TECHNOLOGICAL CHALLENGES OF THE FLYING CAR REVOLUTION

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Flying cars have a long history.

- Aerocar
  - The design was started in 1946, and permission to fly was granted in 1956. It was planned to go into production if more than 500 units were ordered, but only half of the planned number of customers came through, and it never went into production.
- Latest Development Trends
  - Terrafugia Transition
    - Terrafugia, a start-up company founded by MIT graduates, was acquired by China and continues to develop and successfully fly the "Transition" flying car; in 2019, the TF-X was announced (with a 2023 commercialization target).
  - AEROMOBIL
    - Skycar under development by AeroMobil in Slovakia. AeroMobil 5.0 announced in 2018.

https://www.youtube.com/watch?v=wHJTZ7k0BXU

Classification of flying cars

- 1. a car flies with wings
- 2. Small personal aircraft
- 3. human-carrying drones

AEROMOBIL
https://www.aeromobil.com/

Robinson R22
https://robinsonheli.com/

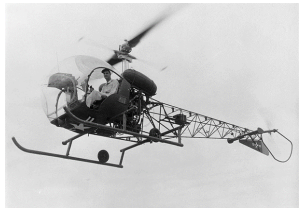
Volocopter 2X
https://www.volocopter.com/

Small Personal Aircraft

https://robinsonheli.com/

- A two-seat reciprocating engine helicopter developed and mass-produced by Robinson Helicopters, a U.S. aircraft manufacturer. Development began in 1973, with the first flight on August 28, 1975. More than 4,400 aircraft were produced by 2012.

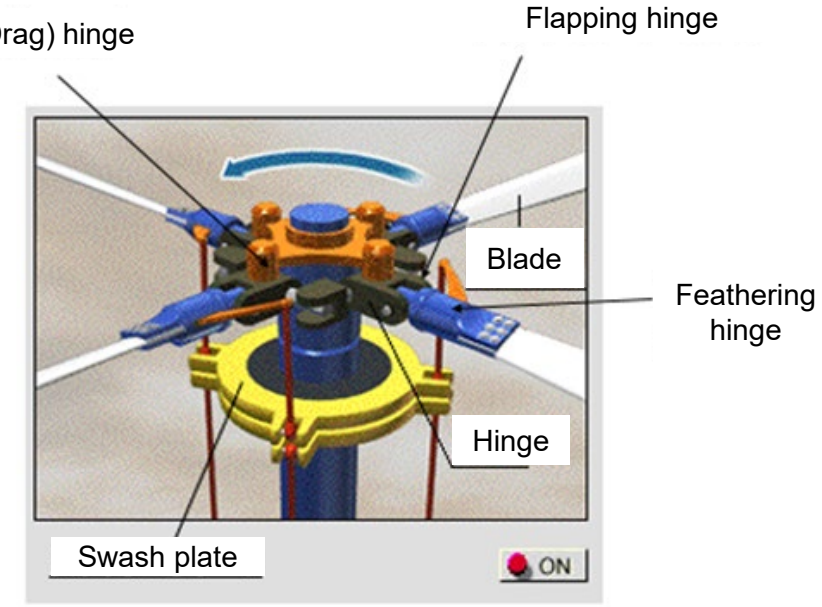
- History of Helicopters
  - 1907 Flight test in France
  - 1923 Juan de la Cierva's autogyro
  - 1936 Focke-Wulf Fw61 (practically first flight)
  - 1940 Sikorsky VS-300 (full-scale flight)
  - 1945 Bell 47 (full-scale civil helicopter)
  - 1951 Kaman K-225 (gas turbine engine), HTK-1 is a twin-engine gas turbine helicopter



Wikipedia

Helicopters are "mechanical gods”.

- James R. Childs (Author)
- Complex rotor hub mechanism
- Expensive and inefficient
- Main applications are military, government, and press.



Hayakawa Shobo (2009/1/1)

Wataru Nishikawa, Toyoaki Miyata (Author), Shinji Suzuki (Supervisor), Multimedia Aircraft Illustrated Book, ASCII,1996

