Vertiports -
Infrastructure and community aspects

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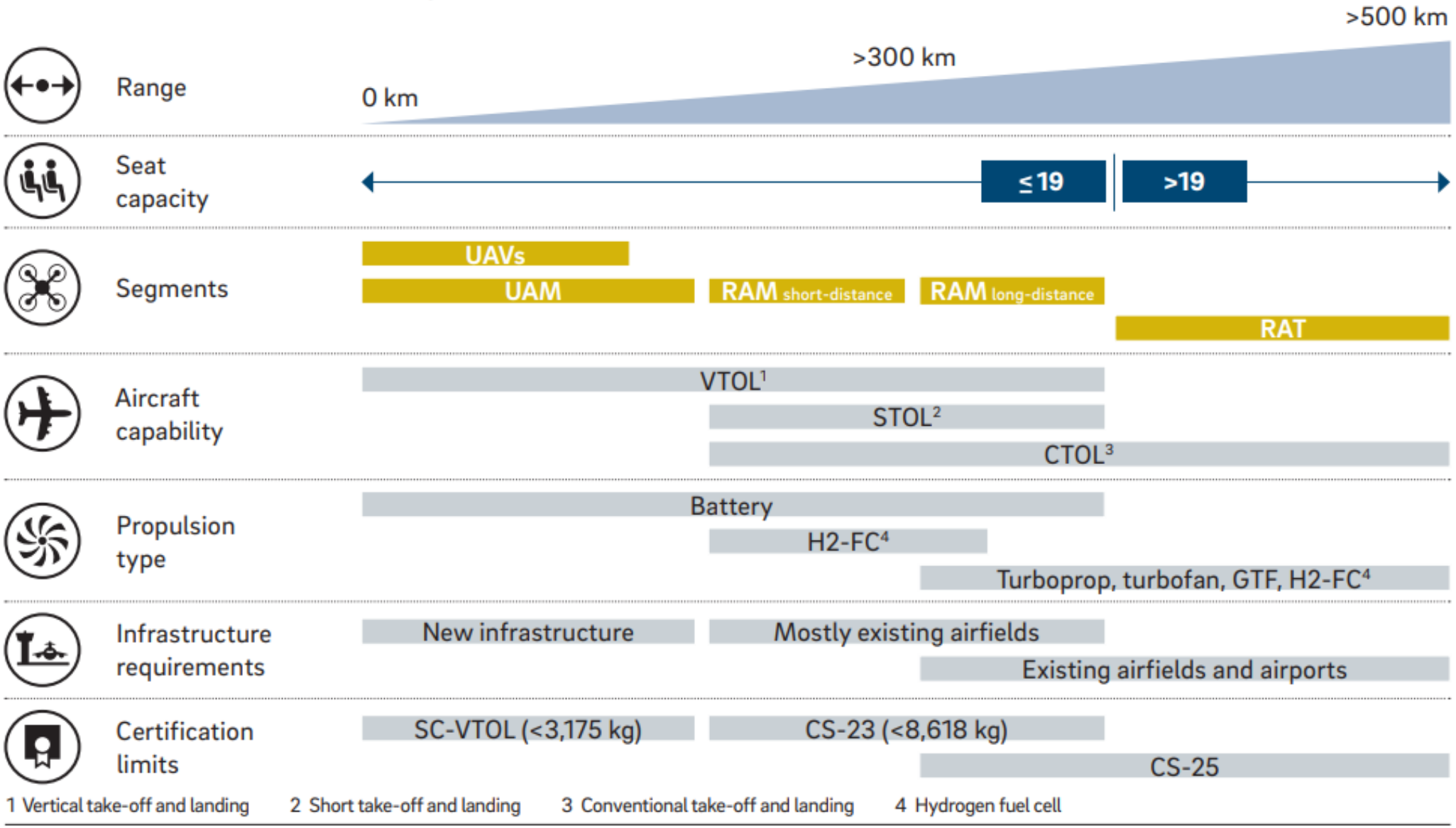
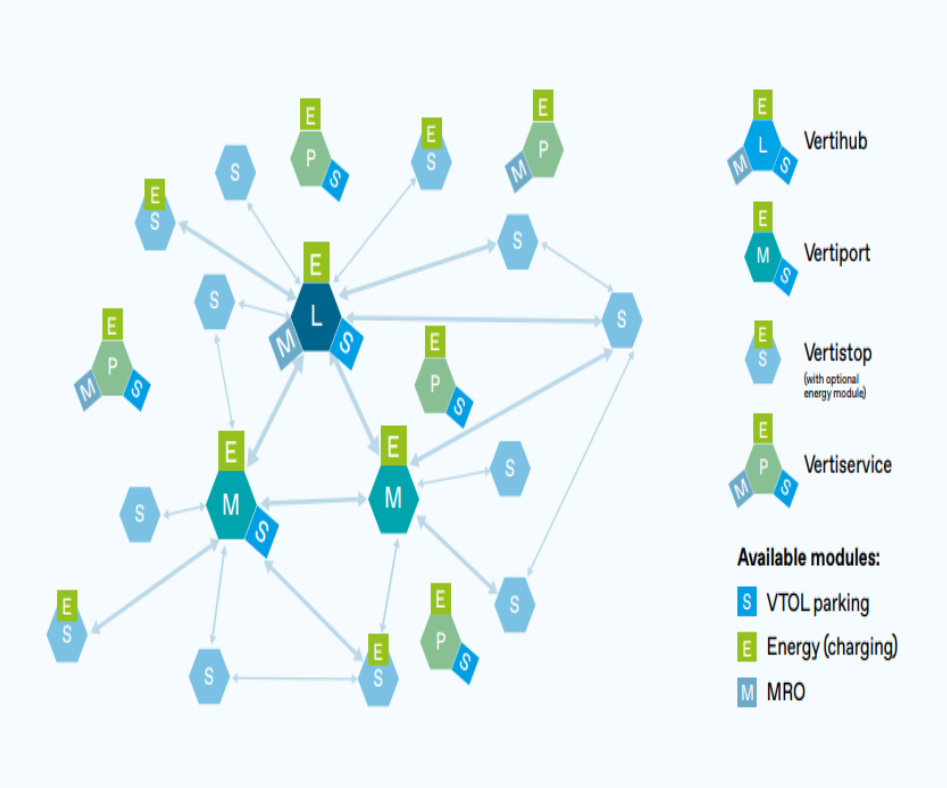
Air systems categories (Source: Roland Berger 2022)



