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# Trends in eVTOL performance

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# Types of eVTOL

- Approx. 820 eVTOL models are proposed/under development.
- Vectored Thrust、Lift+Cruise、Wingless are used in many models.

## Main eVTOL Types

### Vectored Thrust

The wings and/or propellers are tilted horizontally during cruising and vertically during takeoff & landing.

*Image*
*(Joby Aviation S4)*

Over 270 types

### Lift + Cruise

It has fixed wings and vertical rotors for cruising, and propellers for takeoff and landing.

*Image*
*(City Airbus NextGen)*

Over 140 types

### Wingless

Takeoff, landing and cruising using multiple fixed propellers.

*Image*
*(EHang 216)*

Over 230 types

### Electric Rotorcraft

electric helicopter, autogiro.

*Image*
*(Jaunt)*

Over 50 types

### Hover Bikes

Over 100 types

※The number of models was based on Vertical Flight Society web sites. It is including models whose development has been discontinued and prototype models.



Photo source: Each company's website

# Major eVTOLs and certified year



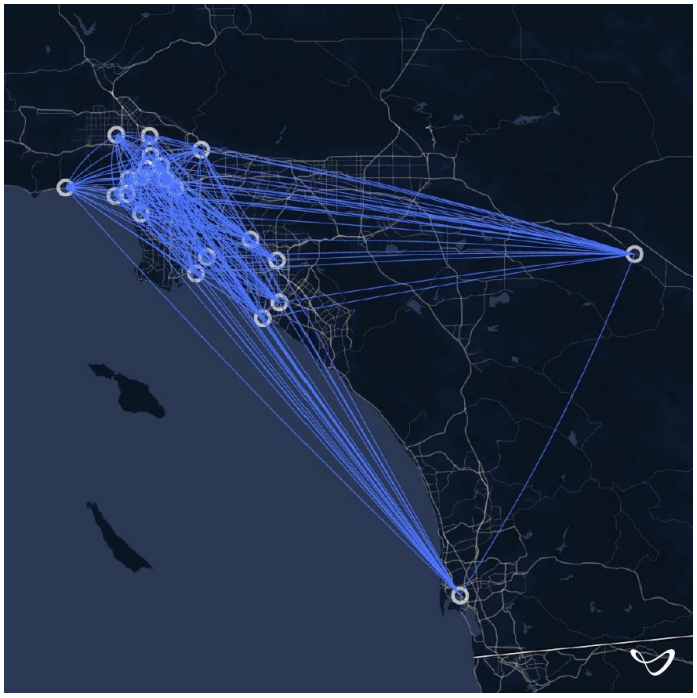



Photo source: Each company's website

# Planned use-case examples

## Air Taxi in the city area

- Average flight range is 40km.
- Cruising speed is ~266km/h.
- Short turnaround time.