Helicopters in Japan

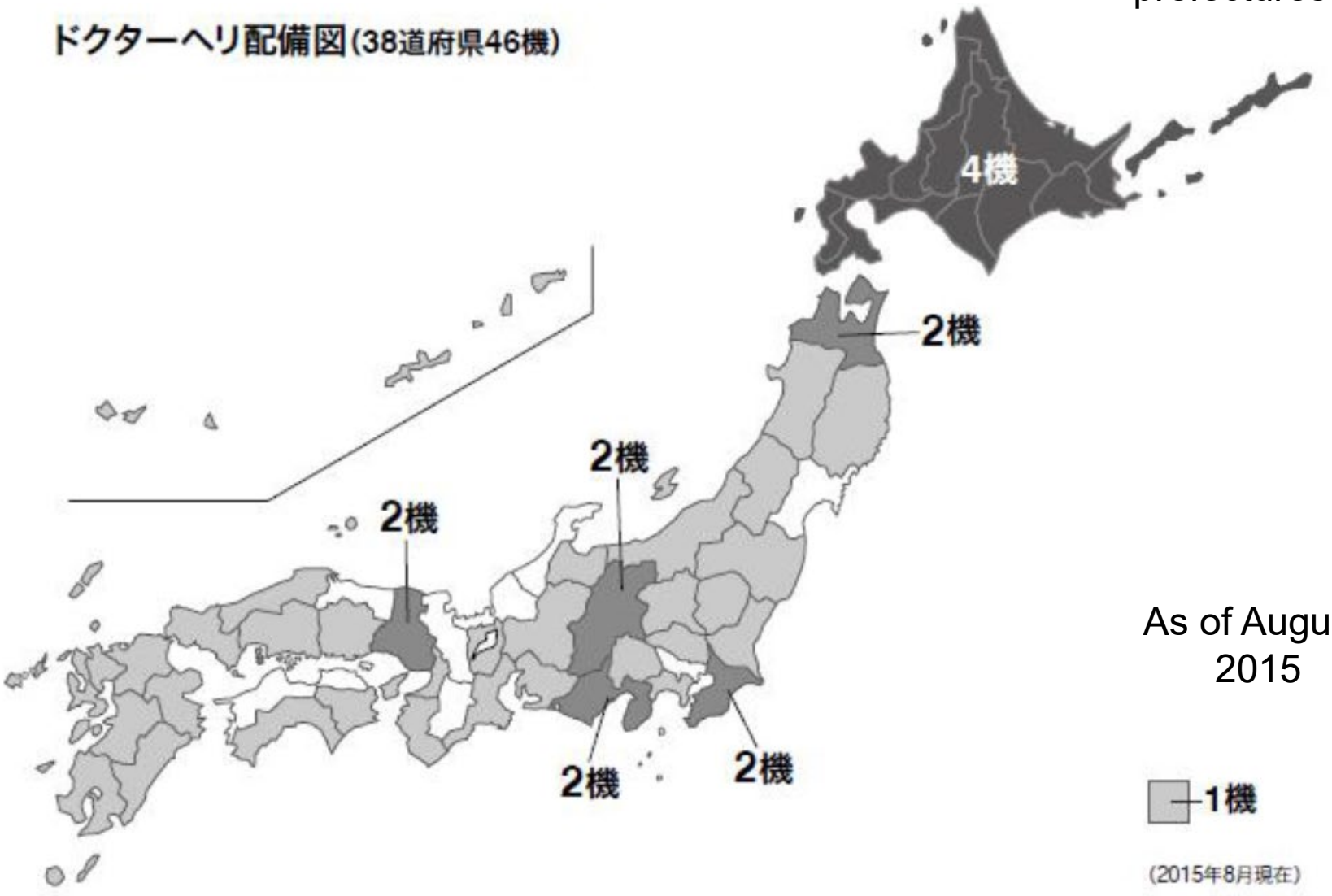
BK117 Kawasaki Heavy Industries, Ltd.

UH-60J Mitsubishi Heavy Industries, Ltd. (Sikorsky)

SUBARU BELL 412EPX
https://aerospace.subaru.co.jp/412epx/

Doctor helicopter deployment status

46 helicopters in 36 prefectures

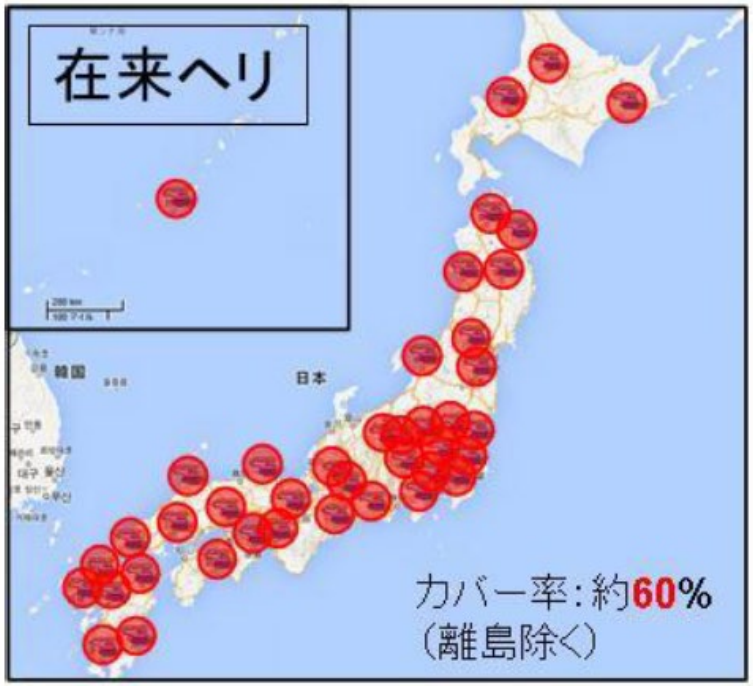


As of August, 2015

Source ：HEM-Net (http://www.hemnet.jp/)

Coverage area of the doctor helicopter

- Coverage that can be reached within 15 minutes > 60%.
- Germany
  - 15-minute rule: initial treatment within 15 minutes
- Switzerland
  - Rescue helicopters reach within 15 minutes (2,700 yen per person per year in donations)



