VERTICAL TAKEOFF AND LANDING (VTOL): TECHNIK UND FAKTOR MENSCH

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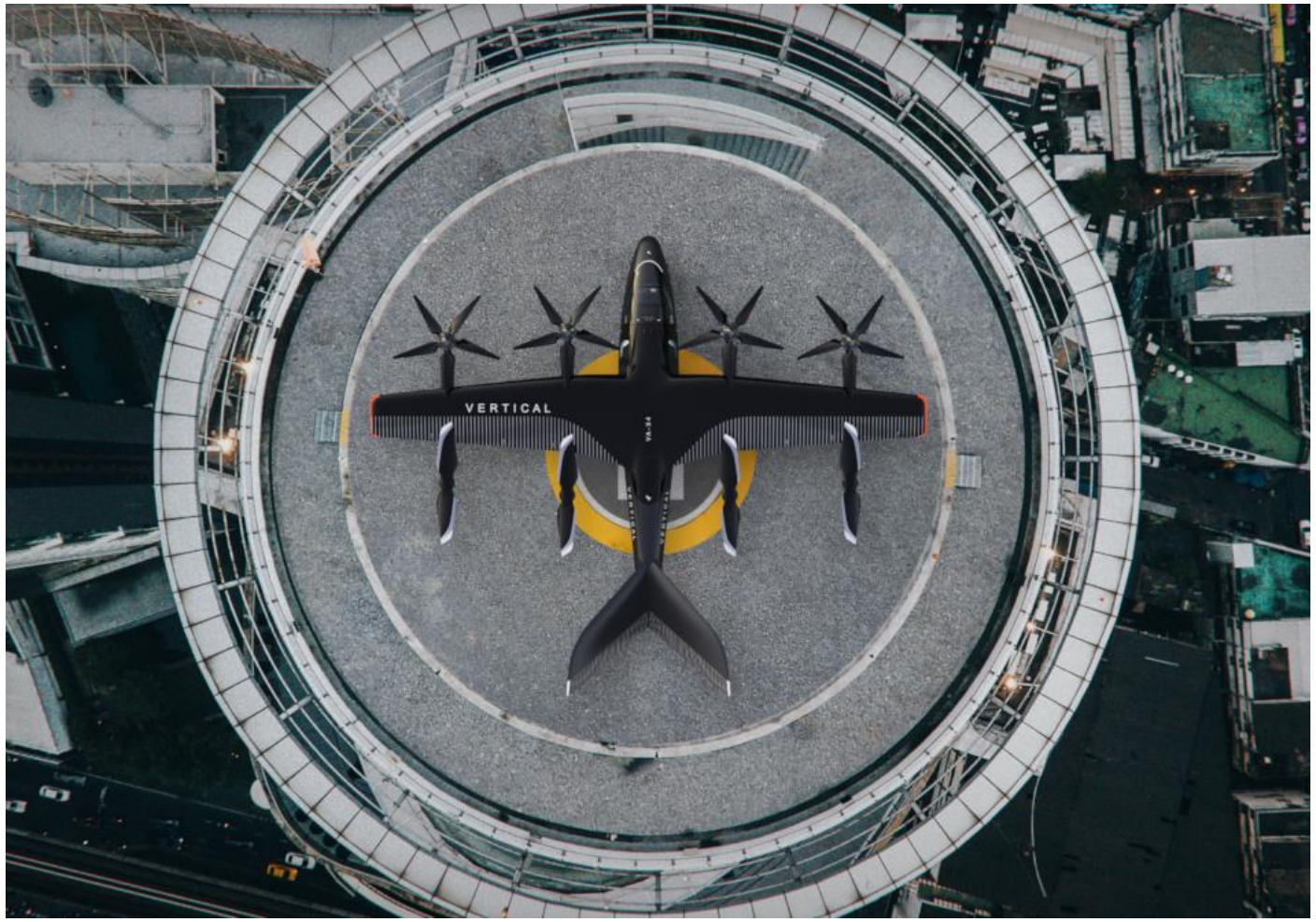


1. EINFÜHRUNG

- Definition
- Technologie
- Eigenschaften
- Kapazität
- Anwendungsbereiche
- Faktor Mensch
- Zukunftsausblick

