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ORIGINAL ARTICLE

# Wild cards in transport

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**Abstract** The analysis of *Wild Cards,* potential low-likelihood but high-impact events, in foresight studies is important in order to counter the tendency of decision makers to deny major surprises. This paper presents the results of an empirical analysis of 14 technological, geo-political and societal Wild Cards in the transport field, carried out within the EU FP7 project RACE2050. The Wild Cards were elicited through interviews and in brain-storming sessions, and then assessed in an online expert survey. For each Wild Card, experts assessed likelihood in different time-frames, the impact on and vulnerability of different industry segments, the breadth of the effect, and the importance for decision makers to prepare. Some weak signals that may hint at a growing likelihood of certain Wild Cards were also suggested. Results show that the likelihood rises with time. Several Wild Cards reach high likelihood in 2040 or beyond, while the time by which full impact is reached varies. Based on these findings challenges and threats for transport have been identified, pointing to the fact that further research should focus on complex scenario building based on interlinks between ongoing trends and Wild Cards.

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"*The biggest surprise would be that the surprise-free scenario would actually occur.*" *Herman Kahn*

## Introduction: the concept of wild cards in foresight

No single method can cope with the inherent uncertainties faced by the attempt to examine alternative futures, be it the futures of transport or any other field of human activity. These uncertainties become ever more severe and influential with the accelerated pace of interrelated technological, societal and other changes. The reality is very likely to surprise us, time and again, even when good foresight studies are available on the relevant subject matter. An appropriate mix of different and complementary approaches and methods is needed, which synergistically may better cope with the inherent uncertainties and disruptions. In particular, inclusion of Wild Cards in foresight studies is therefore important in order to challenge the "conventional wisdom" and the basic assumptions on which forecasts or scenarios are based.

*Wild Cards* are potential future events with low likelihood of occurrence (at least as currently perceived by most people) but with high impact if they occur [1]. The concept was first introduced in 1992 in a joint study by BIPE Conseil, the Copenhagen Institute for Futures Studies and the Institute for the Future, and at that time it focused mainly on the business arena [2]. Petersen [3] later extended the concept to other areas.

Many past foresight studies have tended to focus on most likely possible futures. This is hardly the best way to anticipate strategic surprises. Experience shows that unexpected events always occur and surprise decision makers. Major surprises are often caused simply by denial (which in turn may be the cause of neglecting and missing relevant weak signals).

Schwartz and Randall [4] stress the importance of using imaginative "unlikely" scenarios to counter this effect. Hence, the elicitation of potential Wild Cards as part of a foresight study is not just an intellectual exercise in imaginative thinking, but may prove as an essential means of preparedness for critical future surprises. In other words, Wild Cards can be regarded as the ultimate challenge to "business as usual" scenarios and even to "business as not so usual" scenarios. Wild Cards may result from planned actions, but sometimes with unplanned consequences, such as technological breakthroughs emerging from scientific research, or from unplanned events, e.g., natural disasters. Their low likelihood (and high impact) implies a significant surprise, but the level of surprise can be subjective. An important concept for increasing the effectiveness of Wild Card analysis is *Weak signals*. Weak signals are "precursor events" or "early warnings", namely slight changes in the current state of affairs or in existing trends that–if observed and correctly interpreted–*may* hint at a growing likelihood of occurrence of a certain Wild Card. These signals may be unclear, but they may become clearer in time (if monitored) or stronger, perhaps in combination with other signals. Searching for such signals and interpreting them are challenging tasks and an important subject of research in the Foresight field in recent years (see, for example Hiltunen 2006 [5], Holopainen and Toivonen 2012 [6]), and advances in this domain may enhance the usefulness of the Wild Cards concept for decision makers. It can be said that whereas identified and forecasted/conventional trends narrow down the scope of possible futures, Wild Cards (and weak signals hinting to them) broaden it and create new vistas [7]. Nevertheless, it should be noted that Wild Cards are a relatively young research topic in the Foresight literature, with yet challenging questions, such as what is the best way to generate them or to study their diverse impacts.

Growing interest in Wild Cards and weak signals has been reflected, for example, by the EU FP7 project "iKNOW", probably the first publicly-funded international project that was entirely dedicated to Wild Cards and weak signals[1] including several ones related to transportation.

## Wild cards in transport

Within the EU FP7 project RACE2050 novel scenarios for 2030 and 2050 have been constructed about alternative futures of the European transport industries. In parallel to the construction of "conventional" scenarios, it was decided to consider several potentially surprising and disruptive future developments. Thus, an approach mixing different methods and perspectives was developed combining several steps: 1. Identification of Wild Cards based on literature and experts, 2. Assessment of Wild Cards impact and likelihood by an online expert survey and identification of related Weak Signals, 3. Linking Wild Cards with a classical SWOT analysis to i) exploring additional impact factors for competitiveness and blind spots, ii) providing insights on dynamics of future development due to conflicting impacts of wild cards and iii) identifying potential synergies between Wild Cards and ongoing trends (Fig. 1).

In the assessment step we aimed at a relatively large group since it is difficult to find experts who are experienced in both transportation and in the use of Wild Cards. 281 experts participated in the survey, which is a relatively large number for expert surveys.

The collection and elicitation of a wide range of Wild Cards was carried out by scanning selected publications, in-depth interviews with subject matter experts and several brainstorming sessions with experts. Besides future oriented publications in journals and consultancy reports results of the EU-FP7 project iKNOW focused on Wild Cards and Weak Signals where considered. Another source was the 'Global Europe 2050' report; a detailed description can be found in Hauptman et al. 2014 [8].

Based on these activities, fourteen Wild Cards were selected for a subsequent analysis by means of an online expert survey in order to estimate their potential impact and likelihood (in different time-frames), relevance for the European transport sector, competitiveness and related challenges, as described in further detail in the next section. The number of potential Wild Cards can be very large, and for practical reasons only a small subset of them can be assessed by means of an online expert survey. Needless to say, our study does not pretend to be exhaustive and the modest aim of this exploratory exercise was to enrich the thinking process about transportation scenarios. In selecting the small set of 14 Wild Cards for assessment in the expert survey, the following efforts were made:

(a) To include diverse types of Wild Cards: technological, geopolitical and societal/behavioral.
(b) To reflect (in some cases) totally opposing directions, for example hyper-speed transportation vs. widespread adoption of "slow living".

Some topics, rather frequently described in publications and also mentioned in the interviews and brainstorming sessions, may be currently perceived as "not so wild", or as emerging issues rather than Wild Card—for instance, driverless cars. This is related to the expert-based approach; the selection of Wild Cards reflects the perspective and mindset of experts including what they consider as wild. In other words limitation of Wild Cards "wildness" is based on limited

[1] Full name: "*Interconnecting knowledge for the early identification of issues, events and developments (*e.g., *Wild Cards and associated weak signals) shaping and shaking the future of science, technology and innovation in the European Research Area*". For details see http://wiwe.iknowfutures.eu/iknow–description.

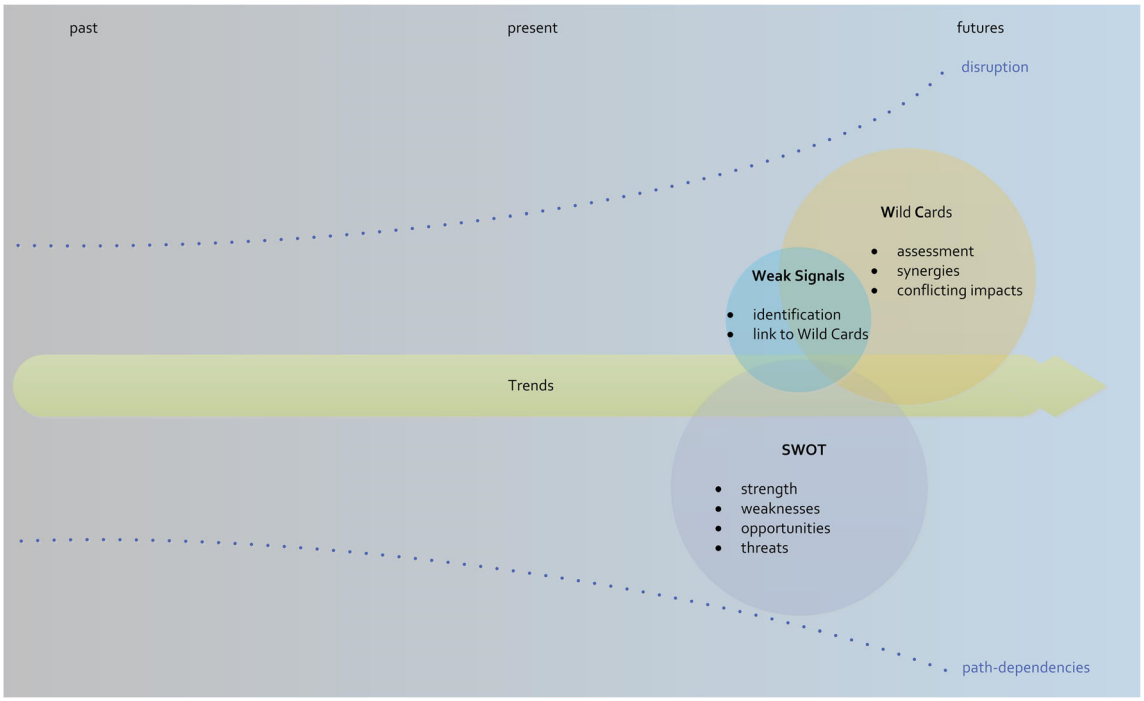


**Fig. 1** Methodological approach

imaginativeness of extreme events in the experts' mind. Following an open scientific-based approach, this needs to be accepted as a result itself. Effort was made to add a somewhat "wilder" dimension—in the case of driverless cars we added the banning of human driven cars (see the full description of Wild Card No.8). The distinction between "emerging issues" and "Wild Cards" is discussed, for example, in van Rij (2013). The limitations were addressed in later steps whereby Wild Cards were combined with the results of a SWOT analysis, helping to identify systemic aspects of Wild Cards in interaction with ongoing trends as well as overlooked areas, which would need to be further investigated.