Source: JAXA

Derived from drones

pilotless aircraft

RPAS CARGO Drone
Astral Aerial

spy plane

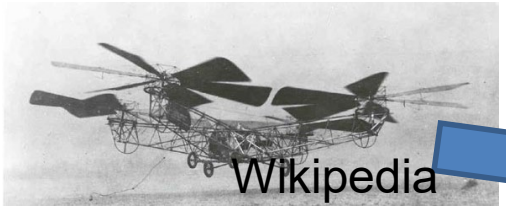
Target Drone

large unmanned aircraft

Pesticide spraying helicopter

https://www.aviationwire.jp/archives/196952

unmanned aircraft

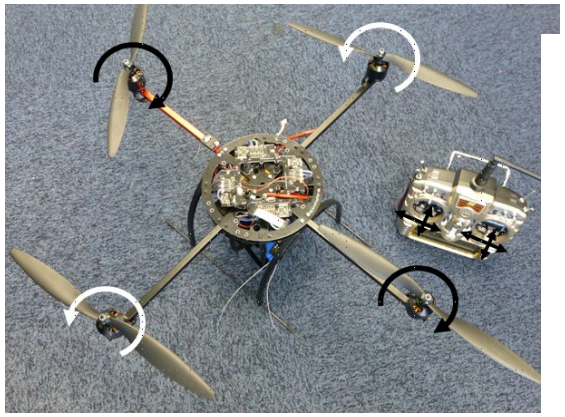


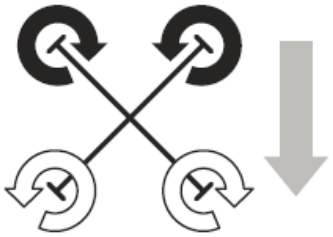
de Bothezat helicopter

multicopter

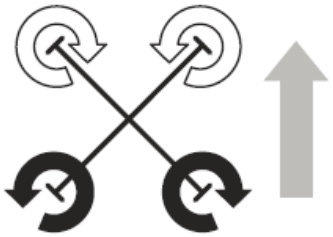
flying car

eVTOL, UAM, AAM
Volocopter

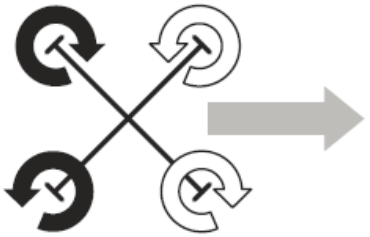




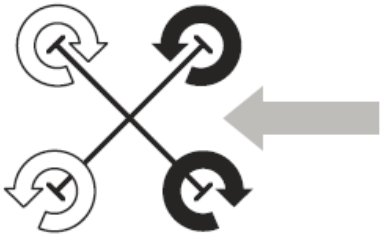
① Backward



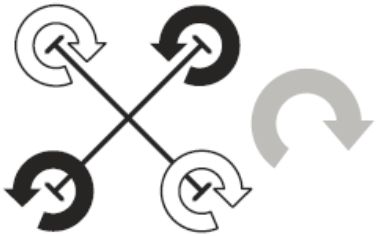
② Forward



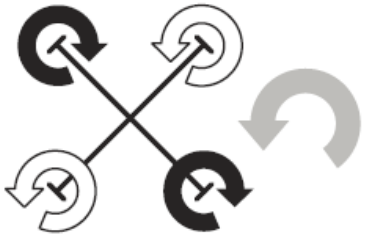
③ Move to the right.



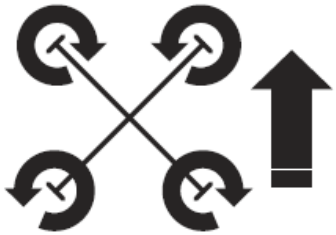
④ Move to the left.



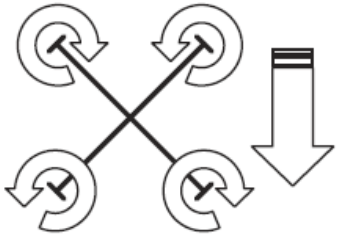
⑤ Turn to the right.



⑥ Turn to the left.



⑦ Climb



⑧ Descent

Increase the rotation speed

Lower the rotation speed

Shinji Suzuki, "Drones open up the sky of the future" (Kagaku Doujin)

Volocopter 2X

- Startup companies in Germany
- Volocopter VC1 flying in 2011
- First manned flight of Volocopter 2X in 2016
- Received a 25M euro funding from Daimler AG in 2017.
- Test flight has been already done in Dubai, United Arab Emirates (UAE), and they announced that they would conduct test flights of an automated hover taxi in late 2019 with the help of the Singapore government. (https://www.jiji.com/jc/article?k=20181025037820a&g=afp)

Wikipedia

Wikipedia

Volocopter successfully conducted manned 'flying taxi' flight in Singapore

https://jidounten-lab.com/x_volocopter-singapore-flyingtaxi

Volocopter launches VoloDrone, a drone for large cargo transport
https://jp.techcrunch.com/2019/10/31/2019-10-31-volocopter-unveils-a-new-evtol-drone-for-heavy-lift-cargo-flights/

Partnering with Grab, a Singapore-based ride-sharing company, and Japan Airlines

Comparing a helicopter to a car

	Robinson R22 	Honda S660 
PAX	2	2
Empty weight	622 kg	830 kg
Engine power	93 kW (125 HP)	47 kW (63 HP)
Fuel capacity	75 L	35 L
Cruising range	556 km	525 km
Width	7.68 m	1.48 m
Maximum speed	188 km/h	
Cruising speed	178 km/h	
Price	About 30 million yen	Approximately 2.2 million yen

Estimated from public information

	Volocopter 2X	Robinson R22
PAX	2	2
MTOW [kg]	450	622
Number of rotors	18	1
Rotor diameter [m]	1.8	7.67
Width [m]	7.67	7.67
Disc loading [kg/m^2]	9.8	13.47
Engine power [kW]	75.6	93
Battery / Fuel	77 kg (Battery)	75 liters
Flight range [km]	25.7	556km
Maximum Speed [km/h]	70	178(Cruise)
Flight duration [min]	27	~180