Source: Joby Aviation Analyst Day, June 3rd, 2021

## Inter-city transportation

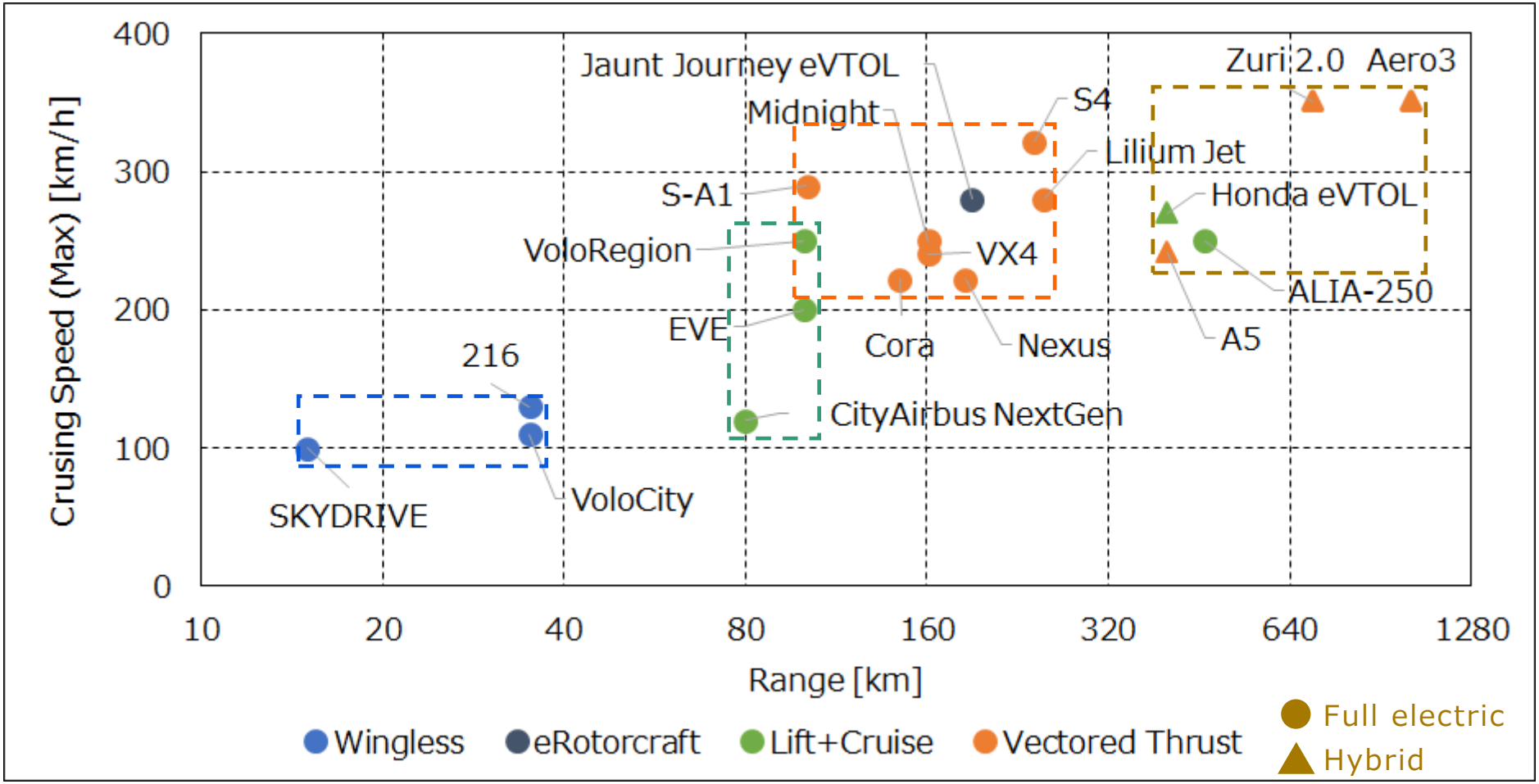
- Maximum flight range is 300km within one hour on a single charge.


Source: Lilium news release

**Long-range flight performance is required, in order to shorten the charging time even in short/mid-range use-case.**

# eVTOL Performance (Range/Speed)

- Wingless → Range:15-35km, Speed:130km/h(Max)
- Lift+Cruise → Range:80-100km, Speed:250km/h(Max) ※*except ALIA-250*
- Vectored Thrust → Range:100-250km, Speed:322km/h(Max)
- Hybrid → Range:400-1000km, Speed:350km/h(Max)