## Assessment of wild cards impact on transport

The assessment of Wild Cards took place in January and February 2014 in an online survey. For each Wild Card the experts were requested to submit their assessments by answering the following questions:

a) What is the likelihood[2] of occurrence of this event, in each of the following timeframes: today-2020, 2021–2030, 2031–2040, 2041–2050, after 2050.

Scale 1 to 5: 1=very low, 2=low, 3=medium, 4=high, 5=very high.

b) A Wild Card has by definition a high impact (negative or positive), but the impacts can vary among different industries. Please assess whether the impact will be mostly negative or positive for each industry (aviation, road, rail, maritime, space)

c) Please assess the fullest impact of the Wild Card on each transport industry as follows: very low, low, medium, high, very high.

d) Every Wild Card brings about change. The change can be sudden (short time till full impact is reached) or rather gradual (longer time will pass till the impact is reached).

Please assess the time by which fullest impact after the Wild Card will manifest itself:

Immediate (within 1 year), short term (1 to 3 years), medium term (3 to 7 years), long term (more than 7 years).

e) How broad will the effect of this Wild Card be?.

Local (a single city), national (a single country), regional (e.g., Asia, Europe), or global.

f) How vulnerable[3] is each transport sector (aviation, road, rail, maritime, space) to the changes wrought by the event?.

Scale 1 to 5: 1=very low vulnerability, 2=low, 3=medium, 4=high, 5=very high vulnerability.

[2] Note that a Wild Card has by definition low likelihood, hence attributing "medium" to "very high" likelihood means that strictly speaking the described event is NOT a Wild Card. However, it is possible that the likelihood will change over time, and the event can be a Wild Card in certain timeframe and a *likely* event in other timeframe.

[3] A vulnerable system has difficulty to adapt to change, whereas a resilient system can adapt easily to change

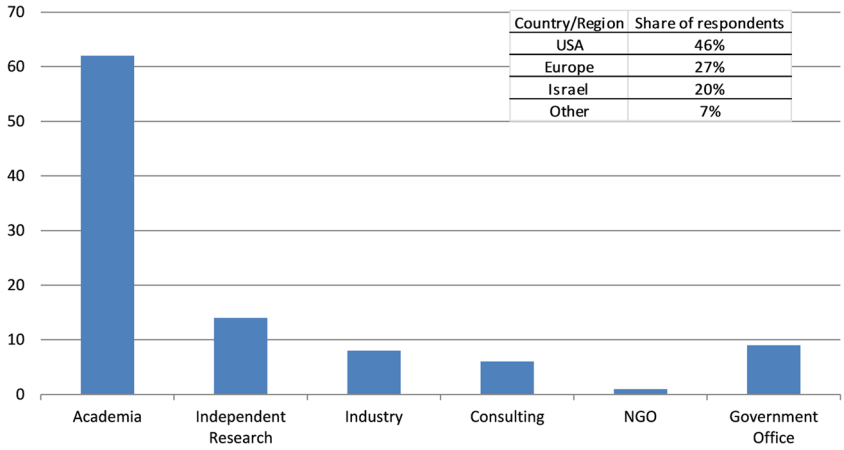


**Fig. 2** Distribution of respondents by region and affiliation

g) Importance to for EU decision makers and transport industry managers to prepare for this Wild Card.
(1=not important at all, 2=low importance, 3=medium importance, 4=very important, 5=critical).
h) Could you suggest some early "precursor events" (weak signals) which, if detected, may hint at a growing likelihood of this Wild Card?

Some methodological points should be emphasized regarding the composition of the experts group. The survey reflects the fact that such a study of Wild Cards is indeed exploratory, as pointed out earlier. It also should be noted that such expert surveys usually do not pretend to be statistically representative. In distributing the invitation to participate we aimed at a relatively large audience, since it is rather difficult to find experts experienced in both transportation and in the use of Wild Cards, and to ensure their involvement. 281 experts participated in the survey, which is a relatively large number for expert surveys (the number of responses to each Wild Card was 42 to 69). Figures 2 and 3 present the distributions of respondents by country/region of residence, affiliation and levels of expertise in main transport domains.

The respondents are mainly from the US, Europe and Israel covering a broad region—with a focus on the western world.

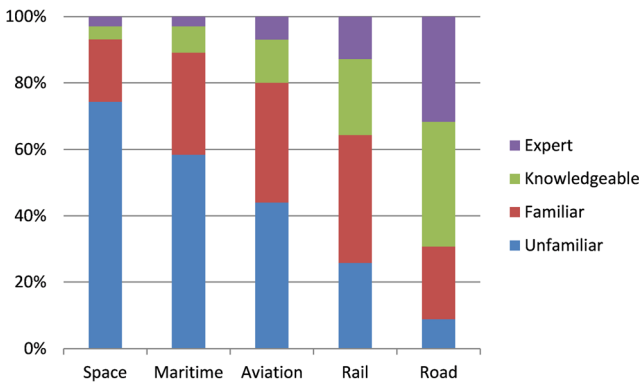


**Fig. 3** Distribution of respondents by level of expertise in different transport areas

However, in our opinion this does not necessarily generate a bias in the results. Several studies address issues of sample size and biases in Delphi surveys, which differ from expert surveys in the procedure of conducting the survey. Hallowell and Gambatese [9], for example, study these issues and conclude that survey samples can be rather small. Additionally, they address possible biases but country diversity is not one of them. In other words, the fact that China or Japan, for example, is not represented among the respondents should not diminish the quality of the results. We are not really looking for information that can only be addressed (or can be better addressed) by experts from China or Japan. In a broader study with even more participants, a comparison between different countries or world regions could provide valuable insights on cross-cultural aspects influencing perception of the future and transport-related Wild Cards.

Since the concept of Wild Cards is mostly studied at universities and not yet fully used in industry, our first target was academia. This group has a high impact via education and research influencing future perspective and real innovation. Gaining insights into the mindset of this group seemed to provide the key to estimating future challenges and opportunities for the transport sector. Further, additional value was provided by contrasting the industries' setting with a scientific-based perspective. 62 % of the respondents are academic researchers from different discplines. Thus, a broad field of expertise was covered, taking into account that today's transport and mobility issues are covered by researchers from various classical and new disciplines.

Since we could not know in advance the level of expertise of the participants in the topics addressed in the survey, we asked them to self-rate Wild Cards impact. We can see that most of the respondents have some level of expertise (are familiar, knowledgeable or expert) in road transportation (91 %). However, most respondents also have some level of expertise in other areas—55 % in aviation, 75 % in rail transportation, 60 % in maritime transportation, and 26 % in space transportation. We anticipated that experts in road

transportation would also be able to answer questions relating to other areas.

From the methodological point of view it is important to bear in mind that since Wild Cards can be initiated by intentional human action, the likelihood perception (and hence the level of surprise) may be different for the initiators as compared to the unaware or those who oppose [10]. In principle, this fact should be taken into account in selecting survey respondents and in drawing conclusions from their responses. In our opinion in the present survey it is reasonable to assume that the number of possible "initiators" of Wild Cards (or "opposers") is insignificant (if not zero), so that no bias is expected to emerge due to this aspect.

## Survey results: impact and likelihood of wild cards in transport

Fourteen Wild Cards were assessed by the experts, including the estimated impact on the different transport sectors, the likelihood of occurrence in different time-frames, and the relevance for decision makers. Experts were also asked to estimate the geographical broadness of the effect of the Wild Cards. It became apparent that Wild Cards expected to have global impact are especially those related to technological change or related to natural resource (use of energy) and political issues (EU-US relations). Only a few Wild Cards, such as slow travel, drones or autonomous cars, were considered to have local or national impact, e.g., due to political regulations (Fig. 4).

### Technology-oriented wild cards, not specific for but with high importance to transport

The likelihood of occurrence of both Wild Cards related to this field, energy abundance and drastic decrease of freight, increases over the next 15 years—although only reaching medium level. Experts estimate the likelihood that two main trends in transport (increasing global freight transport and energy use) will change as low, with tendency to increase to a medium likelihood until 2035 (Fig. 5). Thus, increasing pressure to reduce transport in order to address climate change, budget issues and scarcity of fossil energy use is not reflected in the assessment of these Wild Cards. If any change is expected, it seems unlikely to occur as one of these Wild Cards.