From ICAS2018_0794

eVTOL with wings

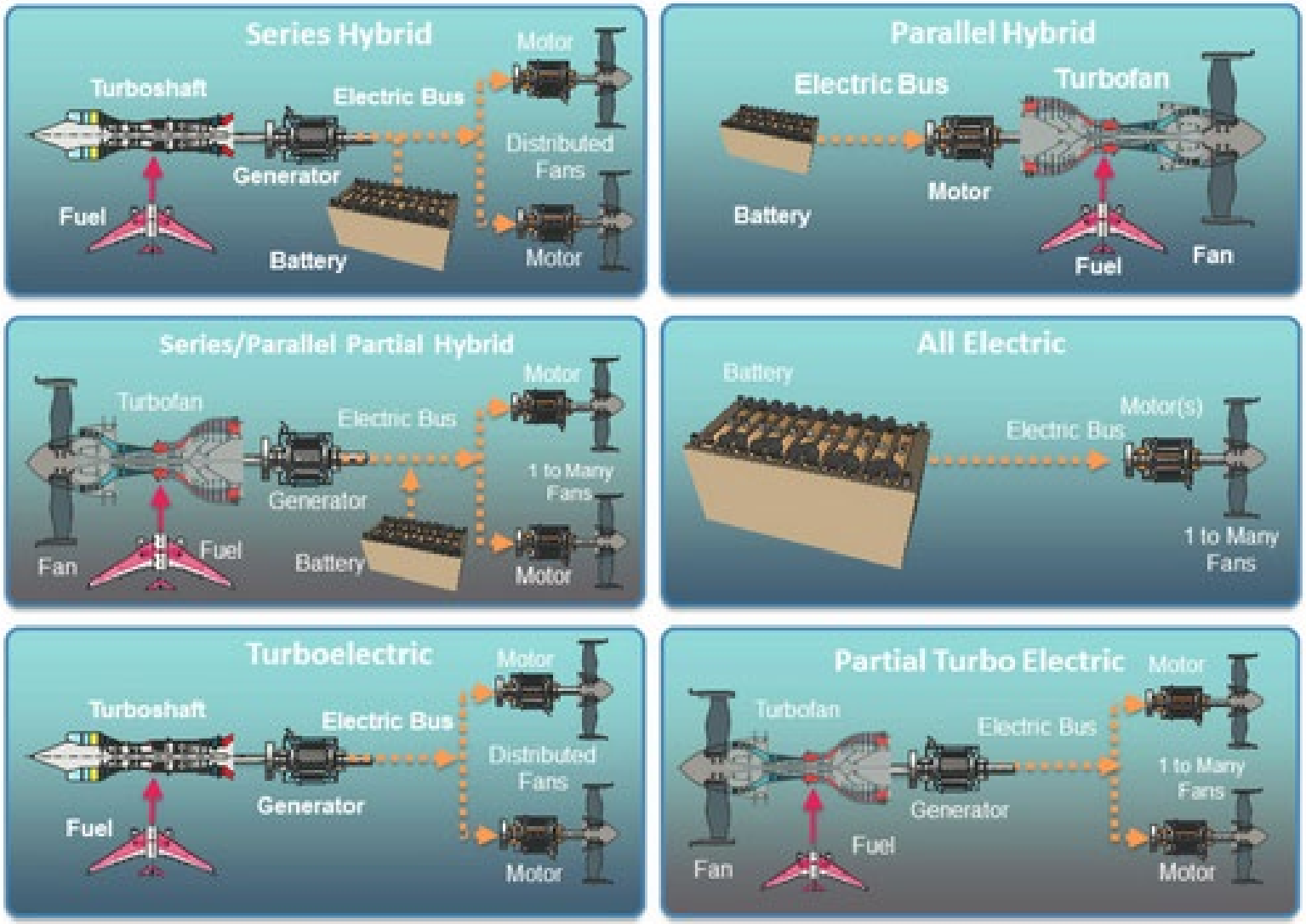
- Boeing acquired Aurora Flight Sciences in 2017 to develop an eVTOL with wings and conduct its flight test.

2019 Paris Air Show

	Volocopter	Aurora	Robinson R22
PAX	2	2	2
MTOW[kg].	450	800	622
OWE[kg].	290	575	399 (Emptty)
Number of Rotors	18	8	1
Rotor Diameter[m]	1.8	1.5	7.67
VTIP[Mac].	0,4	0.74	
Disc Loading[kg/m2]	9.8	56.9	13.47
P Hover[kW]	39.5	160.2	
P Installed	75.6	309.1	93
Specific Energy [Wh/kg]	250	250	~10000
Energy Total[kWh]	19.2	58.5	~750
Battery [kg].	77	233	75 liters
Max Range[km].	25.7	79.5	556km
Vmaxrange[km/h].	70	180	178 (Cruise)
Block Time[min].	27	31	~180

From ICAS2018_0794

hybridization



https://www.nap.edu/read/23490/chapter/7

CO2 Reduction: Toward the 2050 Target (IATA)

