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BRAINSHORING SERVICES

Mobility 2.0:
Connected, Autonomous, Sustainable

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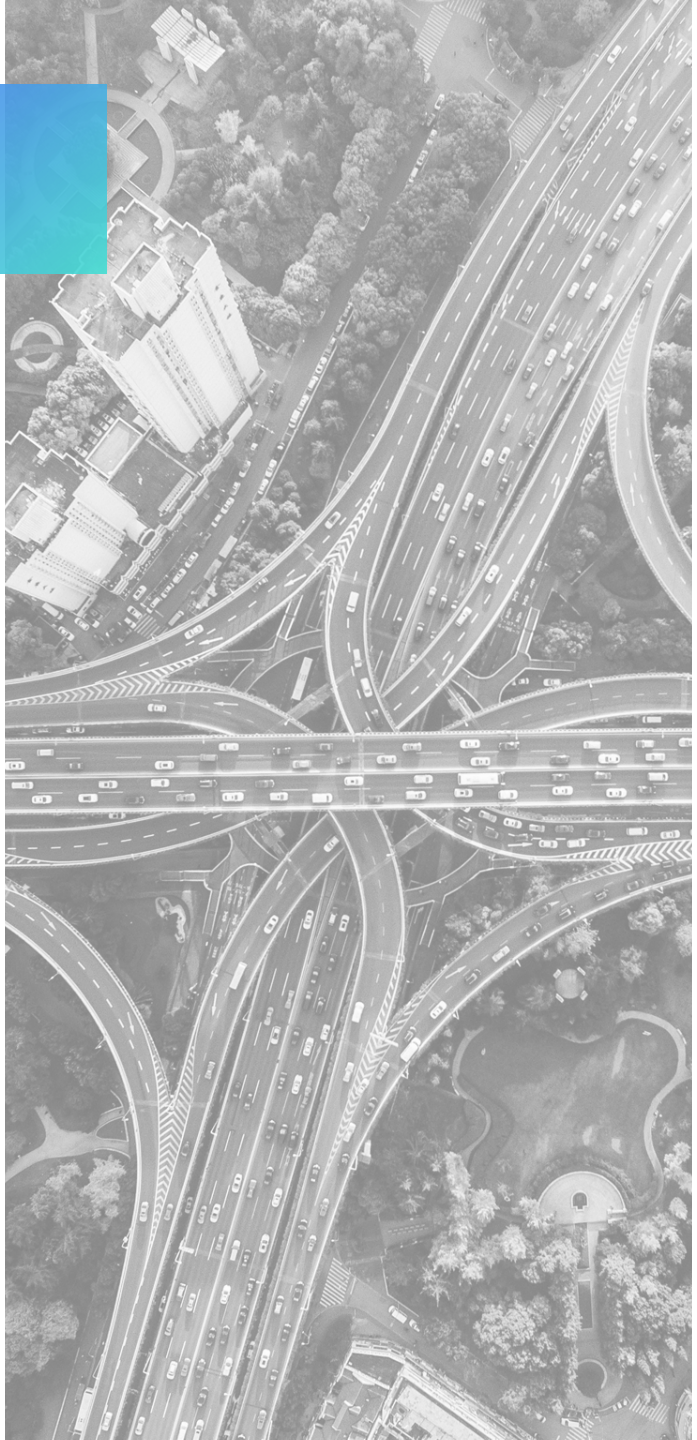


Introduction

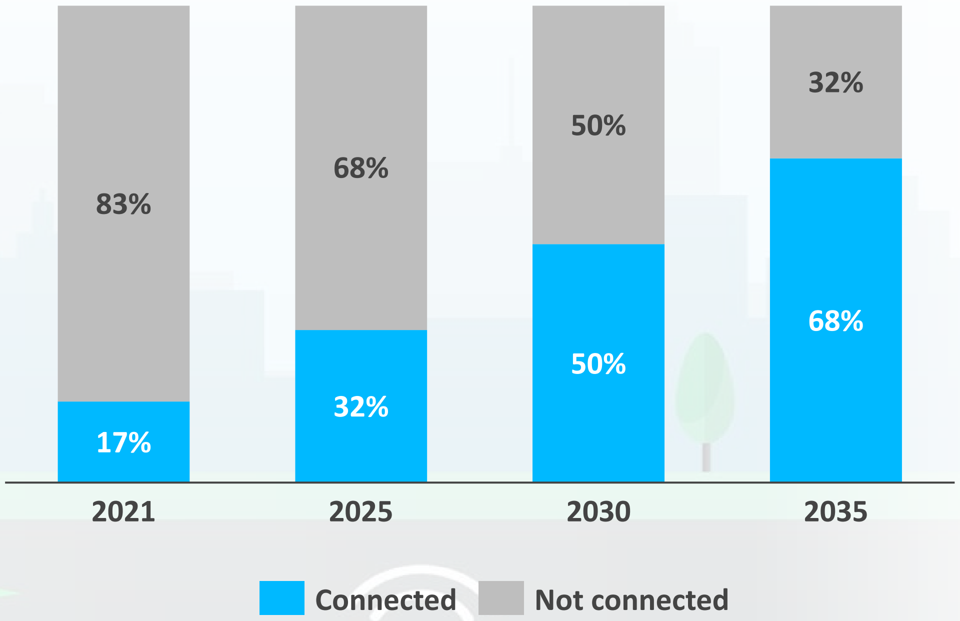
- Mobility is a realm in flux, constantly on the move. The past five years, have seen a complex mix of progress and challenges over the last five years. During this time, connectivity, autonomy, and sustainability have emerged as the defining trends that are reshaping the automotive, aviation, maritime, and railway industries:
  - **Connectivity:** digital connectivity has become an integral part of the mobility equation. Vehicles, aircraft, ships, and trains are evolving into data-rich hubs capable of real-time communication with each other and infrastructure. This shift goes beyond providing passengers with entertainment; it's about improving safety and efficiency.
  - **Autonomy:** Autonomy across the mobility sectors is advancing, albeit with some hesitance in the automotive industry. Semi-autonomous cars are undergoing rigorous testing, whereas autonomous drones and ships are transforming delivery logistics. The prospect of mobility instruments making complex decisions without human intervention carries both benefits such as better efficiency and accessibility and challenges like safety considerations and regulation hurdles
  - **Sustainability:** Mounting concerns about climate change are pushing the need to decarbonize in the mobility industries. Sustainability practices, whether in aviation's fuel efficiency, automotive's EVs, maritime's eco-friendly shipping solutions, or railway's smart rail systems, are not only essential but also a smart business strategy as consumer demand for eco-friendly options continues to grow
- This report provides an analysis of the latest developments and trends in transportation. It examines the current landscape, assesses its impact, identifies key drivers, and provides future projections for connectivity, autonomy, and sustainability in the automotive, aviation, maritime, and railway industries. Through rigorous research and analysis, this report aims to provide an overview of the opportunities in the transportation sector