1. Drastic Decrease in Freight Transport

   This Wild Card was described as: "*Freight transport drastically decreases thanks to a widespread use of additive manufacturing (3D printing) and/or molecular*

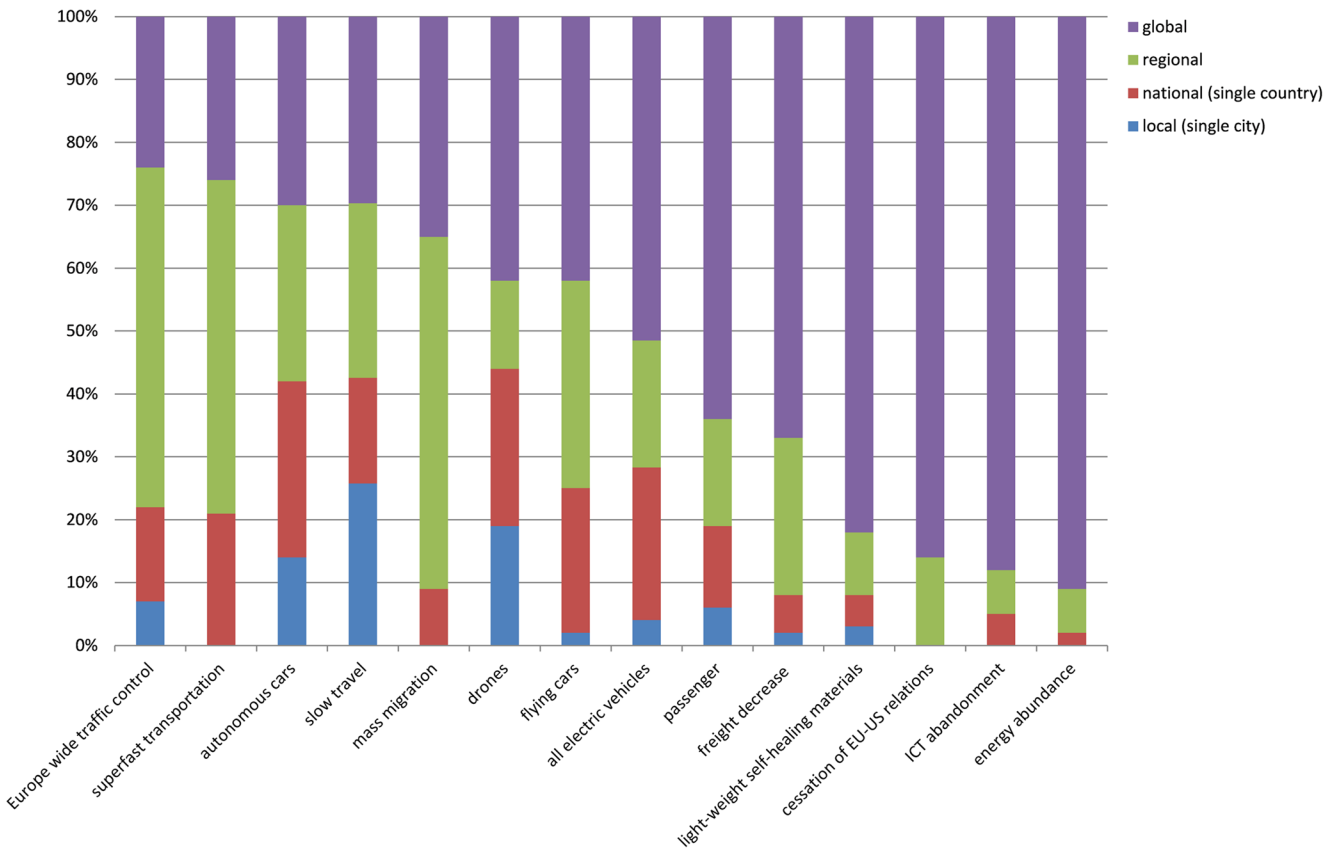


**Fig. 4** Geographical breadth of Wild Cards

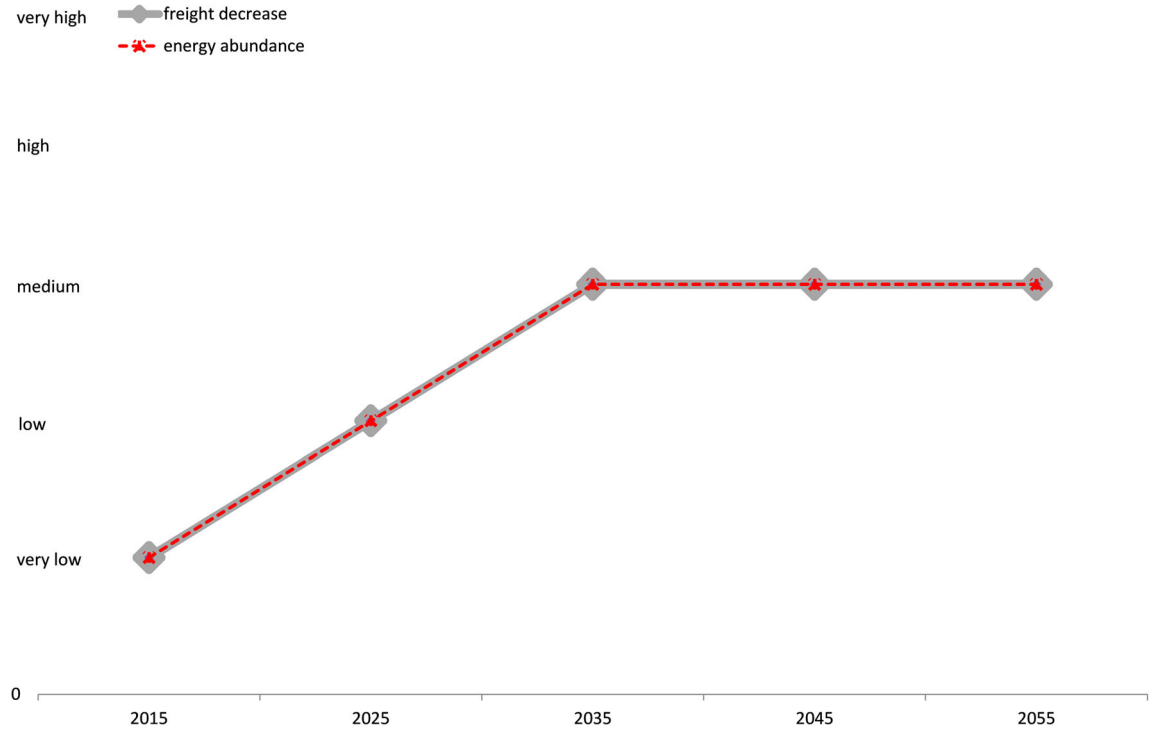


**Fig. 5** Estimated likelihood of Wild Card occurrence as a function of time

*manufacturing, which enable local production (at home or nearby)*". A medium importance was estimated for EU decision makers and transport industry managers (see Table 4, Annex); fundamental structural changes of economy and production appear to be out of scope. Weak signals related to this Wild Card reflect the change of such economic structural change, combined with new production technologies:

- 3D printers become cheaper and proliferate for home use
- The financial crisis has already resulted in more local manufacturing, especially in the US
- Growing variety of materials used in commercial 3d printers
- Trade in selected areas is decreasing despite increased consumption
- Availability of resources (inputs, materials) locally
- Re-orientation of shipping to raw materials vs. finished products
- Energy prices stay very high in spite of economic contraction

2. Energy Abundance

"*Energy saving ceases to be a critical factor in transport, thanks to a technology breakthrough (*e.g., *cheap and efficient extraction of Hydrogen from seawater) or significant cost reduction due to widespread utilization of shale gas and other resources.*" Importance for decision makers was seen as medium to high for EU decision makers and medium for the European transport industry managers (see Table 5, Annex). As weak signals, the following were identified:

- Low cost nuclear fusion as a source of power
- Drop in oil prices
- Tesla car
- Environmental critical events
- Solar energy application to generate hydrogen and oxygen from seawater
- Increased production and investment on shale gas extraction
- Large-scale acquisition of resources by governments under military control

## Geopolitical wild cards

The likelihood of occurrence of the geopolitical Wild Cards differs according to the experts' opinion. While the cessation of the EU-US relations seems to be, and will remain, very unlikely for the whole timeframe until 2050, the likelihood of occurrence for mass migration is increasing—at least slightly (Fig. 6). The latter became more probable after catastrophes concerning migrants in the Mediterranean Sea in 2015, which raised a political discussion about migration from Africa to Europe (which took place after our survey of 2014).

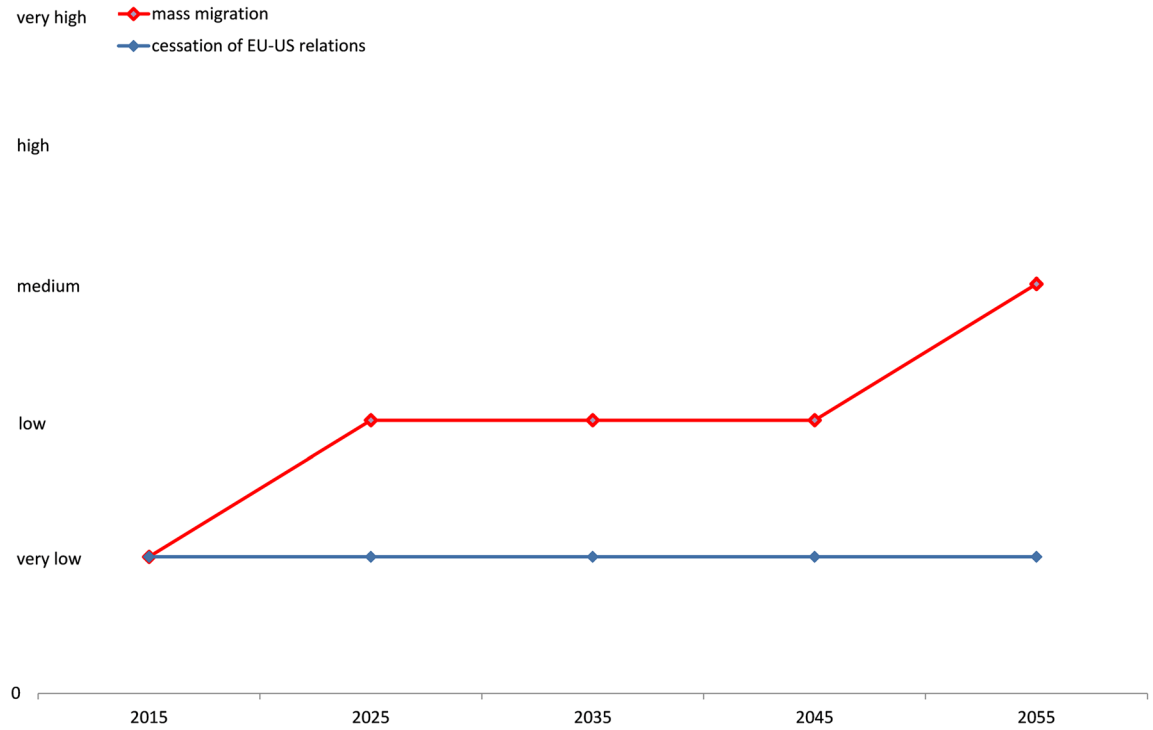


**Fig. 6** Estimated likelihood of Wild Card occurrence as a function of time

3. Total Cessation of Economic Relations between the US and the EU

"*Political tensions and conflicts lead to total cessation of economic relations between the US and the EU.*" Importance for EU decision makers was estimated as medium, for European transport industry managers low (see Table 6, Annex). Weak signals related to this Wild Card are reflect potential changes of political relations—with some signs already apparent in 2015 (again after our survey of 2014):