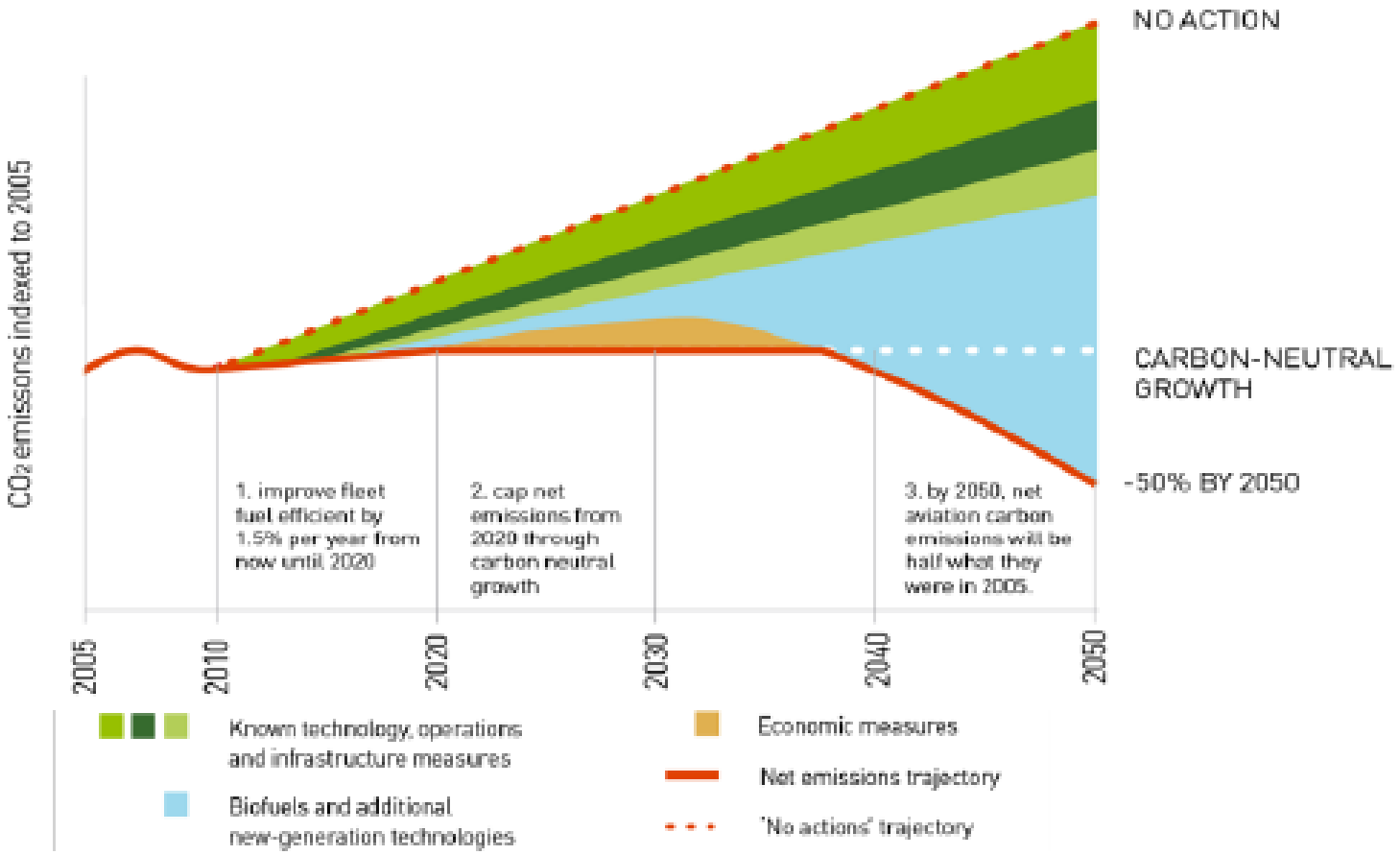


Figure 3: Schematic CO_2 emissions reduction roadmap

https://www.iata.org/en/programs/environment/technology-roadmap/

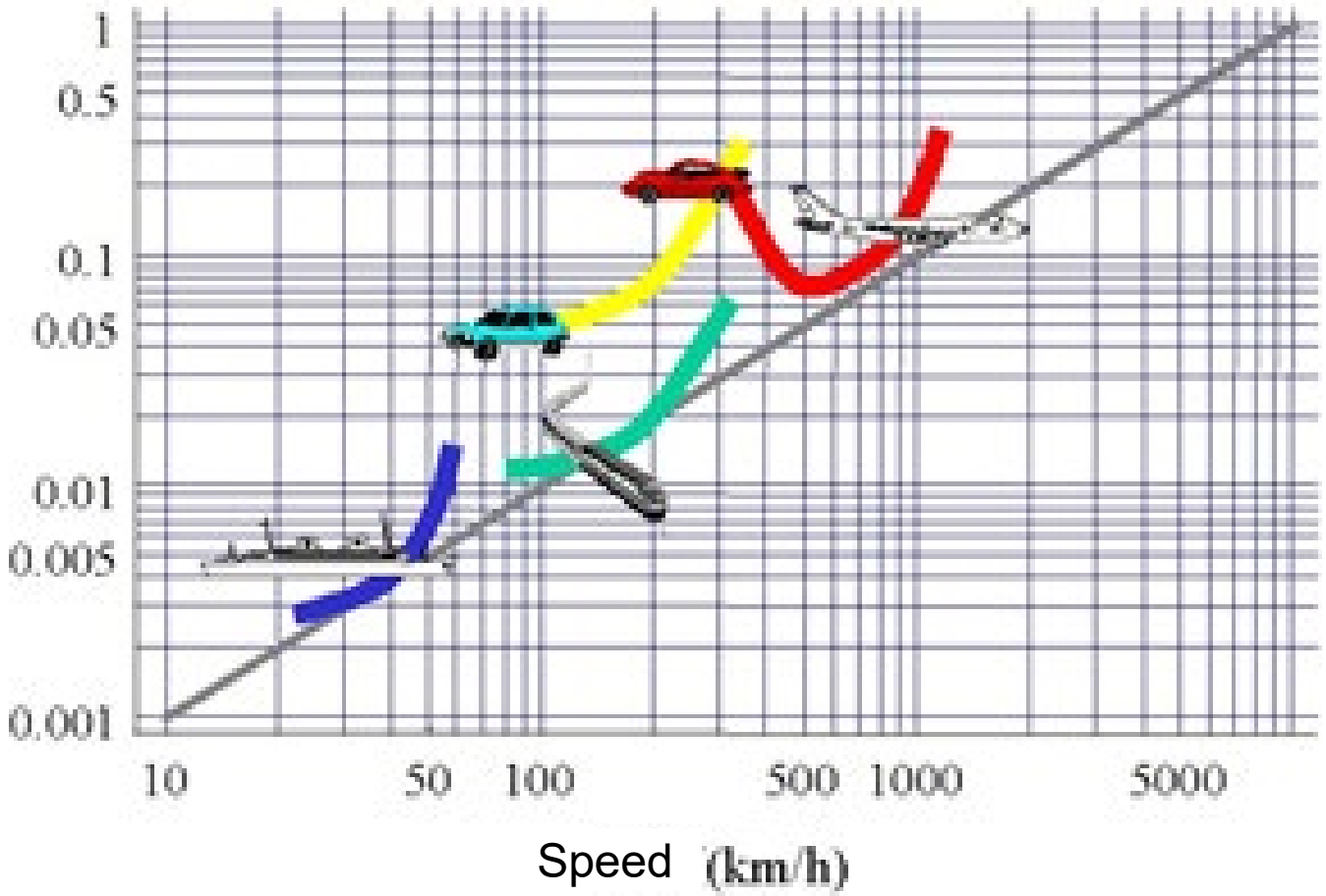
hydrogen-fueled aircraft

- AIRBUS in Europe to commercialize hydrogen-fueled airliner by 2035