Connectivity

Connectivity is transforming the automotive industry. By 2030, connected vehicles are expected to make up half of the global fleet

- **Automotive connectivity** has significantly **evolved over the past decade**. The rise of embedded connectivity is transforming the automotive industry, with most automakers embedding connectivity for critical functions like automated crash notification and remote control
- Connected cars present a shift in the automotive industry from the traditional focus on mechanical components to **advanced on-board systems, flexible connectivity, and infotainment to meet the demand for a seamless connected-car experience**
- The **share of connected cars in the global fleet** is expected to grow from an estimated **one-fifth in 2023** to about **half of the global fleet by 2030**
- In terms of new car sales, **a forecasted 95% of new vehicles sold worldwide will feature connectivity by 2030**, marking a significant increase from the current 50%
- 4G currently holds 90% of the connected car market, but 5G is expected to meet the need for seamless and faster in-vehicle connectivity due to industry trends towards electrification, software-defined vehicles, and autonomy
- The evolution of 5G is also enabling vehicle-to-everything (V2X) technology, allowing direct communication between vehicles, road infrastructure, external networks, devices, and other vehicles

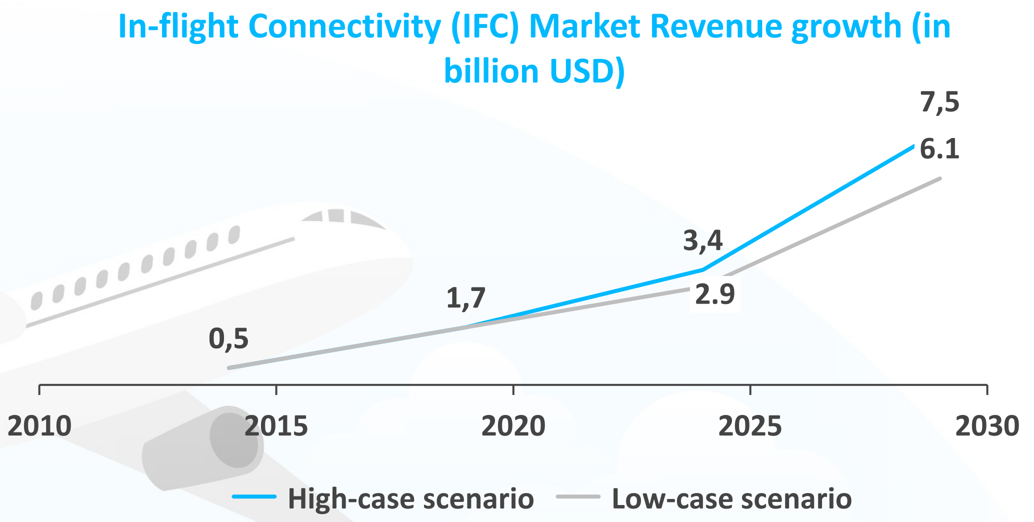
Share of car parc with internet access (%)

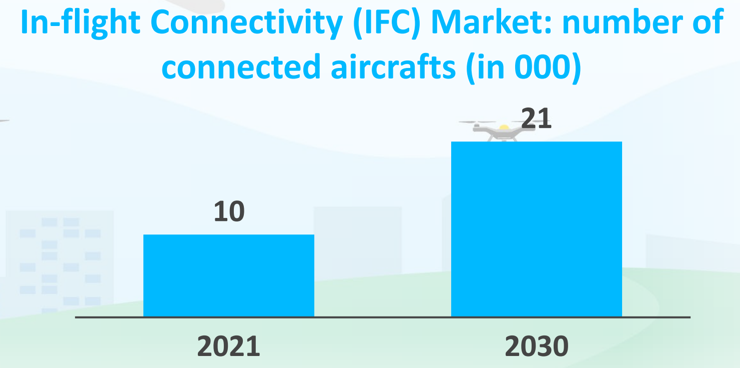


Sources: IBM – Connected cars "Connected cars" (2023), Mckinsey "Unlocking the full life-cycle value from connected-car data" (2021), BCG "As Automakers Transform, So Must Suppliers" (2023), Press search

Connected aircraft are expected to double by 2030, driven by the emergence of LEO satellites

- Airborne internet connectivity and communication services, known as inflight connectivity, have gained immense importance recently due **to rising passenger demand for fast and dependable connectivity while flying**
- **In 2021**, the number of **commercial aircraft connected to in-flight services** saw a 10% rise compared to 2020, reaching a total **of 9,900**
- **By 2030**, It is projected that this figure will double, **surpassing 21,000** aircraft utilizing these services.
- The promising outlook for in-flight connectivity is partly **thanks to Low Earth Orbit (LEO[1]) satellites**, positioned closer to Earth for faster data transmission
- **SpaceX's Starlink** is already providing high-speed onboard Internet, while **OneWeb** plans to offer in-Flight Connectivity by 2024, supported by its 648 LEO satellites