- Import restrictions
- Further strengthening of US relations with Asia
- Disconnection of diplomatic relations between the US and some EU countries
- NSA tapping European leaders phones and mail
- Strong rise of protectionism within US, armies withdrawing, tariffs rising
- Collapse of one economy due to devaluation
- Strengthening of relations between EU and Russia, Africa, Middle East

4. Mass Migration of People

"*Mass migration of people into Europe is caused by the effects of global climate change and/or economic pressures. Border controls collapse.*" Here there is a medium importance for EU decision makers and transport industry managers (see Table 7, Annex). Weak signals are related to climatic and environmental catastrophe, as well as to social inequality and political insecurity:

- Failure to mitigate dangerous climate change; Flooding
- Tensions within European countries
- Increasing evidence of shipwrecked boats carrying migrants
- Significant economic turmoil in Russia, China, or India
- Widespread famine due to persistent crop failures
- Growing economic inequality
- Major spread of illness

## Technological wild cards specific to transport

According to experts' opinions, the likelihood of most technological transport-related Wild Cards is expected to increase over time—especially drones, Europe-wide traffic control, autonomous cars, and superfast transport, as well as all electric cars (Fig. 7). Thus, improved, faster versions of already established technologies are expected to appear—while likelihood for more visionary technologies, such as flying cars but also material innovation, seems to be less important.

5. The Emergence of Drones

"*This Wild Card describes drones as small unmanned air vehicles, which become a major part of the supply chain, and dramatically decrease the delivery cost of light*

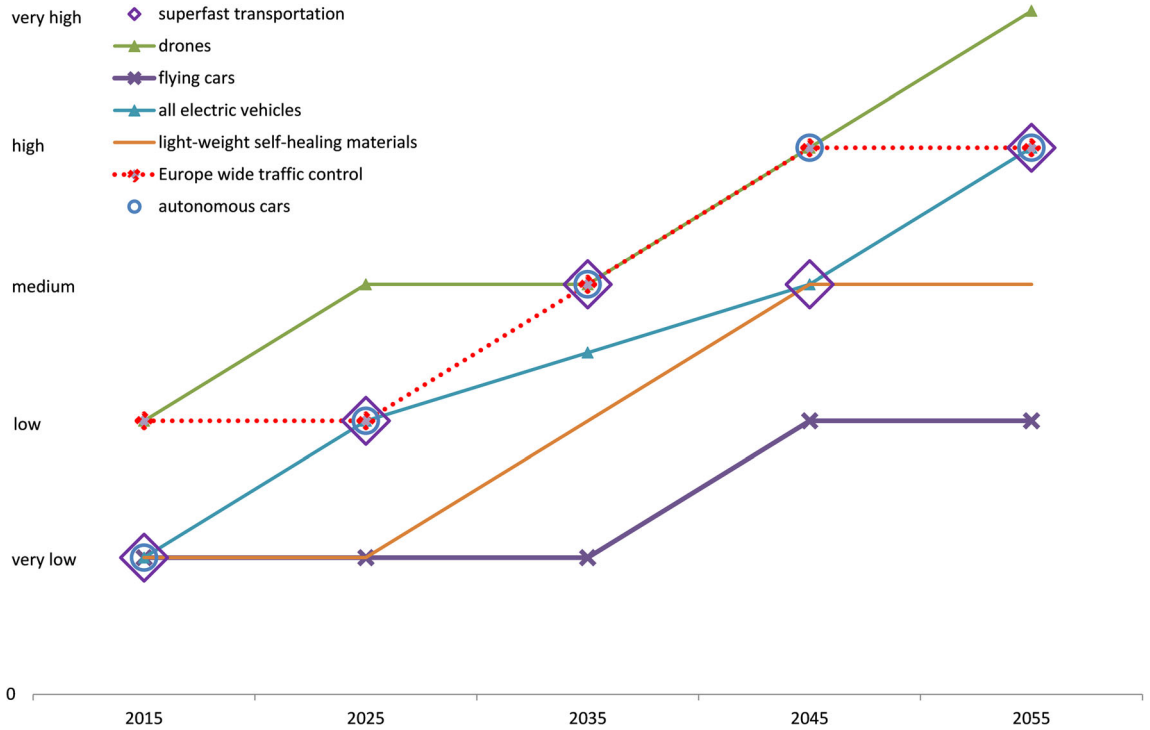


**Fig. 7** Estimated likelihood of Wild Card occurrence as a function of time

*products to relatively short distances.*" According to the expert survey, drones occurrence is of medium importance for EU decision makers and transport industry managers (see Table 8, Annex). Related to this Wild Card are the weak signals in the fields of security and regulation issues—once solved, the likelihood of occurrence should increase:

- Civil aviation authorities and ICAO agree on criteria for safe operation of drones

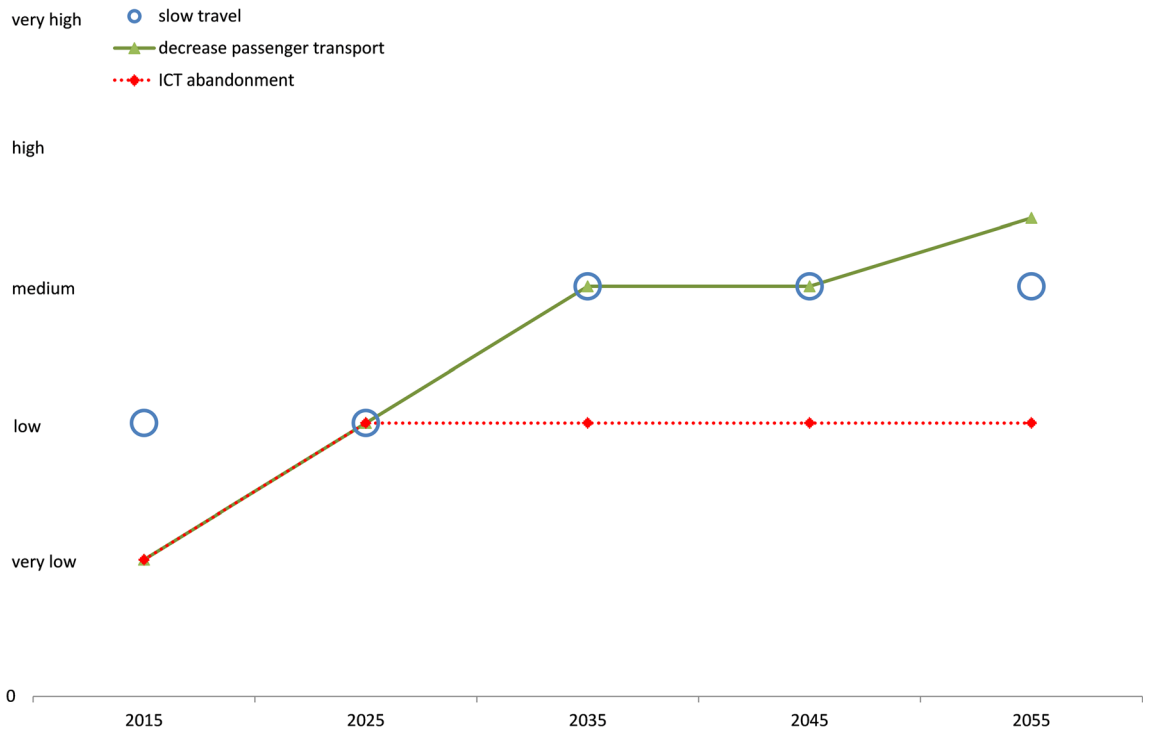


**Fig. 8** Estimated likelihood of Wild Card occurrence as a function of time

**Table 1** Threats and Opportunities related to Wild Cards

| | Threats and Opportunities | Wild Card |
|---|---|---|
| Opportunities | Harmonization of technical standards across Europe strengthens Europe as a united economy | 6. Europe-Wide Traffic-Control System |
| | Establishing safety technologies satisfies demanded accident reduction | 8. Autonomous Ground Vehicles Widely Used |
| | Policies stimulate R&D and innovation | 9. Lightweight Self-Healing Materials Revolutionize Vehicles |
| | Transport industry develops new solutions in the field of sustainable mobility | 10. All-Electric Road Transport, Based on Renewable Energy |
| | Increased urban sprawl and congestion push the proliferation of mass transit systems, which represents a new market | 11. Superfast Ground Transport |
| | The quality of the journey is in the foreground due to many interlocking solutions, which ensures the leading position of Europe due to its quality standards | 13. Massive Abandonment of ICT-based Systems |
| | No corresponding opportunity | 5. The Emergence of Drones |
| | No corresponding opportunity | 7. Flying cars, at last! |
| | The traditional border among transport sub-sectors crumbles because companies develop new initiatives beyond their core business, which is the entry into new markets | No corresponding Wild Card |
| | Europe strengthens quality and productivity of its products | No corresponding Wild Card |
| | Market adaptability supports shift to emerging markets | No corresponding Wild Card |
| Threats | Different political interests of EU member countries have an inhibitory effect on European transport industry competitiveness | 1. Drastic Decrease in Freight Transport |
| | Future developments force development of new materials, information and communication technologies, future fuels and energy | 2. Energy Abundance |
| | Growth of cities and urbanization of rural areas leads to overpopulation of cities and leads to mobility break down | 4. Mass Migration of People |
| | Congestion pricing lowers market share of transport | 12. Slow Travel / Slow Logistics |
| | Road pricing in urban areas reduces market share of vehicles in urban areas | 14. Drastic Decrease in Passenger Transport |
| | No corresponding threat | 3. Total Cessation of Economic Relations between US and the EU |
| | New perspectives and ways of business operation, post ownership-society and "mobility instead of transport" diminish markets | No corresponding Wild Card |
| | Competitors in emerging markets displace EU transport industries leading position | No corresponding Wild Card |
| | Loss of leading position if vertical and horizontal integration and creation of competitive European big players is not undertaken due to market adaption and competitiveness on the market | No corresponding Wild Card |
| | SMOG/ Air pollutants caused by transport | No corresponding Wild Card |
| | Restrictive parking regulations/ policy leads to diminution of commuting trips by car | No corresponding Wild Card |

