To create a flying car industry

The need for integrators to play a core role in developing the industry at a local and regional level

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Contents

Background

The creation of a flying car* industry is looking more and more likely, and desirable. To make it a reality, key players in Japan need to consider how they're going to enter the market. This means thinking about how flying cars can be integrated into our society.

Why this industry is needed

New transportation needs

- Traffic congestion is expected to worsen in the future. A flexible transportation system that includes flying cars can help prevent this.
- The impact of COVID-19 has led to an increased demand for flexbile mobility.

Corporate investment, R&D, and venture capital

- Major Japanese automakers have invested ¥40 billion in the overseas manufacturing of flying cars.
- Major global companies, including a major ride-sharing provider and a major aircraft manufacturer, are developing vehicles and services.

Consumer and government interest

- Concept models presented at exhibitions in various countries are attracting attention.
- The Japanese government has prepared a roadmap for commercialization in 2023 and full-scale market entry in the 2030s.

Japanese players must identify key factors for the social implementation of flying cars and solidify their approaches

Related challenges

Cross-technology, cross-industry initiatives

- To encourage the social acceptance of flying cars, proprietary development is not enough. Collaborative efforts by companies, regulatory agencies and research institutes will be essential.

Integration of advanced technologies and infrastructure

- Not only do aircraft need to be developed, but peripheral systems, such as infrastructure and control systems for safe flight operations, need to be incorporated into these aircraft. Integrators who can perform such tasks will therefore be essential.

Region-specific models for the use of self-driving vehicles

- To make flying cars a part of our society, regional characteristics must be considered. Each region needs to have the people and the knowledge to help local talent play a leading role in introducing self-driving vehicles.

* The term ‘flying car’ refers to a vehicle that people can board, which is based on the concept of a remote controlled or automatically controlled drone, or on the concept of an electric vehicle modified for flight and including power and an automatic control system for flight. The Japanese Ministry of Economy, Trade and Industry officially refers to such vehicles as ‘electric vertical take-off and landing aircraft.’

Purpose of this report

Based on PwC's knowledge, this report provides an overview of four key points for establishing a flying car industry. It also provides key factors for players in Japan to consider when developing market-entry approaches.

01 Anticipating market growth

The size of the passenger and goods transportation market in Japan is expected to grow to 2.5 trillion yen in 2040.

02 Developing use cases

Specific use cases for situations such as intracity and intercity transportation, tourism, lifesaving and disaster relief align with the needs of each region.

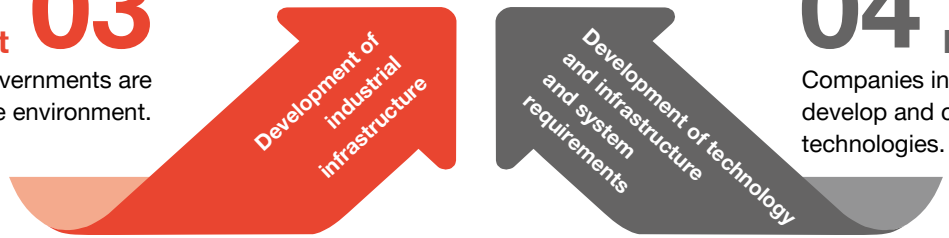
With the growth of integrators, who will play a core role in developing the industry in local regions, domestic players will be able to create and advance a vision to solve mobility-related social issues in each community

03 Preparing the environment

Regulatory agencies and major local governments are focusing on creating rules and preparing the environment.

04 Innovating advanced technologies

Companies inside and outside Japan will collaborate to develop and coordinate aircraft and service-provision technologies.