2. REGELWERK

- EASA SC-VTOL (Basiszertifizierung)
  - Basic / Enhanced
- EASA SC E-19 (Elektromotor)
- EASA MOC-3 SC-VTOL (Batterie)
- EASA RMT.0230 (Training, Lizenzen ...)
- BAZL (Zulassungspflichtige Kategorie)

EASA European Union Aviation Safety Agency	**SPECIAL CONDITION** **Vertical Take-Off and Landing (VTOL) Aircraft**	Doc. No: SC-VTOL-01 Issue: 1 Date: 2 July 2019

Special Condition for small-category VTOL aircraft

Statement of Issue

The Agency has received a number of requests for the type certification of vertical take-off and landing (VTOL) aircraft, which differ from conventional rotorcraft or fixed-wing aircraft. In the absence of certification specifications for the type certification of this type of product, a complete set of dedicated technical specifications in the form of a special condition for VTOL aircraft has been developed. This special condition addresses the unique characteristics of these products and prescribes airworthiness standards for the issuance of the type certificate, and changes to this type certificate, for a person-carrying VTOL aircraft in the small category, with lift/thrust units used to generate powered lift and control.

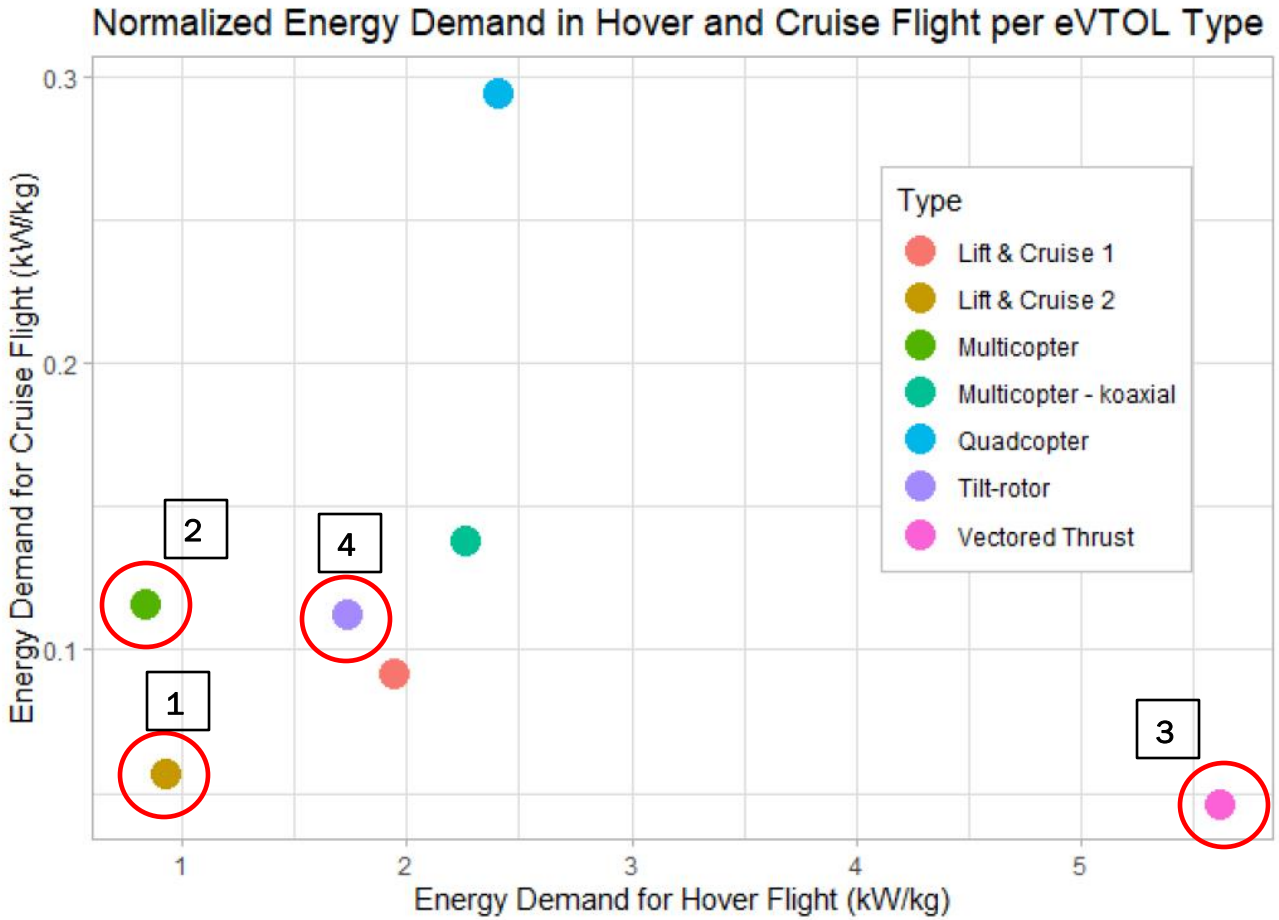
3. AKTUELLE MODELLE

Joby Aviation S4	Volocopter Volocity	Lilium Jet	Vertical VX4	Ehang 216
USA	Deutschland	Deutschland	Grossbritannien	China
FAA	EASA	EASA	EASA & CAA	CAAC
240 km	35 km	300 km	180 km	35 km
320 km/h	110 km/h	300 km/h	320 km/h	130 km/h
2’404 kg	1’924 kg	640 kg	Keine Angaben	Keine Angaben
4 PAX + 1 Pilot	2 PAX + 1 Pilot	5 PAX + 1 Pilot	4 PAX + 1 Pilot	2 PAX (kein Pilot)
Leise (45 dB) Part 135 Fernsteuerung vorgesehen	18 Elektromotoren Rettungssystem Fernsteuerung vorgesehen	Jet-Antrieb Aerodynamischer Flug Kein autonomer Betrieb	Partnerschaften Landeunfall am 09.08.23 Fernsteuerung vorgesehen	Erster kommerziell zugelassener eVTOL Ferngesteuert

4. TECHNIK: BATTERIEN

- EASA MOC-3 SC-VTOL
  - Kategorie Enhanced
  - Minimale Busspannung
- EASA SC E-19
  - Distributed Electric Propulsion
- Lithium-Ion
- Brandgefahr
- Problem: Energiedichte

4. TECHNIK: BATTERIEN



Energiedichte

Aktuell: max. 0.25 kW/kg

1. Joby & Vertical VX4
Cruise: 0.05, Hover: 1.0

2. Volocopter Volocity
Cruise: 0.12, Hover: 0.7

3. Lilium Jet
Cruise: 0.05, Hover: 5.6

4. Ehang 216
Cruise: 0.12, Hover: 1.75

Quelle:
Hagag, N., et al. (2021).
Maximum total range of eVTOL under consideration of realistic operational scenarios.

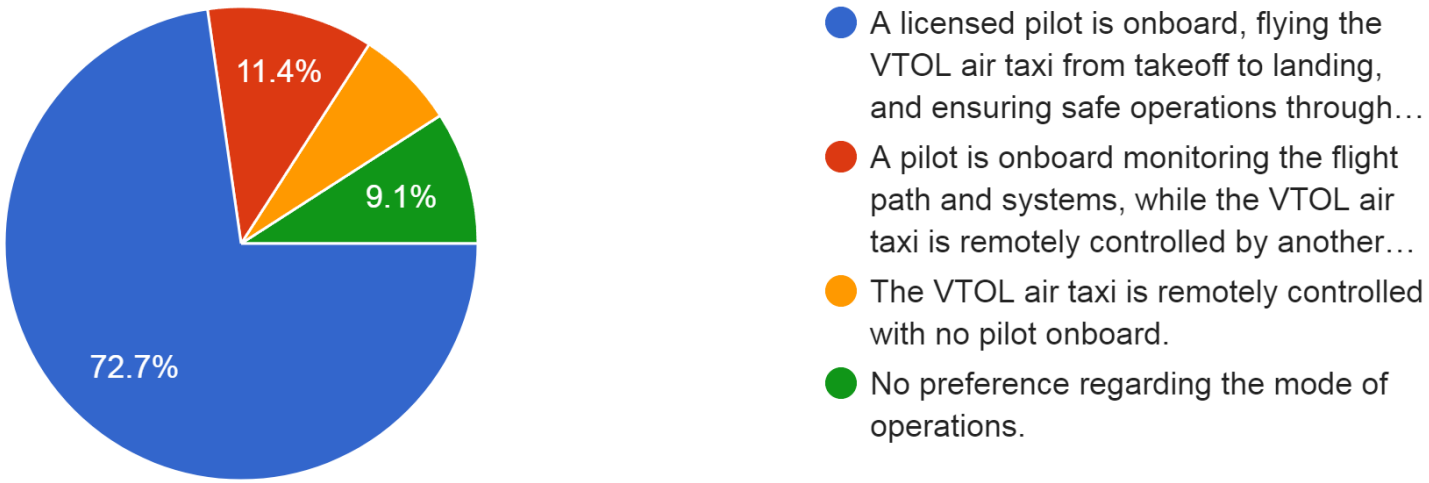
5. TECHNIK: ENERGIEMANAGEMENT

- Energiedichte momentan zu tief
- Hybridantriebe
- Rekuperation
- EASA Energy Policy

6. FAKTOR MENSCH: PASSAGIERE

Imagine yourself as a passenger on a VTOL air taxi. Please indicate which mode of operation you would feel most comfortable with:

44 responses



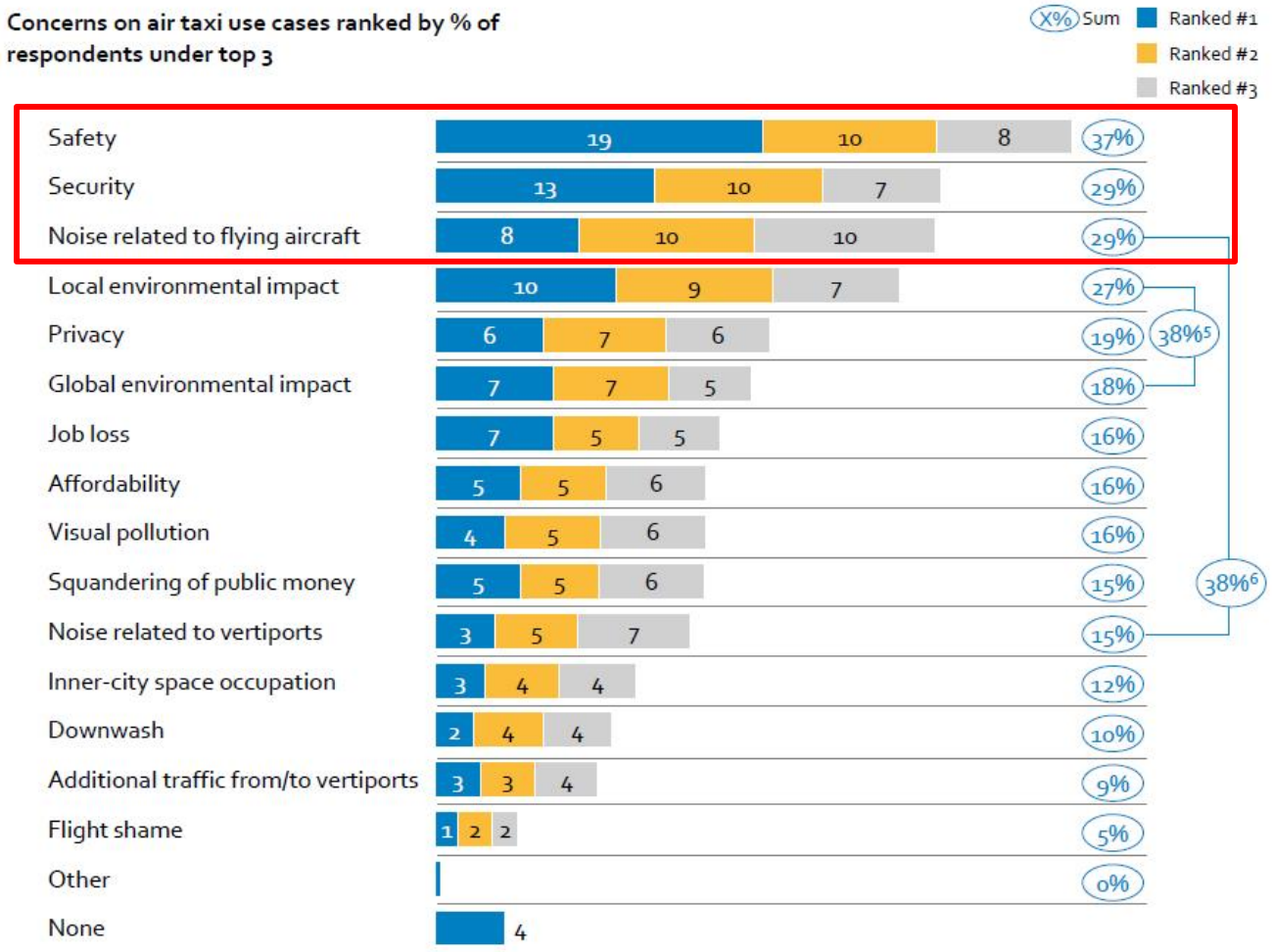
EASA 2021: "Study on the societal acceptance of Urban Air Mobility in Europe" (Seite 9):

A 10 year timeframe, i.e. until 2030: […] it appears <u>unlikely</u> that unmanned transport of people in urban environments may take place within that timeframe […].

6. FAKTOR MENSCH: PASSAGIERE

- EASA SC-VTOL, SUBPART D
- Pilot an Bord
- Vertrauen
- Lärm und Vibrationen
- Perceived Safety (Edwards et al., 2019)
- Soziale Akzeptanz

Figure 39: Noise produced by air taxis is expected to be much higher than that produced by drones



1. Incident due to technical or human failure 2. Incident due to deliberate harmful action, e.g. by criminal organization or terrorists 3. Local environmental impact includes air pollution, negative impact on bird life and insects, decreasing biodiversity 4. Global environmental impact covers climate change 5. Share of respondents that ranked any environmental concern among top 3 answers 6. Share of respondents that ranked any noise related concern among top 3 answers

Source: EASA UAM societal acceptance survey questions C5. What are you most concerned about with respect to air taxis? Please consider your own usage of such a service as well as other people using it (e.g. your family or neighbours), which may affect you as well. Please select up to 6 answers. C6. Please sort your main concerns from 'most concerning' to 'least concerning'.

Quelle:
EASA (2021).
Study on the societal acceptance of urban air mobility in Europe.

7. FAKTOR MENSCH: PILOTEN

- EASA SC-VTOL, SUBPART G
- Hybridsteuerung ohne Ruderpedalen
- Single Pilot Operation (SPO)
- Low Level Flight ~1’000 ft AGL
- Engine Failure
- Pilot Interface

7. FAKTOR MENSCH: PILOTEN

Results: eVTOL Pilot Interface Trends

Pilot Interface trends

- Larger glass, touch with customizable displays.
- Single and dual set-ups.
- Reduced information redundancy.
- Integration of battery information.
- Inceptors – to fly the aircraft.
- Single pilot operations (SPO interface).
- Use of emerging technologies, like synthetic vision, advanced sensors information display.

Bell Nexus Pilot Interface

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EASA Opinion No 03/2023 (Seite 8):
"Increasing levels of automation and pilot assistance systems leading to a different set of competencies and skills possessed by pilots".

Quelle:
Chauhan, B. et al. (2023). *Advanced Air Mobility: A Survey of Current eVTOL Vehicles and Simulation Testbed*

7. FAKTOR MENSCH: PILOTEN

- Training:
  - EASA: Fokus Zertifizierung
  - FAA: Powered-Lift Category Rating
  - CPL/ATPL(H) oder (A)
- Kompetenzen
- Virtual/Augmented Reality
- Inklusion

8. FAZIT

- Zeithorizont
- Regulatorische Hürden
- Batterien
- Elektroantrieb
- Passagiersicherheit
- Öffentliche Wahrnehmung
- Training und Ausbildung

9. EMPFEHLUNGEN

Technisch

- Energiedichte Batterien
- Rekuperation
- Energy Policy

Faktor Mensch

- Umfrage: Pilot an Bord
- Studie: Perceived Safety
- Cockpit Interface
- Flight Path Management

FRAGEN?

QR-Code zu den Handouts
Link: https://qr.link/Y3Xolf

VIELEN DANK FÜR EURE AUFMERKSAMKEIT

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