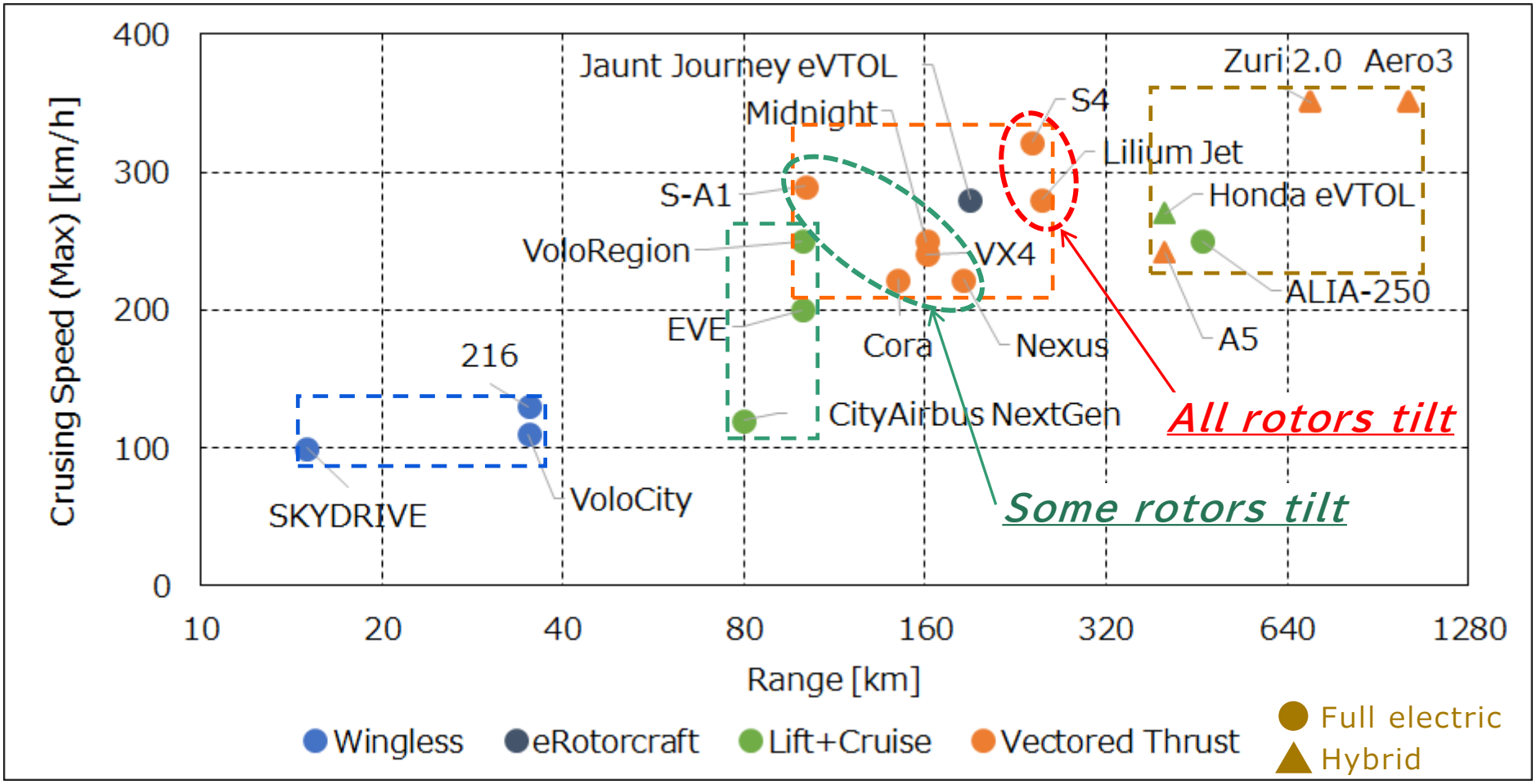





Source: Created by MRI

# eVTOL Performance (Range/Speed)

- Vectored thrust can divided into 2 types.
  - All rotors tilt during cruise → Approx. 250km range
  - Some rotors tilt during cruise → 100-185km range