1

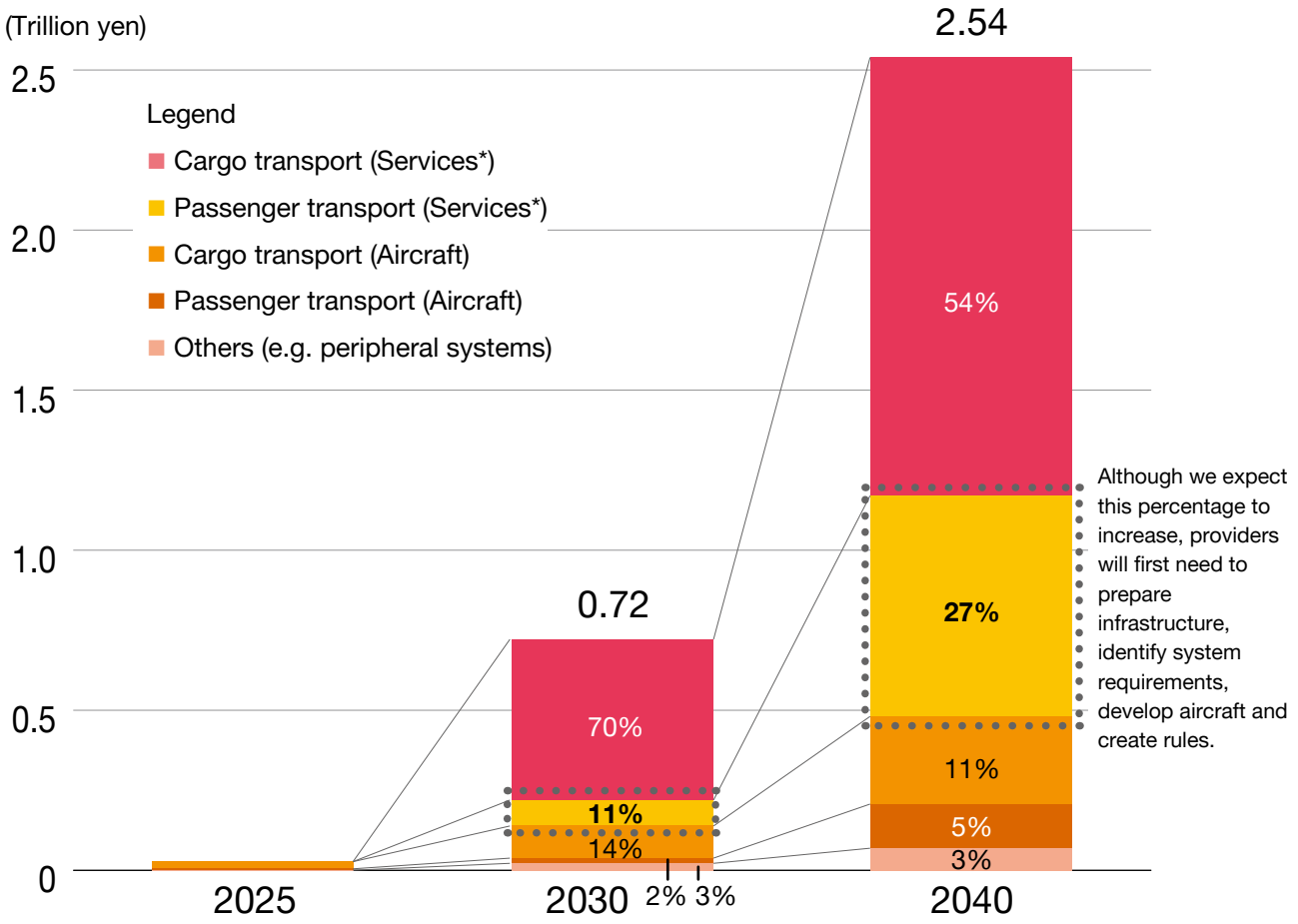
Estimating the Japanese market size

Changes in the Japanese market size by 2040

By 2040, we estimate the size of the flying car market will expand to about 2.5 trillion yen. The keys to achieving this are preparing infrastructure, identifying system requirements, developing aircraft and making rules, with particular focus on passenger transport.

2.5
trillion yen
(2040)

* 700 billion yen in 2030



* Refers to services provided to end users by using flying cars

Source: Estimated by PwC based on publicly-available government information

Driving growth via the service market

We expect players from a wide variety of industries to enter the market. This includes cargo carriers, passenger transport providers and aircraft maintenance providers. The market potential is significant, but to develop the industry, smooth integration is a must.

	Related players*	Services
Services (Transport of passengers and goods)	Energy suppliers	Provision of battery-charging services
	Airport operators	Operation of takeoff/landing ports
	General contractors	Construction of takeoff/landing ports
	Insurers	Provision of liability insurance for damages incurred during flight operations, etc.
	Transporters	Car-sharing and provision of drivers
	Lease/rental providers	Leasing and renting of vehicles
	Control equipment manufacturers	Development and sales of equipment required for safe flights
	In addition to the above, we expect a wide variety of players to enter the market and provide services.	
Aircraft (Transport of passengers and goods)	Aircraft dealers	Sales and leasing of aircraft
	Aircraft developers/ manufacturers	Development and manufacturing of aircraft

*Estimated by PwC based on the composition of players in existing industries

To establish the market, integration of these four matters will be essential:

Matters to be addressed

- **Rule-making**
- **Coordination of design, production and operating standards for aircraft**
- **Definition of service models and alliances**
- **Development and promotion of phase-based verification plans**
- ⋮

The peripheral systems market

To build the services market, flight management mechanisms and systems are essential for keeping flight operations safe. And these peripheral systems are already being developed. With an expected market size of 56 billion yen by 2040, the peripheral systems market is expected to support the expansion of the market for transportation of goods and passengers.

Classification of airspace management

Up to 10,000 meters

Jet planes

From 300 to several thousand meters

Helicopters

Infrastructures and frameworks are already established.

Hundreds of meters

Flying cars

Infrastructures and frameworks need to be established for:

- Cargo transport services
- Passenger transport services
- Cargo aircraft
- Passenger aircraft
- Takeoff/landing infrastructure, battery technology, and operational facilities

Up to 150 meters

Drones

Infrastructures and frameworks are currently being established.

Integrated management

Progress is being made in establishing and developing these flight management systems and mechanisms. As a result, we expect the market size to grow to 56 billion yen by 2040.

Type of system	Role
Control	Approval and management of flight plans issued by authorities
Flight management	Planning of flight routes and management of flight plans
Ground support	Support for takeoff and landing of aircraft etc.
Operation	Maintenance of aircraft etc.
Telecommunication	Communication between aircraft and between aircraft and GCSs*
Security	Measures for information security etc.

