **Investigation of the mobility needs in relation with personal freedom**

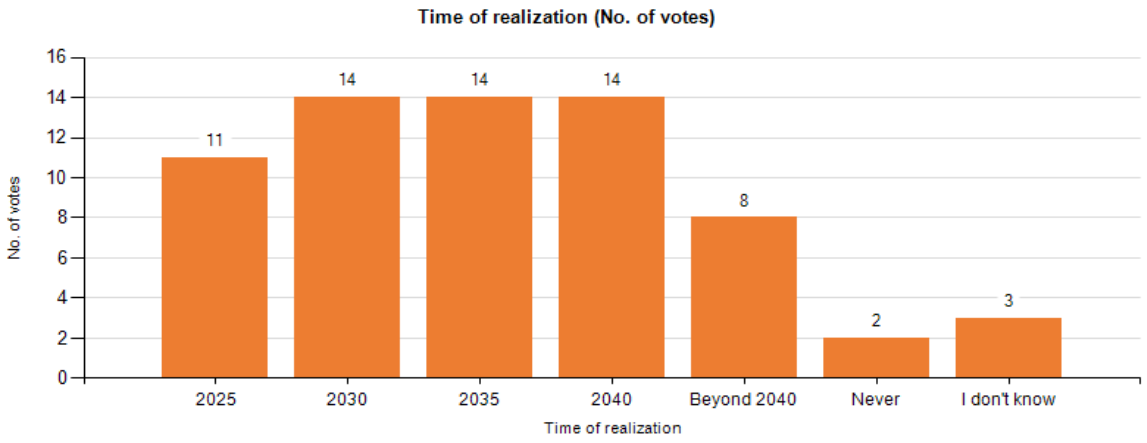
[1] TSSG/WIT The future of Mobility as Service (2016); MaaS Alliance White Paper "Guidelines and Recommendations to create the foundations for a thriving MaaS ecosystem" (2017)

Annex: Relevant Data from the Delphi Survey

The Delphi survey of the BOHEMIA study asked experts about the time of realization of 143 statements about the future, and about the relevance of Research and Innovation for that realization, or about the relevance of the realization for Research and Innovation policy. The experts were asked to justify their judgements with arguments. The whole data set has been published and can be found at: https://ec.europa.eu/research/foresight

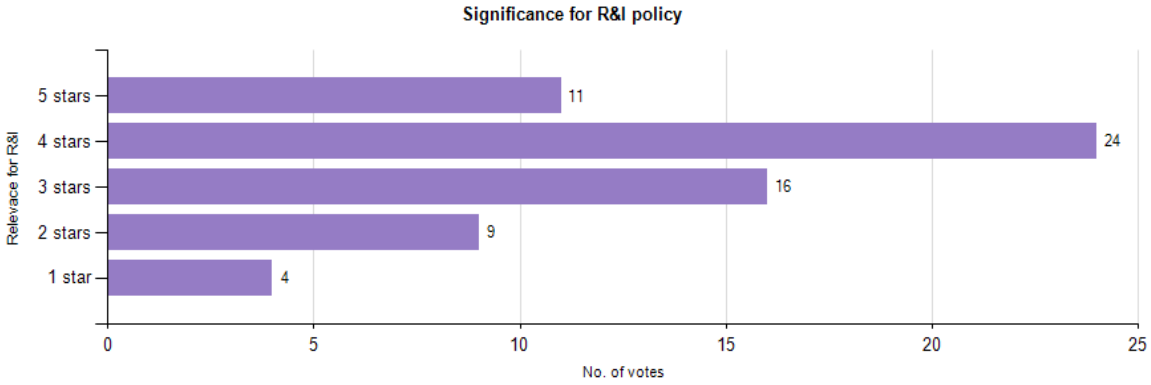
This annex includes the parts of the data set that are relevant to this scenario.