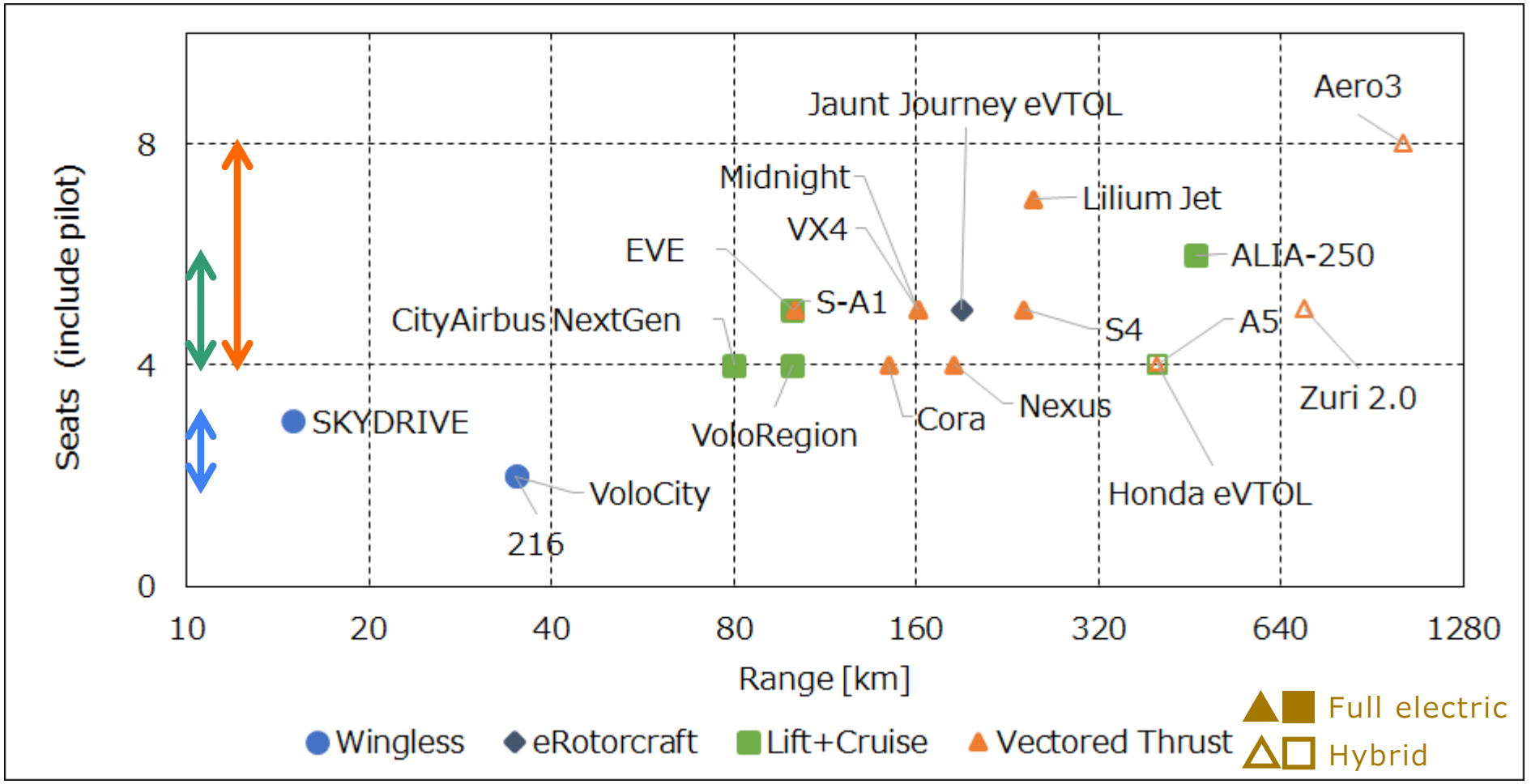





Source: Created by MRI

# eVTOL Performance (Seats)

- Wingless → 2-3 Seats
- Lift+Cruise (include hybrid) → 4-6 Seats
- Vectored Thrust (include hybrid) → 4-8 Seats

