Hype Cycle for Transportation and Smart Mobility, 2021

Published 12 July 2021 - ID G00747417 - 99 min read

By Analyst(s): Pedro Pacheco, Venecia Liu, Ivar Berntz

Initiatives: Manufacturing Digital Transformation and Innovation; Manufacturing IT Optimization and Modernization

COVID-19 has strengthened the transportation sector's appetite for digital transformation, where low ridership has been a trigger for change. IT leaders can use this Hype Cycle to build a more robust and comprehensive digital vision and strategy for their organizations.

Additional Perspectives

- Summary Translation + Localization: Hype Cycle for Transportation and Smart Mobility, 2021
(23 August 2021)

Analysis

What You Need to Know

This Hype Cycle provides a tool for long-term technology planning in the areas of smart mobility and passenger transportation. This research provides CIOs, CTOs and digital leaders of transportation and smart mobility companies, transit agencies and governments guidance on the best technology to include in their postpandemic strategy for transportation of people.

The 2021 Hype Cycle for Transportation and Smart Mobility has shifted significantly by focusing more heavily on transportation of people. It outlines the concepts, technologies and business models related to moving people from A to B. This greater focus has enabled more in-depth insights into all main areas of people mobility:

- Urban smart mobility, like ride hailing or mobility as a service (MaaS)
- Mass transit technologies
- Maritime transportation technology
- Aviation
- Commercial space travel

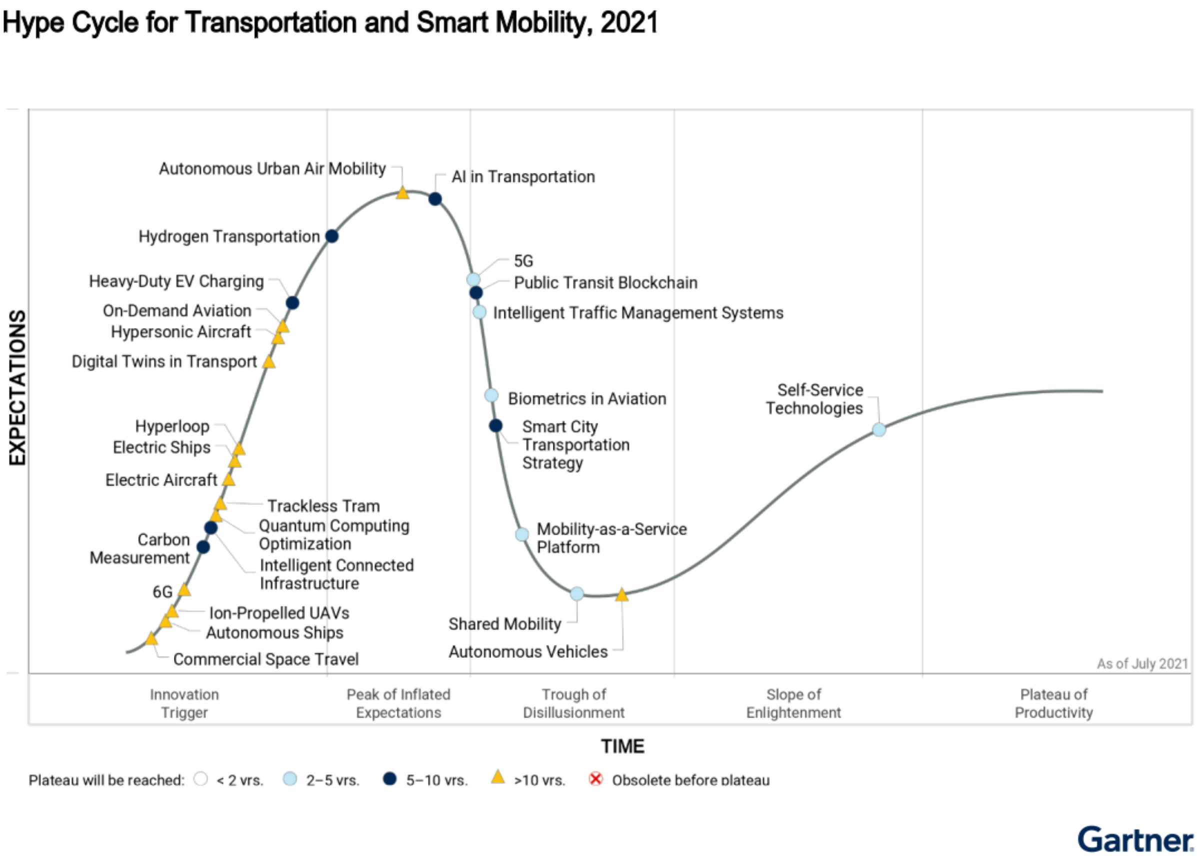
The Hype Cycle

The focus on people transportation has allowed this Hype Cycle to build greater granularity on what are today's main trends shaping how people will travel in the future:

- **New mobility models.** MaaS and shared mobility will emerge from the pandemic strengthened, as the need to recover mass transit ridership and a change in needs created by new work models (remote or hybrid work) open ways for more flexible and adaptable mobility.
- **Carbon neutrality.** Growing concern for greenhouse gases is pushing the adoption of carbon-neutral transportation. Besides the growing penetration of electric and fuel cell road vehicles, the electrification trend shows positive signs in ships. The aviation sector is also developing electrific and hydrogen propulsion, but these technologies won't produce a noticeable impact before the end of the decade.

- **Autonomy.** Autonomous road shuttles are slowly starting to get past the hype, as countries like Germany publish regulation enabling their general adoption. Leveraging the advances made in this area, autonomy starts making its way into ships, where it will deliver main benefits in terms of safety.
- **Operational optimization.** The 2021 Gartner CIO Survey already indicated that the pandemic has opened the appetite of transportation companies for greater technology investment. Technologies aimed at operational improvement (like AI and digital twins) and better experience (like 5G, blockchain and biometrics) will see future growth.
- **Faster and farther.** The need for transporting more people across large distances is pushing several companies to invest in leading technologies that could bear fruit into the next decade. As hyperloop intends to do so on the ground, several projects intend to make commercial hypersonic flight a reality in some years. Finally, companies like Blue Origin, SpaceX and Virgin are inching closer to make commercial space travel a reality, even that just for a super affluent population.

Figure 1: Hype Cycle for Transportation and Smart Mobility, 2021



Source: Gartner

Downloadable graphic: Hype Cycle for Transportation and Smart Mobility, 2021

The Priority Matrix

CIOs need to prepare for the transformational impact of innovations critical to their organization that are two to five years away from reaching mainstream adoption, specifically:

- **MaaS platform —** It has the benefit of allowing a seamless coordination between mass transit and shared mobility, with the purpose of enabling a full door-to-door mobility solution for travelers. Companies in the area of transportation must take steps to form or integrate a MaaS platform and expand its customer relevance, either by quality of service or coverage.
- **Shared mobility —** This model adds greater flexibility to urban transport ecosystems by allowing the sharing of vehicles — be it cars, shuttles or even e-scooters. The pandemic will impact the routine of a large number of people, who will permanently work from home or on a hybrid model. Shared mobility will play a role in enabling a solution of greater flexibility to these commuters. As such, transportation organizations must take action to incorporate shared mobility as part of their offer.
- **5G —** The rollout of its infrastructure is proceeding at a fast pace, already reaching 20% of the world's networks. In the coming two to five years, we expect it can produce a visible impact in transportation, namely by enabling a more robust collection of greater amounts of data and by offering travelers a better infotainment experience.

Table 1: Priority Matrix for Transportation and Smart Mobility, 2021

(Enlarged table in Appendix)

Benefit ↓	*Years to Mainstream Adoption* *Less Than 2 Years* ↓	*2 - 5 Years* ↓	*5 - 10 Years* ↓	*More Than 10 Years* ↓
Transformational			AI in Transportation	6G Autonomous Ships Autonomous Vehicles Commercial Space Travel Hyperloop Hypersonic Aircraft
High		5G Mobility-as-a-Service Platform Self-Service Technologies	Carbon Measurement Heavy-Duty EV Charging Hydrogen Transportation Intelligent Connected Infrastructure Smart City Transportation Strategy	Electric Aircraft Electric Ships Quantum Computing Optimization
Moderate		Biometrics in Aviation Intelligent Traffic Management Systems Shared Mobility	Public Transit Blockchain	Autonomous Urban Air Mobility Digital Twins in Transport Ion-Propelled UAVs On-Demand Aviation Trackless Tram
Low				

Source: Gartner

On the Rise

Commercial Space Travel

Analysis By: Mike Ramsey

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Commercial initiatives aimed at the transport of people into space outside of government-orchestrated research or military flights.

Why This Is Important

Citizen space travel represents a new market for advances in rocket technology and efforts by several private rocket companies to build new space-capable ships. There have been a handful of wealthy citizen space travelers, but it remains almost entirely the province of governments because of the cost and safety concerns. This will change in the next decade and create the potential for citizen space travel and exploration.

Business Impact

The near-term impact of citizen space travel is limited, but the long-term impact is vast. SpaceX provides commercial services to NASA to deliver astronauts to the International Space Station and soon to the moon. Establishing a multi-planet society, or even the ability for citizens to visit space, could create an entirely new transportation segment, massive investments in new technology, tourism and private research.

Drivers

- Regulatory approval for lightly trained, or untrained passengers to travel on spacecraft will be critical in expanding space travel beyond astronauts when in place.
- The lure of an extremely exclusive type of travel could incentivize wealthy people to pay for the experience, not unlike attempting to scale Mt. Everest.
- Reducing the operational cost of reusable rocket technology and multi-passenger space crafts, as well as expanding the number of offerings in the market will be vital to the growth of space travel.

- Proof of success in the early visits to space by citizen astronauts will be critical in allowing more.
- Access to video of astronauts in the international space station has increased consumer interest in space travel, and the opportunity to experience weightlessness.
- Government contacts for astronaut transportation (notably NASA) has provided funding for early design and development.

Obstacles

- There are very few options for traveling to space today and those rockets are primarily used to transport astronauts to and from the International Space Station.
- It costs around $10,000 per pound to launch anything into space, and human cargo is even more difficult because of safety concerns.
- Getting safety and regulatory approval for new space-faring technology is challenging and takes a long time.
- Space travel is still inherently dangerous and has required special training of nearly every crew member because of the inability to send aid in case something goes wrong. Building a high level of safety for ordinary citizens will take several years.

User Recommendations

- Aerospace companies and hospitality companies must include space tourism on their long-term technology radar as a business opportunity.
- Determine whether your company can provide products or services that support the nascent space transport business.
- Look at technology being developed to support space travel and see whether there are earth-bound applications that could leverage the advances.

Sample Vendors

Blue Origin; SpaceX; Virgin Galactic

Autonomous Ships

Analysis By: Jonathan Davenport

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Autonomous ships — including container ships, harbor tugs, ferries or any vessel — operate via an AI algorithm that perceives the ship's environment by fusing together data from onboard sensors (e.g., video, lidar, radar, thermal imaging, sonar and ultrasonic sensors). The output from these sensors is classified and used in combination with global navigation satellite system (GNSS) localization and destination data points by the virtual captain to make piloting decisions.

Why This Is Important

Putting a virtual captain onboard a vessel can either complement human crew members or replace them entirely, which has the potential to increase operational safety and reduce vessel costs. Though the shipping industry has lagged others in its adoption of this technology, it is now — often with financial support from governments — beginning to make investments in proofs of concepts and trials.

Business Impact

- The majority of maritime accidents involve collisions or groundings. Automation can improve safety and reduce costs through labor reduction and operational efficiency improvements.
- Lighter vessels can be designed because crew living space and associated welfare systems are not required. These new vessel designs will result in a reduction in operating costs — primarily fuel — and greenhouse gas emissions.

Drivers

- Autonomous ships will lead to fewer accidents. The European Maritime Safety Agency found that “over the period 2011-2015, half of marine casualties occurred as a result of a navigational nature ... Human erroneous action represented 63% of accidental events.”
- For new vessels, capital costs can be reduced when a vessel is designed without the need to support the human workforce, eliminating the need for walkways, human-machine interfaces (HMIs), and heating and cooling systems.
- Competitive pressures are also encouraging companies to explore autonomous vessels. High-profile investments have been made by companies such as IBM for its Mayflower vessel and Ocean Infinity for 17 autonomous vessels that it plans to launch as part of its Armada fleet.
- Governments are investing in these vessels. For example, Norway provided over half of the investment needed for Yara to develop its autonomous electric Yara Birkeland vessel to help replace diesel trucks with cleaner alternatives.
- Autonomous shipping testbeds are being developed. Zhuhai, a city in China’s Guangdong province, has started the construction of a 300-square-mile testbed, while the Norwegian Maritime Authority and the Norwegian Coastal Administration have designated an area for autonomous trials.
- The UN’s International Maritime Organization’s (IMO) Maritime Safety Committee (MSC) is working on regulations for autonomous vessels. Current trials in international waters leverage the interim Maritime Autonomous Surface Ships (MASS) guidelines that were published in June 2019 and allow vessels to bypass current international shipping law, which states that ocean-going vessels must be properly crewed.
- XPRIZE is staging a competition to promote innovation in autonomous underwater vessels, which could drive advancements in the same way that the DARPA Grand Challenge did for autonomous land vehicles.

Obstacles

- Challenges relate to the virtual captain's ability to handle storms, lost loads, comms/sensor damage, harm to wildlife and piracy threats.
- Removing experienced crew from ships could mean that when accidents do occur (particularly involving fires), they might be more severe without a crew to intervene.
- To overcome risks related to maintaining uncrewed vessels, ship operators might also start to demand higher levels of reliability from their equipment suppliers, to ensure continued vessel operation.
- Autonomous ships face social-acceptance barriers related to "stealing" jobs.