Definitions

'vertiport' means 'an area of land, water, or structure used or intended to be used for the landing and take-off of VTOL-capable aircraft (EASA SC-VTOL-01)



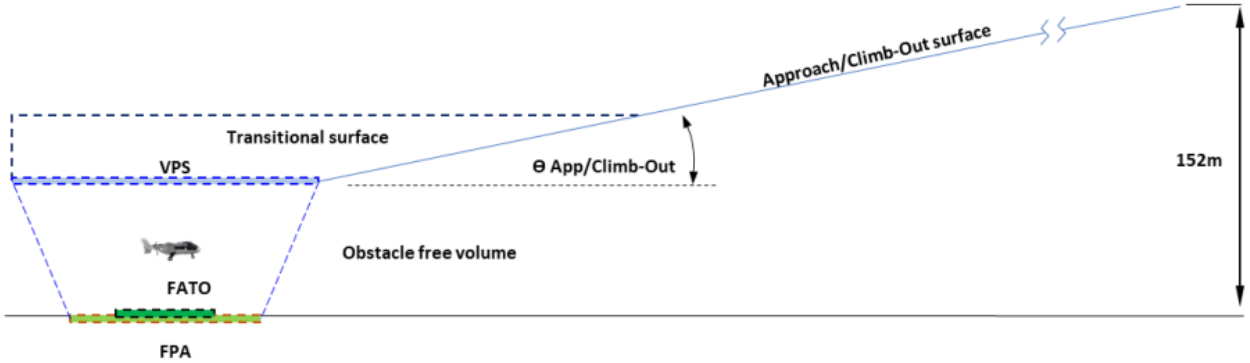
- <u>Vertihub</u> – simultaneous multi-air system operations, recharging capability, ground handling capability, air system maintenance, storage etc
- <u>Vertiport</u> – multi-air system operations, smaller scale facilities/footprint than Hubs
- <u>Vertistop</u> – limited facilities, drop off/pick up only.

- All raise issues of density of operations.
- Distance from nearest access point reduces likelihood of use. Issue of noise in residential areas.
- Passenger or cargo (hub-to-hub or last mile)?
- Not CTOL/STOL (currently limiting scope to urban/metro ranges, not RAM)