1 LEOs are earth-orbiting satellite placed 160 to 1000 km above Earth

Sources: IOP Conference Series “Enabling In-Flight Connectivity with the new Generation of Electronically Steered Antennas” (2023), Press search

In-flight connectivity using LEOs will enhance user experience, global coverage, and route adaptability

Key benefits of LEO In-flight Connectivity adoption

1 **Enhanced user experience and passenger loyalty**

- Lower latency in LEO-based IFC[1] services could transform in-flight experiences, offering an improved internet user experience and fewer service interruptions compared to traditional options
- This enhanced user experience can significantly enhance passenger loyalty. Airlines that invest in LEO-based IFC are well-positioned to retain and attract customers who prioritize connectivity during their flights

2 **Global coverage**

LEO constellations like OneWeb and Telesat Lightspeed offer unprecedented global coverage, including remote and polar regions where GEO systems fall short. This extended reach opens up new markets and opportunities for airlines to serve passengers worldwide

3 **Flexible capacity management**

LEO systems, with their flexible beam technology, can adapt to the dynamic demands of congested airport hubs, ensuring that passengers can start streaming and working as soon as they board the plane

4 **Sponsorship and partnership potential**

LEO IFC providers seek partnerships with entertainment and gaming firms to sponsor services, enabling airlines to provide innovative offerings. Additionally, they collaborate with aircraft companies, like Hughes and OneWeb, for high-speed, low-latency LEO in-flight Wi-Fi

5 **Evolving technology**

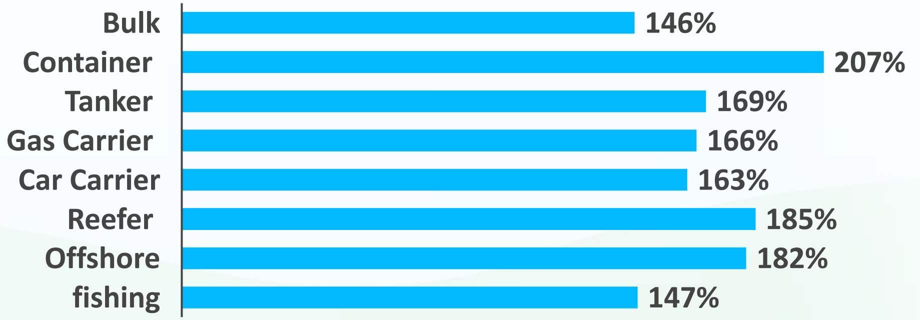
As advancements in antenna technology, like Electronically Steerable Antennas (ESAs), continue to mature, the feasibility and effectiveness of LEO IFC services will further improve, making them increasingly attractive for airlines

1 In-flight Connectivity (IFC) **2** GEOs are earth-orbiting satellite placed at an altitude of approximately 35,800 kilometers directly above the equator
Sources: Press search

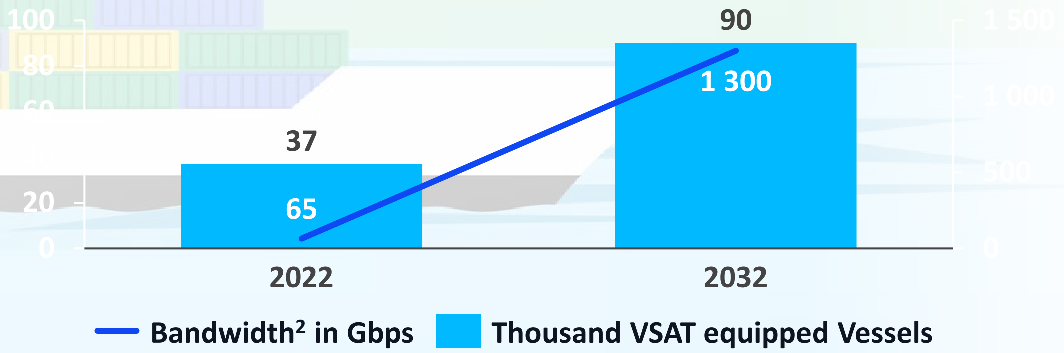
Maritime connectivity is expected to rise in the upcoming decade to meet the growing demand for more advanced features

- The future of connectivity in the maritime industry is promising, **driven by growing demand for data-intensive applications**. In fact, y-to-y **sea data usage** shows **growth** between June 2021 and June 2022, with container shipping leading the way with a 207% increase
- While business applications are driving the demand for data, the key driver remains crew welfare
- Hence, advanced satellite communications, like **VSAT**[1], are poised for **further growth in the coming years** to meet the rising demand for high-speed sea connectivity
- **VSAT-equipped vessels** are expected to grow to **90,000 in 2032**, indicating a CAGR of approximately 8.65% from 2022
- VSAT's expected impact includes **improved operational efficiency, higher crew welfare, and enhanced safety through real-time data access**
- Moreover, connectivity equipment and antenna manufacturers are currently focusing on developing **new VSAT terminals for LEO constellations and smaller vessels**, opening up satellite connectivity to new markets like fishing
- For instance, in 2021, Intellian and KVH introduced **V45c and V30 VSAT antenna equipment**, providing connectivity access to smaller vessels