* Ground control station (GCS): A land- or sea-based control centre that provides the facilities for human control of flying cars.

Source: Prepared by PwC based on the industry trends research

2

Developing use cases

Assessment of major use cases

We assessed the following key use cases that are expected to be prevalent in the market by 2040. Japanese players need to focus on market potential and social acceptability to determine the areas they want to focus on.

Application		Target regions	Market potential	Social acceptability	Advantages *Compared with existing transportation systems
Intracity transportation	Air taxi and delivery services within the same city	Urban	**Large**	Low (Alleviation of traffic congestion)	Reduction of travel time
Intercity transportation	Transportation between airports and towns, or between more remote cities	Urban/ rural	**Large**	Medium (Limited demand for transportation)	Reduction of travel time
Tourism and leisure	Sightseeing	Rural	**Large**	Medium (Demand for unique experiences)	Lower cost compared to helicopters
Emergency medical care	Transportation of patients and medicine	Urban/ rural	Small	**High (Emergency transport, transportation of medicine)**	Prevention of delays in initial response time
Disaster relief	Rescue of disaster victims and transportation of disaster relief supplies	Rural	Small	**High (Relief to disaster areas)**	Advanced flexibility and mobility
Between remote islands	Transportation and movement between remote islands	Rural	Small	Medium (Increased transportation options)	Convenience and reduced travel time
Between depopulated areas	Transportation and movement in areas where public transportation systems are not available	Rural	Small	Medium (Increased transportation options)	Reduction of infrastructure maintenance costs

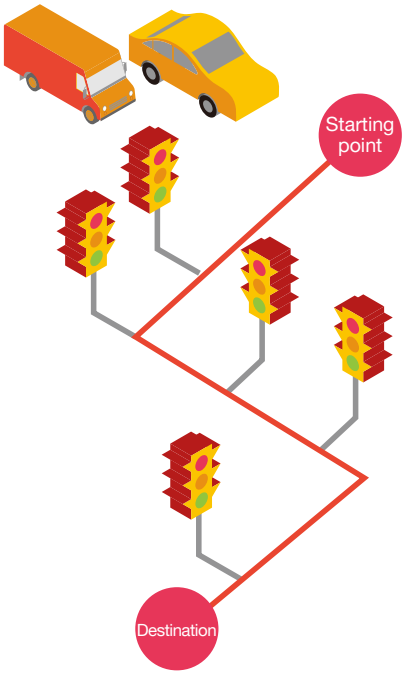
Source: Prepared by PwC based on books on flying cars

Trends in high-potential use cases

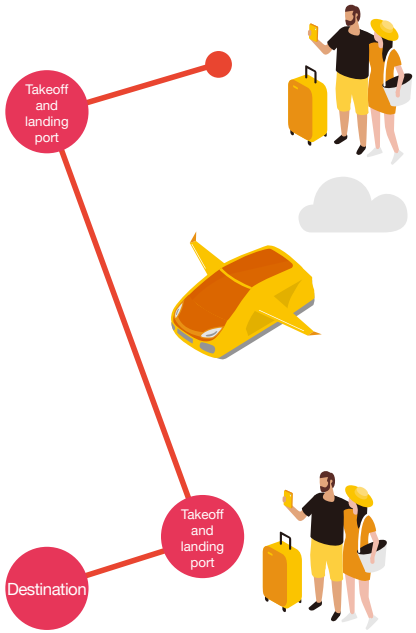
We expect a need for flying cars for passenger transport to surface by 2040. Among other benefits, they could help prevent the spread of infectious diseases. Japanese players should pay attention to consumer needs and build transportation infrastructures to meet them.

Intracity and intercity transportation

Today



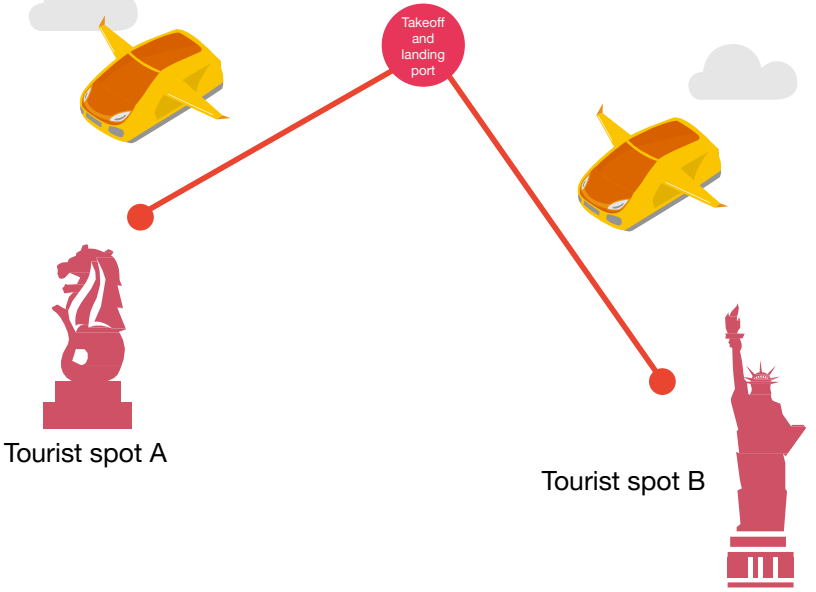
When flying cars become common



The goal is an active transportation system that is not affected by traffic density or congestion. To achieve this, we need to develop embarkation and disembarkation infrastructure, battery technologies, and other elements essential for agile operations.