https://www.cnn.co.jp/business/35159893.html

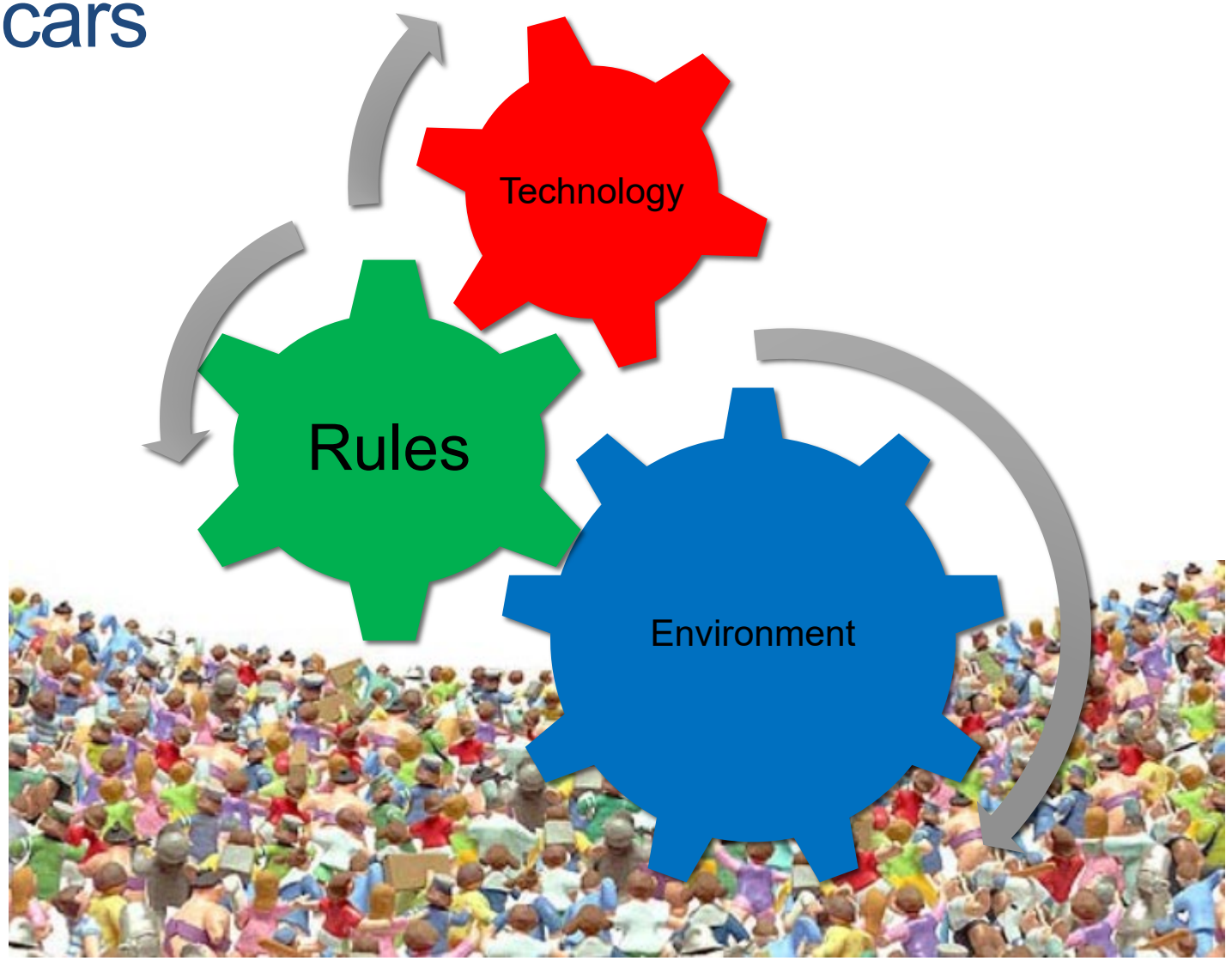
Comparison of energy consumption in transportation

E Energy per unit mass per unit distance



Reference: G. Gabrielli, and TH. von Karman, What Price Speed? Specific Power Required for Propulsion of Vehicles, Mechanical Engineering 72:775(1950).