Data Usage y-to-y growth (2021/2022) by type of ships



Forecasted number of Vessels equipped with VSAT



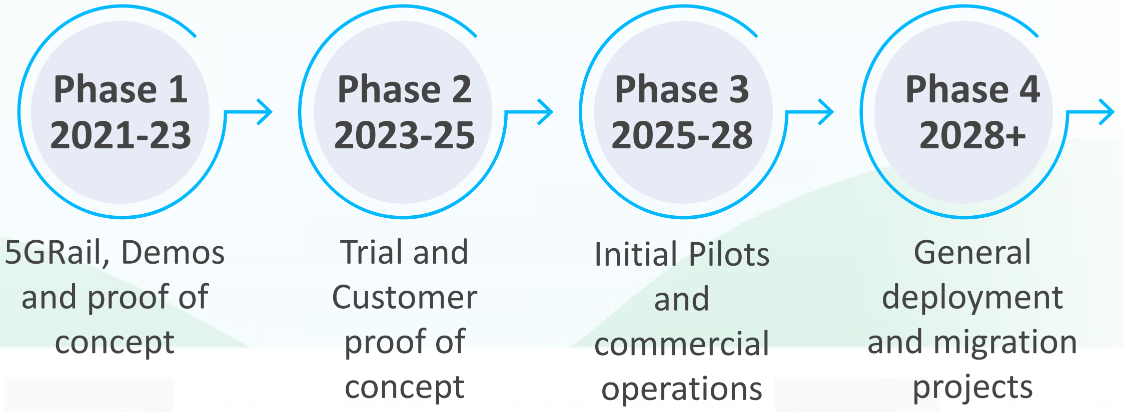
1 **Very small aperture terminal (VSAT)** is a small-sized earth station used in the transmit/receive of data **2** The maximum amount of data transmitted over an internet connection in each period

Sources: Asia-Pacific Satellite Communications Council "Maritime Services" (2022), Euroconsult, inmarsat, Intellian

In rail, the next-generation connectivity system is set to debut by 2030, enhancing rail operational efficiency

- **The increasing digitalization of railways** is driving the replacement of legacy systems with interconnected digital solutions, requiring high-bandwidth communication and cloud infrastructure.
- Currently, the GSM-R[1] technology, with over 230,000 km globally, is used for train-ground data transmission. It offers 2G+ connectivity, which is still suitable for today's data needs. However, it's nearing the end of its lifecycle, **facing obsolescence and limited data capacity compared to modern technologies**
- Hence, UIC is developing the **5G-enabled FRMCS[2], a separate network from the public 5G, as the next-generation mobile communication system** to replace GSM-R in railway environments by **2030**
- In September 2022, **Huawei introduced their FRMCS solution** during InnoTrans 2022 and **announced that it will collaborate** with industry standards organizations, customers, and partners **to advance its widespread commercial adoption**
- Its implementation will enable the **integration of IoT, AI and ML elements and sensors, automation of maintenance and safety operations**, and improvements in the **efficiency of rail operations**

FRMCS transition phases and timeline



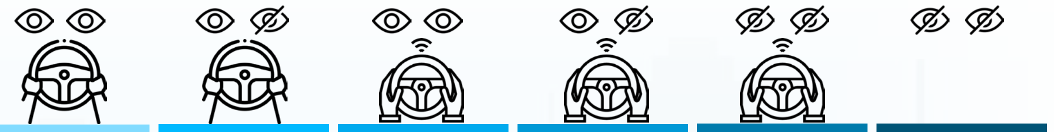
1 Global System for Mobile Communications-Railway (GSM-R) 2 Future Railway Mobile Communication System (FRMCS)
Sources: Unife "Successful Transition to FRMCS" (2021), UIC "The digital railway" (2022), Capgemini "Future railway mobile communication systems" (2023), Huawei, Press Search

Autonomy

Advanced autonomous features will be the new norm by 2025, while timelines for self-driving vehicles have shifted

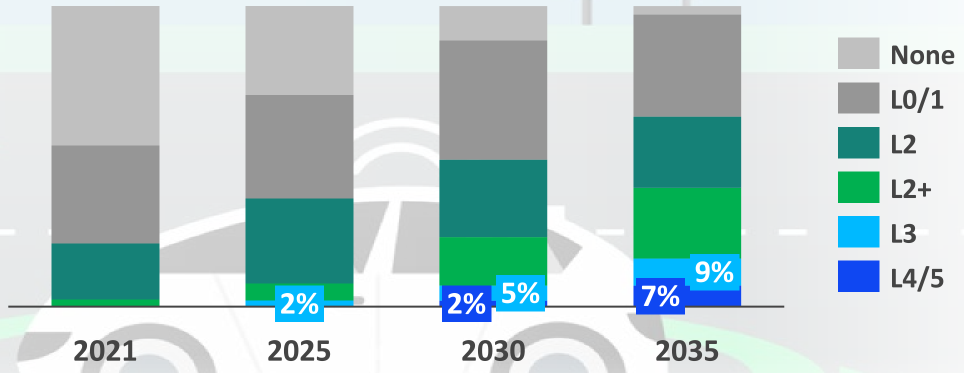
- While there is still **widespread agreement** that **fully autonomous vehicles** are set to revolutionize mobility, the timelines for deployment and customer adoption have been pushed back
- Some automakers are **shifting** their interim **focus** to **partial automation** as an easier and cheaper alternative that can be deployed sooner, while others haven't wavered in the pursuit of fully self-driving technology development
- From 2021 to 2025, new car sales **for L2 and higher are expected to grow by about 70%**. From 2025 to 2030, the share of **L2 advanced systems** in new car sales **will nearly triple**, taking a share of the demand for L2 entry-level systems and eventually matching it by 2035
- While **Level 3 is expected to represent a share of new car sales by the middle of the decade**, the expected timelines for the availability of Levels 4 and 5 vary. **Level 4 automation** is forecasted to be available to consumers **by 2030**, while **Level 5 timelines are more difficult to predict**

Definition of automation levels



0	1	2	3	4	5
No automation The driver has full control of the driver tasks	**Driver assistance** The vehicle features a single automated system	**Partial automation** The vehicle can perform steering and acceleration	**Conditional automation** The vehicle can control most driving tasks	**High automation** The vehicle performs all driving tasks under certain conditions	**Full automation** The vehicle performs all driving tasks under all conditions