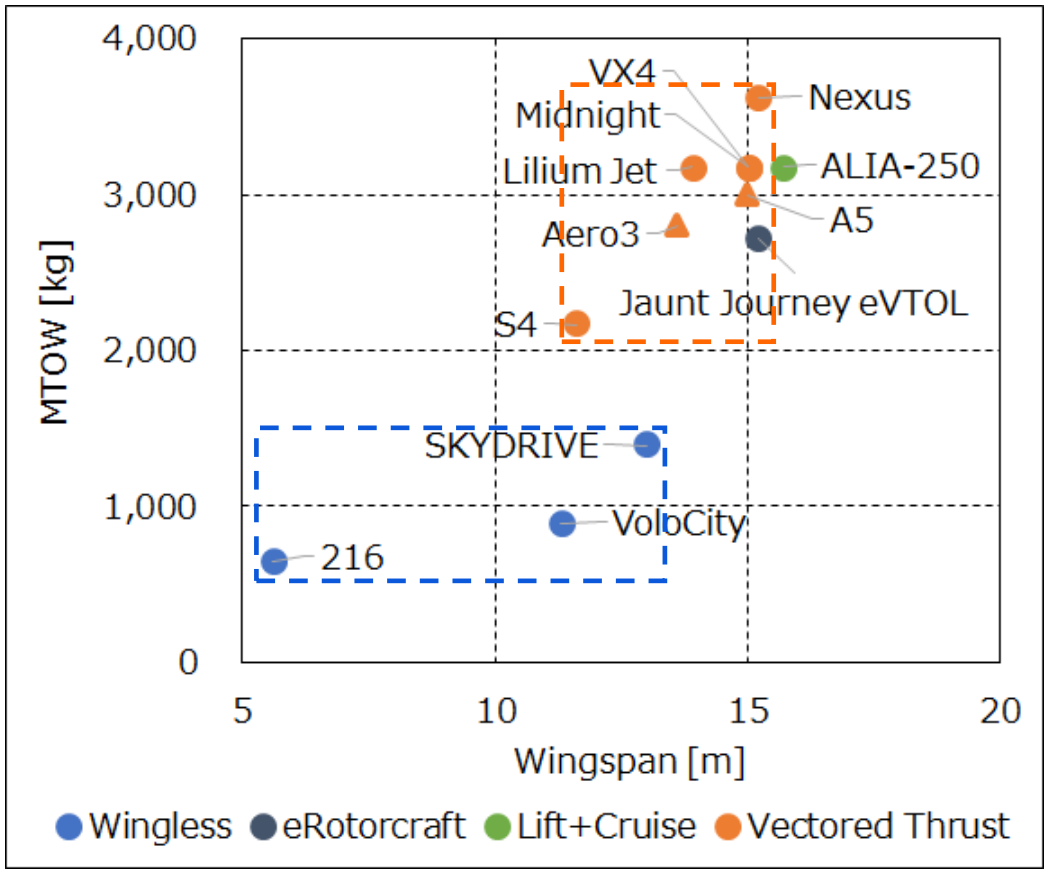


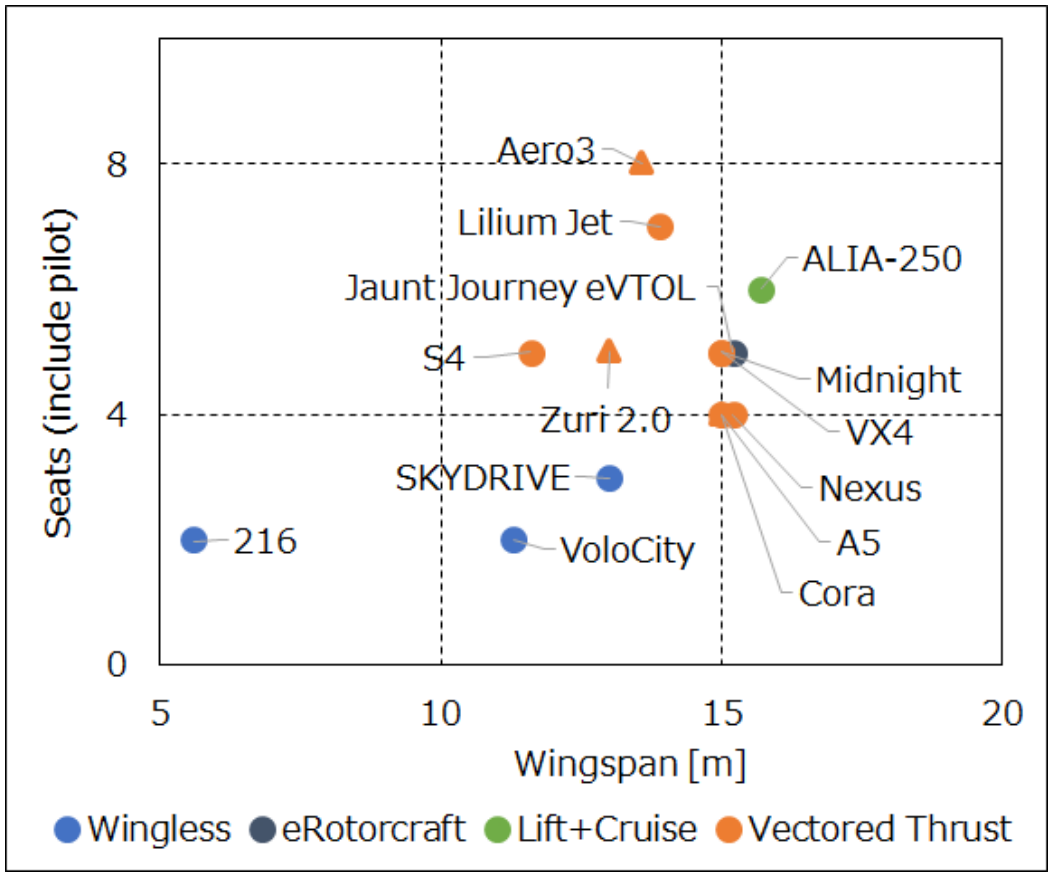

Source: Created by MRI

# eVTOL Performance (MTOW/Size)

- Wingless → MTOW: 650-1,400kg, Wingspan: 5-13m
- Vectored Thrust → MTOW: 2,177-3,630kg, Wingspan: 11-16m

*※The data is less than previous figures because MTOW/Wingspan of some eVTOLs is not open.*




Source: Created by MRI

# Propulsion Type

- Wingless → 12-18 motors
- Lift+Cruise → 5-10 motors (1-2 for cruise)
- Vectored Thrust (Fully/Partially) → 6-30 motors

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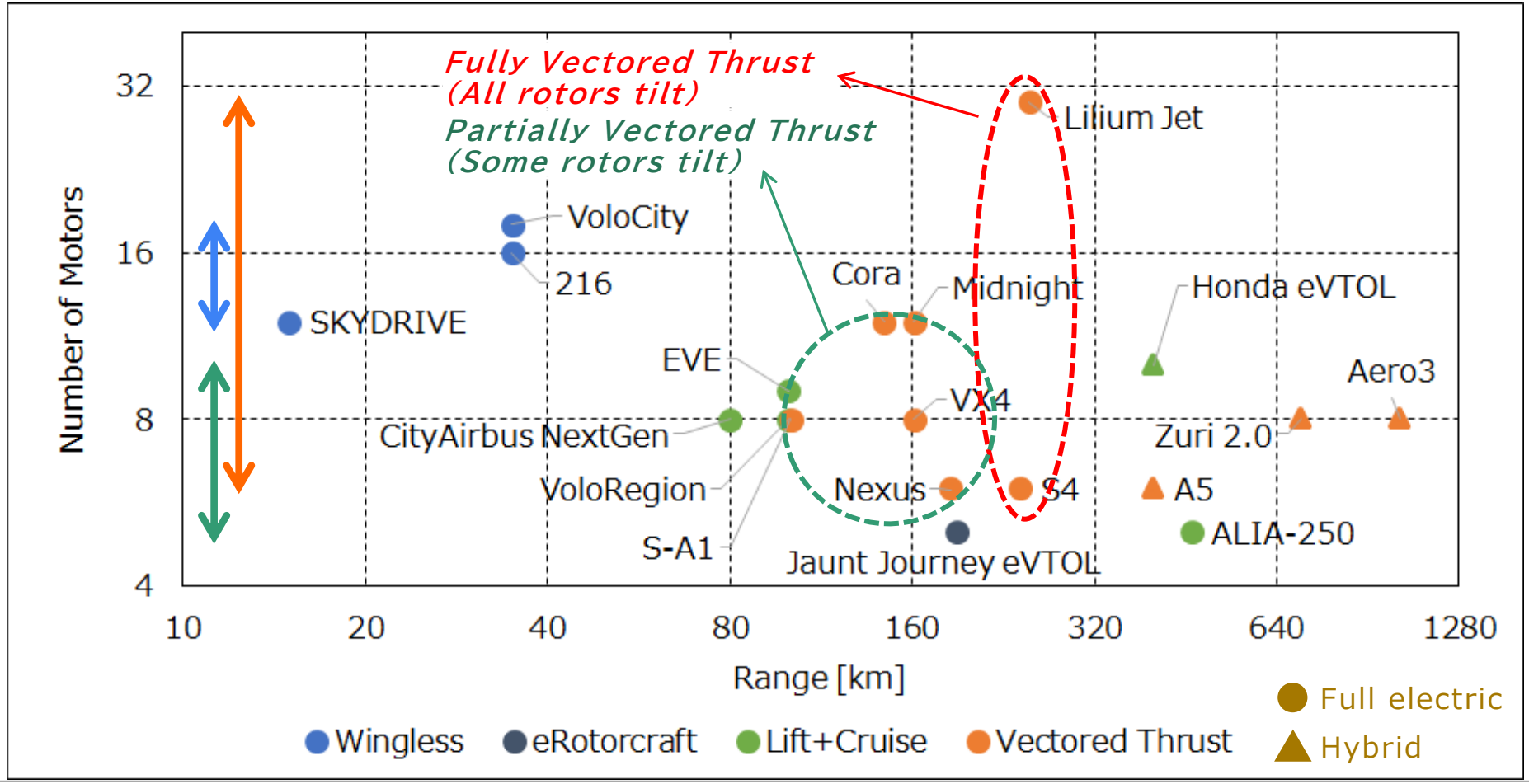
- Full electric
- Hybrid

➡ A wide variety of propulsion systems have been proposed.








Source: Created by MRI

# Challenges with components

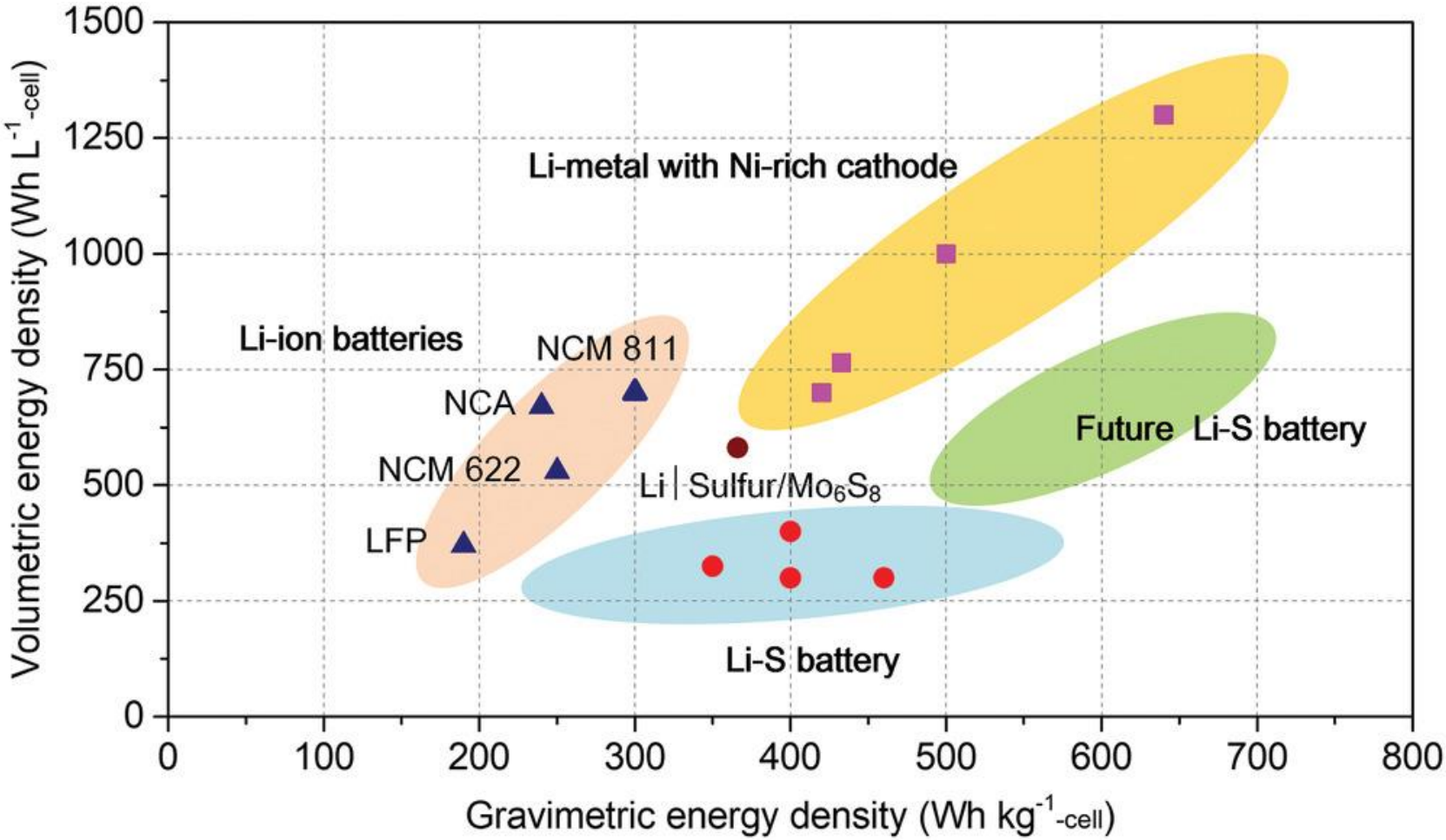
- The examples of challenges regarding component technologies for enhancing flight performance are as follows.

| Component | Examples of Challenges |
|---|---|
| Motor | • Improving short-term output in case of failure.<br>• Cooling mechanism to address heat. |
| Power source (Battery) | • Improving the performance of both capacity density and power density.<br>• Improving the cycle life time. |
| Control/ Management | • Improving automation level of various functions to support pilot tasks. |
| CNS | • Expanding coverage and maintaining/improving accuracy and reliability at low altitudes.<br>• Improving performance for remote pilot & autonomy. |
| Power charging | • Shortening power supply time.<br>• Automation and/or Labor saving of operation. |

*The air-mobility technology roadmap are developing in NEDO ReAMo project, and discussing technical challenges.*