More than 50% of adults licensed to drive in the EU do not own a car



Number of respondents: 65

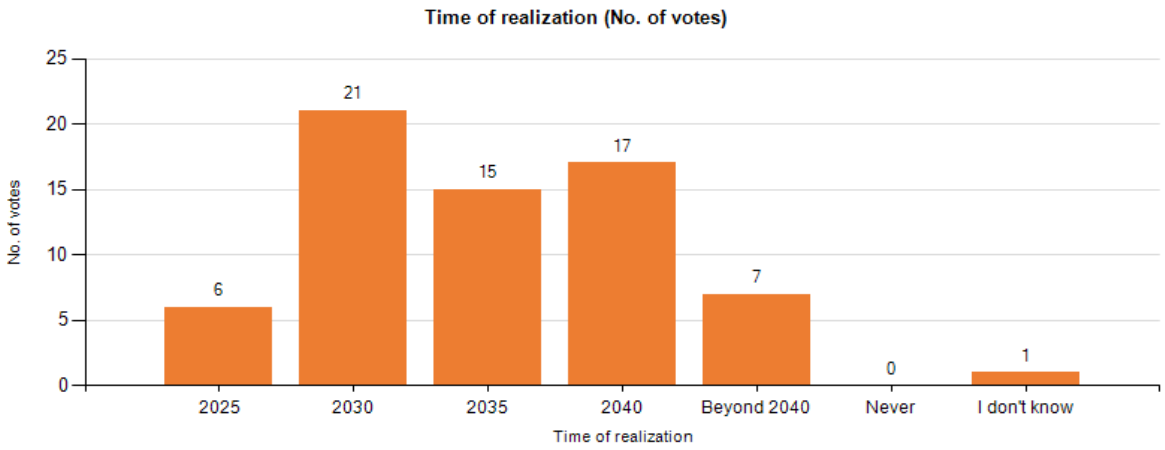
Arguments for time of realization	**No. of votes**
The challenge will be to move from a business model of selling cars to individuals towards a model of selling services.	45
As access to products becomes more important than ownership of things, this trend will continue to grow.	43
In urban agglomerations, there is no space for personal automobiles. Local traffic is expanded to enable fast locomotion for everybody.	30
If public transport or car sharing in rural areas do not massively improve, people need their cars.	24
Only a generation mindset change from "mine" to "ours" will support this development.	7
With level 4 autonomous cars available from ca. 2021, fewer will choose to get a driver's license.	5
The concepts of "driving" and "licensed to drive" will change too, when robotic cars are in general use.	5
Ambitious public transport policies, and the rethinking of our relation to space and time, will be needed to reduce car traffic and ownership.	4
This implies a massive cultural change which is impossible to predict.	3
Just for clarification: We have about 250 million passenger cars in the EU today. How many people are there who have a license to drive?	3
Remote driving is a possible concept to help the AI. And also to clarify the responsibilities. Multiple simultaneous remote driving should be possible.	3
Since alternative activities can be performed while driving, personalisation of the interior fitting personal interest might become an influential factor. So a private car for those who can afford it.	1
You've been reading Reddit futurology, haven't you? This doesn't fit into a few tick the box answers. Urban responses of maybe self-nav are totally different from other modalities. Needs essay.	1