- Use of the technology by major shipping companies or online retailers
- Solution to the security problems
- Affordability of drones
- Drone delivery systems within the United States
- Amazon's announcement of using drones for delivery of packages
- Ability of drone to operate in normal airspace

6. Europe-Wide Traffic-Control System

"*A digital communication network seamlessly integrates traffic info and creates an efficient, accident-preventing transport system in Europe, particularly in trans-boundary agglomeration areas; no more traffic jams. The system is adopted in other highly populated and car-intense regions of the world.*" The importance for decision makers in the EU and for transport industry managers was seen as very important (see Table 9, Annex). The following weak signals are related:

- Agreements on standardizations in relevant areas
- Presence of control infrastructure e.g., UK coverage of smart motorways
- Successful demonstration projects in well-controlled areas
- Establishment of more comprehensive regional control of traffic
- Penetration of V2X capability
- No significant backlash against the big-brothering of individual transport
- Traffic monitoring means on numerous roads (including rural)

**Table 2** Wild Card assessment—main (concise) results from the expert survey

| Wild Card | Impact *=Low **=Medium ***=High | | | Breadth of effect | Main Vulnerability | Importance for decision makers | Main weak signals |
|---|---|---|---|---|---|---|---|
| | Aviation | Road | Rail | | | | |
| 1. Drastic decrease in freight transport | Negative ** | Mixed ** | Negative ** | Global | All ** | ** | 3D Printers proliferation<br>Growing variety of materials used<br>Reorientation of shipping to raw materials |
| 2. Energy abundance | Positive *** | Positive *** | Positive *** | Global | All ** | *** | Low cost nuclear fusion<br>Increased shale gas production<br>Hydrogen production from seawater by solar energy |
| 3. Cessation of economic relations between the US and the EU | Negative *** | Negative ** | Negative ** | Global | Aviation ***<br>Road, Rail ** | ** | Import restrictions<br>Strong rise of protectionism within the US |
| 4. Mass migration of people | Negative ** | Negative *** | Negative *** | Regional | Road ***<br>Rail ** | ** | Growing economic inequality<br>Significant economic turmoil in China, India, Russia<br>Failure to mitigate severe climate change |
| 5. Emergence of drones | Mixed * | Positive** | Mixed * | Global | Road ** | ** | Ability to operate in normal airspace<br>Solution/regulation of security/safety issues |
| 6. Europe-wide traffic control system | Positive * | Positive *** | Positive ** | Regional | Road **<br>Rail ** | *** | Successful demonstration projects<br>Installation of traffic monitoring devices on all roads<br>Penetration of V2X capability |
| 7. Flying cars, at last! | Negative *** | Positive *** | Negative ** | Global | Aviation ***<br>Road***<br>Rail ** | * | Breakthrough in control systems technology<br>Wide use of driverless vehicles<br>Penetration of connected vehicle technologies |
| 8. Autonomous ground vehicles widely used | Mixed * | Positive *** | Mixed ** | National<br>Regional<br>Global | Road *** | *** | First "automated driving area" declared operational<br>Statistic indications that human drivers are causing significantly more accidents than driverless cars<br>Incremental improvements in autonomous capabilities in mass-produced cars |
| 9. Lightweight self-healing materials revolutionize vehicles | Positive *** | Positive *** | Positive *** | Global | All ** | * | Original Equipment Manufacturers (OEMs) buy-in<br>Military deployment of such materials |
| 10. All-electric road transport based on renewable energy | Positive * | Positive *** | Positive ** | Global | Road ** | *** | OLEV buses<br>More than 50 % of road vehicles are battery powered<br>Massive and lasting rise of oil price |
| 11. Superfast ground transport | Negative *** | Mixed *** | Positive *** | Regional | Aviation***<br>Road, Rail ** | ** | Breakthroughs in superconducting materials<br>MAGLEV and other non-contact technologies widely accepted and cost-effective |
| 12. Slow travel / Slow logistics | Negative ** | Positive *** | Positive ** | Local/<br>Regional/<br>Global | All ** | ** | Adoption by opinion leaders<br>% of commuters that use bicycles instead of private cars doubles |
| 13. Massive abandonment of ICT-based systems | Negative *** | Negative *** | Negative ** | Global | Aviation ***<br>Road***<br>Rail** | *** | Failure to address cyber-security threats.<br>Demonstrated vulnerability of vehicles to cyber-attacks.<br>Hackers being able to penetrate NSA in the US. |
| 14. Drastic decrease in passenger transport | Negative ** | Mixed ** | Negative ** | Global | All ** | ** | "Peak car" evident in certain EU countries<br>Decrease in vehicle sales<br>Ubiquitous high-speed low cost Internet connection |

7. Flying cars, at last!

"*Practical pilotless personal airplanes are developed. Coupled with computerized air traffic control, they lead to safe personal air transport systems that do not require piloting skills and are trusted and commonly used by most citizens, providing a useful alternative to today's private cars.*" Importance for EU decision makers was rated as low and for European transport industry managers low to medium (see Table 10, Annex). The following weak signals were identified in the fields of technology and safety, as well as user and market acceptance:

- Fuller penetration of connected vehicle technologies into existing ground transport fleets
- Tests and pilots will be in place for over a decade before it grows quickly
- Wide use of individual driverless surface vehicles on surface roads
- Development of very quiet airplane engines or anti-gravity technology
- Good air traffic control would have to be in place
- Policies and regulations need to be adopted
- Breakthroughs in control systems technology

8. Autonomous Ground Vehicles Widely Used

"*Following the assimilation of autonomous vehicles into public use, a new regulation in one or more countries bans the use of human-driven cars in specific areas.*" The importance for EU decision makers was estimated as medium, while for European transport industry managers very important (see Table 11, Annex). The weak signals of this Wild Card are mainly related to the prove of usefulness, new infrastructures and technologies to be developed:

- First 'automated driving area' declared operational
- Statistics indicating that humans cause significantly more crashes than automated machines
- Success of demonstration projects such as EU FP7 projects CATS and Citymobil
- Incremental autonomous improvements in mass produced autos
- Advanced driver assistance systems (e.g., lane keeping, cooperative cruise control)
- Users' acceptance
- Infrastructure prepared for vehicle autonomy (e.g., wireless beacons)
- Formulation of policies and laws for solving dilemmas concerning accidents between driverless and regular cars

9. Lightweight Self-Healing Materials Revolutionize Vehicles

"*Self-healing capabilities (possibly bio-inspired) are embedded in advanced super-strong and lightweight materials. This leads to inexpensive, maintenance-free vehicles with very low energy consumption.*" For 2015 low importance for EU decision makers and transport industry managers was assumed (see Table 12, Annex). The likelihood of occurrence is expected to increase from 2025 on with weak signals as:

- Developments in relevant advanced materials
- Military deployment of this or similar technologies.
- OEMs buy-in (cost-benefit)

10. All-Electric Road Transport, Based on Renewable Energy

"*All roads wirelessly propel vehicles, or charge their batteries, as they cruise down the road. Batteries have more energy at the end of the trip than at the beginning. The energy source is solar (solar panels embedded in the road), wind (wind turbines embedded in bridges), or other renewable sources.*" The importance for EU decision makers was medium and for European transport industry managers medium to very important (see Table 13, Annex). The related weak signals are infrastructure, cost of energy and technology issues as well as reaching a critical mass and a tipping point for market penetration:

- 50 % of road vehicles are electric
- Consensus on technology appropriate for this
- Massive and lasting increase in oil prices
- Cost of technology drops precipitously

**Table 3** Classification of Wild Cards by fullest impact and likelihood in 2040 or beyond

| Likelihood Impact | very low—low | medium | high—very high |
|---|---|---|---|
| very high | | | 5. Europe-wide traffic control<br>11. All-electric road transport |
| high | 7. Flying cars, at last!<br>3. Cessation of EU-US relations<br>13. ICT abandonment | 2. Energy abundance<br>4. Mass migration<br>9. Self-healing materials<br>12. Slow travel | 14. Drastic decrease in passenger transport<br>8. Autonomous vehicles<br>11. Superfast ground transport |
| medium | | 1. Drastic decrease in freight transport | 5. The emergence of Drones |

- More than 10 fully electric models commercialized
- OLEV buses
- Exceeding the 100,000 electric vehicles sold in Europe

11. Superfast Ground Transport

"*A superfast (more than 1000 Km/hr) revolutionary ground transport (*"*hyperloop*" *or similar) is developed and practically used.*" There was a medium importance assumed for both EU decision makers and transport industry managers (see Table 14, Annex). Weak signals are dependent on advanced prototypes of related technologies:

- MAGLEV or other non-contact technology becomes widely accepted and cost effective
- French TGV becomes world success story
- Breakthroughs in superconductors
- Implementation of maglev line between Tokyo and Osaka

In sum, the analysis shows that technological Wild Cards in transport mainly depend (besides technological development itself) on long-term, structural and regulatory frame conditions, which might block or open a window of opportunity for breakthrough of disruptive events. Especially security related regulations and market related weak signals seem to play a key role.