Share of new car sales (%)



Sources: Berg Insight "The future of autonomous cars" (2021), Statista "eMobility - In-depth Market Insights & Data Analysis" (2022), McKinsey "Autonomous driving's future: Convenient and connected" (2023), BCG "As Automakers Transform, So Must Suppliers" (2023), Press search

Autonomous aircraft development has been growing over the past 5 years, attracting major investments

- The development of **autonomous aircraft** has been **growing over the past 5 years**, with several new entrants and significant investment in the market
- Several **eVTOL[1], electric short-distance aviation companies**, and other next-generation air mobility companies are **raising capital** through venture rounds such as **Beta** (USD 886 million raised) and **Dronamics** (USD 40 million raised) and going public through SPAC deals like **Archer Aviation and Lilium Air Mobility**
- Several **well-established aerospace companies** have also announced **investments in the market,** including Boeing and Airbus
- Autonomous aircraft are being adopted in three key areas: **industrial applications leading the way, followed by cargo, and eventually passenger flights**
- Currently, autonomy is being introduced in **smaller categories of aircraft** before expanding to larger aircraft. However, the **commercial deployment pace** of semi-autonomous or autonomous aircrafts will depend on **the governments' regulatory engagement and the public's trust in the technology**

	2018-2020	2020-2025	2025-2030	2030-2040	2040+
Passenger	▪ Technology development	▪ PoC ▪ Increased regulatory engagement ▪ First thoughts around infrastructure planning	▪ Increasing presence of strategic investment ▪ Limited short-range deployment (e.g., airport shuttle)	▪ Commercial deployment of piloted aircraft, introduction of semi-autonomous flight ▪ Public acceptance increasing ▪ Development of infrastructure	▪ Commercial deployment at scale including autonomous applications with a variety of public transportation applications ▪ Widespread public acceptance
Non-passenger	▪ PoC	▪ Continued PoC ▪ VC investment continues to go into market ▪ Deployment of VTOL for small payload (<150 kg)	▪ Strategic investments pick up ▪ Deployment of VTOL with growing size	▪ Sound public acceptance	▪ Continued high levels of strategic investments ▪ Physical, digital infrastructure, and ground network integration sophisticated

1 Electric vertical take-off and landing (eVTOL)

Sources: AIA and Avascent Report "Autonomous Aircraft and the Transformation in Aviation" (2022), Roland Berger "Advanced Air Mobility: The new flying" (2022), Press Search

The maritime industry is embracing autonomy, with unmanned vessels already in operation

- The maritime industry's latest innovation is autonomous shipping. The International Maritime Organization (IMO) defines **autonomy levels for ships to assess their ability to operate without human intervention**, going from ships with automated processes and decision support to fully autonomous
- As of 2021, there are over **1,000 Maritime Autonomous Surface Ships (MASS)** operated by more than **53 organizations worldwide,** such as Yara Birkeland, Ulstein, and Keppel Offshore & Marine
- Meanwhile, other companies are still developing new autonomous ships and conducting trials such as:
  - **MOL's Unmanned Containership Trial: Mitsui O.S.K. Lines (MOL)** successfully completed the world's first sea trial of an unmanned containership, demonstrating autonomous navigation capabilities
  - **DSTL Trials of the Autonomous Maritime Asset Protection System**: Dstl conducted trials using autonomous systems to enhance asset protection against threats
- By **2030**, the global autonomous ship market is expected to **reach USD 10.74 Billion**

Degrees of ships' autonomy

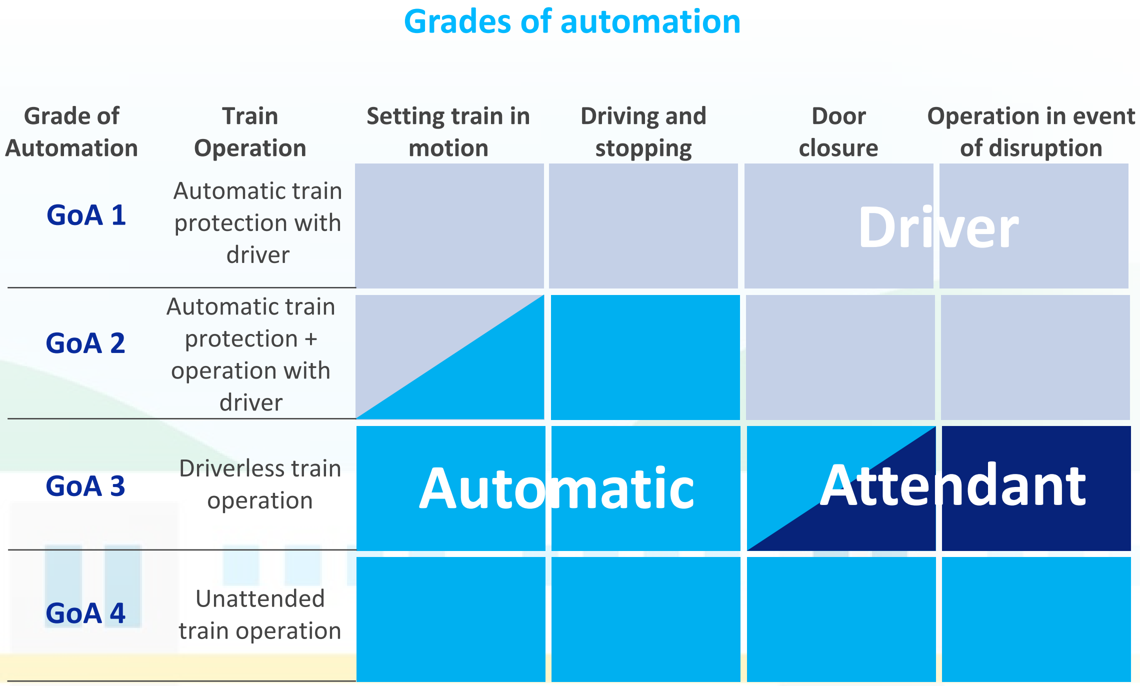
1st level	2nd level	3rd level	4th level
Ship with automated processes and decision support	Remotely controlled ship with seafarers on board	Remotely controlled ship without seafarers on board	Fully autonomous ship