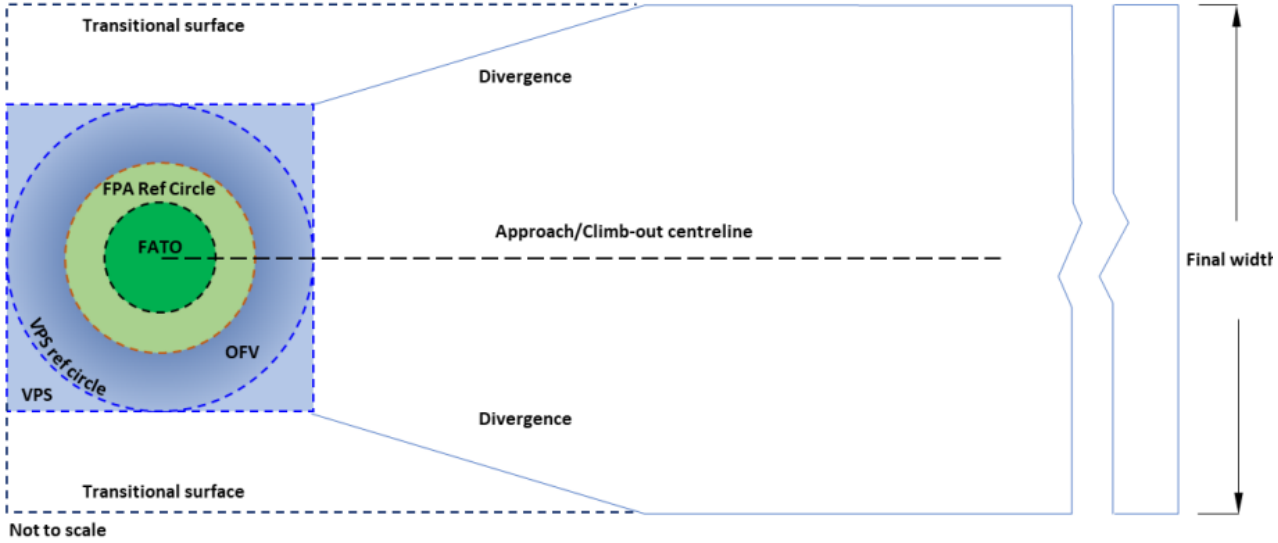
Source: AERTEC

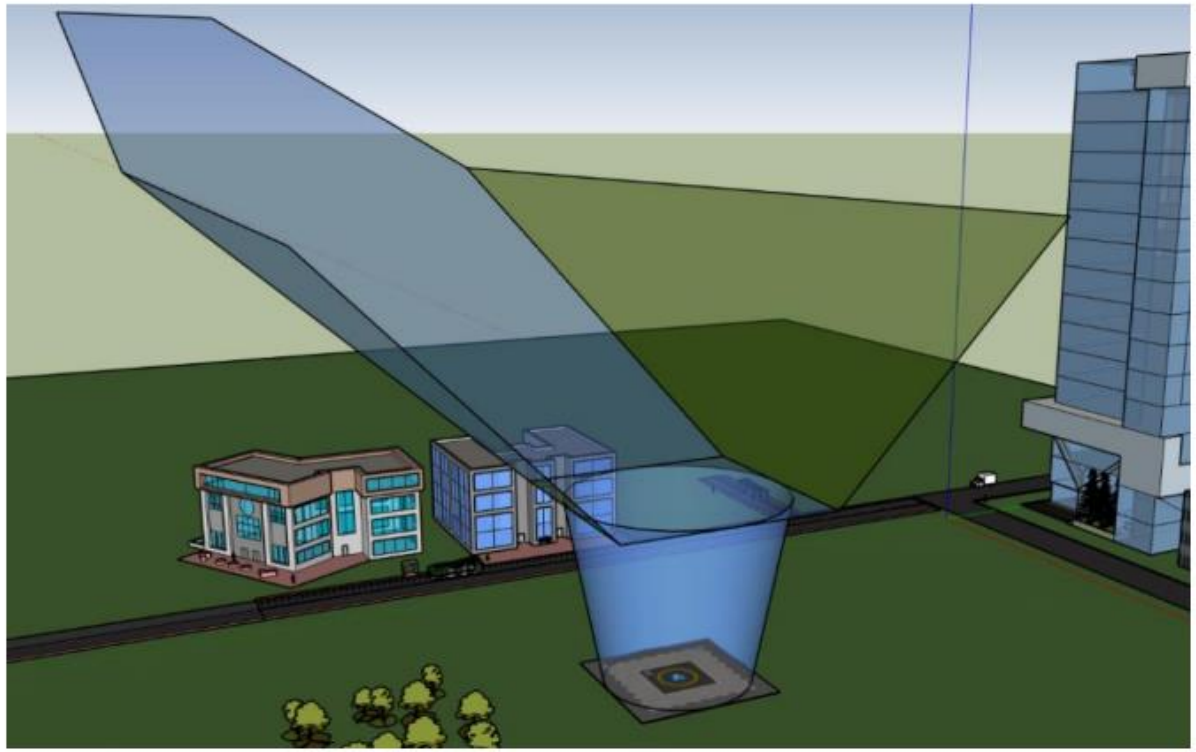
Large cities			Medium cities	
Large, dense, high-income urban city, e.g., Paris, Berlin, Madrid, Hamburg, Vienna, Barcelona			Medium, less dense, medium income, urban/suburban city, Sevilla, Lisbon, Dusseldorf, Riga, Athens	
Outposts, areas of interest or private use	**3-5**	**Vertipads** 	**3-5**	Major suburban commuting stations, private use for high net worth individuals, or in wealthy suburbs
Near concentrations of high origin and destination points	**5-10**	**Vertibases** 	**3-7**	Major corporate headquarters, major retail districts, and major commuting stations
Major airports, city centres, and major commute corridors	**2-3**	**Vertihubs** 	**1-2**	Main airport, downtown, and major work district
	40-60	**Total landing pads**	**20-45**	