## Societal and behavioural wild cards

In contrast to technological Wild Cards, the likelihood of such in the field of societal change is expected to be low in 2015, with only a slightly increasing tendency (Fig. 8). Especially ICT abandonment seems to be difficult to imagine, while opposing trends to recent increasing mobility and speed at least reach a medium likelihood level in experts assessment—although only by 2035, which is almost one generation from today.

12. Slow Travel / Slow Logistics

"*The slow travel movement becomes mainstream (alongside similar movements like* "*slow food*"*), because of environmental concerns plus a counter-reaction to the stress of modern life. Moreover, consumers are willing to wait longer for delivery of goods, in order to reduce environmental costs.*" Experts stated a medium importance of this Wild Card for EU decision makers and transport industry managers (see also Table 15, Annex). Weak signals related to slow travel are especially due to changes in living and working conditions:

- Share of commuters who use bicycle instead of private car is doubled.
- Sustained exorbitant fuel prices
- Adoption by opinion leaders
- Significantly more people are working from home
- Frequent natural disasters attributed directly to climate change and human activity

13. Massive Abandonment of ICT-based Systems

"*Massive abandonment of ICT-based systems (*e.g., *Intelligent Transport Systems, Internet of Things, connected cars, autonomous vehicles…), due to frequent successful cyber-attacks and privacy intrusions.*" While importance for EU decision makers was assumed as medium, this Wild Card might be very important for European transport industry managers. Experts see a high impact of ICT-Abandonment especially on aviation and road, and medium on rail and maritime (see also Table 16, Annex); although likelihood of this Wild Card is rated as low. Weak signals related to this Wild Card are mainly risks, security issues as well as conflicts:

- Failure to address cyber security issues
- Reduced use by opinion leaders
- Breakout of a cyber-war between China and the US
- Cyber/hacking conferences that demonstrate the vulnerability of cars/planes to this type of attack
- Outages of internet become common
- Hackers penetrate the NSA in the US

14. Drastic Decrease in Passenger Transport

"*The need for physical travel drastically decreases, thanks to wide use of information and communication technologies, which include virtual reality, tele-working, tele-education, tele-medicine, virtual tourism, tele-shopping, etc.*"A medium importance of this Wild Card was assumed for EU decision makers and transport industry managers (see also Table 17, Annex). Weak signals are related to peak car and peak oil prices (?) as well as to aspects of reorganization of daily life and work:

- Repetitive travel to work or education becomes unnecessary
- Home-to-work represents less than 20 % of all travel
- Ubiquitous, high speed, low cost connections to the Internet
- Decrease in vehicle and gasoline sales
- "Peak car" evident in many countries.
- Increased % of retail sales being e-sales
- Technology advances to adjust to physical presence (TRUE experiences)

## The meaning of wild cards in transport

### Challenges and opportunities related to wild cards

In a next step, the Wild Cards were linked to opportunities and threats identified by a SWOT analysis for the competitiveness of the European transport sector. Based on statistical indicators and desk research on the situation of the European transport sector in a global comparison, SWOT aspects were deduced. The SWOT was based on indicators measuring competitiveness of the European transport sector in a global context. Trade, exports, GDP and also indicators allowing to compare energy efficiency, as a crucial factor for the transport industry, such as consumption of energy and use of renewable energy were used to identify strengths and weaknesses. Besides this the development of specific industries, e.g., production of the automotive industry, revenue in aviation or market growth of rail industry, to name only a few, were analyzed related to political frame conditions.

The identified SWOT aspects were rated in an online expert survey in order to assess results and to identify threats and opportunities reflecting the mind set and basis for strategic decisions of experts in the transport sector. Linking the results of the SWOT, as a more traditional approach for developing future scenarios, with Wild Cards allowed the identification of additional critical aspects for business strategies of both enterprises for different transport sectors and for policy.

SWOT results were linked with Wild Cards based on the key question "*Which threats/opportunities might come up with certain Wild Cards?*" Based on this, given SWOT elements were questioned and additional ones appeared. Autonomous vehicles, for example, might stimulate establishing safety technologies and thus support the development of this opportunity. On the other hand, safety demand might push distribution of autonomous cars if they ensured a higher degree of safety.

Table 1 shows the linkage of some Wild Cards to opportunities: for example the Wild Card "all-electric road transport" provides the opportunity to developing new sustainable technology solutions for mobility—thus, the establishment of electric road transport could be interpreted as realized opportunities of involved industries. Further, "superfast ground transport" as well as "Europe-wide traffic-control system" Wild Cards are rated as likely and are linked to the opportunities of mass transit systems and harmonization of technical standards in Europe. These aspects describe a field which may be worthy of further observation when searching for new business opportunities to strengthen competitiveness.

None of the Wild Cards can be linked to opportunities related to aspects of market restructuring and industries transformation. Thus, identified Wild Cards would not support the disappearance of traditional borders in the transport market, European product quality or adaptability to Asian markets. One reason might be the rather technological or political focus of Wild Cards—while economy related Wild Cards were not mentioned by the experts.

On the side of threats, only one Wild Card is linked to a threat, the one of road pricing, as it might reduce the market share of vehicles in urban areas. Again, there are no Wild Cards related to aspects of market shifts; experts seem not to consider this field equally important to technological or political aspects. Thus, Wild Cards, disruptive events or unexpected developments which might bring up certain threats due to market shifts may be overlooked—although they might be of greater relevance then unexpected events in other fields. Thus, there is a need to raise awareness of economic and market related Wild Cards. Also additional analysis in this field is recommended. Especially where identified Wild Cards can not be linked to threats and opportunities or the other way around, blind spots in the experts perspective are likely to be the reason.

### Conflicting impacts of wild cards

The character of Wild Cards results in specific uncertainties which have to be dealt with when using Wild Cards to create a future perspective. Being disruptive low-likelihood high-impact events, Wild Cards oppose or contradict established forecasts and trends that are perceived as "likely". They represent by definition conflicts that challenge current knowledge about existing trends and likely developments. Moreover, their impacts on competition can be conflicting and ambiguous—positive or negative.

Indeed, as our expert survey shows, several Wild Cards are likely to have conflicting inter-and intra-sectorial impacts if they occur: a positive impact on a certain transport sector and a negative impact on another sector, or both positive and negative (mixed) impacts on the same sector. Such conflicts, that may represent specific challenges, can be identified to derive implications from challenges for the transport sector and should thus be carefully monitored. The following examples illustrate the relevance of potential interdependencies:

- Related to Drones, the first regulations for commercial use have been developed, increasing the likelihood of implementation. The US Federal Aviation Administration (FAA) has taken first steps to develop regulations for licensing and use of commercial drones. The European Commission has recently started to regulate the operations of civil drones, aiming to allow the European industry to become a global leader in this emerging market. The EC regards drones as a key to the future competitiveness of

the European aeronautics industry (10 % of the aviation market in the next decade, according to some estimates).[4] Such a low-cost and easily available alternative for product delivery may challenge traditional means and create new opportunities, while alleviating much road transport and road congestion. Although it is certain that drones would impact all sectors, it is less clear whether they would lead to low-cost delivery and/or decreased road transport. Effects will depend on consumers' demand and on business development of related industries. The challenge for industries will be to identify market needs, opportunities and threats early on and to modify their own business models according to this.

- A Drastic Decrease in Freight Transport could be an effect of 3D-based local manufacturing (and advancements in the future Nano-molecular manufacturing)—while in return 3D-printing comes with the need of raw material transport. This Wild Card challenges well-established forecasts concerning the significant increase in goods traffic over the coming decades and will affect all transport sectors, especially road transport. 3D printing technology could pose a significant threat to the global transport industry because it may lead to a reversal of the trend of globalization which has benefited most transport sectors, as vast quantities of consumer goods are moved internationally to Western markets from the Far East. However, as is the case with all disruptive developments, it also will offer new opportunities.[5] In the foreseeable future there will still be a need for material supply. Hence, a major new sector of the logistics industry could emerge, specializing in the storage, transport and supply of the raw materials necessary to "feed" the proliferating 3D printers. In addition, looking to the more distant future, one can envision another technological breakthrough (another potential Wild Card?) that, in turn, may threaten this new sector. Enabling affordable local recycling of waste into particles useful for 3D printing might eliminate the need for materials supply. Effects will depend on the kind of materials and their sources, as well as on market acceptance of printed products.
- In case of virtualization and ICT Solutions positive and negative impacts are likely for all industries; especially road will be affected. This Wild Card might decrease the need for transport or lead to a more balanced distribution of traffic over the day, diminishing peak-hours traffic. Reduced roadway demand will have a negative impact on relevant transport providers but could be positive from the environmental and economic perspective due to less need for maintenance. Airlines may be able to focus more on high-value and high-yielding cargo. A decline in peak hour usage of roads and passenger railways would allow for a more even distribution of loads, reducing the need for further investments in capacity. On the other hand, enhanced opportunities would open up for the relevant ICT sector, with the increased demand for novel applications that provide useful substitution for physical travel. Virtual travel may become the emerging or even dominant transport industry with new business models arising. Even if significant physical travel continues, a likely synergy could emerge between ICTs that support virtual travel and the ICTs that support intelligent (physical) transport, including autonomous vehicles. To face decreased mobility demand, all transport industries would need to adapt investments, infrastructure building and demand management to remain competitive.
- The technology of Autonomous Vehicles is no longer a Wild Card. It is maturing, major vehicle in which manufacturers are making progress, and new players such as Google and Tesla may have a great impact on this. It is, however, also important to note that there are different levels of autonomy—"autonomous" is not necessarily "driverless". In our Wild Card, the vehicles are driverless and driving by humans is forbidden, at least in certain areas. The implications could include more use of public transport, and blurring the distinction between rail and road; "road trains" of autonomous vehicles might compete with railways. The effects of autonomous vehicles will depend on the way they will be used. Substituting conventional private cars might increase car use, if traffic flow could be optimized and traveling comfort could be increased for (non-) drivers. If autonomous vehicles are integrated in multi-modal transport systems they might improve seamless mobility by public transport and increased attractiveness; competitiveness of the car-industry would then rely on innovative capacity.
- Challenges and competitive pressure from Superfast Ground Transport would arise for high-speed-trains, while still providing new opportunities for the rail industry. Effects depend on political strategies, which set the agenda in infrastructure investments. Large-scale implementation requires huge investment in the currently non-existent infrastructure: this is a big barrier, but also a big opportunity. The impact on aviation could be more negative than positive, due to likely competition with significant parts of the air transport, in particular in-country, long-distance flights.