Global autonomous ship market forecasts In billion USD

Sources: International Maritime Organization (IMO), UNCTAD "Maritime Autonomous Surface Ships: A critical 'MASS' for legislative review" (2022), Press Search

Full railway automation is already available, but its integration faces passenger skepticism and infrastructure upgrades

- The journey to autonomous rail transport has been gradual, spanning centuries. Automation began in the 1950s and 60s, with the introduction of partial automation for simple routes
- **Today, trains have various degrees of automation**, depending on the involvement of a driver
- **Trains and metros operating at GoA4 are already a reality** (e.g., Rome and Copenhagen Metro), and many governments are working on developing **semi-to-autonomous trains, such as** Finland's Proxion-led consortium working on a short-distance autonomous freight train for the steel and forestry sectors, set to debut by 2023
- However, the future of autonomous trains is advancing toward **widespread market integration**, currently hampered by **passenger skepticism** and the **substantial infrastructure upgrades** necessitating significant investments
- Autonomous trains can help **increase the capacity of existing rail networks by as much as 44%**, lead to up **to 45% less energy consumption** (hence decreasing costs), and provide an enhanced passenger experience



Sources: Press search

Sustainability

EV's full transition will require stringent regulation in the short run and technological advancements in the long run

- **Electric vehicles (EVs) are expected to be the primary option for sustainability,** as they significantly reduce GHG emissions compared to traditional vehicles (52% less for cars and 57% less for trucks over their lifetime) and currently outperform alternative technologies in efficiency and cost savings
- **In 2015**, even the most optimistic projections foresaw electric vehicles making up a **modest 10-20% of new car sales by 2030**. However, today, major **automakers like Volvo, Mercedes, and Bentley** are setting their sights on achieving **a complete transition to 100% electric vehicles by 2030**, and many other prominent manufacturers are following suit
- The trajectory of this transition remains uncertain. However, a preliminary roadmap can be outlined as follows:

EV Full Transition roadmap[1]

Each transitioned vehicle is expected to save over 10 tons of CO_2 per year

Short Term

- **Stricter global emissions regulations, increased zero-emission vehicle mandates, and government incentives**, like the US Inflation Reduction Act[2], can be expected, driven by climate change and sustainability goals

Medium Term

- Advancements in electric car technology are enhancing their affordability and efficiency
- Current long-range EV battery costs are nearing USD 13,000, but **future battery enhancements could reduce this cost to as low as USD 5,000**

Long Term

- The full shift to electric mobility will be possible when **EVs match combustion-engine prices**, cost USD 1,000 less annually to operate, provide over **400 miles of range, offer ten-minute charging, and have ample charging infrastructure**

1 Preliminary roadmap crafted by RSM Global, acknowledging the uncertainties related to the evolving incumbents, newcomers, and supply chain; **2** The U.S. Inflation Reduction Act, passed in 2022, allocates over USD 30 billion for tax incentives, and government EV procurement

Sources: RSM Global "Building a Sustainable Future for the Automotive Industry" (2022), Press Search

In aviation, the primary options for achieving net-zero emissions by 2050 are alternative fuels and redesigned aircraft tech

- Aviation accounts for nearly 3% of worldwide human-generated CO2 emissions, and there's a concern this could rise to 22% by 2050
- Hence, airlines under the International Air Transport Association (IATA) have committed to achieving net-zero emissions by 2050, which involves CO2 offsets in the short term and other key innovations in the medium to long term, such as:
  - **Sustainable Aviation Fuels (SAFs):** SAFs could cut airline CO2 emissions by approximately 70%, with Virgin Atlantic planning a net-zero transatlantic flight using SAF in 2023. Despite higher costs than kerosene and alternatives like batteries and hydrogen, SAFs are more compatible with existing aircraft
  - **Open Fan Architecture Engines:** Redesigned engines with open fan architecture increase efficiency by shedding weight and reducing drag. GE Aviation and Safran target a 20%+ emissions reduction in single-aisle aircraft by the mid-2030s
  - **New Propulsion Systems:** Hybrid electric propulsion and water-enhanced turbofans improve flight efficiency and lower emissions. Airbus and industry leaders collaborate on the SWITCH project to pioneer these innovations

Primary options for decarbonizing the aviation sector

	Hydrogen	Battery	SAF
Efficiency of fuel production and propulsion system	~25%	~60%	~15%
Maximum range in 2050	2500 km and up	Few 100s km up to 1000 km	No limitation
Expected large-scale market entry	Around 2035-40	Around 2035-40	<2030
% of cumulative GHG emissions reduction from renewable fuels (2022-50)	8%-22%	2%-3%	75%-91%
% of final energy demand in 2050	13%-32%	~2%	65%-85%
Challenges	Requires new aircraft designs and storage, longer development time, and may be limited to short-haul flights	Limited to short-haul flights due to weight and size constraints	Can be used with existing aircraft and infrastructure, the primary decarbonization solution for the next three decades