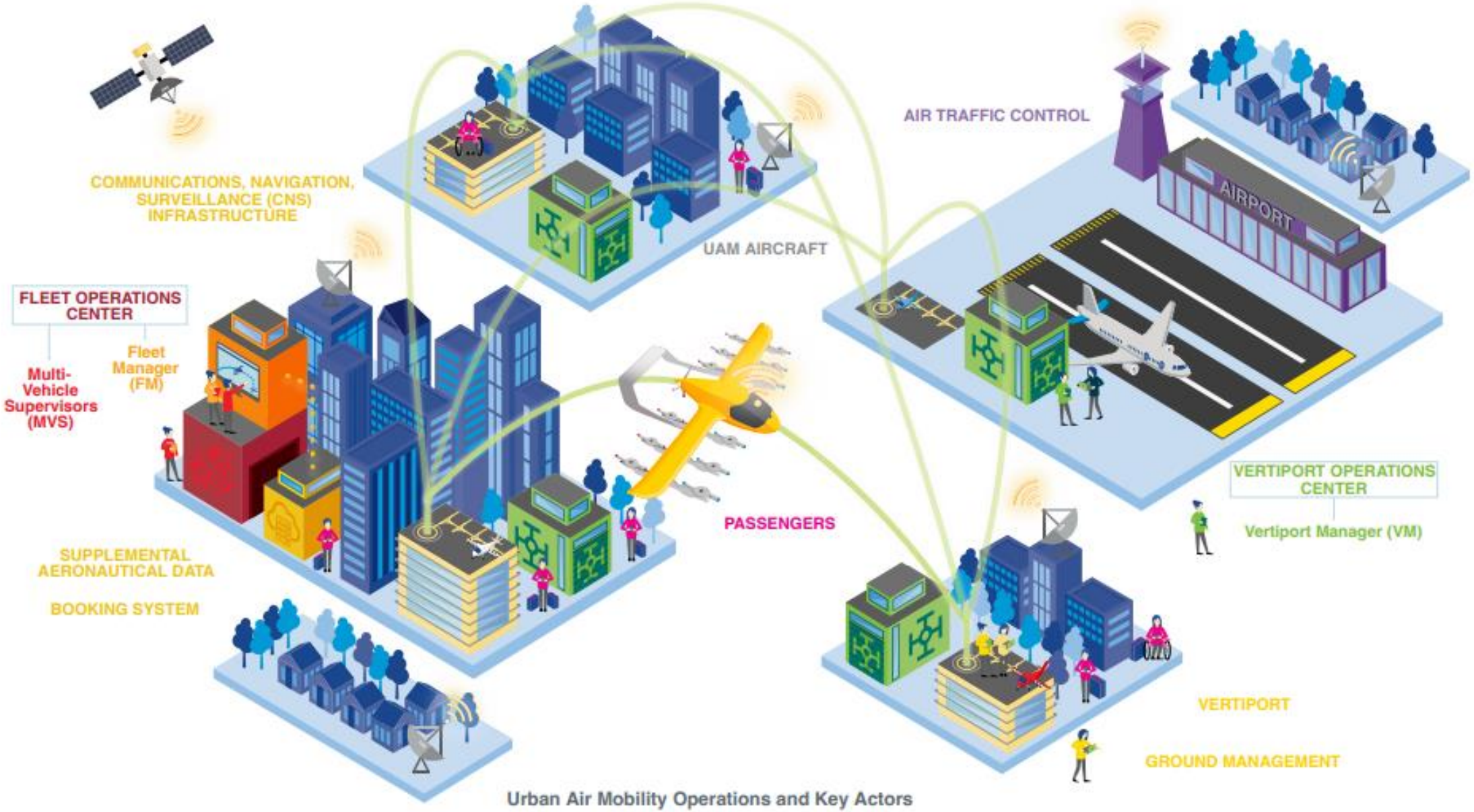
Source: EASA - A study on the societal acceptance of Urban Air Mobility in Europe