[4] European Commission calls for tough standards to regulate civil drones, Apr. 2014, http://ec.europa.eu/transport/newsletters/2014/04-11/newsletter-print_en.htm

[5] "The Implications Of 3d Printing For The Global Logistics Industry", Transport Intelligence Ltd., Aug 2012, http://johnmannersbell.com/wp-content/uploads/2013/11/The_impact_of_3D_Printing_on_Global_Supply_Chains.pdf

- The popularity of Slow Travel or logistics would lead to a shift towards rail or maritime or even active modes of mobility, while energy-intensive, fast and more costly transport modes might find themselves under pressure. These effects might be compensated if, in parallel, the trend of fast speed would continue in certain industry sectors or population groups. One of the implications could be shifting from air transport of people and freight to maritime, and a shift from road to rail—for the environmental benefits rather than "slowness". However, as pointed out by one expert, there could also be some positive impacts on aviation, because in many areas the capacity is constrained and less demand would free up capacity and reduce the need to invest in expanding capacity. Reduced trucking needs on roads may imply negative impact on the trucking providers, and positive impacts as seen from a different angle: reduced congestion and pollution, more sustainability.

### Synergies between wild cards and ongoing trends

Although Wild Cards are defined as events of low likelihood, they are linked to ongoing trends as they are based on expert opinion and thus reflect their associations for the future based on knowledge, experience and observation of cutting edge developments . Thus, in some cases Wild Cards represent extreme versions of currently known possible forecasts, e.g., a technological breakthrough that may drastically accelerate a process that is currently slow and incremental. These links allow the identification of potential synergies, which can be used to coordinate innovation support, support decision making in policy and economy, as well as to develop business and political strategies.

An EU Traffic-Control System was rated as a high likelihood and impact event by experts, could optimize the transport system and thus have a synergetic positive effect, especially for roads. Technologies such as V2I, V2I, ITS and similar already pave the way towards its realization. The participating experts in our expert survey regard it as very important for EU decision makers, as well as for European transport industry managers. However, one expert remarked that the impact on road transport could be unpredictable, as such a system would be based on assumptions about "expected behavior", and past experience shows that behavior may adapt in unexpected ways.

In the field of materials progress super-strong Materials and Self-Healing Capabilities e.g., based on Carbon Nanotubes or Graphene could support the lightweight vehicle development and also support sustainable mobility. Also, the ongoing EU project IASS is concerned with improving aircraft safety by self-healing structure and protecting nanofillers.[6] Such a development is synergistic with all the existing efforts to develop stronger, but lighter and safer, vehicles with less energy needs and less costly maintenance. Another synergy lies in the fact that self-healing materials will have a great impact not only on vehicles but also on infrastructures: bridges, roads, tunnels could become self-healing and less maintenance demanding. Positive impact in all transport sectors can be expected.

The breakthrough of Electric Vehicles is synergic with recent developments in this field. A large-scale development would be the next big step for all-electric vehicles, eliminating the barrier of charging with positive impact on road transport as well as on the environment. There are already limited demonstration projects in this direction (mainly buses) in several countries. For example, in Europe Volvo and the Swedish Transport Administration have begin to study the potential for building electric roads, and a small scale test is planned in Gothenburg during 2015[7]—but not yet using renewable energy. The ambitious US startup "Solar Roadways" is struggling to overcome technological and financial hurdles—and much skepticism and criticism—yet its future is uncertain. Related to this in the field of energy, efforts toward increasing energy-efficient transport could lead to energy abundance—likewise supporting sustainable mobility.

The Wild Card of Energy Abundance is synergic with the existing and foreseen efforts to advance more energy-efficient transport. Nevertheless, there could be unexpected implications in different sectors, including shifts of demand between different sectors. Being more flexible, road freight could better compete with rail if the energy price becomes non-issue. Similarly, air freight could better compete with maritime. On the other hand, such a development could mean more congestion and negative environmental consequences, and could halt the efforts to develop new technologies for environmentally friendly transport.

## Summary and conclusions

In the process of constructing future scenarios and strategies in transport it is important to challenge the "conventional wisdom" and to encourage the discussion on potential Wild

[6] http://www.iass-project.eu

[7] The Volvo Group studies potential to test electric roads in a city, May 2014, www.volvogroup.com/group/global/en-gb/_layouts/CWP.Internet.VolvoCom/NewsItem.aspx?News.ItemId=147298&News.Language=en-gb

Cards—low likelihood but high impact future events. To be useful for decision makers, it is necessary to assess various aspects of these Wild Cards, and to identify related weak signals, which may indicate the growing likelihood of such events. In the present study, an approach for using Wild Cards in research was developed using different methods and perspectives by combining Wild Cards with a classical SWOT analysis and ongoing trends.

Fourteen Wild Cards of various types (technological, geopolitical and societal/behavioral) were identified and assessed by experts in terms of their likelihood of occurrence in different time-frames, the impact on different industry segments (including the time by which full impact is reached), the breadth of the effect (from local to global), the vulnerability of each industry sector to the event, the importance for decision makers, and related weak signals. The main results of the Wild Card assessment are summarized in Table 2 below.

The main observations from the detailed results of the survey can be summarized as follows. All the studied Wild Cards were found to be relevant by the experts in terms of their potential impact on the transport industries, the breadth of their effect and the vulnerability of the various industry segments. Based on the median of the experts' responses, 12 Wild Cards will have "high" or "very high" impact on at least one industry segment, if they occur. For only two Wild Cards the fullest impact, on at least one industry segment, is "medium". The time by which the full impact is reached varies among the Wild Cards.

The likelihood of the Wild Cards occurring at present or in the near term (before 2020) is perceived as very low or low—corresponding to the formal definition of Wild Card. Nevertheless, the likelihood of most of the Wild Cards rises with time, and some of them reach high likelihood in 2040 or beyond, as summarized in Table 3.

Some Wild Cards, such as Superfast Ground Transport or Europe-Wide Traffic-Control System were considered as likely if harmonization of technical standards in Europe is given. For many Wild Cards ambiguous impact was stated. The occurrence and impact will depend on frame conditions. In this context some key aspects were identified: political decisions, market development and especially user reaction, behavior and acceptance. These aspects need to be further observed when searching for new business opportunities to strengthen competitiveness. From a methodological point of view, linking the identified Wild Cards with the "human factor", e.g., by field experiments or in living labs, could provide further information to fill the gap of knowledge concerning the direction of impact of certain Wild Cards.

The combination of Wild Cards assessment with results of a SWOT analysis for competitiveness of the transport sector disclosed blind spots in experts' awareness of disruptive future events. Especially economic and market events may be overlooked (including opportunities and threats coming with them) while impact and relevance of technologies is considered high. Although additional testing and assessment is necessary, the approach was useful to shed light on synergies of different impact factors relevant for the future and their interdependencies. This might help to better integrate dynamics of systemic change in a future perspective. The approach could especially support business strategies, research and business development. By integrating disruptive events described by Wild Cards and Weak Signals with future trends and SWOT elements, dynamics of the future are considered in a more systematic way and with a broader horizon.

Based on the results, a scenario development linking Wild Cards with each other and to ongoing social, economic and political trends could be a next step to develop a future perspective for transport. The occurrence of some of the Wild Cards might not only challenge our wisdom, as stated previously, but also challenge our non-wisdom in the field of mobility. Some Wild Cards lead to the conclusion that physical mobility might change towards virtual mobility, at least to a certain degree. This shift might occur without being realized by consumers—if, for example, local 3D-printing substituted freight transport leading to subsistence economy 2.0. A development of this kind would also lead to a reorientation towards the local in other fields of economic and social life. A hybrid economy and society with revived local community life and virtualized (home) work combined with global contacts, and business relations supported by new technologies could result. In this world, mobility would play a different role—with a transport system rather used for special opportunities than for daily commuting leading to a paradigm shift affecting society, markets, as well as the competitive situations for the transport industries.

## Appendix

The following tables show the results of experts opinion on impact of Wild Cards on different transport sectors, time horizon of occurrance and vulnerability of transport sectors to changes related to the Wild Cards by percentage of experts estimations.