User Recommendations

- Create a strategic vision for business transformation by designing automated processes to complete operational tasks. Don't factor in human requirements at the start — this will constrain your thinking. Think about what you want to achieve, rather than how you can achieve it.
- Analyze how autonomous vessels might be maintained. Modularity will become a key requirement, enabled by a "plug-and-play" approach, so faulty equipment can be removed and quickly replaced in port. Likewise, over-the-air updates to software and firmware will be vital. Electric propulsion technology might also have a role to play for certain use cases.
- Implement best practices by leveraging lessons from other industries that have more mature implementations of other forms of autonomous things.
- Prepare to redeploy staff to higher-value jobs by actively communicating with individuals and trade unions, while putting in place specific training and support packages centered around shore-based tasks.

Sample Vendors

IBM; Massterly; Ocean Infinity; Yara

Gartner Recommended Reading

Lessons From Mining: 4 Autonomous Thing Benefit Zones for Manufacturers

Ion-Propelled UAVs

Analysis By: Jonathan Davenport, Pedro Pacheco

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Ion propulsion is a technique for creating thrust. It works without any moving parts and harnesses the power of “ionic wind.” When high voltage is applied, nitrogen and oxygen molecules in the air are ionized, and these positively charged molecules are drawn toward a negatively charged electrode, banging into other air molecules to create an ionic wind. Ion engines have been used in spacecraft and satellites, but required a dedicated supply of nitrogen and oxygen to operate in space.

Why This Is Important

Ion propulsion has the potential to transform flight. Unmanned aerial vehicles (UAVs) will become airborne without the need for moving parts, such as propellers or turbine blades. As a result, flight will be almost silent (a major benefit in urban areas) and will overcome possible entanglement issues, which impact current UAV safety.

Business Impact

UAV noise pollution is a real issue. NASA conducted a psychoacoustic test that found that the noise-related annoyance levels of traditional UAVs were higher compared with noise from road vehicle drive-bys in residential neighborhoods. These findings cast doubt on whether UAVs could be used in residential areas, which could impact the planned rollout of solutions such as Alphabet’s Wing or Amazon Prime Air. Near-silent ion-propelled UAVs could be the solution to this problem.

Drivers

- The high noise levels generated by propeller-operated drones and vertical takeoff and landing (VTOL) vehicles are prompting vehicle designers to look for solutions, particularly in urban applications. The acoustic footprint of traditional UAVs has been fairly high, in the region of 60 dB to 90 dB, whereas ion-propelled UAVs could significantly reduce the noise, making them well-suited to carrying out activities in residential areas.
- Even if not yet considered as a major issue, propeller-based drones could impact wildlife when these become widespread, which would prompt a strong intervention from environmentalists. Ion propulsion may be seen as a way to mitigate this potential problem.
- The amount of thrust generated by ion propulsion has been a long-standing problem, and given these vehicles require electric power, this entails the usage of batteries. However, the big investments being made in the area of electric vehicles are enabling breakthroughs in terms of battery energy density. A lighter battery means less thrust needed from ion propulsion to achieve sustained flight.

Obstacles

- Traditionally, ion thrusters worked only in a vacuum — for example, to orient satellites. Earth's gravity means that much larger amounts of thrust are required to lift an object. Ion thrusters have typically provided only 0.5 newtons of thrust, meaning each can support approximately 2.25 pounds of weight.
- Battery energy density (kWh/kg) is still a major obstacle to the performance of ion propulsion. Each ion-propelled prototype created so far has been extremely lightweight. Due to their tiny batteries, they're suitable only for short, cargoless flights.
- Moreover, eVTOL autonomous flying vehicles for people transportation will need a transformative technology breakthrough.
- The range of ion-propelled UAVs will be limited when the weight of sensors and cargo is incorporated.
- Navigation will be challenging in all but the calmest of wind conditions due to the UAV's lightweight design.
- Ion thrusters produce ozone, which in high concentrations can be harmful to the health of people.

User Recommendations

Companies that plan to utilize ion propulsion UAVs:

- Follow developments in academic research, such as those being undertaken by MIT and University of California, Berkeley, to see how the nascent technology matures.
- Follow the progress of early-stage companies like Undefined Technologies. Assess whether M&A investment or purchasing this technology is most appropriate at this stage, or this technology can be replicated in-house.
- Track the most recent developments in battery technology, as energy density will be a crucial factor for ion propulsion's success.
- Choose the most suitable use cases to allow for technology adoption growth. UAVs operating in urban environments are the most obvious choice. However, as technology evolves, this may open opportunities in eVTOLs and use cases entailing flights over nature reserves. Military and security services may also take advantage of the ultra light and quiet nature of ion-propelled UAVs for surveillance.

Sample Vendors

Undefined Technologies

6G

Analysis By: Kosei Takiishi

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

6G is the generic name for the next-generation cellular wireless that is expected to be next in line after 5G. In 2021, the features and timetable for 6G are not clearly defined although it's expected to be commercialized in 2028 by some CSP pioneers. 6G will enhance recent 5G capabilities and will be able to provide higher peak data rate (e.g., 100 Gbps to 1 Tbps), lower latency (e.g., 0.1 msec latency), much more connection density and energy efficiency (e.g., 10 times more efficient).

Why This Is Important

The 2030 agenda including 17 sustainable development goals by the United Nations are heavily impacted by the mobile. Many of these social issues and ambitious goals will result in technologies that become part of 5G or future 6G cellular deployments. Design and research for 6G has already begun with many industrial associations, academic and commercial organizations. 5G can solve some of these challenges, but 6G is indispensable for continuous growth and problem solving in the 2030s.

Business Impact

Although there is no clear 6G definition and the telecom industry is just trying to add one generation every 10 years (same as before), many technologies and concepts from 6G research will find their way into other wireless systems (cellular and otherwise) over the next decade. 5G networks will also be modernized and democratized to become software-based networks based on client demands, and 6G will benefit from it.

Drivers

- Different from 4G and current 5G, 6G will become a sort of national network supported or impacted by countries and national policies. Some leading countries have started their initiatives: In August 2020, Korean government announced that the country plans to launch a pilot project for 6G in 2026. In October 2020, the Alliance for Telecommunications Industry Solutions (ATIS) in the U.S. launched the Next G Alliance to advance North American Leadership in 6G. In November 2020, Korean Ministry of Science and ICT hosted the first 6G Global 2020 in Seoul. In April 2021, the U.S. and Japan agreed to jointly invest $4.5 billion for the development of next-generation communication known as 6G.

- Competition for 6G leadership by local organizations has already started and this could further accelerate 6G standardization and commercialization. These major activities are: In July 2020, NTT DOCOMO hosted 5G Evolution and 6G summit and also renewed the 6G white paper published in January 2020. In November 2020, FuTURE Forum in China published 11 white papers for 6G. In May 2021, 6G Symposium Europe was held as a virtual event.

- Many commercial organizations have started their 6G research to be a part of the future 6G patent pool.

Obstacles

- The 5G journey has just started and its best practices and monetization are not clear. Success or failure of 5G will have a major impact on 6G commercialization and business.
- The telecommunications industry has formulated their own specifications and standardization (such as 2G, 3G, 4G and 5G) by themselves. It is unclear whether 6G will be able to incorporate external opinions more.
- Some 6G technologies such as THz wireless may not prove relevant or cost-effective for most cellular user's needs.

User Recommendations

CSP CIOs should:

- Check the current emerging 6G discussion carefully.
- Avoid deploying 6G commercially till late 2020s. However, there could be deliverables of the 6G research projects that emerge in other wireless areas before 6G. For example, THz wireless systems could well emerge before 2030.
- Support your regulators and government to create their new national policy by 5G evolution and 6G.

There is no action required for IT leaders as 6G commercial offerings are not available in the market.

Sample Vendors

Ericsson; Huawei; Nokia; NTT DOCOMO; SK Telecom

Gartner Recommended Reading

Predicts 2021: CSP Technology and Operations Strategy

Carbon Measurement

Analysis By: Pedro Pacheco

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

A digital solution that is used to measure with greater accuracy the carbon footprint generated in the transport of people or goods from A to B.

Why This Is Important

The Paris Agreement prompts the reduction of GHG (greenhouse gas) emissions. As such, determining the carbon footprint of each journey will be key for mobility providers and governments. Travelers are becoming increasingly conscious of their carbon footprint to go from A to B. As such, a digital carbon footprint measurement platform provides the visibility that allows these stakeholders to make informed decisions.

Business Impact

The ability to measure carbon footprint per journey will be of great value in countries prioritizing GHG reduction. More accurate and granular direct carbon measurement, along with other parameters of vehicle usage, allows transportation companies to more effectively determine where and how to reduce their carbon footprints. Finally, travelers would be able to choose their door-to-door itinerary according to its carbon footprint, which allows users to make more informed decisions at this level.

Drivers

- The existence of particular regulations in terms of CO_2 emissions taxation or reduction of tailpipe emissions puts pressure on transportation companies to reduce their CO_2 emissions.
- There is a growing wave of activist investors for whom carbon footprint is a key factor, to the point that even Blackrock has named sustainability a cornerstone of its investment strategy. This puts pressure on companies to reduce their carbon footprint as much as possible.
- The CEO Alliance — an association of CEOs from major European companies focused on supporting the EU's Green Deal plan — has defined digital carbon footprint measurement as one of the eight strategic initiatives it will be developing. As such, this will raise the importance of this topic across the European corporate world.
- The drive on transportation companies to reduce costs of fuel (or electricity) used by vehicles indirectly supports digital carbon measurement. Such tools allow these companies to not only understand their main sources of carbon footprint, but also to develop insights on how to reduce those by looking at how vehicles are operated. For instance, a bus company can train its drivers to reduce fuel consumption when that is deemed an area for improvement.
- A growing new generation of consumers and travelers, focused on sustainability, want more information on the carbon footprint in relation to the products and services they consume. Although this type of visibility is still not generalized, it opens opportunities for the growth of digital carbon footprint measurement.

Obstacles

- The lack of strong legislation supporting CO_2 reduction in several countries means the business need for digital carbon footprint measurement will be small.
- Data availability is often a limitation. The lack of a highly connected transportation ecosystem means that carbon footprint measurement will have to be done indirectly by comparing to similar use cases that have been previously measured. For instance, this is like calculating the CO_2 emissions of a bus by the distance traveled and not by its actual tailpipe emissions. Indirect determination may lead to lower precision, something that counters the purpose of the solution.
- There is a lack of uniform regulation or standards applicable to such solutions. Consequently, the acceptance of the carbon footprint measurement produced by each solution may not be consensual across all governments and organizations.

User Recommendations

- Build governance that leads to a connected open data ecosystem for transportation. This will, ultimately, lead to an easier implementation of carbon footprint measurement solutions. For instance, Germany's Mobility Data Space initiative intends to create a platform for data-driven business models across the transportation ecosystem.
- Lead the effort to define standardization of digital carbon footprint measurement solutions to allow a sound "apples to apples" comparison.
- Invest in solutions that increase the level of vehicle connectivity and data gathering. This will be an improvement in operational efficiency, as it will allow the implementation of direct digital carbon footprint measurement.
- Partner with providers of digital carbon footprint measurement solutions, as they will enable a progressive optimization of the organizations' carbon footprints.

Gartner Recommended Reading

Maverick* Research: Climate Change Needs a Digital Drug Against Delusion

Apply Digital Business to Sustainability

Intelligent Connected Infrastructure

Analysis By: Venecia Liu, Ivar Berntz

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition:

Intelligent connected infrastructure (ICI) is an integrated mesh of technologies to enable the transportation infrastructure to exchange data with surrounding entities, such as vehicles, technicians and equipment. The mesh is made up of elements such as AI, IoT, cloud, analytics, edge computing, telecommunications and autonomous technologies. The transportation infrastructure can include ports, bridges, roads, airports and airways, and highways.

Why This Is Important

CIOs can use ICI as a technology vision roadmap for how technologies can be used in combination to further improve business operations and impact the business. ICI also provides a mechanism for how data assets can be linked to other data assets.

ICI could help achieve better safety, less congestion, shorter wait times and better asset utilization.

Business Impact

Benefits of ICI can improve traffic flows, safety, infrastructure maintenance and notification of asset conditions to avoid hazardous conditions, accidents and roadblocks. Smart ports would benefit from ICI in optimizing operations and improving terminal management by communicating with cranes, rails, port authorities and trucks. Smart airports would benefit from an increased capacity enabled through better orchestration and coordination of members in the airport ecosystem.

Drivers

- Stand-alone technologies such as IoT or AI have provided some benefit to the transportation industry. However, a force multiplier can be achieved when technologies come together to communicate and exchange data to provide combined insights and to empower decision making to execution.
- ICI combines diverse data sources to provide a more holistic view. ICI can also improve asset utilization.
- Asset-intensive industries have been using sensors to track assets and predict maintenance failures. With ICI, they can further impact the business by taking the data and communicating it to other business operations, sharing it with external partners or leveraging the insight to communicate relevant information to passengers.
- Transportation CIOs are pressured to do more with less, and the advantages of ICI inspire methods for how asset data can be further applied to other business scenarios to become data-driven.

Example ICI use cases include:

- Notifying drivers about different road conditions (such as ice or obstacles)
- Monitoring vehicles going into, or currently inside, tunnels, parking lots, facilities, and restricted-access areas and roads to organize assistance or evacuation in case of fire or accidents
- Orchestrating cargo prioritization at the port yard for rail and trucks
- Pulling in diverse data points from ground operations to air traffic control and airlines to decrease airplane gate turnaround time

Obstacles

- ICI is still an emerging area, since it requires digital mesh orchestration and collaboration to be realized across the transportation infrastructure and across various technology touchpoints and entities in the ecosystem.
- The investment to tie all the technologies together is challenging, and it requires coordination by different entities with different reporting structures and goals.
- The risk level is high. New technologies offer new possibilities, but also come with unknown risks. For example, absence of standards and immature technologies can lead to unintended consequences and can facilitate hacking. These will need to be considered in the design, development, implementation and operation of resilient ICI components.