Challenges for social implementation of flying cars

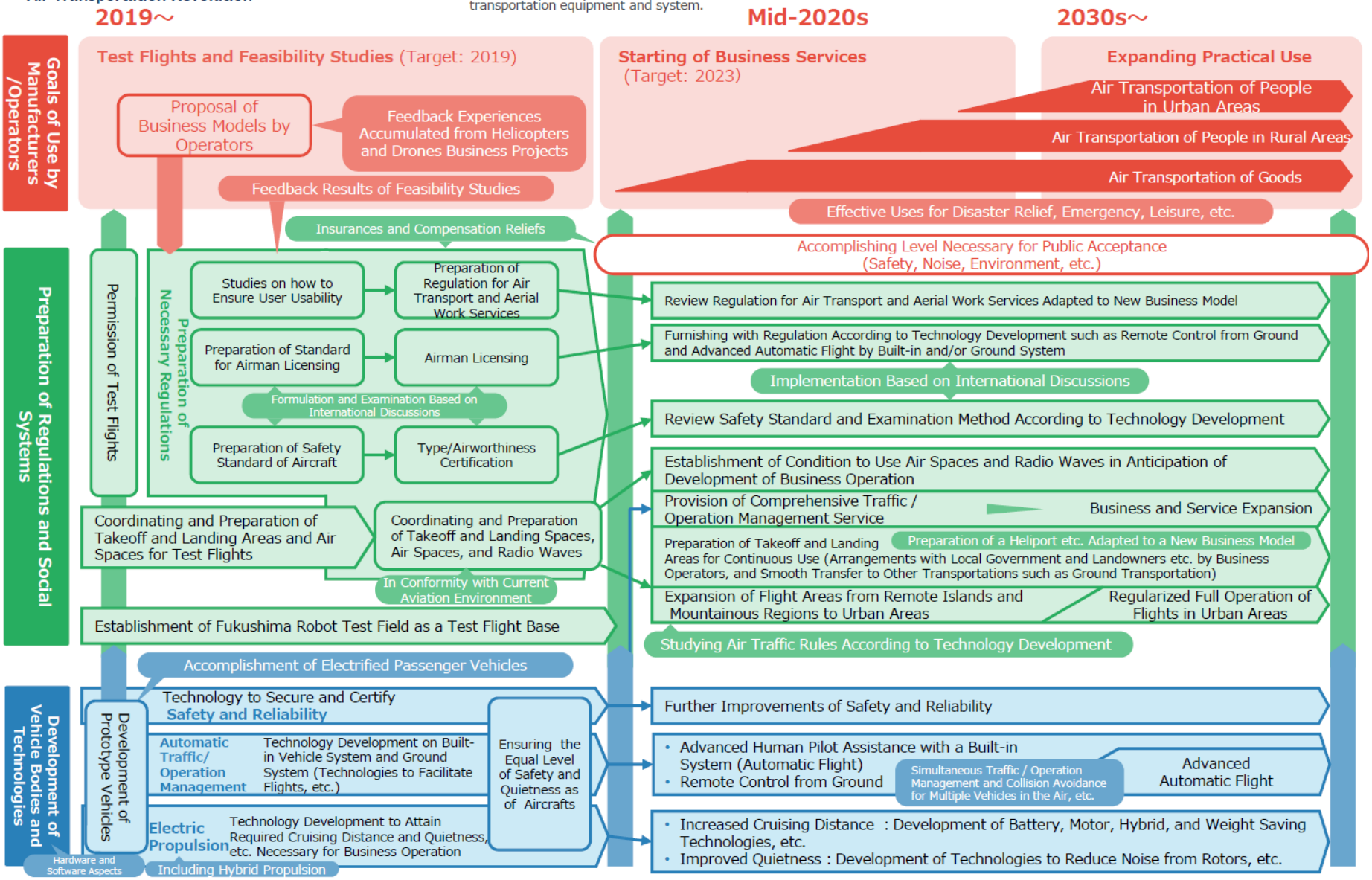


Roadmap towards Air Transportation Revolution

20 December 2018 Public-Private Council for Air Transportation Revolution

This Roadmap depicts a flow of technology developments and establishment of regulations which should be progressed with public-private cooperation. The Roadmap focuses on possibility that realization of more familiar and convenient air transportation means by so-called "a flying vehicle" – an electrified, vertical takeoff and landing, and pilotless aircraft – will lead to solve issues in both urban and regional areas.