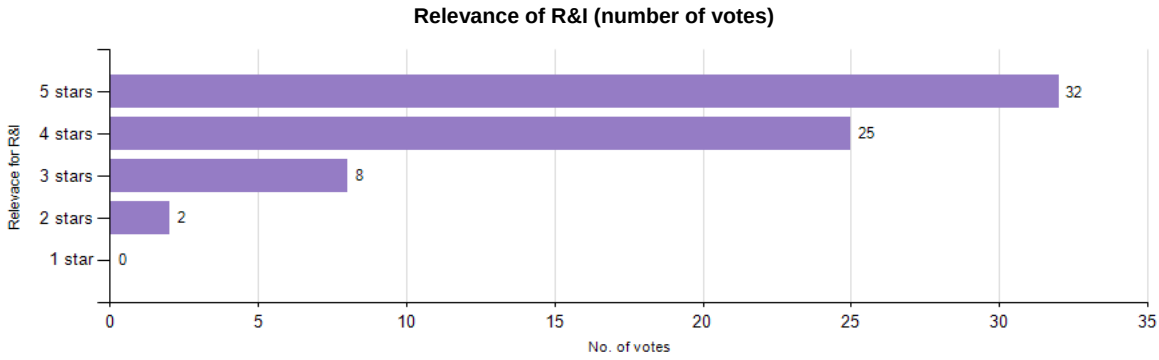
Average: 3.45 **Dispersion:** 1.27

Arguments regarding the significance for R&I policy	**No. of votes**
Mobility solutions need to be developed and politically backed up that allow to plan seamless journey without huge investments.	51
Research on transport will have to become less technological and concentrate rather on key political issues on transport policies at various levels. If not, transport problems will increase anyway.	32
Car sharing for private persons needs to be supported.	26
Transport is not an issue of ownership. Low cost, ubiquitous, environmentally sustainable transportation is needed. It is irrelevant who owns the vehicles.	13
The focus of EU research should be to reduce the number of cars, and not just the CO2 emissions, through better mobility solutions	11
Disruptive innovations including this one will lead to changes in mobility organisation and demand and requires also changes in assessment methods for infrastructure investment decisions.	10
Currently, the EU concentrates on reducing CO2 in cars and not on cutting car fleets in themselves: By 2021, phased in from 2020, the fleet average to be achieved by all new cars is 95 grams of CO2 per kilometre.	4
Mobility and transport have to be considered as major issues of public policies (organisation of urban and rural areas, consumption, distance home-work, lifestyles, etc.).	4
Owning a car or not does not have any influence on R&I policy.	4
Only a generation mindset change from "mine" to "ours" will support this development	3
Nothing much to do with EU. National issue, or more micro than that.	1
Unfortunately EU always arrives late to important changes. USA will lead this change also, despite the automobile industry in Germany, France, Italy or even Spain	1