User Recommendations

CIOs seeking to advise COOs and operations managers on how to optimize operations should consider the following:

- Identify stakeholders in your ecosystem who could benefit from better data insight, such as truck drivers waiting for unloaded cargo, pilots, tugboats, crane operators, rail cargo, shipyard equipment, shippers and emergency services.
- Assess existing data sources, and identify areas where data collection (such as maintenance, planning, forecasting, safety and traffic flow) can impact other business operations.
- Build a technology roadmap with this ICI vision to ensure edge computing or 5G implementations can be leveraged in multiple ways as a data exchange to multiple stakeholders.

Sample Vendors

Alibaba Cloud; Bosch Group; Cisco; Ford Motor; Huawei; IBM; Mercedes-Benz; Qualcomm; Rolls-Royce Motor Cars; Siemens

Gartner Recommended Reading

Market Guide for Vehicle Routing and Scheduling

Market Insight: Roadmap for V2X Technologies for Autonomous Driving — When to Invest

Hype Cycle for the Internet of Things, 2020

Hype Cycle for the Future of CSP Networks Infrastructure, 2020

Hype Cycle for Connected Vehicles and Smart Mobility, 2020

Market Trends: Monetizing Connected and Autonomous Vehicle Data

Quantum Computing Optimization

Analysis By: Pedro Pacheco

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Quantum computing is a type of nonclassical computing that operates on the quantum state of subatomic particles to address problems with vast combinatorial complexity. In transportation, this capability can be used to optimize traffic as well as highly complex operational ecosystems.

Why This Is Important

Quantum computers (QCs) are accelerators, running a limited number of algorithms with far greater speeds than conventional computers. The problems that QCs solve fall into a broad category of optimization, where a traditional algorithm would take impossibly long to find a solution. QCs are superior for solving problems with enormous combinatorial complexity, such as route or traffic optimization, as well complex operations, like the operations at an airline or railway company.

Business Impact

The United Nations has projected that 68% of the population will live in urban cities by 2050. Transit authorities have been looking to optimize urban mobility, including improving routing, reducing commute times and traffic congestion, while seeking a better quality of life and experience for the residents. QCs will be able to optimize the combined efficiency of all means of transportation in response to the needs of growing cities and more frequent travelling of their citizens.

Drivers

Quantum computing has strong potential in transportation by allowing companies to tackle problems that were previously seen as unsolvable or too time-consuming:

- The QC's ability to model and forecast complex ecosystems, like a traffic environment and urban planning, is a point of attraction for several organizations, as it could bring substantial improvements in increasing the efficiency with which people and goods are transported. Volkswagen has already started to test the technology in traffic optimization, using a QC from D-Wave. Ford is working with Microsoft on a use case that utilizes quantum computing to optimize vehicle navigation route guidance. Besides making use of swarming effect information, the model uses quantum computing to run frequent optimizations that take into consideration thousands of other vehicles on the road.
- Several transportation providers feature highly complex operations, like in the case of airlines or a railway company. Some of these companies see QCs as a tool that can unlock opportunities in terms of planning and running these operational processes, including running complex “what-if” scenarios for better disruption preparedness. For instance, these are among the reasons why Delta Airlines is now partnering with IBM in the area of QCs.
- Vehicle design also entails several processes of optimization, and some of them are already evaluating QCs as a way to unlock significant additional improvements, be it in several parameters of vehicle performance or cost. As an example, Airbus launched the Quantum Computing Challenge back in 2019 as a way to accelerate cooperation with academia and startups in this area, with the aim of introducing QCs for commercial applications.

Obstacles

The obstacles pertain to usage practicality and the complexity of using a computer in a totally different way for problem solving:

- **Decoherence.** QCs are somewhat prone to errors due to decoherence, a process where the surrounding environment (like magnetic and electric fields, and heat sources) destabilizes qubits, leading to information loss and diverse results.
- **Modeling and data gathering.** Even if QCs could solve highly complex problems, these still demand building a model of a real ecosystem to extract optimization. Many times, such a model is hard to construct and demands substantial data gathering — something that could be hard to achieve.

- **Shortage of QC programming skills.** QC programming languages are different from other existing languages, which entails the need to hire or train specific expertise.
- **Security.** QCs have the potential to crack most of today's encryption systems. This risk will grow with QC adoption.

User Recommendations

Although QCs are becoming more commercially accessible, they are still in a nascent phase. As such, transportation CIOs must plan quantum computing initiatives with a future mindset:

- Prioritize QC use cases to develop a long-term technology adoption plan. Roll out use cases in line with the evolution of QC technology. For instance, focus on a five-year horizon to deploy real-time applications where speed of calculation is essential. A 10-year horizon is expected for applications combining speed and complexity.
- Set up QC governance and an internal innovation team. This requires a strong executive sponsor, clear innovation processes and support of other functional areas of the company. Bring QC expertise to your company that can lead a future major QC unit in the long term.
- Secure cooperation with a QC-as-a-service provider as a start, to have frequent access to QCs without incurring the cost of buying an actual QC.

Sample Vendors

Alibaba Cloud, D-Wave, Fujitsu, IBM, Microsoft, Rigetti Computing

Gartner Recommended Reading

Innovation Insight for Quantum Computing for the Automotive Industry

Quantum Computing Planning for Technology General Managers

Trackless Tram

Analysis By: Venecia Liu

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

A trackless tram is a mass transit vehicle that does not require tracks for regular operation, but uses autonomous technologies such as computer vision to navigate on roads. Trackless trams use electric propulsion and, therefore, are viewed as a sustainable mode of mass passenger transit. Their main advantage eliminates requirements to install and maintain a rail track while facilitating faster passenger onboarding when compared to buses.

Why This Is Important

Trackless trams provide an alternative to light rail without the heavy infrastructure costs of installing rail tracks into the road for short-distance mass transit. This also makes it easy for trams to share the same road with other vehicles. Within an urban area, there is a need to provide mass transit services to alleviate traffic congestion for personal use vehicles, but to do so in a cost-effective manner, given continued pressures this pandemic has had on government funds.

Business Impact

There are financial cost savings by deploying trackless trams versus light rail. This makes it easier for mass transit operators to deploy and expand the coverage of tram services. From an environmental standpoint, moving people en masse helps to reduce the carbon footprint from personal vehicle usage, while at the same time providing a mass transit solution for congested city centers.

Drivers

- Transit authorities seek ways to improve the mobility experience of their residents and visitors. Trackless trams provide a way to enable mass passenger transit at a comparatively lower cost than light rail, and can aid in reducing pollution and city congestion. Trackless trams are also being considered from outer suburbs to the city center.

- There are also advantages of trackless trams over double decker buses when you consider wheelchair access and time to embark and disembark.

- There is interest to adopt new technologies and trackless trams using autonomous technologies. While optically guided buses have existed for nearly two decades with a deployment in Rouen, France, the concept of a trackless tram using more advanced technologies is being touted.

- The fast progression of autonomous drive technologies for road vehicles can easily be adapted to trackless trams in order to improve their operation and overcome some of their earlier limitations.

- It is easier for a trackless tram to share roads with other vehicles due to the absence of tracks. Rail tracks sometimes pose a risk for road vehicle drivers as they are a slippery surface that can, in some circumstances, cause accidents.

Obstacles

- Some hype exists with trackless trams being viewed as “glorified” conjoined shuttle buses. There are not many suppliers for the market, which may lead to proprietary vendor lock-in.

- An optically guided bus system was used in Las Vegas, but there were challenges with reliability given oil spills and markings on the virtual track for the camera-based guidance system. This has raised concerns about trackless trams with regard to weather impacts such as fog or snow conditions covering the virtual track. As such, a combination of additional technologies such as lidar, GPS, edge computing and other V2X technologies is being evaluated.

- As COVID-19 is leading many to relocate outside urban areas, and many rely now on micromobility as their choice for urban commute, it may be that the extra capacity of trackless trams over buses won’t be needed in the future.

- The fact that trackless trams operate autonomously may raise concerns from unions on possible redundancy for tram and even bus drivers.

User Recommendations

- Evaluate traffic patterns to identify traffic bottlenecks. Work with city planners to model additional infrastructure requirements where trackless trams could be an advantage by enabling better service together with reduced investment and maintenance costs.
- Adopt a holistic perspective on total cost of ownership when choosing different types of transportation to suit the needs of your city. For instance, a trackless tram allows for a substantial and continuous cost reduction on infrastructure, as you don't need to install nor maintain tracks.
- Follow developments from manufacturers of trackless trams as the technology will continue to evolve. It may also be useful to interact with technology companies in the area of autonomous driving as a way to use their technology to help mitigate some of the limitations currently experienced by trackless trams in terms of autonomous operation.

Sample Vendors

China Railway Rolling Stock Corporation Zhuzhou Institute; HÜBNER; Siemens

Electric Aircraft

Analysis By: Mike Ramsey

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Aircrafts operating under electric propulsion, for the purposes of transporting people or goods. These aircraft could include helicopters, planes and VTOL planes that use electricity rather than liquid fuels.

Why This Is Important

Electric air transportation, in the short term, addresses the need for reducing greenhouse gas emissions and other pollution from liquid-fueled aircraft. In the long term, electric aircraft will also provide a way to continue to provide long-distance transportation when petroleum-based fuel becomes more expensive to extract from the Earth.

Business Impact

Electric aircraft already are making an impact at the small scale in the form of personal and commercial drones, where most of these vehicles are electrically powered. They have the benefit of easy start up and repairability when compared with combustion and jet engines. There are numerous startups making electric plasma jets and propeller-driven aircraft. Still, most of the new vehicles that have been produced to date are limited in size, range and speed. Electric aircraft may be ideally suited for short flights, where the cost of operation is high for liquid-fueled planes, especially jet planes.

Drivers

- Pollution regulation and the demand to reduce greenhouse gas emissions are the largest drivers for adoption of this technology.
- The development of lighter, more powerful and less-expensive batteries is very likely to expand the use of electric aircraft, especially for short-distance vehicles.
- Most early efforts to develop autonomous urban aircraft use an electric powertrain. If these vehicles begin to get market traction, it will help to increase the market penetration of electric aircraft.

Obstacles

- The weight of batteries relative to the energy required to power planes, jets or helicopters over long distances is a challenge.
- There have been some examples of long-distance electric aircraft, but they are mostly demo aircraft and travel at low speeds, and can carry only a small number of people.
- The lengthy period of certification for new aircraft is especially challenging for new technologies in aerospace. It can take a decade to get an airplane to be qualified as safe for passengers.
- It may take many years to develop electric plasma jets that could come close to the range of liquid-fueled jets, and even then the recharging time of a battery-electric jet is likely to be substantial because of the size of the batteries.

User Recommendations

- Investigate short-distance routes that could be replaced by electric aircraft as a first step in consideration of electric aircraft into a fleet.
- Watch whether experimental electric aircraft received FAA approval for passenger flights because it likely will create an easier pathway for other companies to produce these aircraft.
- Check for signs that regulators will approve the use of electric drones over urban areas as this will be a key first step toward allowing larger vehicles to operate in a similar theater.

Gartner Recommended Reading

Tech Providers 2025: Competing in the Age of Climate Change and Radical Decarbonization

Maverick* Research: Climate Change Needs a Digital Drug Against Delusion

Electric Ships

Analysis By: Jonathan Davenport

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Electric ships use chemical energy stored in rechargeable battery packs to power an electric motor, with no secondary source of propulsion. Investment in electric ships is motivated by the need to address fuel efficiency, sustainability and emission requirements, as well as market demands for lower operational costs.

Why This Is Important

Electric propulsion can help get the maritime sector toward net-zero emissions. Electric propulsion is limited by the prohibitive weight and cost of batteries when used in heavy-duty and long-range applications. So, at present, light-duty marine applications and smaller boats are most suited to electric propulsion, where the vessel can be charged at the end of its voyage. Key candidates for this technology include ferries, inland waterways, coastal shipping and workboats.

Business Impact

Greenhouse gases emitted by maritime fleets can be reduced or completely eliminated by using electric vessels. For companies that want to reduce their carbon footprint, electric vessels can also be used as an alternative to transporting goods by road. There is also potential for reduced operational costs because electric motors require far less maintenance than combustion engines and are much more energy-efficient.

Drivers

- The maritime industry’s carbon footprint is daunting. As a whole, the sector accounts for 2.5% of global greenhouse gas emissions. Plus, shipping accounts for 13% of global sulfur dioxide emissions, along with emissions of other noxious pollutants. Most ships run on diesel or bunker fuel, which is inexpensive, but dirty, containing 3,500 times more sulfur than passenger vehicle diesel.

- Government incentives and political pressure may incentivize the maritime industry to switch to better energy sources. For example, government assistance has already been given to stimulate companies’ participation in smart grid projects to enable the electricity power grid to respond to increased peak loads caused by electric ship charging.

- The cost of energy from renewable electricity can, in most European countries, compete with energy from fossil sources.

- Eliminating the internal combustion engine simplifies the ship’s propulsion system, reducing the need for human intervention and making it easier to incorporate autonomous technology into vessels.

Obstacles

- Diesel technology is a reliable form of marine propulsion and auxiliary power generation.
- Batteries are heavy and occupy substantial space. Water currents also affect energy consumption, so electric ships have difficulty in traveling long distances without places to stop and charge.
- Thermal runaway is a risk for batteries and can lead to explosions.
- The initial capital investments in new battery and motor technology are significant (more than $1 million per ship).
- Shore connection and charging infrastructure investments would also be required. Government support will be necessary to make electric vessels a reality.
- Regulations for lower carbon emissions can be enforced only when the ships are within territorial waters. Out on the open ocean, no laws pertain.
- Experienced engineers and an established repair and spare parts network are often lacking.