1. Drastic Decrease in Freight Transport

**Table 4** Drastic decrease in freight transport—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 31 % | 45 % | 23 % | 27 % | 27 % |
| | Negative | 56 % | 47 % | 63 % | 63 % | 10 % |
| | Irrelevant | 14 % | 8 % | 14 % | 10 % | 63 % |
| Fullest impact on transport industries | High | | | | | |
| | Medium | x | x | x | x | |
| | Low | | | | | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest, median | Short term 1–3 years | | | | | |
| | Medium term 3–7 years | x | x | x | x | |
| | Long term 7 years + | | | | | x |
| vulnerability level of transport sectors to changes wrought by the Wild Card (median) | High | | | | | |
| | Medium | x | x | x | x | |
| | Low | | | | | |
| | Very low | | | | | x |

2. Energy Abundance

**Table 5** Energy abundance—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 94 % | 92 % | 78 % | 82 % | 81 % |
| | Negative | 2 % | 4 % | 15 % | 9 % | 19 % |
| | Irrelevant | 4 % | 4 % | 7 % | 9 % | 0 % |
| Fullest impact on transport industries | High | x | x | x | x | x |
| | Medium | | | | | |
| | Low | | | | | |
| | Very low | | | | | |
| Time to fullest impact after Wild Card manifests | Short term 1–3 years | x | x | x | | |
| | Medium term 3–7 years | | | | x | |
| | Long term 7 years + | | | | | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | x | x | x | x | x |
| | Low | | | | | |
| | Very low | | | | | |

3. Total Cessation of Economic Relations between the US and the EU

**Table 6** Cessation of EU—US Relations—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 7 % | 7 % | 7 % | 2 % | 2 % |
| | Negative | 91 % | 69 % | 64 % | 93 % | 85 % |
| | Irrelevant | 2 % | 24 % | 29 % | 5 % | 13 % |
| Fullest impact on transport industries, median | High | x | | | x | x |
| | Medium | | x | x | | |
| | Low | | | | | |
| | Very low | | | | | |
| Time to fullest impact after Wild Card manifests | Immediate | x | | | x | |
| | Short term 1–3 years | | x | x | | x |
| vulnerability to changes wrought by the Wild Card | High | x | | | x | x |
| | Medium | | x | x | | |
| | Low | | | | | |
| | Very low | | | | | |

4. Mass Migration of People

**Table 7** Mass migration—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 9 % | 9 % | 19 % | 12 % | 7 % |
| | Negative | 68 % | 82 % | 74 % | 59 % | 26 % |
| | Irrelevant | 23 % | 9 % | 7 % | 29 % | 67 % |
| Fullest impact on transport industries | High | | x | x | | |
| | Medium | x | | | x | |
| | Low | | | | | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | x | x | x | | |
| | Medium term 3–7 years | | | | x | |
| | Long term 7 years + | | | | | x |
| vulnerability to changes wrought by the Wild Card | High | | x | | | |
| | Medium | x | | x | | |
| | Low | | | | x | |
| | Very low | | | | | x |

## 5. The Emergence of Drones

**Table 8** Drones—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 35 % | 58 % | 29 % | 25 % | 14 % |
| | Negative | 33 % | 36 % | 35 % | 16 % | 8 % |
| | Irrelevant | 32 % | 6 % | 36 % | 59 % | 78 % |
| Fullest impact on transport industries | High | | | | | |
| | Medium | | x | | | |
| | Low | | | x | x | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | x | x | | | |
| | Medium term 3–7 years | | | x | | |
| | Long term 7 years + | | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | | x | | | |
| | Low | x | | x | x | |
| | Very low | | | | | x |

## 6. Europe-Wide Traffic-Control System

**Table 9** Europe wide traffic control—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 49 % | 97 % | 67 % | 44 % | 20 % |
| | Negative | 10 % | 3 % | 15 % | 56 % | 80 % |
| | Irrelevant | 41 % | 0 % | 18 % | 0 % | 0 % |
| Fullest impact on transport industries, median | Very high | | x | | | |
| | Medium | | | x | | |
| | Low | x | | | x | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest, median | Short term 1–3 years | | x | x | | |
| | Medium term 3–7 years | | | | | |
| | Long term 7 years + | x | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | | x | x | | |
| | Low | x | | | x | |
| | Very low | | | | | x |

7. Flying cars, at last!

**Table 10** Flying Cars—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 20 % | 60 % | 16 % | 7 % | 19 % |
| | Negative | 66 % | 33 % | 42 % | 19 % | 14 % |
| | Irrelevant | 14 % | 7 % | 42 % | 74 % | 67 % |
| Fullest impact on transport industries, median | High | x | x | | | |
| | Medium | | | x | | |
| | Low | | | | | |
| | Very low | | | | x | x |
| Time to fullest impact after Wild Card manifest, median | Short term 1–3 years | x | | | | |
| | Medium term 3–7 years | | x | x | | |
| | Long term 7 years + | | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | x | x | | | |
| | Medium | | | | | |
| | Low | | | x | | |
| | Very low | | | | x | x |

8. Autonomous Ground Vehicles Widely Used

**Table 11** Autonomous Cars—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 19 % | 66 % | 33 % | 12 % | 4 % |
| | Negative | 14 % | 30 % | 26 % | 2 % | 4 % |
| | Irrelevant | 67 % | 4 % | 41 % | 86 % | 92 % |
| Fullest impact on transport industries, median | High | | x | | | |
| | Medium | | | x | | |
| | Low | x | | | | |
| | Very low | | | | x | x |
| Time to fullest impact after Wild Card manifest, median | Short term 1–3 years | | x | | | |
| | Medium term 3–7 years | | | x | | |
| | Long term 7 years + | x | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | | x | | | |
| | Medium | | | | | |
| | Low | x | | x | | |
| | Very low | | | | x | x |

## 9. Lightweight Self-Healing Materials Revolutionize Vehicles

**Table 12** Lightweight self-healing materials—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 90 % | 90 % | 79 % | 76 % | 81 % |
| | Negative | 10 % | 7 % | 9 % | 2 % | 2 % |
| | Irrelevant | 0 % | 3 % | 12 % | 22 % | 17 % |
| Fullest impact on transport industries | High | x | x | x | | x |
| | Medium | | | | x | |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | | | | | |
| | Medium term 3–7 years | x | x | x | x | |
| | Long term 7 years + | | | | | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | x | x | x | x | x |
| | Low | | | | | |
| | Very low | | | | | |

## 10. All-Electric Road Transport, Based on Renewable Energy

**Table 13** All electric—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 27 % | 94 % | 47 % | 20 % | 11 % |
| | Negative | 18 % | 6 % | 24 % | 7 % | 2 % |
| | Irrelevant | 55 % | 0 % | 29 % | 73 % | 87 % |
| Fullest impact on transport industries | Very High | | x | | | |
| | Medium | | | x | | |
| | Low | x | | | x | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | | x | | | |
| | Medium term 3–7 years | | | x | | |
| | Long term 7 years + | x | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | | x | | | |
| | Low | x | | x | | |
| | Very low | | | | x | x |

## 11. Superfast Ground Transport

**Table 14** Superfast transport—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 13 % | 50 % | 78 % | 20 % | 4 % |
| | Negative | 80 % | 43 % | 18 % | 17 % | 0 % |
| | Irrelevant | 7 % | 7 % | 4 % | 63 % | 96 % |
| Fullest impact on transport industries | High | x | x | x | | |
| | Medium | | | | | |
| | Low | | | | x | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | x | x | x | | |
| | Medium term 3–7 years | | | | | |
| | Long term 7 years + | | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | x | | | | |
| | Medium | | x | x | | |
| | Low | | | | x | |
| | Very low | | | | | x |

## 12. Slow Travel / Slow Logistics

**Table 15** Slow travel—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 12 % | 55 % | 61 % | 39 % | 6 % |
| | Negative | 57 % | 37 % | 19 % | 18 % | 16 % |
| | Irrelevant | 31 % | 8 % | 20 % | 43 % | 78 % |
| Fullest impact on transport industries | High | | x | | | |
| | Medium | x | | x | | |
| | Low | | | | x | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | | | | | |
| | Medium term 3–7 years | x | x | x | | |
| | Long term 7 years + | | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | x | x | x | | |
| | Low | | | | x | |
| | Very low | | | | | x |

## 13. Massive Abandonment of ICT-based Systems

**Table 16** ICT Abandonment—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 2 % | 7 % | 7 % | 5 % | 2 % |
| | Negative | 86 % | 86 % | 83 % | 81 % | 71 % |
| | Irrelevant | 12 % | 7 % | 10 % | 14 % | 27 % |
| Fullest impact on transport industries | High | X | x | | | |
| | Medium | | | x | x | |
| | Low | | | | | x |
| | Very low | | | | | |
| Time to fullest impact after Wild Card manifest | Immediate | x | x | | | |
| | Short term 1–3 years | | | X | X | X |
| vulnerability to changes wrought by the Wild Card | High | x | x | | | |
| | Medium | | | x | x | x |
| | Low | | | | | |
| | Very low | | | | | |

## 14. Drastic Decrease in Passenger Transport

**Table 17** Drastic decrease in passenger transport—influence on transport sectors

| | | Aviation | Road | Rail | Maritime | Space |
|---|---|---|---|---|---|---|
| Impact (% of responses) | Positive | 25 % | 49 % | 31 % | 20 % | 15 % |
| | Negative | 57 % | 38 % | 50 % | 28 % | 4 % |
| | Irrelevant | 18 % | 23 % | 19 % | 52 % | 81 % |
| Fullest impact on transport industries | High | | x | | | |
| | Medium | x | | x | | |
| | Low | | | | x | |
| | Very low | | | | | x |
| Time to fullest impact after Wild Card manifest | Short term 1–3 years | | | | | |
| | Medium term 3–7 years | x | x | x | | |
| | Long term 7 years + | | | | x | x |
| vulnerability to changes wrought by the Wild Card | High | | | | | |
| | Medium | x | x | x | | |
| | Low | | | | x | |
| | Very low | | | | | x |

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