50% of passenger transport is fully automated



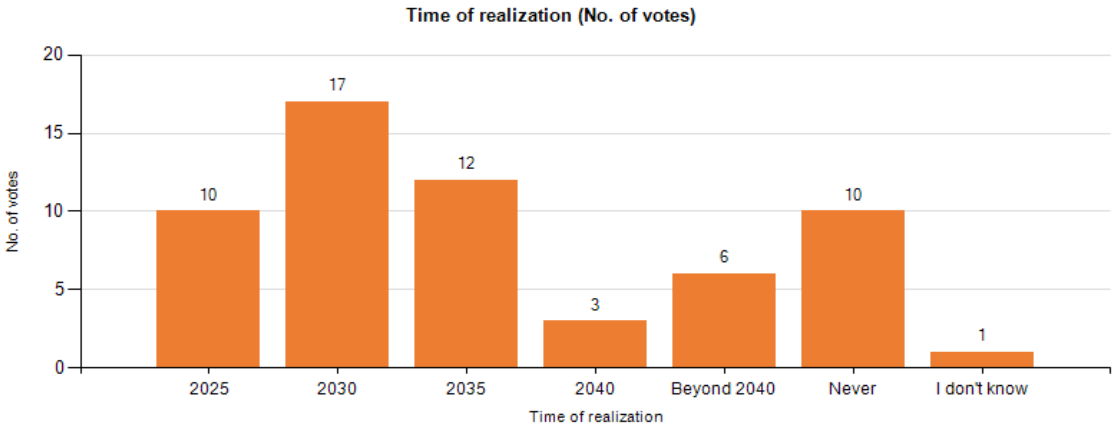
Arguments regarding the time of realization	No. of votes
By 2030 the safety level of driverless cars will be higher than that of 'regular cars' (operated by human drivers).	46
Driverless vehicles will be restricted to certain lanes for a long period of time.	26
Challenges in establishing agency and responsibility in driverless cars causes delays in adoption.	25
Owning a car is old-fashioned. The future belongs to small, fully automated, electric mobility cells. By 2030, a few cities could already have reserved their inner centre for this kind of shared mobility systems.	24
Vehicles for passenger transport will be dual mode, automatic in some environments and manual elsewhere. Still, most of the kilometers may be driven by AI driver.	20
Car-to-car connectivity needs to be adopted first on a large scale.	14
Passenger transport conceptually includes all types of machines, planes, trains, metro, trams, ships and boats and 1 to N wheel vehicles... 50% of that capacity will be fully automated rather soon.	9
Open Data will provide real-time data to enhance decisions about car mobility.	7
Cars need to be fault-tolerant and meet SIL-4 requirements; plus there is a need for an independent regulating body (like in aviation).	7
Depends whether we look at inner city transport or longer distance. Inner city transport will be (electric-)bicycle based. No need to automate (see Copenhagen). There is no need for cars whatsoever.	5
Definition-dependent. Most passenger air miles are probably flown by autopilots already: is it disqualified because there is a pilot in the cockpit?	5
Uber already started a field trial of automated cars.	4
It will depend from the adoption of mobility services: if we accept not to own our car, it will be easier (in economic terms) to develop automated vehicles with shared vehicles.	3
Automation of passenger transport by railways will take longer and will only provide a cost advantage where automation of road transport provides also other benefits for the user.	2
Long periods to renew vehicle fleets.	2
Already today, a lot of passenger transport operations are automated, e.g., trains, trams, etc. Next step is in cars and truck transport.	1



Average: 4.30 **Dispersion:** 0.61

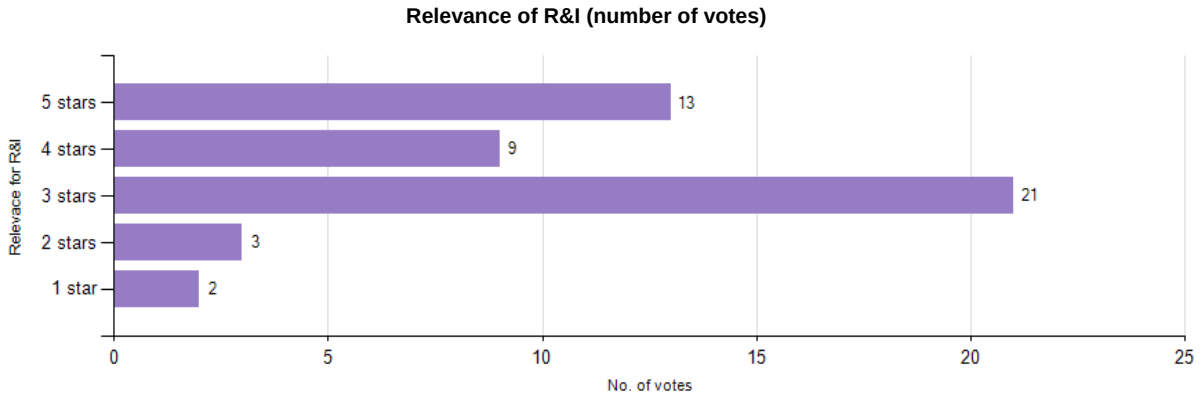
Arguments regarding the relevance of R&I	**No. of votes**
A better integration of these systems in the evolution of the cities requires interdisciplinary research and social innovation.	46
Europe is an important car producer and driverless technologies are key to the competitiveness of this industry.	40
The security of driverless systems (ie vulnerability to hacking/misuse) is a key issue.	32
Risk management in AI decisions needs better ethical foundations.	16
Developing vehicle technology that can cope with the unpredictable behaviour of non-automated road users and stray objects (litter, birds, dogs) is crucial.	15
Citizens' engagement in R&I is a must in order to progress both from a technical and from a social perspective.	13
Automated vehicles, smart infrastructure and cloud are key topics in smart mobility. Research should support all three.	12
The driverless technologies are still in a close-to-market stage.	6
Impact on (un)employment needs further assessment.	4
Investments should be provided to Startups devoted to Software as a Service (SaaS), as they represent the highest potential in Smart Mobility.	3
Developing ways of solving deliberate or non-deliberate human-induced gridlock is critical.	3
Publicly funded research needs to focus on those aspects that are not financed by the private sector anyway: security, System Integration/Standards, ethical aspects of AI, responsible R&I	2