Source: CASA Guidelines for Vertiport Design 2023

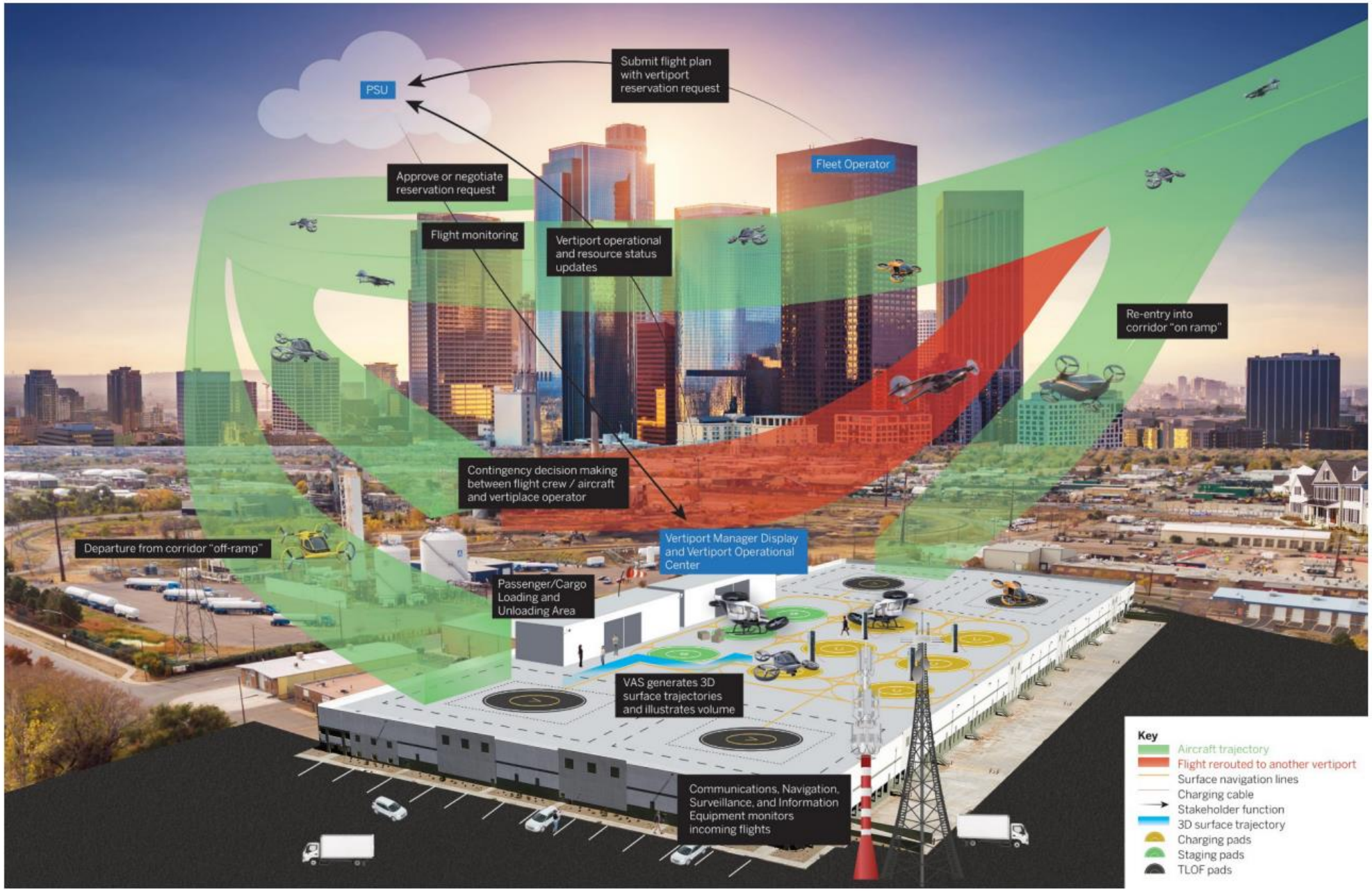




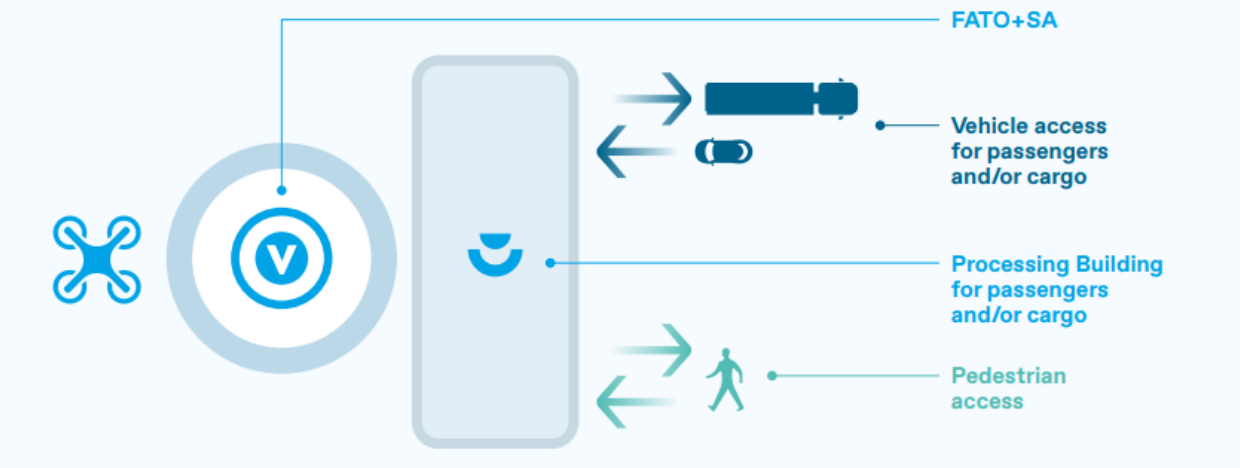


Source: Boeing and Wisk Concept of Operations for Uncrewed Urban Air Mobility (2022)