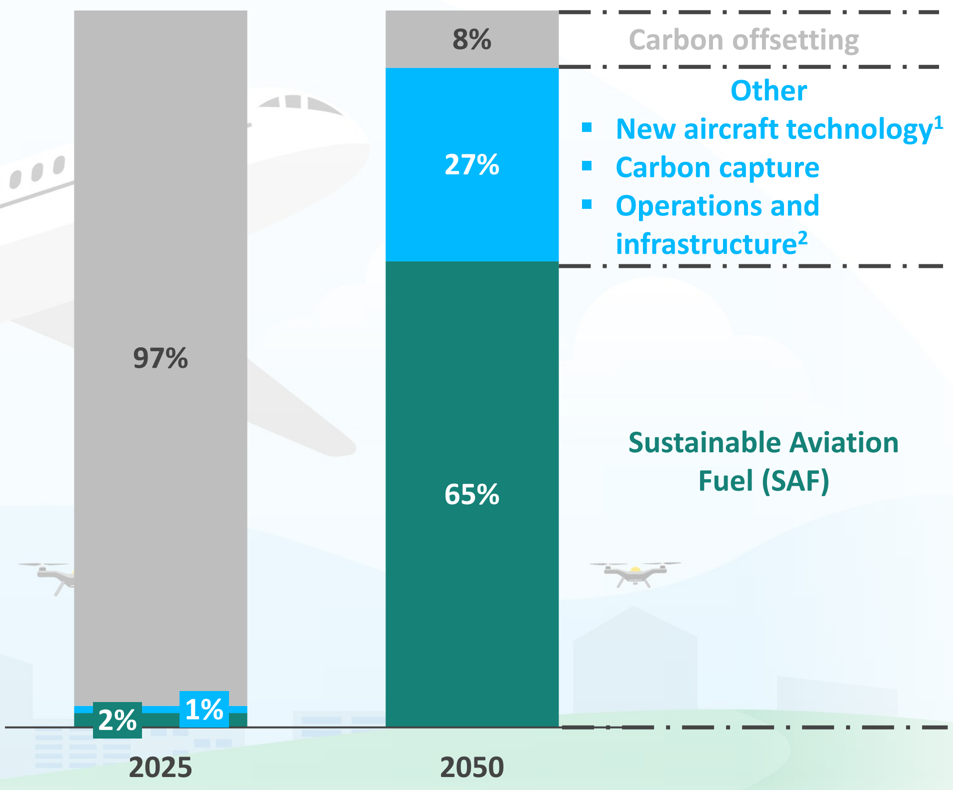
Best | Medium | Worst

Sources: IATA "Net zero 2050: sustainable aviation fuels" (2021), IATA "Update on Sustainable Aviation Fuels (SAF)" (2023), Energy Transitions "Making Net-Zero Aviation Possible" (2022), Press Search

SAF is anticipated to play a central role in achieving net-zero emissions, potentially reducing 65% of emissions by 2050

- Aviation decarbonization requires international cooperation. In 2022**, 184 ICAO member states set a net-zero aviation goal for 2050**, focusing on innovative aircraft technology and efficient operations
- While carbon offsetting will primarily drive carbon reduction efforts at 97% by 2025, **SAF** is projected to become a prominent solution, surging to **65% by 2050**
- National governments play a key role in promoting SAF with supply-side incentives:
  - In 2023, the EU launched **ReFuelEU** to boost SAF use by mandating **blending SAF with Kerosene**
  - The **US** is allocating **USD 3.3 billion** to raise the **SAF via tax credits and grants**
  - Asian countries are also advancing with SAF through partnerships between governments, projects, and agreements
- Thanks to these combined efforts and a growing demand, SAF production was boosted to around **300 million liters (240,000 tons) in 2022**, marking a **200% y-on-y increase**

IATA projections on the emissions reduction contributions by technology type for a net-zero future for aviation



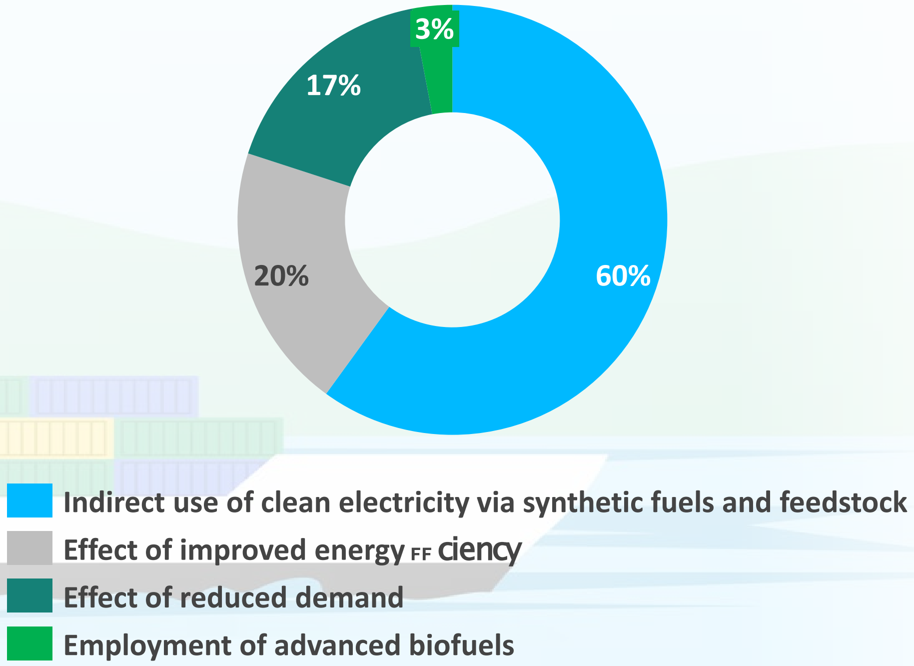
1 Innovations in airplane design and systems aimed at reducing emissions and enhancing efficiency; **2 Operations:** Strategies and practices for more efficient aircraft usage, including air traffic management improvements / **Infrastructure**: equipment and infrastructure required to support sustainable aviation such as SAF, hydrogen and electric infrastructure

Sources: UP Partners "The moving world report" (2023), IATA "Net zero 2050: sustainable aviation fuels" (2021), Energy Transitions "Making Net-Zero Aviation Possible" (2022), Press Search

The maritime industry can achieve net zero by 2050 using powerfuels, advanced biofuels, and efficient vessels