Tourism and leisure

When flying cars become common



Flight routes must be planned to balance demand and safety. Embarkation and disembarkation points need to be built in a way that doesn't negatively impact their surroundings. And an environment must be developed to enable operations even in rural areas.

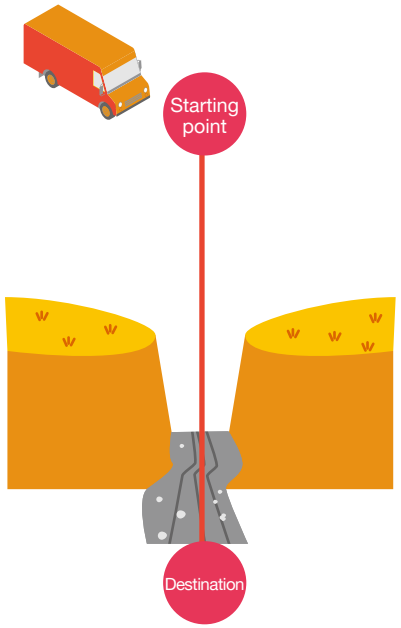
Source: Prepared by PwC based on research and interviews with stakeholders in Japan

Trends in highly socially acceptable use cases

In fields where the use of flying cars is particularly likely to be accepted, they could be introduced as early as around 2030. Domestic players can gain a foothold to enter larger markets by accumulating experience through PoCs in these fields.

Disaster relief

Now



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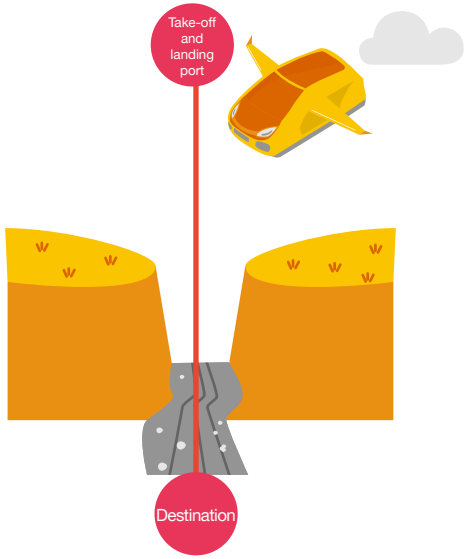
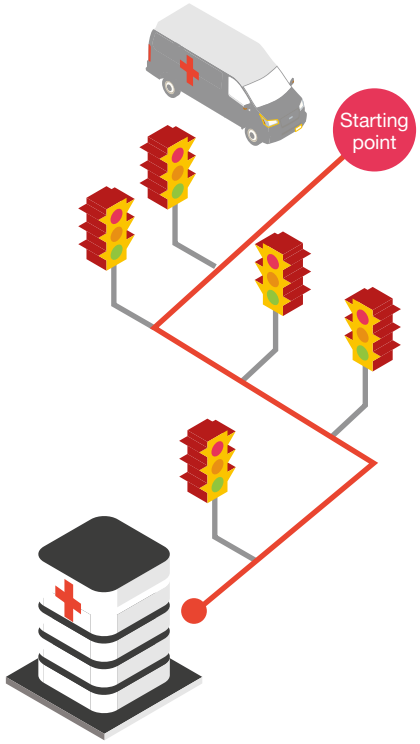


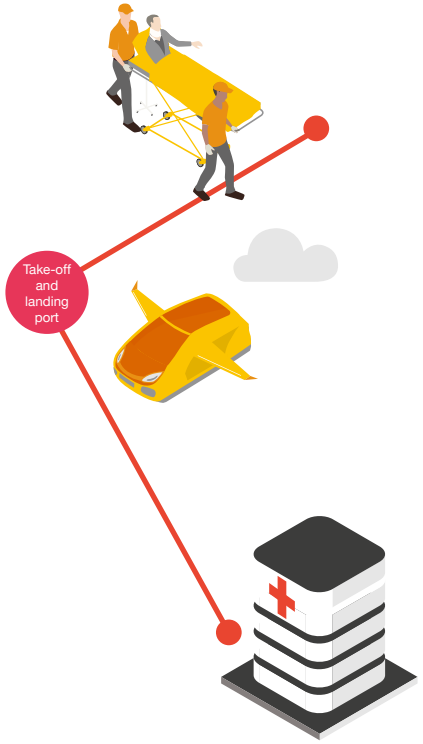
By establishing takeoff and landing operations and infrastructure technology, these projects can establish a foundation for safe operations even in urban areas.

Emergency medical care

Now



When flying cars become common



Flying cars will be used more often for emergency medical care than for disaster relief. The large amounts of data and experience accumulated during this use can be used to enhance flight technology and optimize routes.