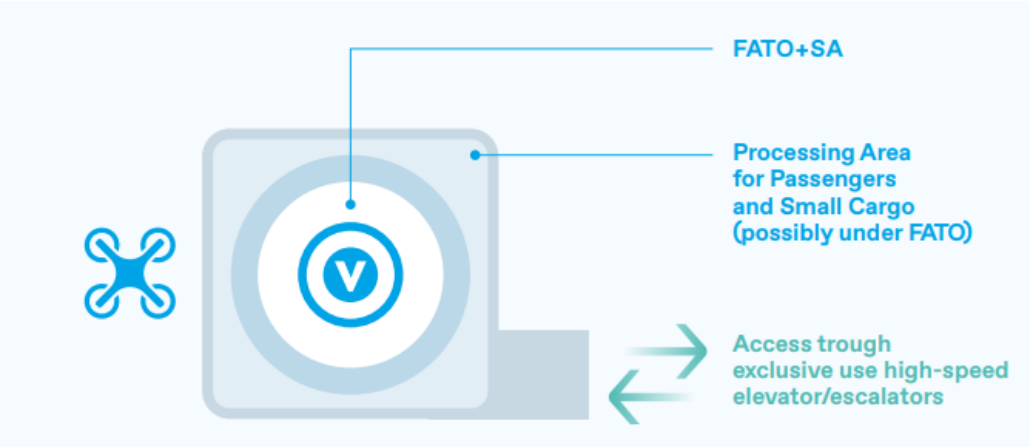
HIGH-DENSITY AUTOMATED VERTIPORT CONCEPT OF OPERATIONS



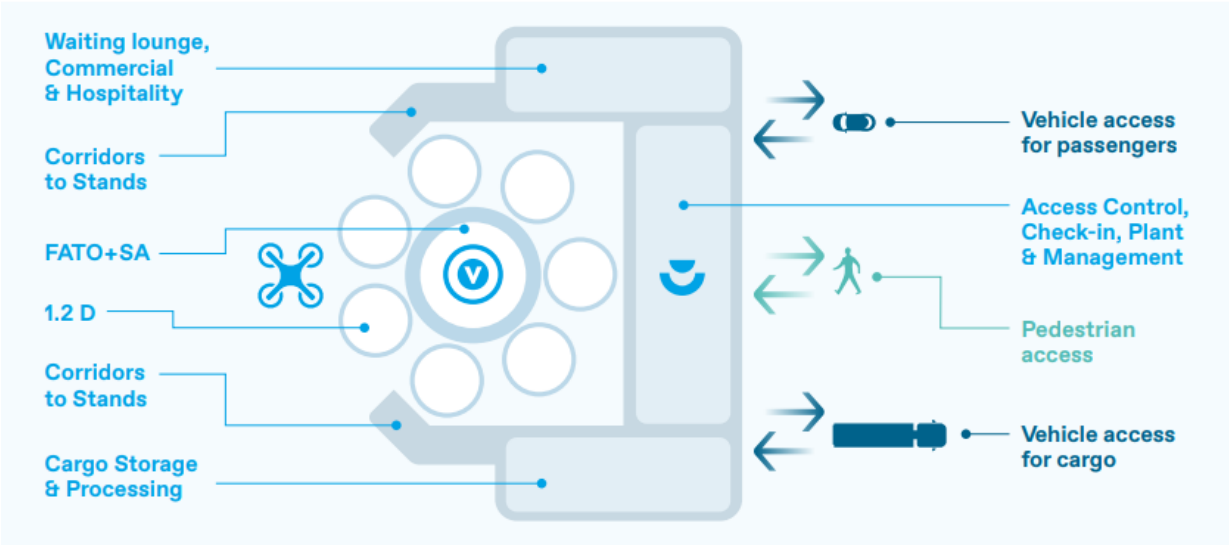
Example Vertiport/Vertistop Layouts



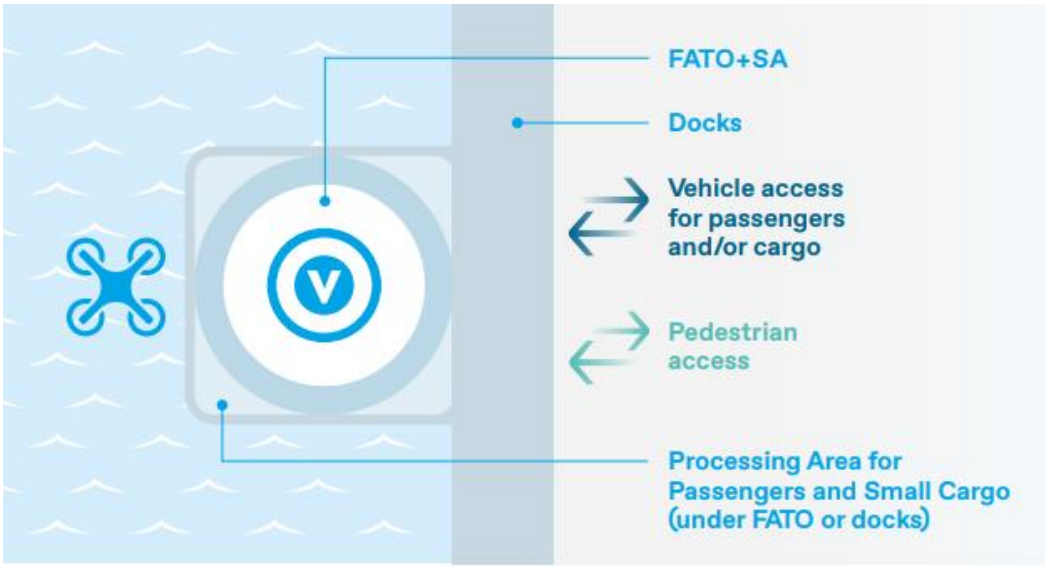
Vertistop: open surface



Vertistop: on elevated structure



Vertiport: open surface



Vertistop: floating (marina)

Source: Bluenest UAM

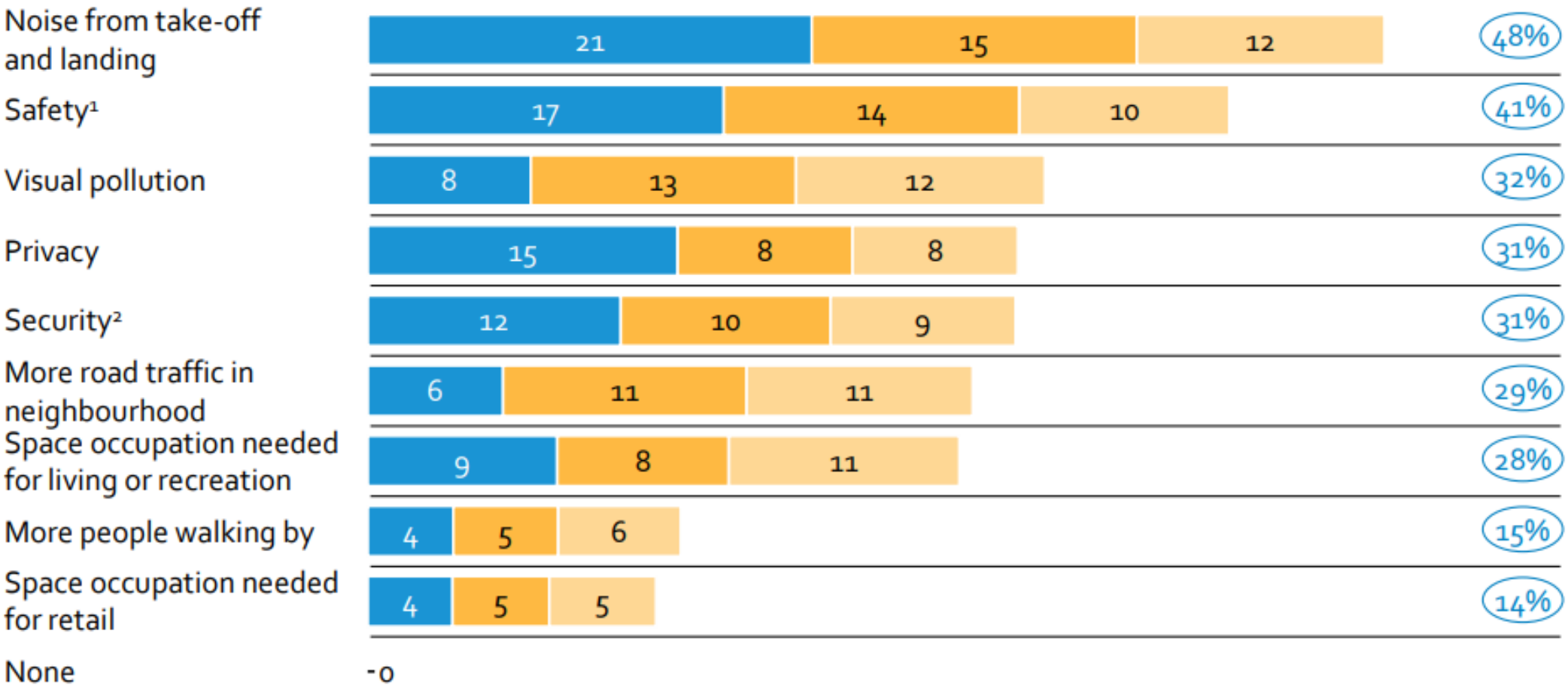
Assessment of unit-development costs for types of UAM infrastructure (National Academy of Sciences)

Cost component	Comments	Vertipad	Vertiport	Vertihub
Pad material costs, $	• Constructed of reinforced concrete [1] • **Vertipad**: 1-pad, FATO area[2] 4500 sq-ft, total area 20,000 sq-ft • **Vertiport**: 2-pad, 7-10 parking spots, FATO area[2] 4500 sq-ft, total area 165,000 sq-ft • **Vertihub**: 1 to 2-pad, 20 parking spots, FATO area[2] 4500 sq-ft, total area 380,000 sq-ft	$66,000	$500,000	$1.25M
Time for pad construction, Manhours	• .055 manhours per sq-ft • Anchored in surveys of helipad development projects with published timelines	1,100	9,075	20,900
Flight deck labor cost, $	• Labor rate of $25 per person hour • **Vertipad**: Crew of 10 working 8-hour days, completion time ~14 days • **Vertiport**: Crew of 15 working 8-hour days, completion time ~2.5 months • **Vertihub**: Crew of 25 working 8-hour days, completion time ~3.5 months	$28,000	$228,000	$625,000
Charging station cost, $	• Mean cost of an analogous electric vehicle charging station (equipment and install) • **Vertipad**: Single charging station, as a backup for emergency or atypical events • **Vertiport**: 8 charging stations assumed • **Vertihub**: 20 charging stations assumed	$52,000	$416,000	$1M
Terminal cost, $	• Average rate of $197 / sq-ft[3] • **Vertipad**: Likely not to exceed 3000 sq-ft[4] • **Vertiport**: Assumes 35,000 sq-ft terminal • **Vertihub**: Assumes 80,000 sq-ft terminal	$591,000	$6.9M	$15.8M
Site and operational capex, $	• Land procurement and preparation (survey, grading, soil treatment) • Safety and security (barricades, lighting, cameras, *etc.*) • Regulatory compliance assurance and inspection	$500,000	$4.1M	$9.5M
Total cost, $/location	• **Vertipad**: Costs may range from $1 – 2.5M • **Vertiport**: Miscellaneous costs may lead to cost variance of $2 - $5M • **Vertihub**: Miscellaneous costs may lead to cost variance from $5 – 10M	**$1.2M**	**$12.1M**	**$28.1M**

1 Reinforced concrete priced at $3.30 per sq. ft. (ConcreteNetwork.com)
2 FATO area (1.5 x rotor diameter)^2 uses assumed 'rotor diameter' of 45 ft.
3 Facility development cost reflects average rate for total construction cost, including labor
4 Terminal space has been scaled based on occupancy and capacity assumptions

SOURCES: Federal Aviation Administration, Heliport advisory circular; Compass International, Airport costs; and US DOE electric vehicle equipment cost

Public concerns relating to Vertiports



1. Incident due to technical or human failure
2. Incident due to deliberate harmful action, e.g. by criminal organization or terrorists

Source: EASA UAM societal acceptance survey questions C11. Assuming that a take-off and landing-station is close by (under 50 metres), what are you most concerned about? Please select up to 6 answers. C12. Please sort your main concerns from 'most concerning' to 'least concerning'.

Source: EASA - A study on the societal acceptance of Urban Air Mobility in Europe

Current status

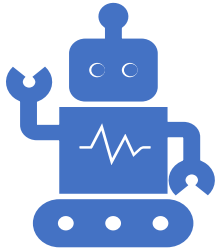
- No commercially operating vertiports
- Regulators taking a performance based approach = depends upon the air system being supported/ops model.
- Transport planners largely ignoring AAM as it is not mass transit – few plans for integration with existing mass transit infrastructure.
- City planners leaving it to the market unless there's a 'prestige' event
- Social licence/public perception – focus slipping as introduction date recedes. Not enough on the vertiport ops aspects (noise/traffic/location etc).
- Urban environment complex (building hazards, funnelled wind etc), very large volume of possible traffic (ATM)
- High demand locations have high land costs

Current problem for vertiports

“Forget the hype, concept plans and fancy designs, the reality is that there is no existing industry in vertiport infrastructure anywhere in the world as there aren’t any aircraft commercially certified to use them…Until we have the aircraft approved, there is no point in building anything as we don’t know what the requirements will be”

(Clem Newton-Brown, CEO of Skyportz, 2021)

Future issues



Autonomous operations/automation

Uncrewed vertiports (like AAM systems) increase likelihood of operations profitability (security of air systems/ground operations/'border' issues?)

Development of remote ops systems.

Battery life/power output/recharge speed

Impacts range of air system = spread of network/number of flights per charge

Landing/take off biggest drain on battery, better battery life = more landings = better network coverage

Modular batteries allow for swapping, issues of storage/recharge location/power usage in locality = safety issues (urban/populated location)

Recharge/swapping time impacts on Turnaround Time (yield/utilisation)

Future issues (cont)

- Building regulations (populated/urban environment)
  - Safe power management
  - Battery storage
  - Fire safety/emergency response
  - Retrofitting
- City planning
  - Zoning (commercial mixed with residential)
  - Integration with mass transit systems
- Scalability of vertiport/network
  - Hard in urban environment (individual land costs, proximity to buildings etc)