Drone traffic logistics has emerged as an important economic sector employing 1.5% of the total EU workforce (including maintenance experts, service, “drivers”, packaging etc.)



Number of respondents : 58

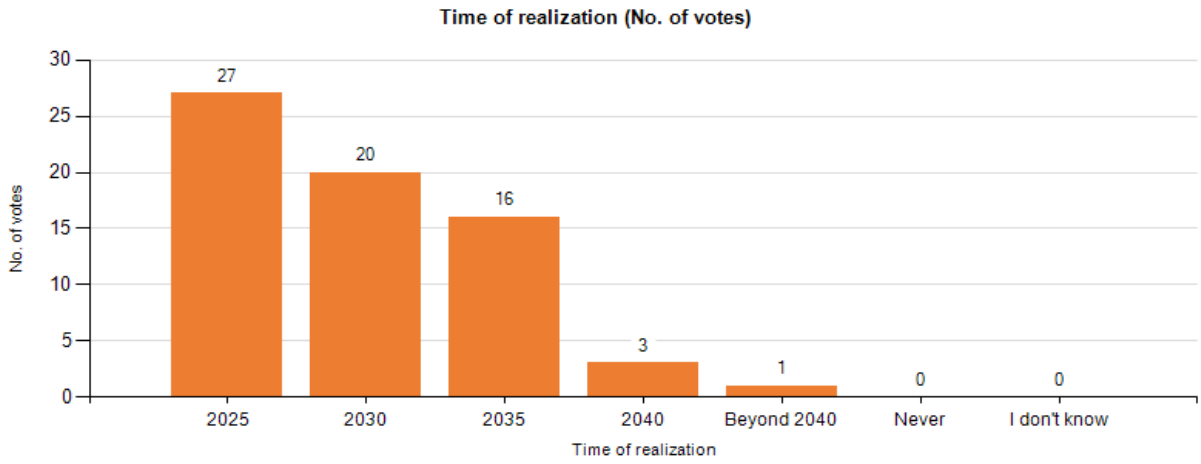
Arguments regarding the time of realization	**No. of votes**
Personal security will be important to manage for drone use in populated areas.	30
There is currently no drone traffic infrastructure in the EU.	28
Drones' promise of improving transportation services in critical services, especially in the crowded European cities, has no real match or alternative at this point.	17
I doubt that drones have a major role and provide a significant return on investment unless for very specific issues.	16
There are about 220mn employed persons in the EU, 1.5% of which is 3.3mn. The total number of employees in air-traffic and support activities (inside and outside airports) is currently below 2mn across the EU28.	12
Drones and their impact on last mile logistics may be important, but the impacts on workforce may be rather negative. One main aim of automation is to reduce all transaction costs.	12
Drones can serve several niche markets such as locations that are hard to reach, urgent deliveries of parcells in congested areas, movements from automated (parcel delivery) vehicle to the door, etc.	9
Drone-based freight transport and delivery, between cities but also including rural areas, will be a major driver.	6
If the security-related work force is included, then 1.5% of the work force is plausible due to the broad range of possible security threats that would come with intensive use of drones for logistics.	4
Drones can add significant value in ports speeding container unloading and eliminating reshipment and storage, however, autonomous operation lessening the need for drivers is likely.	2



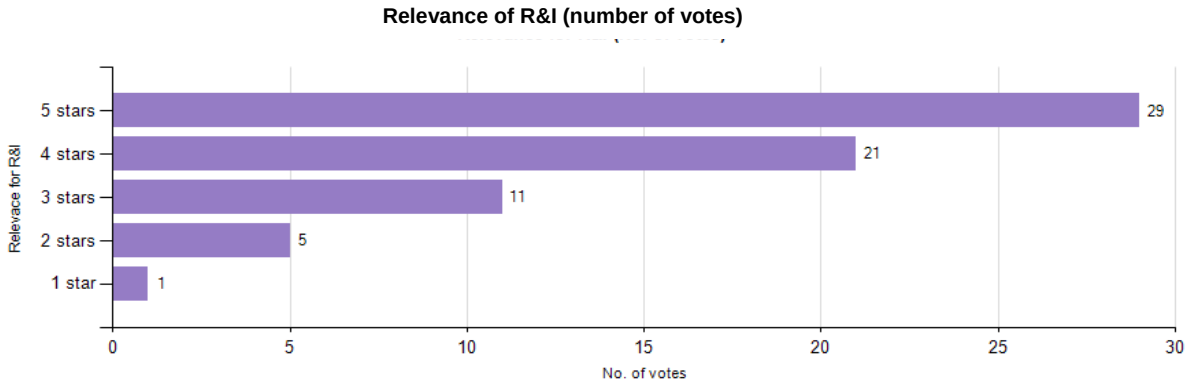
Average: 3.58 **Dispersion:** 1.18

Arguments regarding the relevance of R&I	**No. of votes**
A working traffic management system has (yet) to be developed for the crowded modern cities.	36
Current mangement systems are not suitable for supporting intermixed drone/airplane traffic. A complete conceptual rethinking and new technologies are needed.	23
Drone transportation in public spaces may very well be a false good idea (but could work in private places). Trans-disciplinary research is urgently needed not to waste too much money.	14
There is too much hype in this field. Other domains have a much high importance.	12
Extraordinary range of security and safety concerns to address many of which must be addressed if smart cities with autonomous robotics are to be realized.	8

Electric mobility (fuel cells, solar cars etc.) has replaced 20% of the internal combustion engine vehicles on EU roads



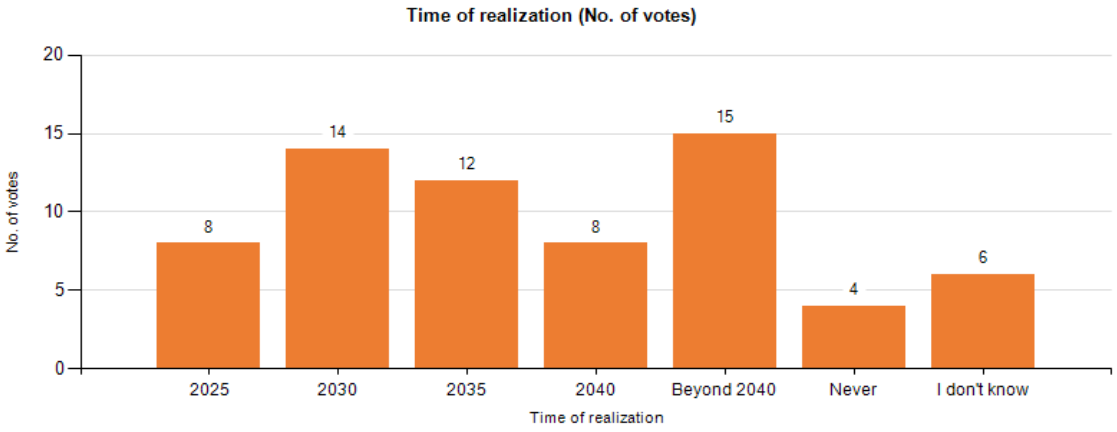
Arguments regarding the time of realization	No. of votes
The autonomy of electric vehicles is increasing.	47
Air quality in the cities will become a major attraction factor in the competition for the best brains.	40
Consumers have a preference for electric vehicles due to ease of use, comfort, lower maintenance costs etc.	18
Production costs for electric vehicles (batteries and other components) are expected to fall drastically over the next decade.	18
New developments in the solar industry will continue to drive down the costs of solar energy.	16
There is a major issue with building the required energy distribution system.	12
Electric cars are only an alternative to fuel propelled cars, hidrogen and other alternatives will be in place in the future.	10
In Germany, it has been proposed to ban petrol-powered cars in favour of electric vehicles by 2030.	8
Such penetration is a minimum requirement to achieve the 2030 renewable targets.	8
Norway will ban new sales of fuel cars by 2025.	6
Batteries' energy density is too low.	4
Battery-operated electrical vehicles will dominate. Generating electricity in the vehicle brings in significant burden of cost, weight and complexity. Recharging technologies and infrastructure are important.	4
Production cost for such vehicles and the lack of recharging infrastructure are the major obstacles for a fast development.	4
Batteries are rapidly improving and will in a few years be able to charge within a few minutes, will be light, cheap and will provide a range of about 800 km.	4
The problem with the electric car industry is the lobbies that push for petrol-based propulsion engines.	3
Electric cars are already faster than combustion engine cars in rallycross; and the technology is transferable to regular automobiles.	2
Drivetrain electrification and vehicle automation are converging and mutually reinforcing technology paths. Ultimately, automated vehicles will only be meaningful if electrified.	2



Average: 4.07 **Dispersion:** 1.06

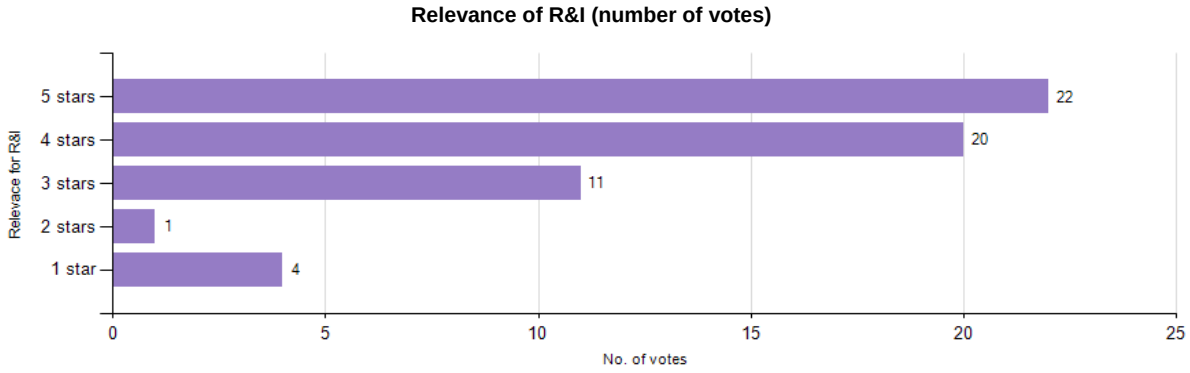
Arguments regarding the relevance of R&I	**No. of votes**
Electric mobility needs to be integrated in the broader context of smart cities.	45
To compete against combustion engines, a breakthrough in battery efficiency is still necessary.	41
Integration of electric vehicles as power storage devices in smart grid systems allows improving (peak) load management.	26
Given the reliance on expensive materials (e.g. rare earths), the costs of which are likely to rise with growing demand, alternative material options are needed.	21
E-Vehicles need to be economically accessible for everybody and high-density recharging infrastructure needs to expand faster	16
Smart cities will necessarily have to rely on alternative sources of energy to succeed.	10
Improved battery technology will also make it possible to store energy at charging stations and reduce peaks in demand. Also options to collect energy at charging stations (and Solar-Road) to be used.	7
Research in fast charging is required in order to meet customer demand.	6
Convenient user interface for charging is needed. Current manually plugged cables are not acceptable.	5
Without real leaps in energy production and storage, our entire way of life is not viable.	3
First we need excess current from renewable sources, before e-mobility is a "green" technology. Therefore, focus must be on electricity generation.	3
The potential will be limited because of the inherent chemistry of batteries unless nuclear energy is used to compensate for the stochastic nature of alternative energy sources	3
Fuel cells and H2 economy need to remain in the picture to diversify energy sources including H2 derived from local biomass for circular economy.	2
Super capacitors offering extremely rapid energy storage and far greater number of charge-discharge cycles can address multiple problems. Graphene, CNTs could reduce demand for rare earths.	2