# Battery performance trends

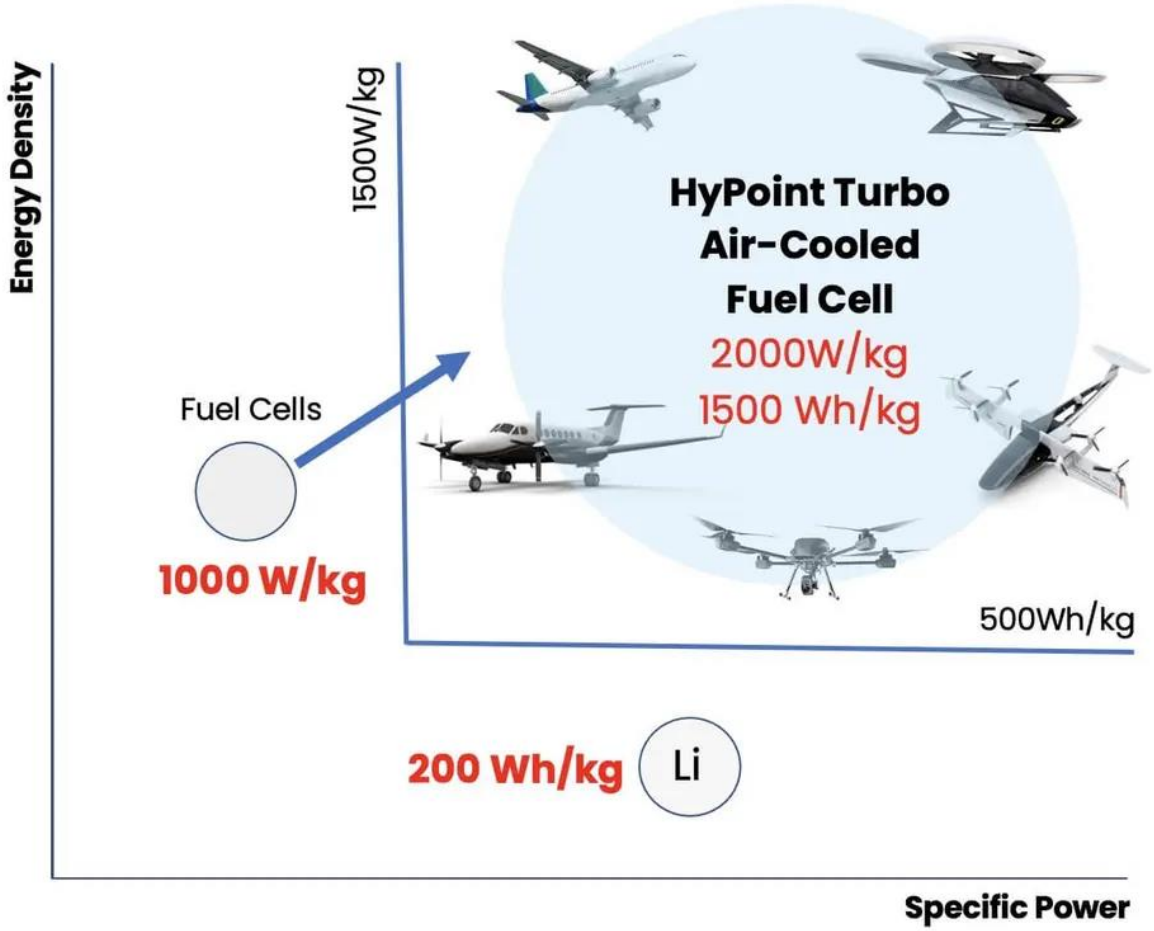
- Current Li-ion batteries energy density is 200-300Wh/kg.
- Development of Beyond LIB (Li-S, Li-metal, Li-Air, …) are required.




Source: Liu et al, Strategy of Enhancing the Volumetric Energy Density for Lithium–Sulfur Batteries (2020)

# Availability of hydrogen fuel cells

- HyPoint has developed air-cooled hydrogen fuel cell system.
- It supplies at least 2000W/kg power density and up to 1500Wh/kg energy density, with plans to increase 3,000 W/kg by 2024.




Source: https://www.h2-view.com/sponsorships/hypoint/

# Charging performance

- Charging time of eVTOL

| | |
|---|---|
| Time for full charging | 30-60 min |
| Time for charging under operation | 5-15 min (※ from some operational plan) |
| Time for battery swapping | 5 min |

- Examples of charging facilities

| | Green Motion/Pipistrel | | Beta |
|---|---|---|---|
| Model | SKYCHARGE Mobile | SKYCHARGE 40 | Beta Charging Pad |
| Image |  |  |  |
| Power | 22kW | 20 kW, 40 kW | 320 kW |
| Voltage | 530V DC | ? | 480V AC |

Photo source: Each company's website

# Summary

- A comprehensive trend of flight performance of major eVTOLs was presented; in particular, focusing the differences depending on the concept.

- The technical issues at the component were outlined, and trends of power source were introduced.

未来を問い続け、変革を先駆ける

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