- The demand for decarbonizing the shipping industry is robust, driven mainly by:
  1. **Regulation Push**: Stricter rules from the IMO[1] and governments, such as CII[2], SEEMP[3], and the EU's Fit for 55[4], are driving the shift away from carbon fuels
  2. **Affordable Green Tech:** Lower renewable energy costs make eco-friendly technology and alternative fuels more cost-effective
  3. **Competitive Edge**: Firms embracing sustainability, tech adoption, and decarbonization gain a competitive edge. Customers prefer responsible, tech-driven solutions, boosting their reputation.
- Hence, the IMO has set regulations to reduce emissions **by 40% by 2030 and 70% by 2050 compared to 2008 levels**, aiming for accelerated decarbonization in 2023 as part of its carbon neutrality strategy below the 2°C limit
- IRENA suggests that reaching net zero at the 1.5°C limit in 2050 requires **four main actions:**
  - Indirect electrification using powerfuels
  - Advanced biofuel adoption
  - Enhancing vessel energy efficiency
  - Reducing sectoral demand due to shifts in global trade dynamics

Projected Impact of Key CO2 Reduction Measures in IRENA's 1.5°C Scenario[2]

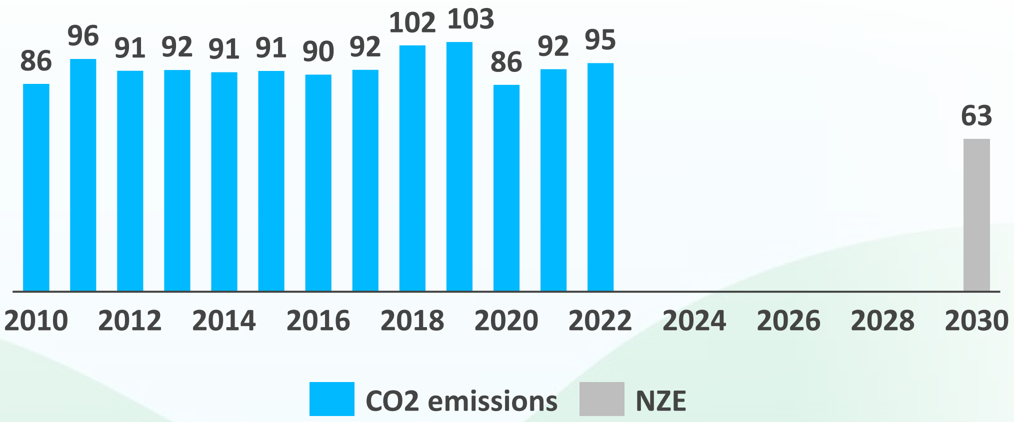


1 International Maritime Organization (IMO) **2:** Carbon Intensity Indicator (CII) **3** Ship Energy Efficiency Management Plan (SEEMP) obliging all vessels over 400GT to be developed and regularly updated by shipowners
4: EU's **"Fit for 55"** package aims to reduce the net GHG emissions by at least 55% by 2030 **5:**Reaching net zero emissions by 2050 while limit the global temperature rise to 1.5°C
Sources: IMO "Revised GHG reduction strategy for global shipping adopted" (2023), IRENA "A pathway to DECARBONISE THE SHIPPING SECTOR By 2050" (2021), Press Search

Smart rail systems and electrification are vital for a decarbonized railway by 2050

- Railway systems will be crucial in the pursuit of a **decarbonized future by 2050**. They are energy-efficient and environmentally friendly due to their design, which minimizes friction between trains and tracks, setting them apart from other forms of motorized transportation
- In 2022, IEA[1] reported that the global average rail greenhouse gas (well to wheel) intensity was **19g CO2 -eq/passenger-km** compared to **211g for large cars**
- Rail currently relies equally on electricity and diesel for its energy mix. However, projections indicate that electricity will constitute 65% by 2030. Meanwhile, diesel's contribution to freight energy consumption, currently at two-thirds, needs to drop to 40% by 2030.
- The future of mobility in cities relies on the implementation of intelligent rail systems that are **both environmentally and economically sustainable**. These systems need to operate efficiently, reliably, and safely to enhance the quality of life for residents
- Despite their eco-friendliness, there is still room for improvement in making rail-based transport systems even greener

CO2 emissions from rail in the Net Zero Scenario, 2010-2030



- Rail is the least emissions-intensive mode of passenger transport – its expansion will **help reduce overall emissions**
- To meet the IEA projections, there's a need for railways to increase their share of the transportation sector by **more than 40% by 2030**. This would primarily involve a transition away from aviation and road transport

Sources: 1 The International Energy Agency Rail Transport, Press search

Conclusion

- As we wrap up our journey through the future of mobility, one thing is crystal clear: the road ahead is full of twists and turns. While exciting technologies and eco-friendly ideas have emerged, the mobility industry is also facing a complex journey with various challenges

- This path to the future is tangled with issues like rules and regulations, tricky economics, trust concerns, and the task of revamping our infrastructure. Governments worldwide are working to regulate self-driving vehicles and vessels and promote sustainability while balancing connectivity, innovation, and safety. Financial constraints may hinder progress, particularly in less affluent regions. Trust and public acceptance are crucial, given concerns arising from incidents involving autonomous vehicles. Additionally, upgrading infrastructure to support better connectivity, autonomy, and electrification in vehicles remains a challenging task

- Companies and organizations must strategically expand across diverse markets and segments while optimizing their operational models. Collaboration, investment in research and development, clear communication, sustainability commitment, and infrastructure advocacy are areas where stakeholders should focus their efforts

- In the private sector, collaborative efforts are vital for transformative change, with tech giants leading in research and innovation. In the public sector, government-industry cooperation, particularly with tech leaders, is crucial. Governments should support emerging trends through regulations and incentives, promoting innovation and sustainable mobility solutions, thus benefiting the nation

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