Source: Prepared by PwC based on research and interviews with stakeholders in Japan

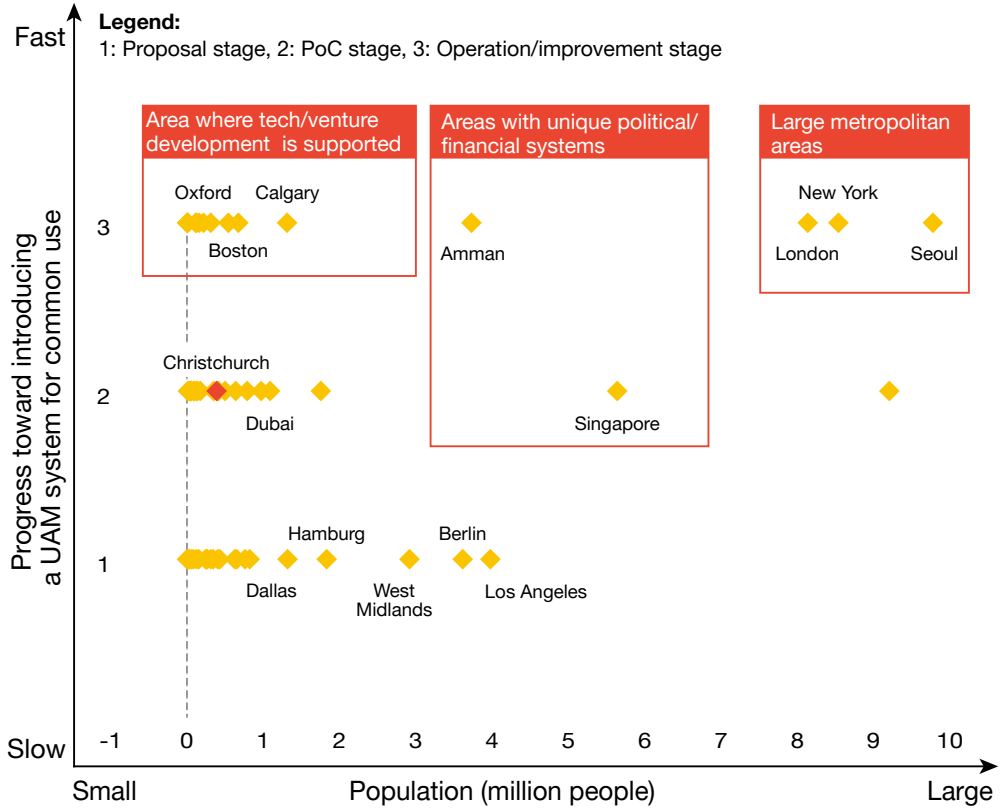
3

Preparing the environments

Global progress

In large metropolitan areas where the need for passenger transportation is high, some projects are already in the operational stage. Remarkable progress can also be seen in Asian and Middle Eastern cities that have distinctive political and financial systems, as well North American cities where a lot of tech and venture development takes place.

Urban air mobility (UAM) services in major cities (2018)



Large metropolitan areas

- Many companies have offices in these cities, and air traffic systems are already in place. This provides advantages in terms of business and development.
- Many cities face higher traffic congestion as a result of population growth, which leads to higher demand.

Areas with unique political/financial systems

- The verification process, including PoCs, can be conducted relatively quickly and easily.

Areas where tech/venture development is supported

- These areas have a great deal of venture activity, which is possibly driven by academics and other experts residing nearby.

We consider the key points to be understanding the large-scale needs of urban areas and making use of advanced systems, talent and expertise.

Source: Prepared based on PwC's research

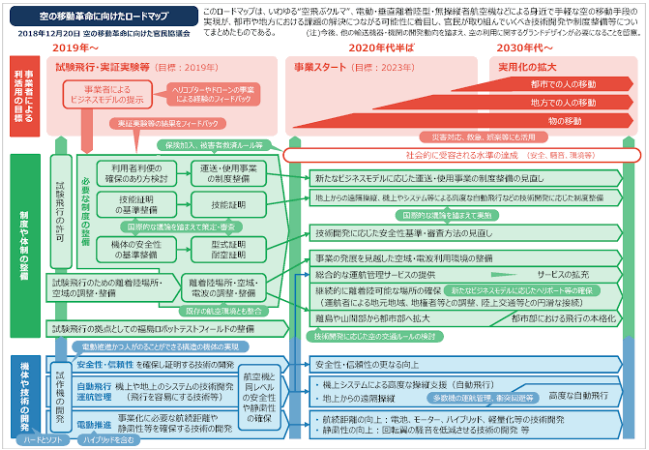
System design by various national authorities

Many countries in Europe and North America are making progress on creating roadmaps and specific rules for operations. Japan should also work on preparing an environment and making rules, as well as preparing and updating a roadmap and monitoring overseas trends.

Prepare and update the roadmap → **Develop flight rules** → **Revise related systems**

Japan

- Japan has been gradually developing a roadmap to share issues with domestic institutions, related companies and organizations while considering social acceptability.



Overseas (NASA, EASA*)

- Overseas organizations are competing to take the lead in the development of the industry and the international standards, including rule-making.