Electric energy storage systems for trucks (more than 10 tons) that allow transport over distances of more than 500 km with one charge are available in every EU country



Number of respondents : 61

Arguments for time of realization	**No. of votes**
The demand for energy storage increases as a response to the larger share of renewables.	34
Progress is accelerating in the development of different types of batteries. New solutions allow for large-scale storage.	31
What cannot be produced locally will be transported by rail (long distance) and distributed by truck locally - long distance trucks will be irrelevant.	17
Deployment will be driven largely by costs and local environmental restrictions. Major ports with air quality issues may mandate electrics but long-haul diesel trucks are likely to remain competitive.	9
Hybrid (battery + fuel cell as range extender) might be an interesting alternative.	8
Will truck transport over distances of more than 500 km be relevant in the future when products will be produced locally by 3d-printing?	5
An electric truck is like a horse in winter, which uses much of its capacity to transport its own energy.	4
Advances from graphene flagship will supply the necessary technology.	4
Hydrogen cars will be more popular.	4
We should look not at substituting fuel as energy storage system for transport, but at fuel cells to convert chemical energy in electric energy on board.	2
Batteries for long distance transport is a waste of resources. E-mobility has to play out its advantages on short distances first (recuperation and 0-emissions in cities).	2
These are random points unrelated to an essentially unimportant assertion.	2
The efforts being made in the field of passenger cars will be translated to the freight sector as soon as some cost targets are achieved. E-cars expected to reach parity with ICE cars by 2020.	2
Countries' policy could become a key factor, but the stronger resistance could come from truck producers.	1



Average: 3.95 **Dispersion:** 1.24

Arguments for time of realization	**No. of votes**
Beyond the development of battery storage, energy recuperation systems need further developments.	25
Cars and trucks can become important storage systems once the charging time can be reduced, which requires an investment in relevant R&I.	24
The efficiency of energy storage solutions needs to be further developed and be made scalable.	23
Electricity storage remains a key barrier for the energy transition. Maximum efforts both from private and public sector are needed.	16
New solutions for long distance transport (rail and electric last mile in a form of combined traffic - containers on rail) are being called for.	14
The massive energy storage systems will require more infrastructure development (e.g. hydroelectric pump storage) than new technologies.	10
Research on renewable sources is the limit. If the stored energy comes from fossil fuels (or derivates), electrical transportation can't become a smart option.	4
The market for these new technologies is huge and EU countries should strive to acquire relevant IPR.	4
SkyTran type systems for package delivery could compete with the total cost and offer higher speed and service than truck or rail if roadways are included in the cost structure. Need huge RD effort.	2
EU FCH JU might provide a solution to that problem. Efforts should be intensified.	1

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It is now 2040. A new cultural and business model has emerged: half of EU citizens do not own a car but rely on seamless intermodal mobility services. Passenger vehicles are increasingly automated and run on electricity, while freight transport also benefits from automation, with a massive use of drones for last-mile delivery, and high-performance power storage systems for trucks.

Studies and reports