User Recommendations

Operators of maritime fleets:

- Assess which (if any) vessel operations would be suitable for the utilization of an electric powertrain by looking at the distance that vessels travel, the water conditions and ability to recharge at destinations.

Operators of road vehicle fleets:

- Calculate the greenhouse gas emissions and impact of utilizing trucks on road networks versus electric ships to move manufactured goods between locations. Study best-practice examples, such as those provided by the Yara Birkeland, which aims to replace the 40,000 diesel-powered truck journeys a year to deliver its fertilizer.

CIOs working for government organizations such as departments of transportation:

- Partner with electric utilities to build a long-term (20-year) electric ship business case. Assess the incentives and investments to install port-side charging infrastructure and what benefits, such as reduced greenhouse gas emissions, would be delivered.

Sample Vendors

ABB; Corvus Energy; Damen; Hitachi; PortLiner; Schneider Electric; Wärtsilä

Hyperloop

Analysis By: Pedro Pacheco, Venecia Liu

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Hyperloop is a mode of transport using low-pressure vacuum tubes to propel transport pods at an ultra-high speed (beyond 1,000 km/hour or 621 mph) in a virtually friction-free environment from one point to another. Hyperloop technology can be used to transport people or goods.

Why This Is Important

The past year has seen some progress toward a hyperloop commercial deployment. The Korean Railroad Research Institute successfully ran a scale model of its hyperloop at speeds beyond 1,000 km/hour (621 mph) and expects to start a commercial hyperloop service by 2025. At the same time, Virgin Hyperloop has done the first test with human passengers, but only at a speed of 160 km/hour (100 mph). Even if these tests didn't feature a real-size hyperloop train, they are steps in the right direction.

Business Impact

Hyperloop could play an important role in achieving governments' objectives for zero-carbon, fast mass transportation. The high speeds that hyperloop offers could make it a more environmentally friendly alternative to air travel.

Some studies suggest hyperloop could be one-half to two-thirds the cost of a high-speed train and more than double or triple the speed of the fastest train. Hyperloop requires less energy consumption than a conventional train, and it is positioned as safer and quieter.

Drivers

There has been a lot of hype around this technology, starting with Elon Musk. He has driven the concept forward from the original Hyperloop Alpha paper published in 2013 to the annual SpaceX-sponsored competitions, which has resulted in prototypes and signed development agreements with nations around the world, including the United Arab Emirates, France, India and Indonesia.

On top of that, the Paris Agreement and a major drive to reduce transportation's carbon footprint (one of the main contributing sectors) has triggered the interest of many investors, companies and governments. Currently there aren't any alternatives to the plane when it comes to transporting a large number of people at the highest possible speed across many hundreds of miles. However, the aerospace industry struggles to develop a propulsion system that is carbon-neutral, fast and cost-effective. This gap is opening the door to alternatives. High-speed trains are already a main form of transportation in countries like China, Japan, France and Germany. However, they cannot compete with the plane in speed across distances beyond 200 to 300 miles. Countries like China and Japan are investing large sums to expand their coverage of magnetic levitation (maglev) trains. These use magnetic levitation to reduce the friction with the tracks, which allows them to ride at speeds around 700 km/hour (435 mph). However, the level of energy required to operate a maglev is still substantial. As such, this means hyperloop — because it runs on near vacuum — could still present an advantage over maglev trains.

Obstacles

Concerns have been raised about how pods are developed, oxygen requirements and the necessary safety equipment and emergency exit considerations. In July 2020, HyperloopTT and TÜV SÜD announced the first completed certification guidelines for hyperloop systems.

Even if, on paper, hyperloop presents better performance than maglev trains, it also presents significantly larger technical hurdles to overcome. If organizations developing hyperloop technology are not able to produce breakthroughs in the next few years, there is a chance the focus may change toward maglev. Even if a maglev train is slower than a hyperloop, this is technology that is already in commercial use today and, hence, just needs to be expanded in terms of coverage. Besides, maglev's speed already puts it as a strong point-to-point alternative to commercial flights.

User Recommendations

- Transport authorities and CIOs must keep monitoring the developments toward a commercial hyperloop system and the existing roadblocks before deciding to invest. Even if last year has presented some evidence of progress, caution is still recommended. Understanding the progress of South Korea toward a 2025 commercial launch is key, since this is a country with the most aggressive timeline for deployment.
- Governments must also consider other alternatives in their mass transport strategy, like maglev technology or high-speed rail, as a low-carbon alternative to aviation.
- Governments must not totally discard aviation as a high-speed, zero-carbon mass transport solution. Even though many challenges lie ahead for aviation, synthetic fuels and hydrogen could also become viable more toward the end of this decade.

Sample Vendors

Delft Hyperloop; HyperloopTT; The Boring Company; TransPod; Virgin Hyperloop

Gartner Recommended Reading

2021 CIO Agenda: Global Perspectives for Transportation

Digitopia 2035: All Stories Collected

Digital Society Infrastructure Will Set the Enterprise's Business Context

Digital Twins in Transport

Analysis By: Venecia Liu

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

A digital twin is a virtual representation of an entity such as an asset, person or process and is developed to support business objectives. Digital twins in transportation relate to the digital twin applications in this industry used to improve asset maintenance, planning, station information modeling and other use cases.

Why This Is Important

Transportation CIOs can use digital twins to assess a situation and predict outcome-based scenarios for planning and strategy purposes. Simulations can be done to improve operational performance in a virtual environment versus physical runtime of assets that will take time and resources. Using digital twins for the modeling of processes can also improve performance in terms of better customer service or reduced operating costs.

Business Impact

- Digital twin simulations such as the impact of sand to an aircraft jet engine have proven the need for increased maintenance, hence improving safety.
- Digital twin modeling of a new airport terminal build can determine passenger flow impact in comparison to space and design concepts.
- Digital twin of rail can, for instance, help rail operators increase the frequency of trains.
- Digital twin of a port can identify bottlenecks in operations.

Drivers

- Digital twins can assist in the planning and forecasting of infrastructure demands and expose any weaknesses in the processes, assets, governance and IT competencies.
- Digital twins can be used for building information management of new airport builds, as well as simulations of aircraft parts to determine maintenance schedules.
- A broad range of airports and rail organizations have been exploring the use of digital twins and releasing RFPs to acquire digital twins.
- Equipment, operations services and IT vendors are increasingly highlighting the business benefits of digital twins in transportation. Benefits include cost optimization, asset lifetime improvement and passenger health monitoring.

Obstacles

The adoption of digital twins is rather nascent in this industry as there are challenges with understanding the use-case potential and the applicability for how digital twins can really enhance overall business operations and improve the bottom line.

User Recommendations

Transportation CIOs must:

- Gather use cases of utilization of digital twins in several other sectors and even in transportation. This will provide the necessary insight to find a broad number of use cases within their own organization.
- Quantify the possible financial benefit brought by digital twins as a way to generate a strong business case for investment.
- Strengthen the data collection capabilities of their critical processes as a way to set the foundations for the introduction of digital twin models.
- Engage with their business unit peers to ensure the business case has clear metrics the IT organization can support.
- Make sure there is a culture change process in place to drive adoption of the digital twin by frontline workers.

Gartner Recommended Reading

What Should I Do to Ensure Digital Twin Success?

Tool: 50-Plus Digital Twin and IoT Cost Optimization Examples

Strengthen 4 Elements for Successful Management and Governance of Digital Twins

Toolkit: Enterprise Readiness for Digital Twin Deployment

Hypersonic Aircraft

Analysis By: Ivar Berntz

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Hypersonic aircraft are capable of flying at exceptionally high speeds — exceeding Mach 5 or five times the speed of sound. Current commercial jet aircraft fly at air speeds that are lower than Mach 1 (the speed of sound). Flight speeds between Mach 1 and Mach 5 are called supersonic. At Mach 6, one would be flying at around 2 km per second. That is 7,200 km per hour. Fuel permitting, one could fly across the world and back in a day, with time to spare.

Why This Is Important

What if we could travel to or do same day parcel delivery to a different continent? Most jet airliners operate today in the Mach 0.71 (approximately 540 mph or 870 km/h) to 0.85 (approximately 647 mph or 1,041 km/h) speed range. While appropriate for shorter haul flights, it makes for lengthy long-range flights, some up to 18 hours (Singapore to NY). While supersonic flights could cut some longer flight times by half, hypersonic aircraft could cut it down dramatically.

Business Impact

- Potential advantages of hypersonic flight are numerous, including reduced travel times and improved space access.
- As hypersonic aircraft reduce the duration of transoceanic or transcontinental flights, they would also allow for longer commutes. At hypersonic speeds — above Mach 5 in aviation parlance — it would be possible to travel from New York City to London in about less than two hours, instead of the eight hours the trip takes today on a conventional airliner.

Drivers

- As people cannot make time, there's an inherent value to speed. Therefore, supersonic (meaning above the speed of sound) and hypersonic (meaning five times the speed of sound or faster) flights have been hyped as the next era of commercial aviation since at least the 1950s.

- The most famous commercial supersonic aircraft, the Concorde, reaching Mach 2.04, was retired in 2003. Besides high fuel consumption, it was prohibited from flying supersonic over land due to the noise pollution from its sonic boom. To circumvent this limitation, NASA is working on a Quiet Supersonic Technology test bed, otherwise known as QueSST. It experiments with an aircraft shape that would turn the sonic boom from an aircraft flying at Mach 1.4 at 55,000 feet into nothing more than a perceived "heartbeat" to individuals on the ground.

- According to The Drive, a large business-jet-sized aircraft that can sustain supersonic Mach 1.4 for thousands of miles would mean a whole series of possibilities for passengers, cargo and also the USAF. One company claims it already has a sizable order backlog for such a supersonic business jet, capable of drastically cutting transit times over vast distances. Use cases range from rapidly deploying small groups of passengers and/or cargo around the globe, VIP airlift and rapid logistics to emergency response missions.

- Now, at an even higher hypersonic speed of Mach 5 and above, given range, aircraft could perform same day package deliveries to several major capitals, worldwide. As a result there is so much interest in developing the required technology, with parallel efforts happening in Europe, China and the U.S.

- New technologies promise to make passengers and cargo travel at hypersonic speeds a reality in five to 10 years, but given the time that it has taken to develop a commercially viable supersonic (not hypersonic!) jet thus far, it might though take a tad longer.

Obstacles

- With the exception of the Concorde, building civilian airplanes capable of flying faster than the speed of sound has proven to be an elusive goal.
- At hypersonic speeds, the air dissociates and high heat loads are created. At Mach 5, fuselage friction can create temperatures of 1,000 °C. This requires use of materials like titanium, or even ceramics, to avoid melting metal in the engine, which would interfere with the combustion that generates the propulsive power.
- New engine technologies need to be created. The X-15 experimental jet used a rocket propulsion system to achieve Mach 6 flight. Recently, the unmanned X-43A used a scramjet, or supersonic combustion ramjet, to fly at Mach 7. Combined cycle engines, which blend together the capabilities of traditional jet turbines and ramjets or scramjets, might be part of the solution.

User Recommendations

- For airlines and transportation providers: Include this technology on your long-term planning. Start developing use cases with a high ROI that will allow you to play a role in bringing the technology to market — for the transport of VIP travelers as well as for shipping goods where time is a critical requirement.
- For governments: Ensure this strategic technology is on your radar as it can be applicable not just for military applications, but also for its ability to connect far away locations with main economic hubs.

Sample Vendors

Boeing; Exosonic; Hermeus; Hypersonix; IO Aircraft; Lockheed Martin

Gartner Recommended Reading

Aerospace and Defense Government Supply Chain Outlook, 2019

On-Demand Aviation

Analysis By: Ivar Berntz

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

On-demand aviation is the concept of having a ride-sharing, Uber-like experience, when booking airplanes, helicopters or electric vertical takeoff and landing (eVTOL) aircrafts. It is a more affordable version of the fractional ownership or charter flight business models that already exist at the higher end of the market.

Why This Is Important

The sharing economy has expanded itself to become one of the most recession-proof business models with successful companies like Airbnb, Uber and others. On-demand entrants want to create a new market for aviation sharing economy services. This will require new systems, specific aircraft designs, improved avionics, specific infrastructure, changes in regulations, expansion of air traffic control systems, new insurance models, more pilots and technicians, etc.

Business Impact

On-demand aviation:

- Gives customers the possibility to board an on-demand or ride-sharing flight quickly. In some cases even from downtown locations, e.g., by using a vertical takeoff and landing (VTOL) aircraft.
- Provides important time savings, e.g., getting through airport security, waiting for boarding and depending on location, time in traffic.
- Creates an elevated experience that customers may afford and thus elect to pay a price premium.

Drivers

- Private airplanes, like cars, are an underutilized asset. They are also expensive to own and operate. On-demand aviation via flight-sharing makes economic sense as it bypasses current traffic bottlenecks for existing routes and allows for new ad hoc destinations.
- It saves time as current airport infrastructure is located outside of urban centers, requiring plenty of time for both transportation as well as for security procedures.
- It also increases the chances of on-time departure and arrivals, as commercial aviation timeliness tends to suffer when asset utilization needs to be kept high due to low profit margins.
- There is also an incentive for pilots who need to fly a certain number of hours required to keep their license and who will be able to do so more easily.
- There have already been some early pilots by Uber and others of on-demand helicopter flights, which demonstrate that technology platforms can be adapted to aviation as well.
- Other ecosystems, like catering, hospitality, ground transportation, etc. will be able to offer new services and locations to discerning clients, leveraging flexible schedules and group sizes.