Takeoff/ landing ports	• Consideration of the use of heliports and offsite takeoff/landing ports
Pilot licenses	• Consideration of a new type of license based on existing small-aircraft licenses
Airspace	• Establishment of an airspace to avoid collision with other aircraft
Safety standards	• Establishment of safety standards such as strength of aircraft

Prepare a detailed system with the goal of launching businesses in each market area (logistics and transportation)

*EASA: European Union Aviation Safety Agency, NASA: National Aeronautics and Space Administration

Source: Information about Japan is based on public information released by the Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure and Transport. Information about other countries was compiled by PwC based on public information released by EASA and NASA.

Efforts of local governments in Japan

The following prefectural governments are developing PoC projects related to the use of flying cars, and providing testing fields. These efforts are expected to facilitate the development of the environment and the planning of flight routes that take into account the characteristics of each local region.

Prefectures developing PoC projects

	Osaka	Tokyo	Mie
Target	• Flight for about one hour using a single-seater six-propeller aircraft	• Practical public use of advanced technologies	• Solutions to various regional issues related to transportation, tourism, disaster prevention, daily life etc. • Maintenance and improvement of the quality of life in local communities • Creation of new businesses
Example use cases	• Demonstration flights at the Osaka Expo	• High-speed transportation services using connection points with various means of transportation • New transport services in areas with insufficient public transportation • Rescue work and supply transport during a disaster	• Lifestyle support for remote islands and depopulated areas • Tourism resources and means of transportation • Disaster prevention and improved industrial efficiency
Schedule	2025	N/A	2023: Logistics 2027: Passenger transport
Location	Yumeshima, Maishima	Seaside area, Nishi-tama area	Toba, Shima, Minami-ise, Kumano

Prefectures providing testing fields

	Fukushima	Aichi
Target	• Establishment of a national center for safety evaluation through the cooperation of the industrial, academic, and government sectors	• Development of flying cars and production sites
Support provided	• Provision of one-stop support services including intermediary support functions for the preparation of PoC (support through cooperation of the industrial, academic, and government sectors)	• Development of aircraft and indoor/outdoor flight tests at the Monozukuri Creative Base SENTAN
Testing fields	Fukushima Robot Test Field	Flying car test field
	Minami-soma, Namie	Toyota

Source: Prepared by PwC based on publicly-available information published by the Japanese Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure, Transport and Tourism.

Keys to regional success

The flying car industry faces two major challenges at the local and regional level. First, developing concepts based on local industrial trends. Second, gaining the acceptance of the residents. To overcome these challenges and find success, a multifaceted plan is needed.

Key points	**Can agreement and cooperation be reached among government leaders, workers, experts, and local industries?**	**Does the business model enable local talent to play a leading role?**
Drawbacks	**Even if such initiatives are carried out in advance, they may not be specific enough, and may fail to extend to the actual workers.**	**Even if concrete demonstrations succeed, projects may lose momentum due to a lack of engagement with local communities.**
Solutions	**Develop sustainable models for each region (for example, by using reference models)**	**Create methods for impacting the community and stories from the residents' point of view**
	Consider the stakeholders involved in the flying car market from a market perspective, and take specific issues (interests and expected obstacles) into account when carrying out the plan	Encourage the integration of flying cars into local economic activities, based on key issues for impact creation in the region
	Use a reference model (Technology owned by PwC, assets for creating a business ecosystem)	Make plans based on knowledge of regional revitalization and smart cities
		Make use of networks involving other regions and use case studies from Japan and other countries

Source: Prepared based on projects promoted by PwC

4

Developing businesses with internal and external technologies

Approaches of leading overseas companies

With a focus on the strength of their own technologies and partnerships with other companies, overseas companies are making progress in the practical introduction of flying cars by enhancing the necessary advanced technologies.

Legend: Orange text describes collaborations with other companies related to advanced technologies.

	Major US-based ridesharing company	German flying car venture	Airbus	Lilium	Bell	EHang	Joby Aviation	Kitty Hawk
Current efforts	• Aiming to implement a service-based vertical integration model • Jointly developing aircraft with eight companies including Bell • Collaborating with major US corporations to develop takeoff/ landing ports and power sources • Making flight rules in close cooperation with the regulatory agencies	• Aiming to implement an aicraft development-based vertical integration model • Jointly developing automated flight sensors with Intel • Cooperating closely with the regulatory agencies in Europe and Asia to plan flight routes	• Aiming to be a provider of integrated services by working on infrastructure development and service roll-out • Developing aircraft in collaboration with companies such as Siemens and Volkswagen	• Developing aircraft and reservation services for transportation	• Collaborating with leading companies to develop services • Collaborating with multiple companies such as Safran and Thales to develop aircraft that can fly with simple operations • Jointly developing automated flight sensors and power supplies with major US companies	• Developing aircraft by using knowledge of large drone development • Focusing on collaboration with mobile communications companies in anticipation of automated flights • Collaborating with the regulatory agencies and local servicers of various countries to introduce passenger/ goods transport	• Working on development toward mass production by making use of the design, materials, and electrification technologies of the major automobile companies	• Obtained experimental airworthiness certifications from the Civil Aviation Authority (UK) and the Federal Aviation Administration (US). • Putting priority on noise reduction measures

	Service need-based (urban transportation)	In-house need-based (aircraft technology)
Types of efforts	» These companies are aiming to provide one-stop services based on the urban transportation needs by building mechanisms that include infrastructure and systems as well as aircraft. » Social acceptability needs to be considered in order to put these services to use in society. Most of these services will be created through joint development among multiple companies.	» Theses companies are working on developing aircraft that can be used for transporting both passengers and goods. » They are focused on reducing weight and on electrifying and automating aircraft. Joint development with other knowledgeable companies is underway.