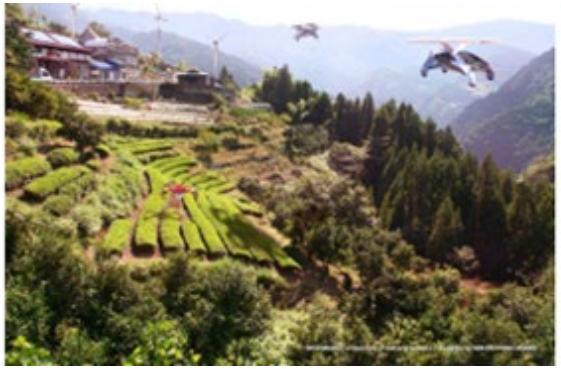
(Note) It should be recognized that a grand design pertaining to use of the sky will be necessary under developmental trends of other transportation equipment and system.



https://www.meti.go.jp/shingikai/mono_info_service/air_mobility/index.html

Gradual expansion of use

Transport of goods



Transport of people in rural areas

Transport of people in cities

https://www.meti.go.jp/shingikai/mono_info_service/air_mobility/index.html

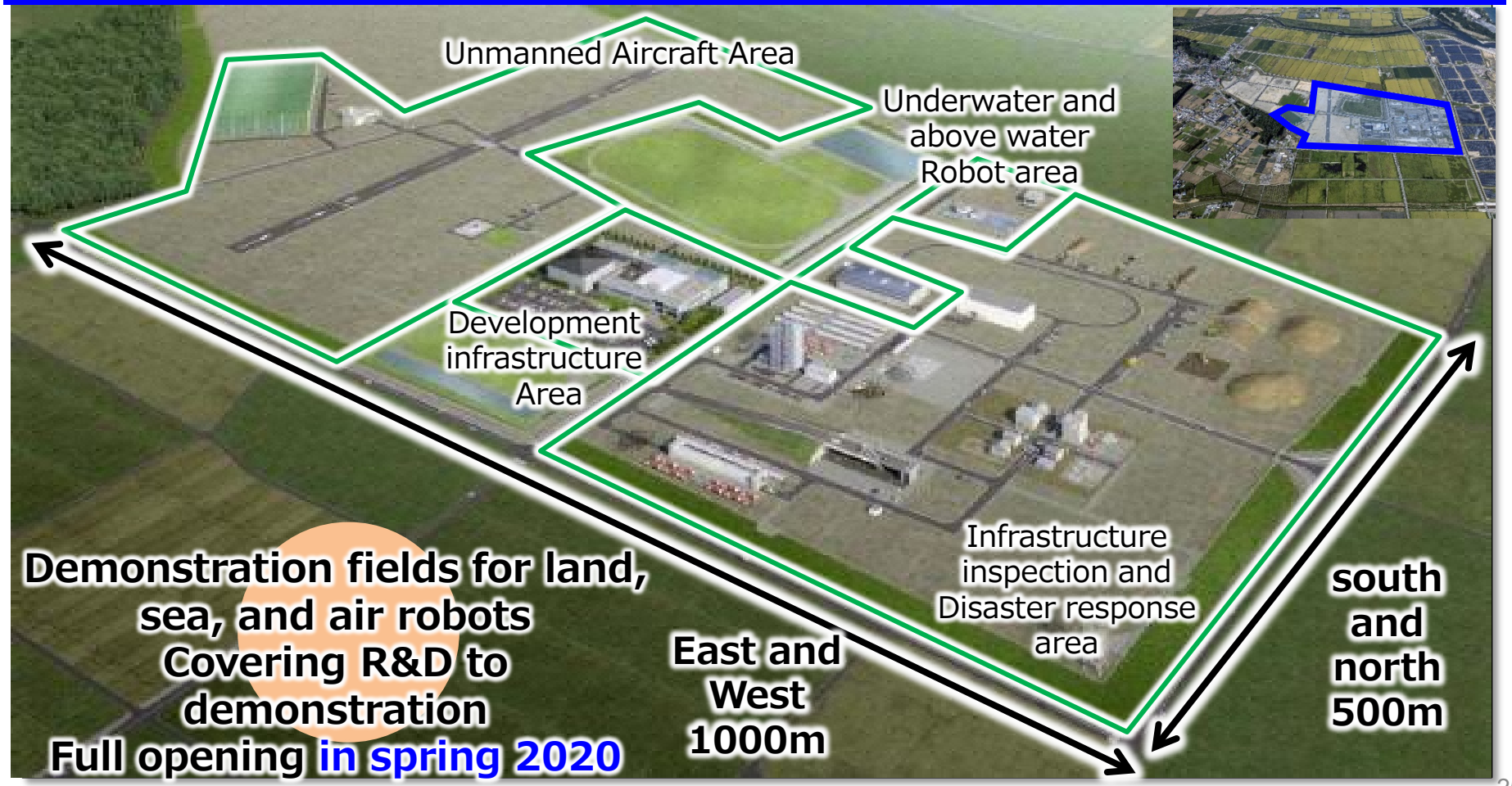
- Practitioner Level WG (2020-)
  - Use Case Study WG
  - Aircraft Safety Standards WG
  - Pilot Proficiency Certification WG
  - Operation Safety Standards WG

Challenges for social implementation of flying cars

- Safety
- Needs
- Implementation cost
- Environmental issues (noise, CO2)
- Energy Issues
- Infrastructure such as ports, navigation, and communications
- Development environment, flight test environment
- Feasibility study

Overview of the Fukushima Robot Test Field

- **A base for the realization of a robotics industry cluster for the purpose of industrial reconstruction in the Hamadori area, etc.**
- An unprecedented R&D center that provides a comprehensive testing environment for land, sea, and air field robots



https://www.fipo.or.jp/robot/

THANK YOU VERY MUCH FOR YOUR ATTENTION.