Obstacles

- **Infrastructure** — Current infrastructure is unlikely to accommodate urban air mobility at scale. For eVTOLs, helipads might get charging capabilities, but new custom-built, large-scale facilities requiring prime real estate in densely populated urban environments will be needed.
- **Cost** — In the future, autonomous aerial taxis using eVTOLs or similar could eventually be cheaper than cars on some routes.
- **Public Acceptance** — We expect early adopters to be willing to try eVTOL aircraft while early flights are piloted. To scale, a fully autonomous solution will be needed — and when autonomous aircraft are introduced, considerable work will be needed to drive customer acceptance.
- **Tools, Regulations and Air Traffic Control** — Tools and processes for monitoring air traffic and flight data at the required scale do not exist yet and will require new digital systems. Legislation must also allow for pilot and aircraft remuneration.

User Recommendations

- Evaluate how several new on-demand aviation experiments evolve worldwide.
- Act preemptively by striking tentative partnerships early so that you can educate yourself and your organization about the hurdles and benefits encountered by others.
- Prepare your infrastructure and systems to connect to these new players by moving to a composable digital architecture.
- Evaluate alternatives and/or complementing partners by taking into consideration that some of the development will be done by ecosystem partners.
- Co-develop the requirements, get the benefit of early lessons and a jump-start into the market by choosing strategically, the experiment(s) in which to participate.

Sample Vendors

Aston Martin Lagonda; BETA; Jaunt Air Mobility; Joby; Karem Aircraft; Kitty Hawk; Lilium; Pipistrel; Vertical Aerospace; Volocopter; Workhorse

Gartner Recommended Reading

The Future of Data-Driven Transportation Ecosystems

Video: Uber — How On-Demand Networks Are Reshaping Logistics

Lazy Economy Business Models Usher in a New Era of Hyperconvenience

Market Impact: Regulation Is Making Way for Autonomous Deliveries

Why Autonomous Flying Drones Must Be on the Radar of Mobility Sector CIOs

Heavy-Duty EV Charging

Analysis By: Pedro Pacheco

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

This pertains to technology used to efficiently charge heavy-duty electric vehicles, including buses, trucks and electric ships, in a way that allows those to perform with a high degree of operational efficiency, i.e., limiting vehicle charging time and maximizing operation time.

Why This Is Important

Regulations across several markets like Europe, China and California will boost adoption of electric buses and trucks. For instance, the EU will mandate a CO2 tailpipe emission cut of 30% by 2030 (in comparison to 2019 levels). However, using large EVs for long distances is not practical without a dense fast-charge infrastructure. This caveat makes these vehicles commercially nonviable for long-distance traveling.

Business Impact

For heavy-duty OEMs in areas like Europe, it will be essential to have a dense network of purpose-made EV chargers; electric trucks and buses will not reach mass adoption without it. The Association of European Automobile Manufacturers (ACEA) has pledged to impose specific regulations prompting member states to install at least 11,000 chargers for heavy-duty vehicles every year until 2025 — up from practically zero today. As such, this clearly defines an urgent necessity for heavy-duty chargers.

Drivers

- The Paris Agreement has prompted several nations to reduce vehicle CO2 emissions through legislation. As this is already visible in passenger cars, heavy-duty vehicles are now next in line. As OEMs need to raise sales volumes of electric buses and trucks, their use in long trips is only practical when a network of dedicated fast chargers is in place across the main roads. Given that buses and trucks require a much larger battery than a passenger car, they also need higher-power chargers, reaching 2 MW and beyond. These vehicles are driven much more than a passenger car, and their profitability depends on it, so a short recharge time is even more crucial. Besides the need for a dedicated charging infrastructure, a high number of chargers is also essential. For instance, in Europe, truck stops across main road corridors are frequently packed during nights and weekends. If parking is already an issue, then imagine what this says in terms of the needed number of chargers.

- Similar drivers apply to the shipping sector, but to a lesser degree. Even though shipping produces 2.5% of global greenhouse gas emissions, regulation lags well behind road vehicles in supporting zero-emission ships.

- As road-going EV technology evolves fast, this will make it more economically feasible to adopt it in shipping — especially since electric powertrains have considerably lower operating costs. Currently, this enables a steady pace of adoption in ships like recreational boats and ferries for short sea connections.

Obstacles

- Absence of standards. There still aren’t standards deployed for this type of charger. The Megawatt Charging System is currently being developed by the CharIN consortium, but is not expected to be ready prior to 2022, which means infrastructure and trucks can only be developed after that.

- Regulation. While some regions have already developed stringent legislation prompting the progressive phase-out of internal combustion engines in heavy-duty vehicles, this still doesn’t happen in most of the world. This heavily conditions the need for a heavy-duty EV charging network.

- Risk aversion. Even in regions where incentives for EV charger installation are in place (like the EU), charge point operators fear a long investment payback period. The higher power of these chargers also requires upgrades to the public grid, which adds to the size of investment. The utilization rate of each charger is crucial, and these companies fear investing too early, before there are enough vehicles to justify it.

User Recommendations

- For any type of incumbent: Invest in a dedicated heavy-duty charger network only in regions adopting a strong regulatory framework that supports the electrification of this type of vehicle. Without regulation, vehicle adoption will grow slowly, which is a threat to infrastructure profitability.
- For vehicle OEMs: Take a chance to invest and build partnerships for developing a heavy-duty charging network. Infrastructure may not grow fast enough to respond to vehicle user needs. Start by investing in roads where infrastructure is needed to unlock major deals with large customers.
- For charge point operators: Overcome risk aversion. Partner with OEMs, utilities and investors to set up infrastructure. Monitor vehicle sales penetration to judge the right time to deploy infrastructure. Implement loyalty models where charging will be an enabler to profit from selling other services and products.

Gartner Recommended Reading

Guide to New Business Models in the Electric Vehicle Ecosystem

Top 10 Trends Driving the Utility Industry in 2021

At the Peak

Hydrogen Transportation

Analysis By: Pedro Pacheco

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

These vehicles for land, sea and air have a propulsion system that uses hydrogen as a fuel. They may rely on a fuel cell that converts hydrogen and air into electricity and vapor. Some other vehicles rely on an internal combustion engine that burns hydrogen. Some aircraft may also use jet propulsion that replaces jet fuel with hydrogen.

Why This Is Important

The Paris Agreement will have a gradual but dramatic impact in the decarbonization of transportation, making zero-emission mobility a must. For these reasons, hydrogen propulsion represents a possible alternative for long-distance travel (buses, trucks and ships) and aircraft propulsion. Battery electric vehicle (BEV) propulsion is not expected to cover all these needs, at least in this decade, due to limitations in energy density, speed of recharge and weight.

Business Impact

For land and sea transportation, the business impact of hydrogen hinges heavily on public incentives and the pace of BEV technology. Hydrogen still has a chance if incentives can enable a price-competitive green hydrogen distribution network before BEV technology can fulfill use cases for long-distance travel on land and sea. However, batteries' very low energy-to-weight ratio means hydrogen still stands a good chance of becoming the main green solution for aviation toward the end of the decade.

Drivers

- Both the EU and China have put together regulation and incentives promoting hydrogen fuel cell cars and heavy-duty vehicles, even though those incentives and regulations are similar for BEVs.

- Hydrogen has a strong role to play on the energy side — both in energy storage and heating. For instance, the EU predicts hydrogen's part of the energy mix will grow from 2% in 2018 to 13% to 14% by 2050. For that matter, EU's Green Deal is subsidizing several projects of green hydrogen production and distribution. As governments and companies invest in hydrogen production for several purposes, this will lower production costs and, hence, will benefit the transportation sector.
- Refueling a hydrogen vehicle is considerably faster than a BEV, especially for large vehicles. This factor drives some companies to see hydrogen as a serious alternative to BEV technology.
- Both Airbus and Boeing plan to put on the market hydrogen-powered planes by the end of the decade. This means hydrogen is, at the moment, the only viable carbon-neutral alternative for aviation.
- In 2018, the International Maritime Organization defined that global shipping emissions must fall by at least 50% by 2050, compared with 2008 levels. Even if less stringent than road vehicle legislation, this still creates an opportunity for hydrogen applications.

Obstacles

- Production and distribution of hydrogen are not yet possible in a cost-effective manner, especially for hydrogen produced through renewable energy. Besides the cost of renewable energy, this is an energy-intensive process of relatively low efficiency. In addition, that infrastructure is not abundant enough to allow broad coverage to hydrogen-powered vehicles.
- Incentives and regulation are essential to jump-start the use of hydrogen in transportation — both for vehicles and for subsidizing its supply chain. Absence of those makes the business case for hydrogen very hard at this stage.
- BEVs for commercial applications (buses and trucks) are already considerably more widespread than hydrogen vehicles, especially for urban environments. As such, the success of BEVs will definitely be a roadblock for hydrogen vehicles, since both are competitor solutions in terms of zero-emission transportation.

User Recommendations

- Focus on regions with incentives favoring not only hydrogen-powered vehicles, but also the production of green hydrogen. Hydrogen supply infrastructure is a key bottleneck to the adoption of hydrogen-powered vehicles, and the reason why it needs governmental support.
- Focus on the entire business model to address all the obstacles to successful adoption of hydrogen in transportation. This may include looking at infrastructure and hydrogen production and even driving the adoption of hydrogen in other areas like energy storage and heating for cost reasons.
- In terms of transportation, prioritize aviation applications for long-term investments in hydrogen transportation. While BEV technology remains a threatening competitor for hydrogen in road transportation and shipping, it is not yet in a position to become an alternative in commercial aviation.

Sample Vendors

Airbus; Ballard; Bloom Energy; Boeing; Doosan; Hyundai Kia; Robert Bosch; Toshiba; Toyota

Gartner Recommended Reading

Emerging Technologies and Trends Impact Radar: Enabling Power and Energy Technologies

Autonomous Urban Air Mobility

Analysis By: Mike Ramsey

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Flying autonomous vehicles, or unmanned aerial vehicles (UAVs), are for carrying passengers, primarily over short distances in urban areas. These encompass self-operating aircraft that are sometimes referred to as “flying cars” or passenger drones and are designed to operate without a human pilot either in the vehicle or remotely operating. These vehicles include air taxi services, primarily, but do not include commercial delivery drones.

Why This Is Important

A significant number of companies are working on new aircraft that are piloted by artificial intelligence and designed to create a more agile, less expensive and quicker way to execute air travel, primarily in congested areas. The goals of the projects include:

- Faster travel in densely populated areas
- Economical air travel over short distances
- Safer operations
- Lower carbon emissions

Business Impact

The impact of UAVs is likely to be moderate for most companies, though it could be quite high in a limited set of mobility service businesses. For most people, these vehicles will be for extra convenience and not primary travel. They may be the equivalent of robot-piloted helicopters, lowering the cost of operations and perhaps increasing the availability of a preexisting service. Special use cases in remote areas or difficult topography will lead to much faster adoption on a special use basis.

Drivers

- The development of clear safety standards, air navigation regulations and operating guidelines by countries, states and provinces will help to speed the implementation of autonomous air mobility when the technology is ready to be deployed.
- A new network of information collection and sharing between different parts of the ecosystem that would give the location of vehicles, determine clear pathways and also track passengers would aid with the deployment of the vehicles.
- Advances in high-performance computing and sensors that are used in ground autonomy are certain to benefit aerial operations. The prospect of fast, economical and, ideally, safe flight, point-to-point, in urban areas has already attracted significant capital and will continue to do so.

Obstacles

While the prospect of direct flights over congested areas is tantalizing, these vehicles face significant challenges to implementation:

- The technology is not currently validated by federal authorities and ensuring safety of such a system could take several years.
- Regulations are such that distances of a mile or more may be required between the vehicles over urban areas, limiting their usefulness. Infrastructure in cities is not currently available for landing areas to accommodate large numbers of vehicles and the vehicles produce significant noise.
- Many versions of the vehicles are battery-powered, limiting their range significantly when compared with standard helicopters or planes.
- Cost is a significant obstacle to the widespread use of the technology. For instance, in comparison to a helicopter, even eliminating the cost of the pilot, the total operation cost will still make autonomous urban air mobility prohibitive to the vast majority of the population for the foreseeable future.

User Recommendations

- For CIOs in organizations dependent on transportation and logistics, add these vehicles to the long-term technologies that may need to be obtained or used in your processes. While it may be decades before these vehicles proliferate, they are nearly certain to grace the skies at some point. Assess what problems in transportation, both for moving people and cargo, might be solved by using these vehicles. Consider how systems might need to be altered internally to allow for use of the vehicles.
- Start investing in autonomous delivery drones as a stepping stone to urban passenger UAVs. These are less challenging to implement (as they are not meant to transport people) and many of their aspects (like technology and traffic control solutions) should be common to UAVs for transport of people.

Sample Vendors

Airbus U.S.; Bell; Volocopter

Gartner Recommended Reading

Why Autonomous Flying Drones Must Be on the Radar of Mobility Sector CIOs

Hype Cycle for Drones and Mobile Robots, 2020

AI in Transportation

Analysis By: Venecia Liu, Pedro Pacheco

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Artificial intelligence is a discipline that applies advanced analysis and logic-based techniques, including machine learning, to interpret events, support and automate decisions, and take actions. Its use in transportation provides benefits such as improving safety and customer satisfaction and enabling cost reduction.

Why This Is Important

AI enhances operations and augments job functions where labor costs are being scrutinized as the sector recovers from the pandemic. Examples of AI benefits include enhancing the safety of operations and reducing asset failure, improving passengers' satisfaction by providing faster responses to their questions or needed information via chatbots, and speeding up operations through biometric boarding and baggage screening.

Business Impact

- AI improves transportation planning, design and forecasting; passenger engagement; operations and maintenance; surveillance systems; biometrics and facial recognition; and autonomous vehicles.
- AI enhances the ability to synthesize data, identify patterns and arrive at conclusions. It also provides quicker analysis for decision making and thereby increases efficiencies.
- Autonomous vehicles, drones and robots can provide efficient and reliable operations to optimize transit.