Both types of effort are based on partnerships with other companies

Source: Prepared by PwC based on publicly available information published by each company

Approaches for collaboration with Japanese companies

Japanese companies that have taken a lead in the development of prototypes are strengthening their cooperation with other companies. To continue to develop the industry, we expect them to engage in further cooperation in the areas of infrastructures and systems.

	SkyDrive Inc.	teTra aviation corp.	Kawasaki Heavy Industries, Ltd.
Business model	• Developing, designing, manufacturing, and selling flying cars and drones for transportation of heavy goods	• Developing single-passenger aircraft for intracity and intercity transport, with the goal of making travel more comfortable	• Developing an aerial means of cargo transport that can be used to affordably carry medium-weight cargo over short and medium distances
Collaboration with government agencies	• Participated in a public-private conference for future air mobility • Was selected as eligible to receive a subsidy of up to 500 million yen from the Tokyo Metropolitan Government	• Participated in a public-private conference for future air mobility	• Participated in a public-private conference for future air mobility
Collaboration with corporations	• Currently developing crew seats in collaboration with JSSJ and Mizuno	• Currently working with JAXA on a joint project to develop quieter ducted fans	• N/A
Collaboration with academic societies	• Participated in the Electrification Challenge for Aircraft (ECLAIR) Consortium led by Keio University	• N/A	• Participated in the Electrification Challenge for Aircraft (ECLAIR) Consortium led by Keio University
Progress in development	• Started Japan's first manned test flights in December 2019. Also started selling industrial drones and conducting PoCs in collaboration with multiple companies.	• Received an award in the GoFly Competition. Acquired special airworthiness certificates and fight permits from the FAA to conduct test flights	• In May 2020, conducted a successful levitation experiment with a large hybrid drone testing machine called a 'flying truck'
Future plan	• Develop aircraft with the goal of starting sales of flying cars in 2023, and of providing flying tours at Expo 2025.	• Display the product at a US event in 2021, with the ultimate goal of commercialization.	• In addition to manufacturing aircraft, roll out services such as transportation to and from 'sky ports' (takeoff and landing ports), aerial imaging, and urban development.

Source: Prepared by PwC based on publicly available information published by each company

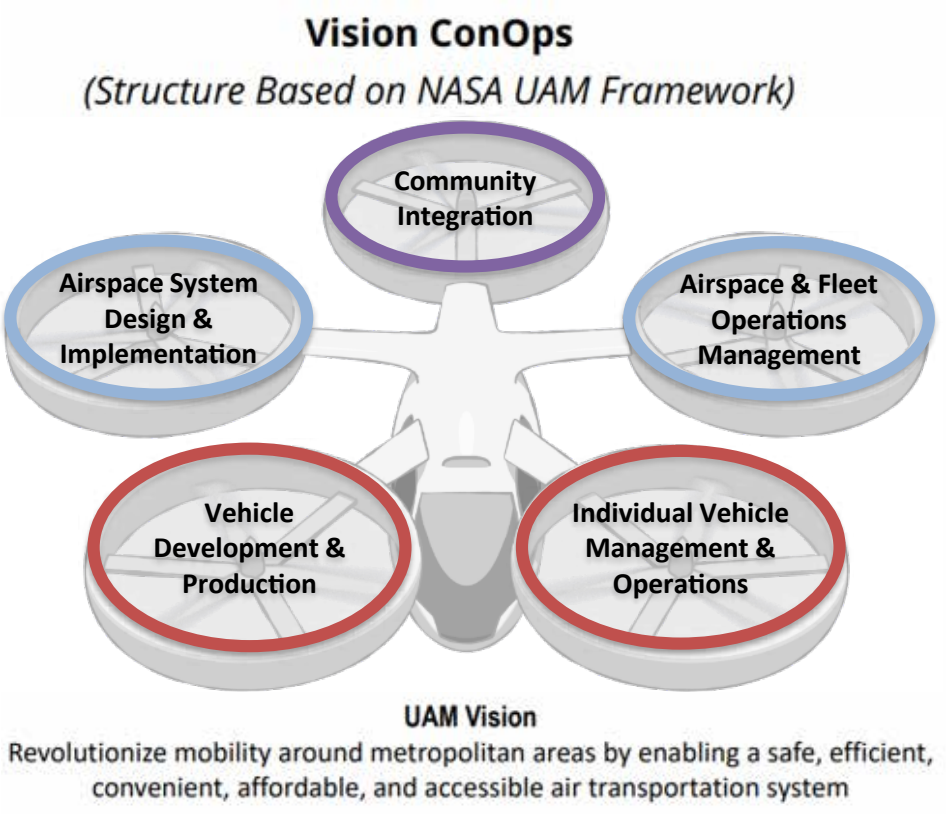
5

PwC's view: Keys to practical usage

The importance of integrators

To launch this industry, integrators will plan an important role. An integrator provides thorough supervision of both technical issues (infrastructure, systems etc.) and social issues (acceptability etc.). This helps keep projects from focusing on a single technology, such as aircraft or flight operations.

NASA's framework



Suggestions based on NASA's framework

- Work towards social acceptance
- View the overall state of aircraft design, production and operation
- Define requirements for aircraft, infrastructures, and systems
- Develop flight policies and define service models

Integrators with the following capabilities will be sought in each region:

- Technological capabilities and a track record in the aviation industry
- Comprehensive ability to flexibly incorporate and conceptualize new internal/external technologies
- Leadership capable of defining business models and engaging with stakeholders

Source: Prepared by PwC based on publicly-available information published by NASA

Region-specific ecosystems

Current PoC efforts are a starting point, not the final goal. By developing the necessary cutting-edge technologies and clarifying which companies will be responsible for which functions in each region, region-specific ecosystems need to be developed for both rural and urban areas.

Today

Start PoCs

- Conduct PoCs in depopulated areas, mountainous areas and remote islands, where demonstrations are less likely to be affected by third parties, and obtain certificates of conformity.

Increase social acceptance

- Make rules related to flying cars.
- Create the necessary advanced technologies.
- As a result, increase social acceptance.

2023 onward

Launch operations in rural areas

- Obtain flight permits for cargo transport to rural areas.
- Gain recognition as a part of transport infrastructure that can be used to solve social issues.

Increase payload

- Increase loading capacity to enable passenger use.
- As power supply technology advances, use flying cars for long-distance transport.

2030 and beyond

Expand flight routes to include urban areas

- Make rules for flight operations in urban areas.
- Create technologies to prevent collisions and crashes.
- Advance automation technology to avoid obstacles etc.

Source: Prepared based on PwC's knowledge

PwC's framework for emerging aviation

Our framework for emerging aviation organizes the elements needed for next-generation aviation businesses. Going forward, we plan to foster the development of the integrators on whom the development of the industry hinges, and to support collaboration to solve the issues faced by Japanese players.

Technology

- Electrification/batteries
- Autonomous flight
- Cyber security

Creation of safety standards equivalent to safety standards for airplanes

Infrastructure

- Takeoff and landing ports
- Standardisation
- Service platform

Development of a base model involving the public and private sectors

Systems and standards

- Safety certification
- Flight operations management
- Radio operation

System design based on overseas trends

Social acceptance

- Safety
- Noise
- Downwash

Enhancement of social acceptance through PoC

6 Contributing authors

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Prior to PwC, Tatsu Watanabe worked for a major US IT company and a consulting firm. As the head of the transport industry and aerospace and defense (A&D) industry, he has led a number of projects ranging from the development of strategies and organizational reform to IT implementation support.

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Prior to PwC, Shinichiro Sanji worked for a major Japanese think tank and a consulting firm. He has lead projects focused on advanced technology including robotics that span the industrial, government, and academic sectors and serves as a liaison among companies, government agencies, industrial associations, and academic institutions.

PwC Consulting LLC
Advisor
Junichi Miyagawa

Junichi Miyagawa has been engaged in the development and design of aircraft for about 40 years at a major heavy industry manufacturer. Starting from aerodynamic design, he has long been a leader in the field of basic design that defines the aircraft concept. Recently, he is mainly involved in MRJ basic design, business design and sales management.

PwC Consulting LLC
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Yasuaki Sawai

Yasuaki Sawai worked for a major heavy industry manufacturer for about 10 years (engaged in the defense and commercial aircraft businesses) and a global consulting firm. He has been engaged in a wide range of projects mainly for global manufacturing industries including strategy development, operation reform, and system implementation support, and currently in charge of the A&D sector.

PwC Consulting LLC
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Prior to PwC, Shuhei Iwanaha worked for a consulting unit of a major accounting firm and a global-affiliated statistical analysis software vendor. He led the launch of an IoT analytics consulting service business, and has provided IoT, AI and MaaS solutions focusing on the development of drones and other flying-car related businesses. In particular, he focuses on approaches for business expansion from legal and regulatory perspectives for early-stage technologies.

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Takashi Nakajima

Prior to PwC, Takashi Nakajima worked for a global-affiliated manufacturer and a consulting firm. At PwC, he mainly focuses on the areas of air mobility and MaaS, and is also involved in a cross-industry consortium. He has worked with various players throughout the value chain from aircraft manufacturers to servicers on projects such as market research, business model examination and alliance development. For major Japanese manufacturers, he provides support for market research on market-entry of eVTOL business, identification of discussion points, alliance formation etc.

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Prior to PwC, Gerry Su worked for a major system engineering company. He has been engaged in projects for market research and business strategy development related to advanced technologies such as drones and IoT sensors. In addition to providing support for formulating mid-term business development plans for private manufacturers in the field of flying cars (eVTOL), he is also involved in the industry group’s market research.

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Published: January 2021 Control No: I202012-03