Drivers

- Organizations are adopting AI to achieve operational and business benefits such as efficiencies in network operations, routing, scheduling, planning and monitoring as well as cost optimization in both cargo transport and passenger transport.
- AI chatbot features have reduced call center labor costs, and natural language processing is aiding maintenance, repair and operations staff.
- As shown by Gartner's 2021 CIO Survey, the level of digital maturity among transportation companies is improving. This growing maturity will help these companies better understand the benefits of AI and better implement the internal resources and governance to develop and implement AI solutions.

Obstacles

- There is a lot of hype around AI, which is causing confusion. Several vendors use AI as a marketing ploy, making it difficult for transportation CIOs to identify truly valuable AI-based offerings.
- Companies sometimes struggle to see a tangible benefit from the technology due to technical limitations and an inability to define tangible targets for success. In addition, in some cases, the integration of AI solutions with existing infrastructure proves challenging.
- Some companies invest in AI without determining suitable business cases in advance. Therefore, obtaining executive leadership sponsorship can be a challenge.

User Recommendations

- Ensure AI use cases are linked to business performance metrics to further justify and contribute to future investments. For instance, link AI to the amount of cost savings or the percentage of customer satisfaction improvement.
- Build an AI strategy for the whole organization to ascertain economies of scale. Employing multiple vendor solutions for different use cases will later lead to vendor management challenges and siloed systems.
- Retrain internal IT skill sets to build up AI capabilities — such as robotics engineering, data science, RPA expertise and computer vision programming — depending on your AI application. Several e-learning course platforms offer training services such as data science and machine learning to upskill your team.
- Learn about the legal implications for AI in applications such as facial recognition for passengers as well as the use of autonomous technologies internally and externally and jurisdictional regulations.

Sample Vendors

Alibaba Cloud; Google; OXplus; KONUX; LexX Technologies; Noodle.ai

Gartner Recommended Reading

2021 CIO Agenda: Global Perspectives for Transportation

Emerging Technologies: Top Edge AI Use Cases for Asset and Operational Intelligence

5 Building Blocks to Achieve Autonomous Transportation

Why Autonomous Flying Drones Must Be on the Radar of Mobility Sector CIOs

Legal's First Steps for Developing AI Governance

Infographic: AI Use-Case Prism for Transportation

Cool Vendors in AI in Automotive and Smart Mobility

Sliding into the Trough

5G

Analysis By: Sylvain Fabre

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

5G is the next-generation cellular standard by the 3rd Generation Partnership Project (3GPP). The standard targets maximum downlink and uplink throughputs of 20 Gbps and 10 Gbps respectively. Latency is as low as 4 milliseconds in a mobile scenario and can be as low as 1 millisecond in ultra-reliable low-latency communication scenarios, and massive scalability. New system architecture includes core slicing as well as wireless edge.

Why This Is Important

5G is key for industry digital transformation, with 162 operators rollouts (Source: GSA, April 2021), 20% of mobile networks (up from 9% one year ago). 3GPP 5G standards releases deliver incremental functionality:

- R15: Extreme mobile broadband
- R16: Industrial IoT (massive IoT, slicing and security
- R17: MIMO enhancement of MIMO, Sidelink, DSS, IIoT/URLLC, bands up to 71GHz, nonterrestrial networks and RedCap
- R18: Under definition

Business Impact

- Material impact on multiple industries and use cases by enabling digital transformation.

- 5G enables three main technology deployment and business scenarios, which each support distinct new services, and possibly new business models (such as latency as a service), namely enhanced mobile broadband (eMBB) supports high-definition video, mMTC supports large sensor and IoT deployments, and URLLC covers high-availability and very low-latency use cases, such as remote vehicle/drone operations.

Drivers

- Increasing device penetration: Gartner estimates that 5G-capable handset penetration will reach 87% in 2023 in Western Europe, similar to North America.
- Operational cost savings for industry use cases.
- Agility — in particular, in oil and gas and manufacturing.
- Requirements from industrial users value 5G lower latency from ultra-reliable and low-latency communications (URLLC) and expect 5G to outperform rivals in this area.
- Demand for massive machine-type communications (mMTC), to support scenarios of very dense deployments up to 5G target of 1 million connected sensors per square kilometer.
- Increased availability of industry-specific spectrum options (e.g., CBRS).
- mMTC addresses the massive scale requirements of IoT.

Obstacles

- Availability of spectrum, in particular for industrial private networks, in some countries.
- Security concerns over certain vendors, and when using 5G in critical industrial scenarios.
- Readiness of R16 solutions; availability and pricing of networks and modules.
- Use of higher frequencies and massive capacity requires very dense deployments with higher frequency reuse.
- Uncertainty about use cases and business models that may drive 5G for many CSPs, enterprises, and technology and service providers (TSPs).

- Different dynamics by regions: where in many parts of Africa for example, 5G would not be the next step up from lower bandwidth services, and handset cost may be an inhibitor for lower-income subscribers. Adoption is more aggressive in APAC and NAR, with Europe cautiously enthusiastic — and the developing world lagging.
- Feedback from some industrial clients mentioned that the majority of their use cases could be serviced by a 4G private network, and/or NB-IoT and other LPWA such as LoRa.

User Recommendations

- Enable a diverse network that can offer adequate and cost-effective alternatives to 5G for many use cases (e.g., LPWA, NB-IoT, LoRa, Wi-SUN).
- Enable 5G for temporary enterprise connectivity, mobile and FWA secondary/tertiary use cases for branch location redundancy, as long as 5G is not the primary link for high-volume or mission-critical sites, unless there are no other options.
- Provide clear SLAs for network performance by testing installation quality for sufficient and consistent signal strength, signal-to-noise ratio, video experience, throughput and coverage for branch locations.
- Ensure backward compatibility to 4G devices and networks, so 5G devices can fallback to 4G infrastructure.
- Focus on architecture readiness — such as SDN, NFV, CSP edge computing and distributed cloud architectures, and end-to-end security — in preparation for 5G.
- Build their ecosystem of partners to target industry verticals more effectively with 5G.

Sample Vendors

Cisco; Ericsson; Huawei; Mavenir; Nokia; Qualcomm; Samsung; ZTE

Gartner Recommended Reading

U.S. Telco 5G Plans Take Shape

Emerging Technologies: 5G Technology Spending, 2020 Survey Trends

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

Market Guide for 5G Network Ecosystem Platform Providers

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

Public Transit Blockchain

Analysis By: Ivar Berntz

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Blockchain is a distributed ledger technology with irrevocable, yet publicly traceable, transaction records. In public transportation, recent use-case ideas often involve multipart transactions, like mobility as a service, intermodal commute payments, toll collection, or spare parts origination and usage tracking.

Why This Is Important

Distributed ledgers like blockchain are becoming increasingly necessary to address public transportation provider requirements. Benefits include the following capabilities:

- Digitizing transactional contracts
- Event tracking
- Capacity optimization and matching
- Authentication of payments or source-to-usage goods

The position of this innovation profile reflects continued interest in, but decelerated momentum for blockchain initiatives across the transportation sector.

Business Impact

Blockchains matter because they allow nontrusting members of a transaction to interact in a verified way, without the need for a trusted intermediary. It provides for easy, traceable data exchange with secure confirmation of operations, and in peer-to-peer transactions. For instance, a payment could be done via a mobility-as-as-service app to the transportation provider(s) directly from the bank account of the traveler, saving money on commissions while increasing speed.

Drivers

- Blockchain is a strong enabler to a fully holistic, open data ecosystem in transportation as all parties would easily exchange information with trust and traceability, while protecting data deemed private or confidential.
- Expectations and demands from consumers paralleled with the increasing need for digitalized networks will increasingly shape and influence future applications for blockchain. There is already a demand for more collaborative and orchestrated delivery of products, assets and services. For example, integrated ticketing for trip chains composed of various service providers, like one per leg, using automatic, tamper-proof and transparent accounting procedures, could realize significant business improvements.
- Large cities, with taxis, buses, rental cars and light rail, among others, require every traveler to be individually registered with each of these services. A blockchain platform can unite all transport stakeholders under one trusted application. This means that the onboarding and validation process of user information will be the same for all the mobility services offered. Additionally, users can use biometrics for the validation process, if desired, to pay securely and receive a consolidated invoice.
- Early collaborators and adopters will gain a competitive advantage. However, because of the multienterprise nature of blockchain use cases, public transportation may get wrapped up into broader initiatives involving private and public actors.
- Early hype has been focused on financial transactions, but given competition, it is likely that contract management will see increasingly higher volumes of adoption, albeit at slower rates.

Obstacles

- As other overhyped innovations, supporting tools, like blockchain platforms are still unproven. Resources and expertise to develop, maintain and govern blockchain systems are lacking. Multiple use cases for blockchain across public transportation are yet to be proven and several alternatives for some of the issues it solves already exist. For example, multiple transport companies use the Oyster Card in London.
- Public transportation organizations are normally risk averse. Blockchain will require cultural shifts focused on shared value creation, trust and consensus across all levels of the business. Protocols must be established for secure transactions and governance mechanisms for the blockchain ecosystems.
- Solution adoption and cadence could be dependent on how regulators demand interdependent process steps and verifications across digital and physical transactions during high-risk or critical stages of transportation, insurance or maintenance.

User Recommendations

- Evaluate if this is the right moment and initiative for your organization given its strategy by discussing the risks involved in this process with your peers.
- Establish or join a dedicated working group or consortium to accelerate the deployment of blockchain in your operations.
- Educate your peers and co-workers, recognizing that the terminology surrounding blockchain across transportation is in flux and in need of more granular and broader interpretation, especially between public and commercial transportation use cases.
- Identify specific high-risk transportation routes or markets that exhibit transactional complexity or have exhibited variable or low levels of service. These are prime candidates for blockchain.
- Assess blockchain's ability to map and execute across specific transportation use-case criteria and risks — such as location, status and ownership — and its planned timing and positioning across your strategy technology roadmaps.

Sample Vendors

BiTA; DOVU; Fleetio; Omnitude; Tencent; Vottun; Whim

Gartner Recommended Reading

Supply Chain Brief: Industry Consortia to Drive Education and Standardization of Blockchain in Transportation

Toolkit: Accelerate Your Blockchain Technology Competency Across the Supply Chain

Top 10 Strategic Technology Trends for 2020: Practical Blockchain

Blockchain Technology Spectrum: A Gartner Theme Insight Report

Intelligent Traffic Management Systems

Analysis By: Venecia Liu

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Intelligent traffic management systems are advanced systems to manage traffic flow. They incorporate infrastructure sensor data, camera data and vehicle data, together with data on traffic lights and the surrounding environment in real time, to automatically adjust traffic flow based on road conditions and context of the traffic situation. Intelligent traffic management systems also take into consideration safety, efficiency, vehicle speed, air quality, congestion and vehicle routes.

Why This Is Important

Intelligent traffic management systems can improve the traffic congestion of a city center. Optimizing traffic flow with the use of intelligent traffic systems may also reduce commute time, subtly enhancing drivers' emotional well-being and perceived quality of life. Intelligent traffic management systems using edge computing, AI-based cameras, IoT sensors and real-time data can inform and adjust traffic signal lights in near real time to react to a given situation.

Business Impact

Government agencies are recognizing additional benefits for using intelligent traffic management systems as a new source of revenue, such as dynamic pricing and tolling. Using intelligence from intersection cameras enables law enforcement to use this data for driving violations (such as not wearing a seatbelt or talking on mobile devices while driving). Adjusting of traffic signal lights can assist with first responders getting to their required destination in a safer manner.

Drivers

- Intelligent traffic management systems improve traffic flow to provide a better experience for residents.
- Intelligent traffic management could provide additional revenue sources for highway agencies considering it for dynamic pricing to enable single drivers in high-occupancy vehicles (HOVs), or by adjusting pricing based on time of day or during peak holiday traffic.
- Public safety can be enhanced with intelligent traffic management via tracking illegal driver behavior with those using video images.
- Some of these intelligent traffic management systems have better design configurations, utilizing technologies to eliminate the electronic toll infrastructure and gantry with infrastructure at the side of the road to further reduce setup costs.
- Traffic management with edge computing done at the traffic light intersections can analyze patterns of driving violations and send the relevant information to central operations. Faster processing and lower cost have enabled smaller boxes to do powerful calculations to enable traffic management systems to become more advanced and sophisticated.
- Traffic light synchronization has been implemented for many years, but intelligent traffic management systems avail multiple sources of data to analyze and automatically take action in real time.
- Improvements in the systems should reduce the physical infrastructure road requirements.

Obstacles

- Many cities have implemented a traffic management system so the additional cost to migrate to an intelligent system could be cost-prohibitive.
- CIOs without an "intelligent connected infrastructure" vision to see data benefits garnered from intelligent traffic management systems will not have the foresight to push forward with system implementation.
- Privacy concerns with using AI-based cameras in some jurisdictions will also pose challenges.
- The ideal state of adjusting traffic lights to enable emergency vehicles to quickly maneuver the city streets will only be possible if different municipal government agencies work together to enable data to be pulled together into the traffic management systems. This would require coordination of and participation across multiple agencies and other entities in the wider ecosystem, such as transport agencies working with public safety, health and human services, and hospitals/emergency vehicles.

User Recommendations

- Establish a broader view for how traffic data can provide additional insights to other government agencies and divisions.
- Examine additional revenue potential of intelligent traffic management system use cases and potential business models that can be explored with dynamic pricing and data monetization.
- Create benchmark data on before-and-after implementation to use as justification for expansion areas.

Sample Vendors

Advantech; Cisco; Efftronics; Huawei; IBM; INRIX; Kapsch Group; Panasonic; SCATS; Siemens

Gartner Recommended Reading

2021 CIO Agenda: Global Perspectives for Transportation

Cool Vendors in AI in Automotive and Smart Mobility

Market Guide for Transportation Mobility

Biometrics in Aviation

Analysis By: Ivar Berntz, Venecia Liu

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Biometrics in aviation use unique biological or behavioral traits to corroborate a person's claim to an identity previously established to obtain access to an electronic or digital asset, e.g., gate access or immigration status.

Why This Is Important

Biometric methods in aviation, once used solely for immigration e-gates, have grown to encompass self-service baggage drops, airline lounge access, airport security access and boarding of aircraft using facial recognition, fingerprints and even retinal scan. Biometric techniques have demonstrated the ability to efficiently and quickly verify a person's identity.

Business Impact

- Beginning with the pandemic, airlines started to utilize facial recognition and gesture-based technologies to eliminate touch-based biometrics.
- Biometric-based identification is difficult to falsify and, additionally, can speed up the process of onboarding passengers, airline and airport employees.
- Concerns about privacy, personal data capture and storage by airlines, cross-border collaboration, surveillance, and monitoring move the profile into the Trough of Disillusionment.

Drivers

- Biometrics, in the form of facial recognition, addresses an important post-COVID-19 concern: touching the same touchscreen interfaces as others who might unknowingly be contaminated, as well as handing over documentation back and forth across multiple parties.
- While many airports are facing financial setbacks to further invest, new airport builds are considering facial recognition in their seamless passenger journey vision.
- The technology is typically used in one-to-one comparison mode (biometric verification) to support an implicit or explicit identity claim.
- Efforts to make travel more quick, efficient and seamless could be aided by biometric identification.
- Adoption and proof of efficacy in some countries, such as China, could help to speed it in areas that have not adopted it yet.
- Eventually, the technology will evolve to be used in one-to-many search mode (biometric identification) — where a person simply presents a biometric trait and the system determines the identity from a range of candidates.

Obstacles

- There is a balance between creating a seamless passenger experience, by eliminating bottlenecks where passengers would have to queue for a long time, and privacy regulations.
- Some citizens have raised concerns about privacy, personal data usage by the airline (when those are used to authenticate boarding or other services), cross-border collaboration, surveillance and monitoring.
- Collecting passenger information requires regulatory compliance on data ownership, data storage, data retention, data security and data vulnerability.
- The cost of implementing this technology and creating and maintaining a new database of biometric features will likely restrain its growth.

User Recommendations

Transportation CIOs should:

- Reevaluate the use of biometrics facial recognition from a touchless standpoint while balancing data privacy.

Data and analytics leaders should:

- Review how biometric data should be handled and stored. Architectures differ in privacy-relevant data security concerns, but the architectural choices cannot avoid general regulatory requirements set out in the EU General Data Protection Regulation (GDPR) and similar privacy mandates. Under GDPR, Biometric data is another form of sensitive data.

Sample Vendors

Cognitec Systems; Materna IPS; NEC; Safran; SenseTime; SITA; Thales (Gemalto); Vision-Box

Gartner Recommended Reading

Invest in Hands-Free Technology to Encourage Customer Visits Postpandemic

Top Trends in Government for 2021: Citizen Digital Identity

Market Guide for User Authentication

Technology Insight for Biometric Authentication

Three Biometric Authentication Risks You Can't Ignore

Smart City Transportation Strategy

Analysis By: Pedro Pacheco, Bill Finnerty

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Smart city transportation strategy defines goals for a sustainable and holistic technology and data exchange collaboration between different transportation- and mobility-related urban ecosystem stakeholders. This collaboration includes a variety of mobility, local transport, parking and new last-mile logistics applications.

Why This Is Important

A transportation strategy can help cities address fluctuating mobility and transportation requirements of urban ecosystems, especially during postpandemic recovery. For instance, while public transport is often coping with less passengers and more individual journeys, last-mile logistics is booming in different form factors, like drones and e-bikes.

Business Impact

A smart city transportation strategy supports a future-proof investment plan for governments in parking, street and intersection domains, together with the designation of carriers for passengers in public transport. It takes into consideration congestion and travel velocity for commuters, logistics, tourism and other travel forms. Data platforms and analytics will be key to develop sustainable and carbon-neutral transportation options, as well as social and equitable mobility concepts.

Drivers

- Smart city transportation strategy is approaching the Trough of Disillusionment. Urban ecosystems and local governments have realized the need for a revised comprehensive postpandemic approach as mobility and transportation behavior will affect investment strategies. However, a certain lack of strategic planning capabilities from a number of transit agencies will lead smart city transportation strategy to dip into the Trough of Disillusionment before it can reach the Plateau of Productivity and an advanced level of maturity.
- These local governments have also started to address themes like spatial planning, data sharing and management of solutions. For instance, several cities are starting to take steps toward the creation of their own mobility as a service (MaaS) ecosystems and platforms. This is a decisive step toward the deployment of a fully integrated mobility strategy in a user platform. In some cases, there are also projects to build an open data ecosystem encompassing the entire transportation ecosystem — something that can provide major future benefits by enabling an overall improvement of transportation at several different levels.
- Cities are dealing with increasingly complex problems — like congestion and pollution. These highlight the growing need for technology investments — in transportation and other areas — as a way to solve these complex problems. These demand advanced planning and technological foresight, both incorporated into a smart city transportation strategy.

Obstacles

Local transit authorities with the power to develop smart city transportation strategies usually encounter the following obstacles:

- Limited know-how or skepticism hinders transit planners when defining long-term investments into innovative transportation technologies.
- Changes in political power sometimes create a problem of continuity for the fulfillment of a long-term strategy.
- Local transit authorities often cannot define long-term targets or KPIs that are specific, measurable, attainable, relevant or time-bound. As such, this generates major obstacles in defining a clear strategic course.

User Recommendations

- Set the policies and governance to enable a transportation open data ecosystem. This will enable, later on, major gains in terms of transportation planning and an overall improvement of transportation services.
- Ensure your smart city transportation strategy assesses the impact of these socioeconomic changes and defines appropriate action. COVID-19 will bring permanent changes to cities, like people moving out of urban centers due to remote work.
- Develop an overall transportation strategy around specific, measurable and time-bound targets. This will make it easier to choose the right technology to enable reaching those targets. Focus on KPIs and other references like ISO 37120 or ITU-T.
- Build a technology radar to provide visibility of all major transportation technologies coming up in at least the next10 years. This enables a greater understanding on how technology can best help your organization fulfill its smart city transportation strategy.

Sample Vendors

MaaS Global; Mott MacDonald; Optibus; PTV Group

Gartner Recommended Reading

COVID-19 Scenarios for Automotive and Transportation CIOs

3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively

Use Scenarios to Plan for the Future of Mobility 2025: The Scenarios

Mobility-as-a-Service Platform

Analysis By: Pedro Pacheco

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

Mobility as a service (MaaS) is a platform that provides users seamless availability, planning and booking of different means of transportation — vehicles, boats, bikes, scooters and other transport modes — to go from A to B. Supporting systems enable providers to efficiently serve travelers by providing intelligent, real-time, context-aware data exchange and service offerings between operators, passengers, assets, routes, timing and traffic patterns.

Why This Is Important

A MaaS platform is a major factor in reducing congestion by providing a door-to-door solution that puts together all forms of mobility and public transport. It allows public transport to offer a better service to its customers while, at the same time, being able to reduce costs and, in some cases, emissions. MaaS also offers an opportunity to collect more data that can be used to better respond to travelers’ needs.

Business Impact

A MaaS platform, when properly developed and managed, can contribute to reducing congestion, emissions and public costs. It achieves that by offering travelers greater convenience in terms of door-to-door travel, hence providing a strong alternative to a personal car. As such, it represents a major tool that local, regional and even national governments can leverage to achieve emissions targets and reduce costs with road infrastructure.

Drivers

- The pandemic has created in travelers the need to diversify means of transportation as well as get a clearer picture in terms of transport availability and capacity. Transportation providers, on the other hand, need to build greater visibility into the needs of travelers, as their routine has, in many cases, been permanently affected by the pandemic due to remote work.

- It is often hard for transit agencies to adequately respond to the needs of all travelers only through mass transit. This strengthens the need for a combination of mass transit and shared mobility. In some cases, this is even valid at regional and national levels, as large transit operators need to team up with transit agencies and shared mobility providers in order to enable a more holistic and convenient door-to-door transportation solution.

- Benefits can be derived by leveraging contextual information about residents, businesses and mobility needs mapped against real-time data such as time of day, number of vehicles and travelers, pricing of road traffic per time of day and user/environmental impacts. That could include pollution, noise, productivity and environmental quality. These services are also being integrated with public transportation, providing subsidized, on-demand rides in areas where regular service is not practical.

Obstacles

- Transit authorities have been sluggish in defining rules and governance for MaaS, and in taking the first step to form an MaaS ecosystem.
- Some mass transit players have an old infrastructure from the connectivity standpoint, which makes it hard for MaaS to operate at its full potential, due to limitations in data collection and exchange.
- Some providers are not embracing a spirit of cooperation, trying to protect their “territory” and not sharing any data with other transportation players in the ecosystem.
- COVID-19 is heavily impacting passenger volume on public transport and taxi or ride-hailing services. This can slow down the investment in MaaS solutions in the near future.
- While MaaS can improve the transportation of people from door to door, in some cases it can also trigger a move of users from mass transit to personal shared mobility (car sharing, ride hailing). If the move reaches a certain proportion, this could generate higher emissions and congestion.

User Recommendations

For transit agencies:

- Set up a data ecosystem and data governance in order to make sure there aren’t any barriers to data sharing with all stakeholders involved in the ecosystem, either public or private.
- Use MaaS as a key tool to bring commuters back to public transit by reassuring a low risk of infection and providing a mobility solution that is more in line with the needs of people embracing remote work or a hybrid situation.

For MaaS platform providers:

- Build partnerships in order to grow MaaS ecosystems from urban to region or even national.
- Expand into last-mile delivery as a key area for expansion of MaaS ecosystems.

For mobility/transit operators:

- Expand MaaS ecosystems into regional or even national ecosystems.
- Use MaaS as a way to provide transportation in a more flexible, on-demand way.
- Use MaaS to offer travelers a clearer picture of the carbon footprint for each option they choose.

Sample Vendors

MaaS Global; Moovit; Trafi; Transit

Gartner Recommended Reading

3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively

2021 CIO Agenda: Global Perspectives for Transportation

Use Scenarios to Plan for the Future of Mobility 2025: The Scenarios

What CIOs Need to Know About Micromobility

Shared Mobility

Analysis By: Mike Ramsey

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Shared mobility encompasses the use of ride-hailing or other on-demand mobility models that manage the pickup and drop-off of customers, primarily through a mobile application. These platforms often offer cars, but could offer bikes, scooters, boats and even helicopters.

Why This Is Important

Shared mobility has fundamentally created an entirely new channel and methodology for travel and for the use of transportation assets. By creating an IoT platform that can schedule, book, route and manage payment of travel, consumers have lower-cost options to get around in urban areas, and drivers are more able to use their vehicles to make money. In addition, these same platforms have been leveraged to offer micromobility services, such as floating bikes or e-scooter shares.

Business Impact

Shared mobility — primarily through Uber and other ride-hailing platforms — has had a huge impact on transportation, which is likely to continue. Although the model suffered in 2020 after the onset of lockdowns, usage has snapped back. Shared mobility has created new ways of getting around in urban areas, but its impact hasn't been all good. Traffic in city centers has sometimes increased as people have traded walking, riding public transportation and biking for inexpensive ride-hailing.

Drivers

- The end of the COVID-19 pandemic will have a significant positive impact on shared mobility as people return to work in urban centers and begin to do more entertainment and travel, which helps to increase shared-mobility usage.
- Shared mobility may be positively affected by the rise in electric vehicles as their price drops. In addition, the cost of operating ride-hailing cars should fall as more vehicles use electricity rather than fuel. This also could also reduce pollution concerns in urban centers where the increase in traffic from ride-hailing initially raised concerns.
- The rise of autonomous vehicles (AVs) could also increase shared mobility because the AV is ideally suited to perform mobility services.

Obstacles

- The economics of shared mobility have always been a problem. Many shared mobility platforms have been unprofitable, and it is difficult to see an easy path toward profitability.
- Changes in culture around working from an office versus at home, as well as the uncertainty around when the pandemic will recede, could impede shared mobility.
- Laws in certain regions that require ride-hailing providers to be considered employees or limit them against taxi operators may change the structure of the primary companies offering services and make it more difficult to expand.

User Recommendations

- Look for ways to connect these services into a holistic transportation strategy, enabling payment or scheduling options that complement public and private transportation options.
- Be wary of investing in, or connecting with, services that skirt city regulation, because the services could quickly be frozen out for an individual town.
- Create transportation plans as a means to improve traffic congestion, to address pollution concerns and to even provide lower-cost transit.
- Look for ways to use shared mobility to provide transportation options for people who feel uncomfortable in public transportation as a result of the pandemic or who aren't able to use public transport, like the elderly.
- Set up data exchanges for mobility and related ecosystem datasets that can be combined for new services on last-mile logistics, as well as adjacent service potentials in touristic, health and insurance business sectors for CIOs working for industrial and commercial clusters and real estate development.

Gartner Recommended Reading

Smart City Funding Models: It's Time to Be Creative

Turning Smart Cities Into Intelligent Urban Ecosystems

Market Trends: 5 Smart City IoT Deployment Trends to Drive Innovation Opportunities

3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively

Autonomous Vehicles

Analysis By: Jonathan Davenport

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Autonomous vehicles use various onboard sensing and localization technologies, such as lidar, radar, cameras, GPS and map data, in combination with AI-based decision making, to drive without human intervention. While self-driving passenger cars are getting most of the attention these days, the technology can also be applied to vehicles that transport goods.

Why This Is Important

Autonomous vehicles have the potential to change transportation economics, cutting operational costs and increasing vehicle utilization. In urban areas, cheap fares and high quality of service may cannibalize private car ownership. Road safety will also be increased as the AI systems will never be distracted, drive drunk or speed. Autonomous features on privately owned vehicles enable productivity and recreational activities to be undertaken, while the vehicle handles the driving operations.

Business Impact

- Autonomous vehicles have the potential to disrupt established automotive business models.
- Technology companies are building high-performance computers on which to run their self-driving software platforms.
- After the office and home, vehicles will become a living space, like airplanes, where digital content is both created and consumed.
- Over time, staff members currently undertaking driving roles must be retrained and redeployed to other, higher-value-adding roles within the company.

Drivers

- Some progress is being made toward autonomous vehicle regulations and standards. Automated lane-keeping system (ALKS) technology has been approved by the United Nations Economic Commission for Europe (UNECE). This forms the first binding international regulation for SAE Level 3 vehicle automation, with a maximum operational speed of 37 mph. Likewise, the German government aims to enact laws that enable autonomous vehicles to operate without special permits by 2022. Companies like Intel, Waymo and Aurora are working on the IEEE 2846, which will create a standard that describes the scenarios to be considered when developing autonomous road-safety-related models.

- To take advantage of the new regulatory landscape, automakers are beginning to announce Level 3 solutions. These autonomous vehicles provide drivers with safety and convenience features, reduce vehicle fuel consumption and improve traffic management. Honda is the first company to announce a commercially available Level 3 vehicle, though only 100 will be produced.

- Improvements are also being made to the perception algorithms and broader self-driving systems for Level 4 vehicles that will operate as robotaxis. Fully driverless operations have started, with Waymo operating in Arizona and WeRide operating in California without safety drivers. The flexibility of vehicle operational design domains (ODDs) has been showcased — e.g., Mobileye's perception algorithm required minimal additional training when it tested vehicles in new locations. Mobileye has developed its self-driving software on the roads in Israel, but showcased its autonomous technology in both Munich and Detroit. Likewise, Yandex has made great strides, showcasing how its autonomous vehicles are capable of handling the harsh weather conditions of winters in Moscow.

Obstacles

- Designing an AI system that is capable of driving a vehicle is hugely complex. As a result, the cost of bringing a commercial autonomous vehicle to market has been greater than companies could have previously envisioned. This has required significant investments to be made in companies. Acquisitions have occurred, and further market consolidation is expected — e.g., Walmart has invested $2.75 billion in Cruise; Cruise acquired Voyage in March 2021; Aurora acquired Uber's ATG in December 2020; Amazon acquired Zoox for $1.2 billion in June 2020; Apple bought self-driving startup Drive.ai in June 2019.
- When autonomous vehicles are commercially deployed, autonomous vehicle developers, not the human occupants, will be liable for the autonomous operations of the vehicle. This raises important issues, should a vehicle be involved in an accident.
- Challenges increasingly include regulatory, legal and societal considerations, such as permits for operation and the effects of human interactions.

User Recommendations

Governments must:

- Craft national legislation that ensures that autonomous vehicles can safely coexist with an older fleet of nonautonomous vehicles.

Autonomous mobility operators should:

- Support consumer confidence in autonomous vehicle technology by remaining focused on safety to deliver on the vision of an accident-free road environment.

Self-driving system developers should:

- Seek out use cases, such as mining, agriculture or airports, where autonomous vehicles can operate in restricted areas safely without regulatory restrictions. Use these implementations to drive early revenue and gather data and insights to improve the performance of self-driving systems.

Traditional fleet operators looking to adopt autonomous technology into their fleets should:

- Minimize the disruptive impact on driving jobs (bus, taxi and truck drivers) by developing policies and programs to train and migrate these employees to other roles.

Sample Vendors

Baidu; Cruise; Mobileye; Waymo; Yandex; Zoox

Gartner Recommended Reading

Market Trends: Monetizing Connected and Autonomous Vehicle Data

Forecast Analysis: Autonomous Vehicle Net Additions, Internet of Things, Worldwide

Utilize Partnerships to Secure a Winning Position in the Autonomous Driving Ecosystem

Market Insight: Use Situationally Aware Platforms to Enable Safe Autonomous Vehicle Handovers

Tech Providers 2025: Product Leaders Must Strategize to Win in the Evolving Robotaxi Ecosystem

Climbing the Slope

Self-Service Technologies

Analysis By: Ivar Berntz

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

Self-service technologies encompass interactive computer terminals, such as kiosks, featuring specialized hardware and software, or user devices like smartphones and watches, that access information and perform tasks. The kiosks are typically located in either high-traffic areas, such as airports, hotels, rent-a-car stations, theme parks, malls or restaurants to expedite processes, or places where having personnel isn't economically justified.

Why This Is Important

Although self-service technologies have been widely deployed globally and are at a mature stage, the COVID-19 pandemic accelerated the demand for touchless interactions like voice, gestures or biometrics. As 2021 progresses, users will increasingly be able to choose how to interact with product and service providers, i.e., in person, virtually or a combination of both (a hybrid, total experience).

Business Impact

COVID-19 has made in-person interactions less appealing to people. Simultaneously, new uses of existing technologies have made it easier to implement self-service, touchless stations. Contactless biometrics, gestures or app communications for various use cases like airplane boarding, car rentals, etc., are making self-service more popular. However, these new services and locations also require extensive testing and capital investments.

Drivers

- Self-service technologies are a winning proposition for customers and companies alike. They transfer the burden, and the cost, of executing various tasks from product/service providers to customers, who in turn get more control over making choices at their own pace.

- With extended sanitary precautions, social distancing requirements and thorough cleansing due to COVID-19, this innovation evolved to offer more options for touchless user interactions.
- In transportation, touchless technologies are important to establish public trust by making travelers feel more secure, with less risk of contamination by others.
- Human-machine interfaces (HMIs) are already able to leverage virtual, augmented and mixed reality, allowing customers to avoid touching physical elements, such as a touchscreen. Touchless kiosks, while being a customer touchpoint, need to be seen as part of a broader trend that transcends channel thinking, such as multichannel or omnichannel. These touchpoints allow for multiple modalities of interaction, like touch, voice, vision or gesture — in effect, a “multiexperience” journey for customers.
- Use cases for self-service channels continue to expand and range from enabling customers to order groceries or apply for a job, to retrieve data (e.g., schedules) and interact with sales (e.g., seat/room selection or check-in). Customers can also get access to upsells and cross-sales of goods or services (e.g., upgrades), verify identity, check for potential signs of illness (e.g., temperature, respiration, heartbeat), print out documents (e.g., boarding passes), etc.
- Touchless, self-service stations also have the added economic benefit of requiring even less maintenance than regular ones, as they do not get as dirty nor need to be substituted as often due to less abrasion.

Obstacles

- With travel restrictions being gradually relaxed in many geographies, we see deployment of touchless self-service options becoming less urgent.
- A balance between touchless interactions and human needs has to be found. Human beings, by nature, crave touch. Interacting with others, being able to physically touch products, feeding off the energy of others at live events — these needs will persist.
- Knowing which issues require live interaction and which do not — and quickly routing customers accordingly to the appropriate channel to gain the most rapid resolution — is key. There will always be instances when a customer needs to speak to a real person about an issue.

User Recommendations

- Start by studying various customer journeys to understand touchpoints and wait times.
- Target to reduce the need for in-person contact and for on-site or remote personnel performing repetitive, difficult-to-optimize, low-value-added tasks.
- Gauge optimal deployment of self-service stations, possibly augmented with smartphone-enabled services, to gain cost reduction and customer satisfaction benefits.
- Aim for a balance when using common use self-service (CUSS) kiosks to reduce both operating costs and space requirements at airports, versus the specific needs of companies' business model and customers. In future, CUSS will also most likely be touchless and incorporate biometrics, gesture control, voice recognition and additional thermal or humidity sensors.

Sample Vendors

Diebold Nixdorf; KIOSK Information Systems; NCR; Olea Kiosks; SITA

Gartner Recommended Reading

Deploying Best-in-Class Customer Service Across Self-Service and Assisted Channels

How the COVID-19 Pandemic Impacted Contact Volumes and Self-Service Migration

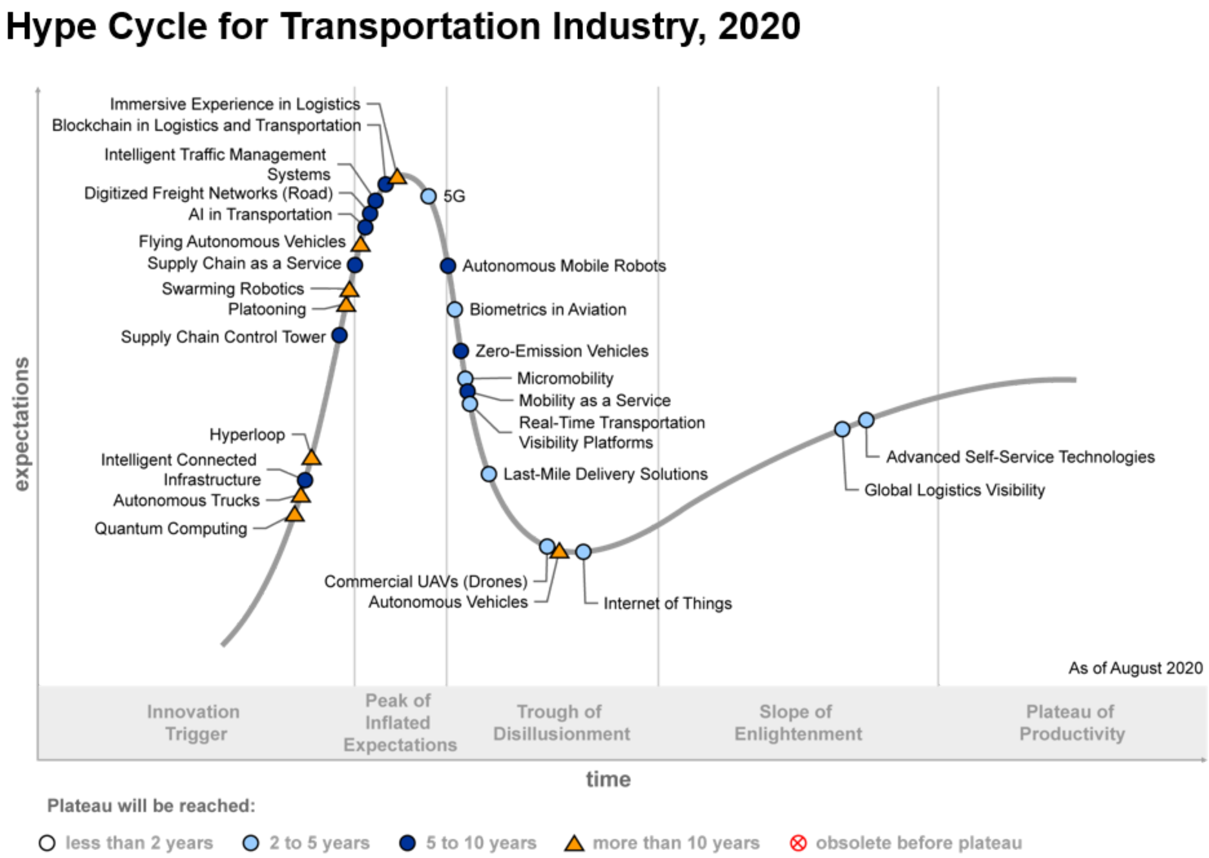
Improve Self-Service Adoption Through Search Engine Optimization

Interview: How LG&E and KU Reduced Call Volume Through Self-Service

Top Strategic Technology Trends for 2021: Total Experience

Appendixes

Figure 2. Hype Cycle for Transportation Industry, 2021



Source: Gartner
ID: 467939

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase ↓	Definition ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner

Table 3: Benefit Ratings

Benefit Rating	*Definition*
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels ↓	Status ↓	Products/Vendors ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner

Document Revision History

Hype Cycle for Transportation Industry, 2020 - 13 August 2020

Hype Cycle for Transportation Industry, 2019 - 29 July 2019

Recommended by the Authors

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Create Your Own Hype Cycle With Gartner's Hype Cycle Builder

3 Ways Transportation CIOs Can Shape a Mobility-as-a-Service Ecosystem Effectively

What CIOs Need to Know About Micromobility

2021 CIO Agenda: Global Perspectives for Transportation

Mitigate COVID-19's Impact on Public Transport With On-Demand Transit

Table 1: Priority Matrix for Transportation and Smart Mobility, 2021

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational			AI in Transportation	6G Autonomous Ships Autonomous Vehicles Commercial Space Travel Hyperloop Hypersonic Aircraft
High		5G Mobility-as-a-Service Platform Self-Service Technologies	Carbon Measurement Heavy-Duty EV Charging Hydrogen Transportation Intelligent Connected Infrastructure Smart City Transportation Strategy	Electric Aircraft Electric Ships Quantum Computing Optimization
Moderate		Biometrics in Aviation Intelligent Traffic Management Systems Shared Mobility	Public Transit Blockchain	Autonomous Urban Air Mobility Digital Twins in Transport Ion-Propelled UAVs On-Demand Aviation Trackless Tram

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Low				

Source: Gartner

Table 2: Hype Cycle Phases

Phase	*Definition*
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Phase	*Definition*

Source: Gartner

Table 3: Benefit Ratings

Benefit Rating	*Definition*
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner

Table 4: Maturity Levels

Maturity Levels ↓	*Status* ↓	*Products/Vendors* ↓
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner