DUBAI WORLD CONGRESS
FOR SELF-DRIVING TRANSPORT
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Urban Air Mobility

Taking Public Transportation into the 3rd Dimension

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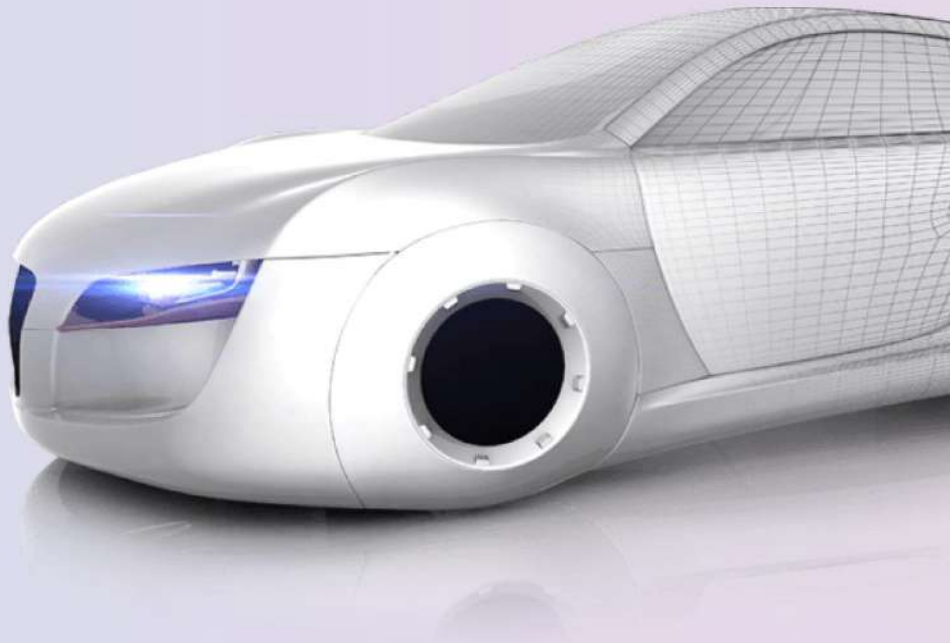

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URBAN AIR MOBILITY – THE NEXT REVOLUTION IN TRANSPORTATION?

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Unlocking the 3rd dimension has a great potential to save significant time in people's life

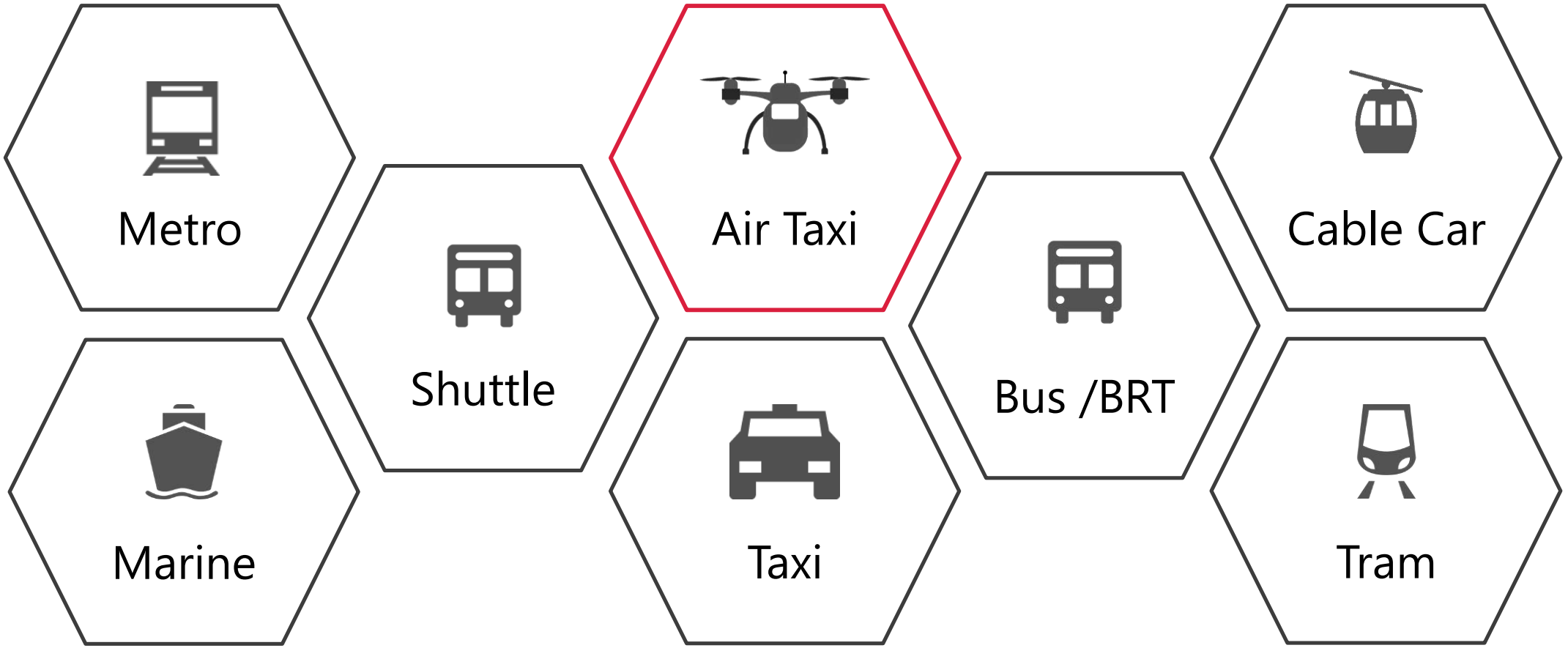
Dubai became one of the most exciting cities in the world and is expected to continue to grow even further

Source: googlemaps

Source: boredpanda

Source: RTA, FEV

RTA's Self-Driving Transportation Strategy is multimodal, defined autonomy targets for PT[2] modes and was complemented by Air Taxis



1) Public Transportation

Source: RTA

Air Taxi Services are already in operation, for example in New York City – but with the operation of conventional helicopters

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OVERVIEW OF SELECTED AIR TAXI SERVICES IN OPERATION TODAY

San Francisco

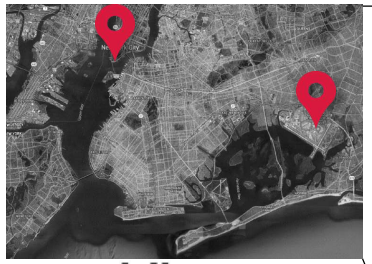
BLADE

VOOM AN AIRBUS COMPANY

São Paulo

VOOM AN AIRBUS COMPANY

New York City



Uber

BLADE

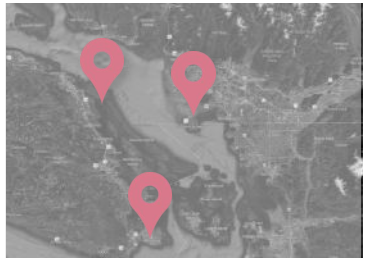
Los Angeles

ORBIC AIR

London

AAG ASSOCIATED AIRCRAFT GROUP

British Columbia



Helijet

New York City

Costs for ground transportation:

- Taxi (yellow cab): US $ 55
- Uber "Black": US $ 120
- Uber "Black SUV": US $ 180

45 to 90 min

dependent on traffic situation

Source: NYTimes, Blade, Voom, OrbicAir, AAG, Helifjet, FEV

The RTA investigated already in 2017 on autonomous aerial taxis – and launched the world's first demonstration flight

URBAN AIR MOBILITY – THE NEXT REVOLUTION IN TRANSPORTATION?

Source: RTA, FEV

New electrical Vertical Take-Off and Landing (eVTOL) aircraft concepts are enabled by key technologies

ENABLING TECHNOLOGIES FOR EVTOL AIRCRAFT

- Battery technology
- Distributed Electric Propulsion (DEP)
- Controls / Automation technology

VTOL = Vertical Take-Off and Landing
Source: FEV

Future eVTOL aircraft are a game changer for Urban Air Mobility because of key improvements compared to conventional helicopters

ADVANTAGES OF NEW VTOL AIRCRAFT CONCEPTS

CONVENTIONAL HELICOPTER

- Safety Objective 10^{-7} 1)
- High CAPEX and OPEX
- High noise, limiting operation
- High energy consumption and emissions
- Up to 2 pilots

FUTURE EVTOL

- Safety Objective up to 10^{-9} 2)
- Significantly lower CAPEX, OPEX reduced by half
- Significantly reduced noise
- Significantly reduced energy consumption and emissions
- Highly automated

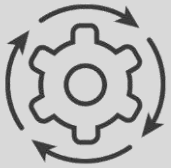
Note: Safety Objective referring to Function Development Assurance Levels (FDAL)
1) Class II rotorcraft
2) Under investigation by industry/authorities

Source: FEV

But it's more than just the aircraft; key success factors for the entire ecosystem need to be addressed to establish an effective Air Taxi Service

KEY SUCCESS FACTORS TO ESTABLISH AN AIR TAXI SERVICE

1 OPERATIONS

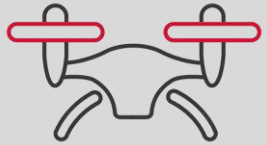


- Effective use case and target setting
- Customer value adding routes & network, incl. MaaS integration
- Optimized operations as key for financial viability
- Public acceptance

2 AIRSPACE INTEGRATION

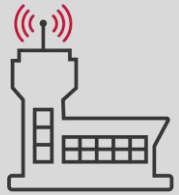
- Effective airspace integration
- Safety-focused route monitoring concept
- Selection of suitable UTM partner

3 EVTOL AIRCRAFT



- Selection of the right eVTOL air taxi (OEM):
  - Technical capabilities to fulfill use case requirements
  - Aircraft design suitable for public transportation

4 EVTOL INFRASTRUCTURE

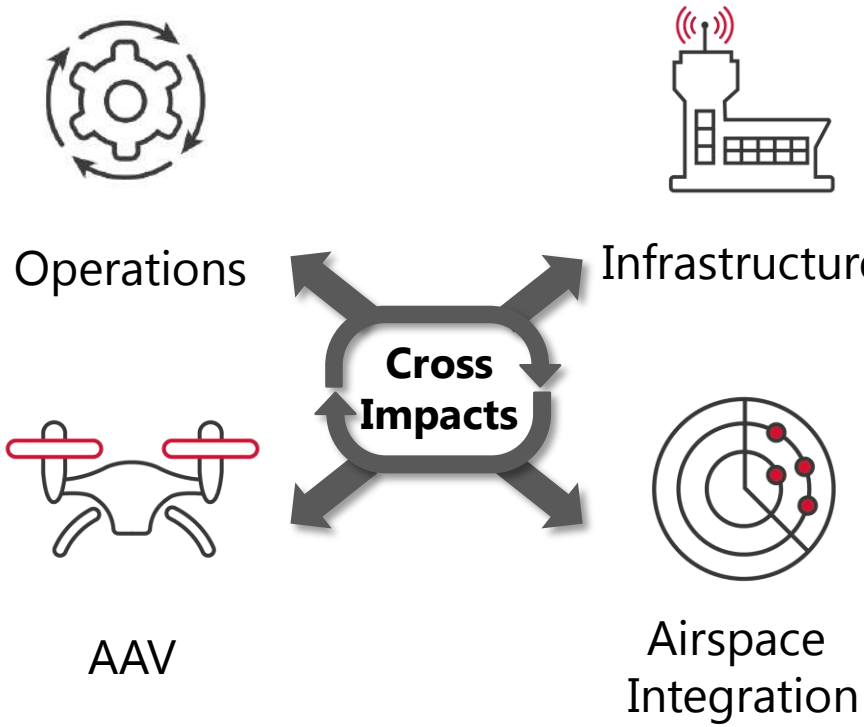


- Feasible locations within existing city infrastructure
- Throughput optimized, dedicated infrastructure
- Cost efficient design optimized for a short customer journey

Close cooperation with authorities for certification across all dimensions

Source: FEV

We applied a structured approach to define requirements for the entire AATS ecosystem and to identify all interfaces



Review of regulations and standards

Prepared by:

>1,200 requirements defined

Reviewed by Independent Assessor

Supported by:

Source: Collective project result from:

Air Taxi Service can be established for different use-cases resulting in different requirements for the entire eco-system

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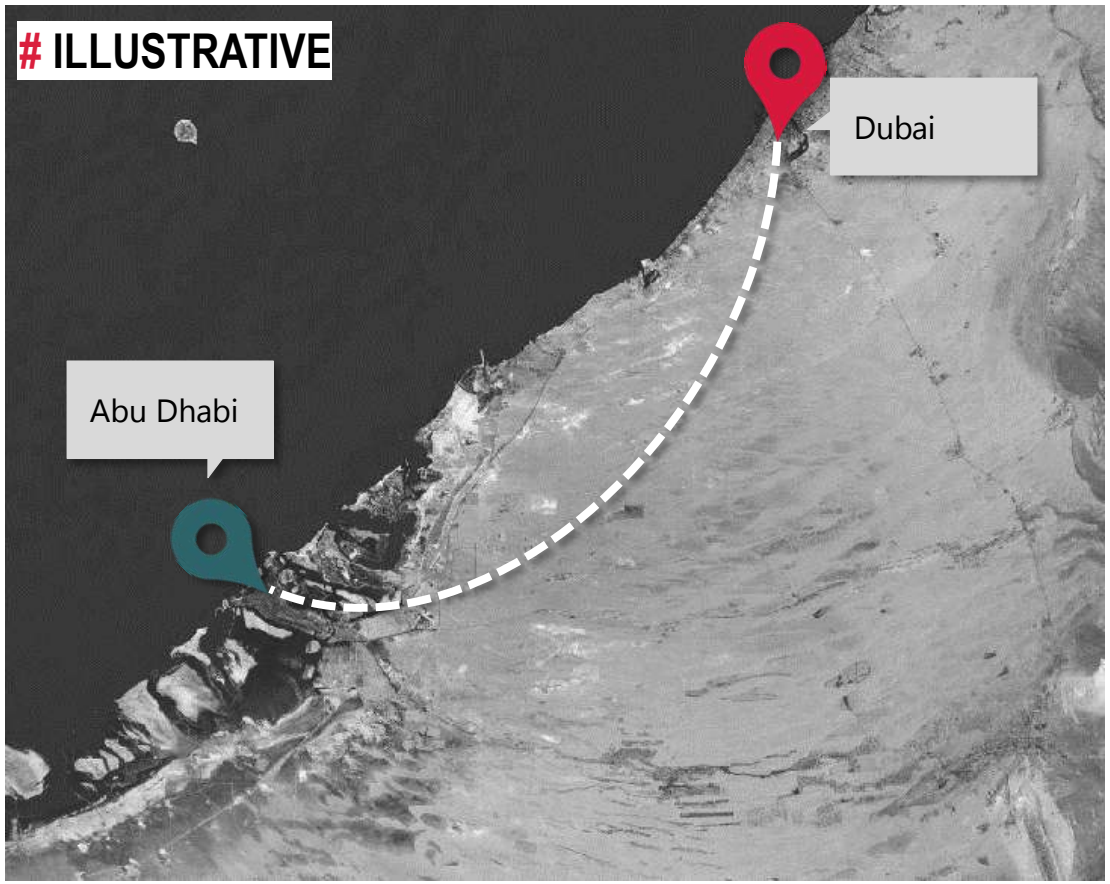
ILLUSTRATIONS OF AN INTERCITY AND INTRACITY USE-CASE

Intercity



Intracity

Source: google maps, FEV

Besides the use-case, there are several important factors which need to be analyzed to define an effective route and location selection

ROUTE AND SITE SELECTION PROCESS

Consideration of…

Use Case

Intercity or Intracity
Frequency and Availability

Expected Demand

Daily commuters, business travelers, leisure trips, modal split

Proximity to POIs[1]

City centers, sights, industrial zones, dense residential areas, etc.

Plot Characteristics

Size, Noise Consideration, Multimodal Integration

Airspace Integration

Feasible flight paths, Traffic Management (UTM/ATM)

1) Point of Interests
Source: FEV

Airspace integration is a key success factor: Available airspace, take-off / approach paths and traffic management need to be considered

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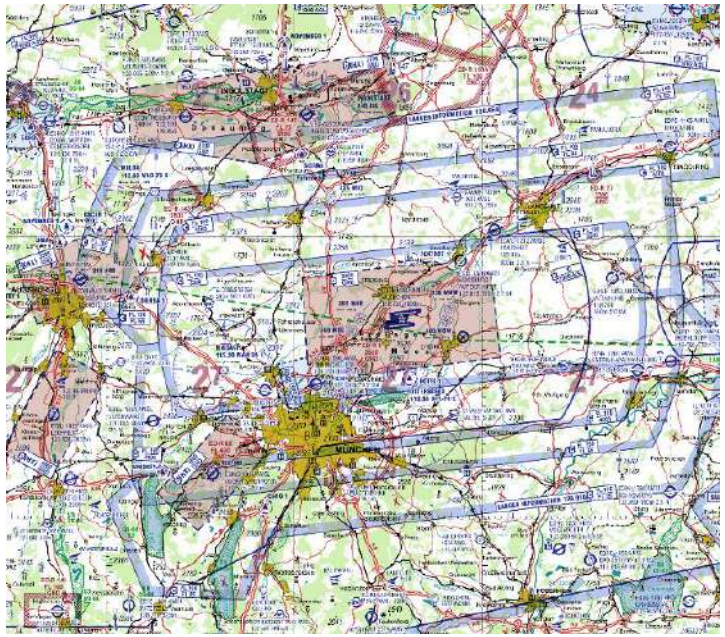
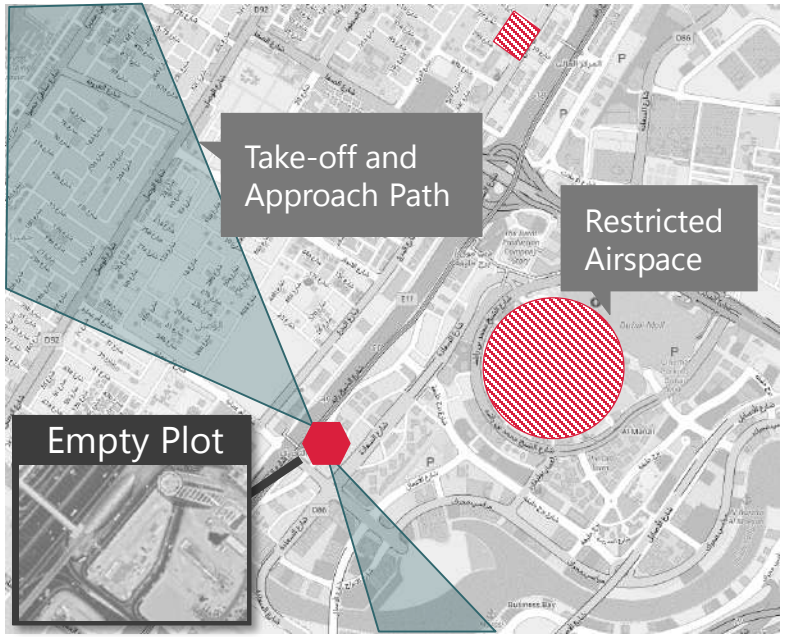
OVERVIEW OF IMPORTANT AIRSPACE INTEGRATION ELEMENTS

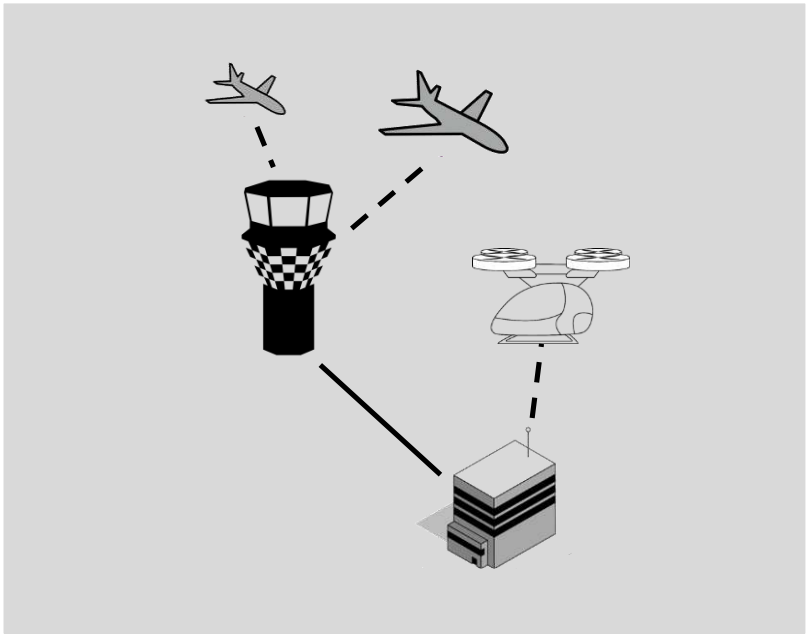
1 Available Airspace

2 Feasible Take-Off / Approach Path

3 Traffic Management Integration



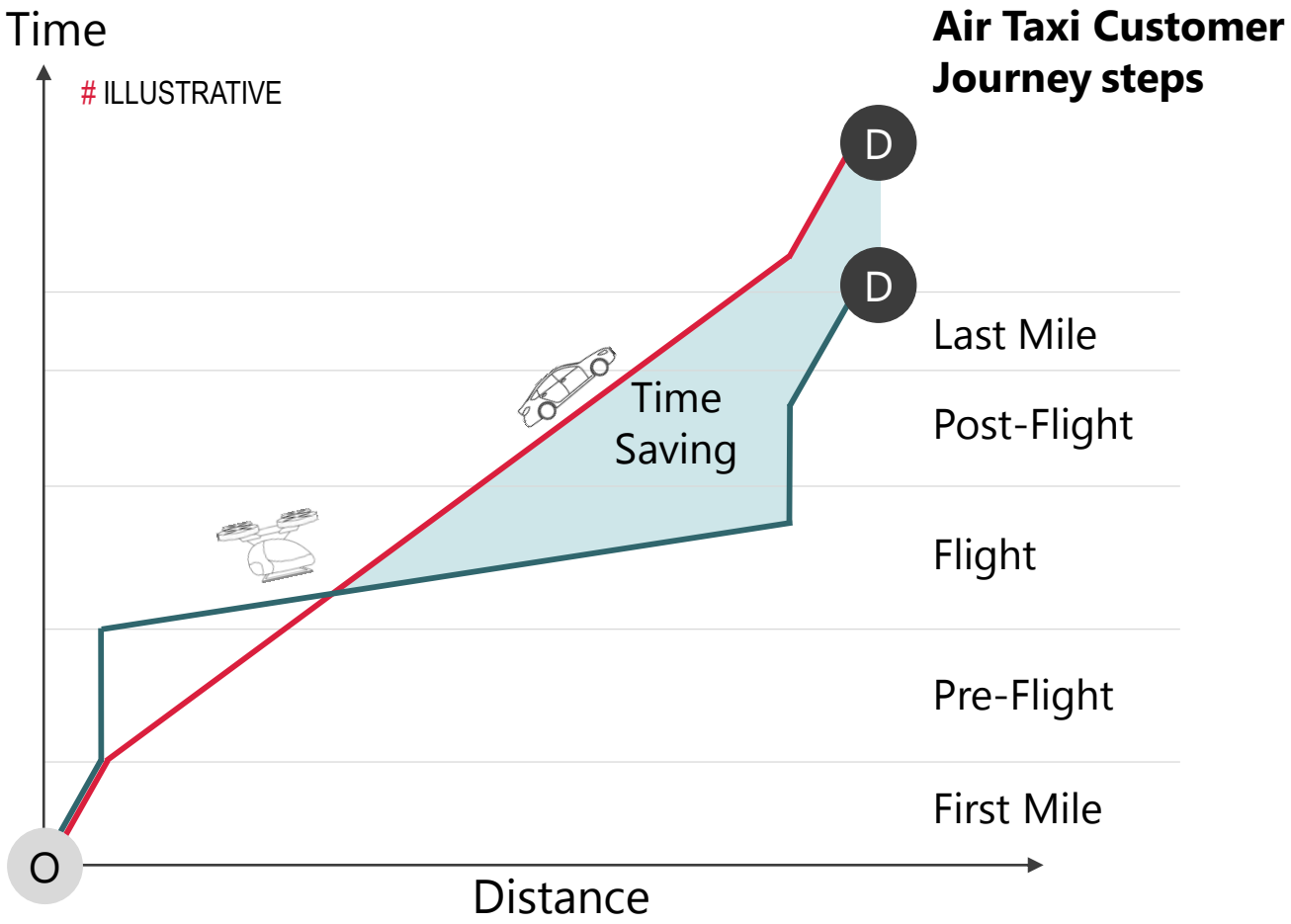




Source: ICAO, googlemaps, FEV

Time for FMLM[1] and procedures at the infrastructure significantly impacts the trip duration and must be considered for route/location planning

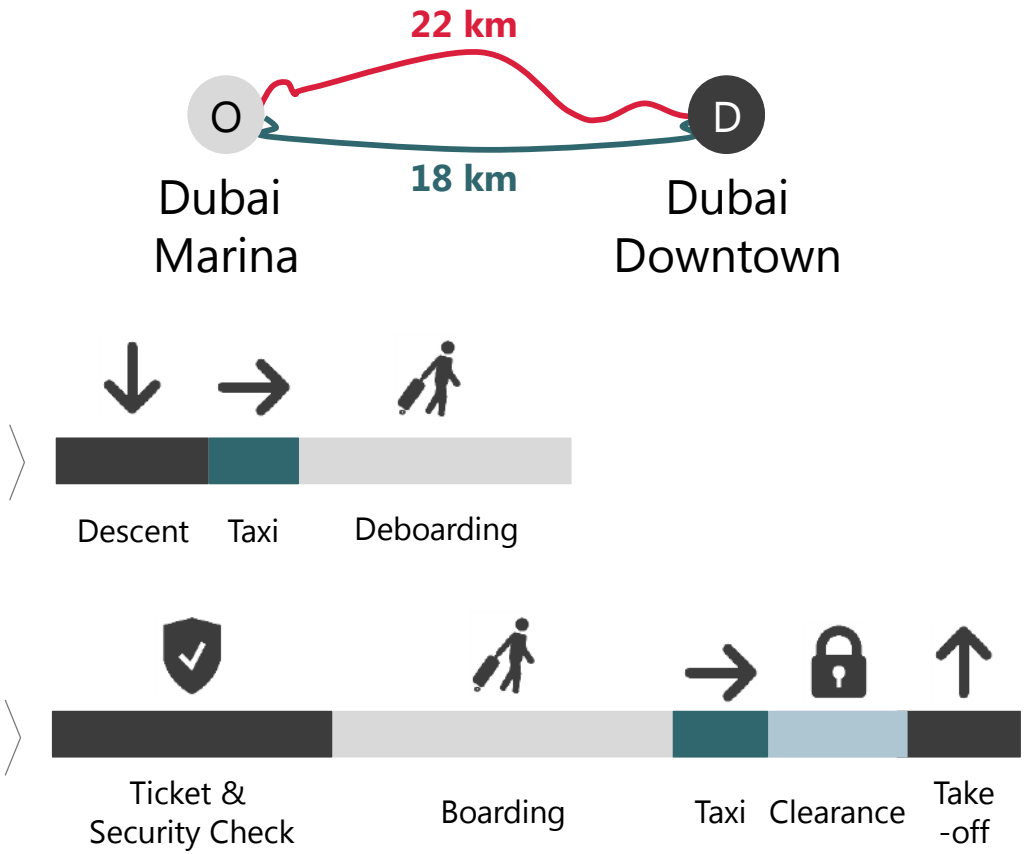
TRAVEL DURATION BY CAR AND BY AIR TAXI



1 FMLM = First Mile Last Mile
O = Origin, D = Destination
Source: FEV

INTRACITY TRAVEL

ILLUSTRATIVE



There is a broad variety of eVTOL concepts under development, coming from established aerospace companies and start-ups

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OVERVIEW OF SELECTED EVTOL CONCEPTS

110+
Concepts

30+
Full-Scale Models

25+
Models with conducted flight tests

1) Cora vehicle shown, not Heaviside
Source: Bell, Aurora, Volocopter, Airbus, Kitty Hawk, Vertical Aerospace, Lilium, Pipistrel, FEV

Tilt Wing/Rotor concepts have several advantages, but are also more complex compared to Multirotor and Lift&Cruise

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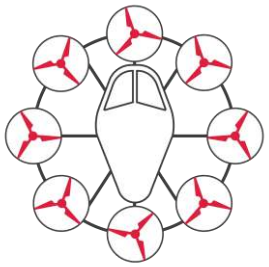
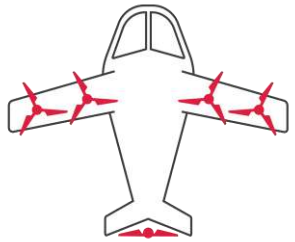
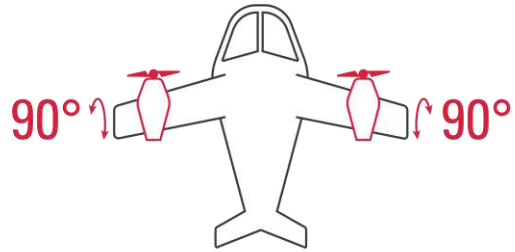
COMPARISON OF EVTOL AIRCRAFT ARCHITECTURES

	MULTIROTOR (WINGLESS)	LIFT & CRUISE	TILT WING/ROTOR
			
Cruise Efficiency / Speed			
(Transition) Complexity			
Emergency Maneuverability			
Hover Efficiency			

Source: FEV

A sensitivity analysis shows which type of aircraft should be selected to accomplish the required average speed to make the routes attractive

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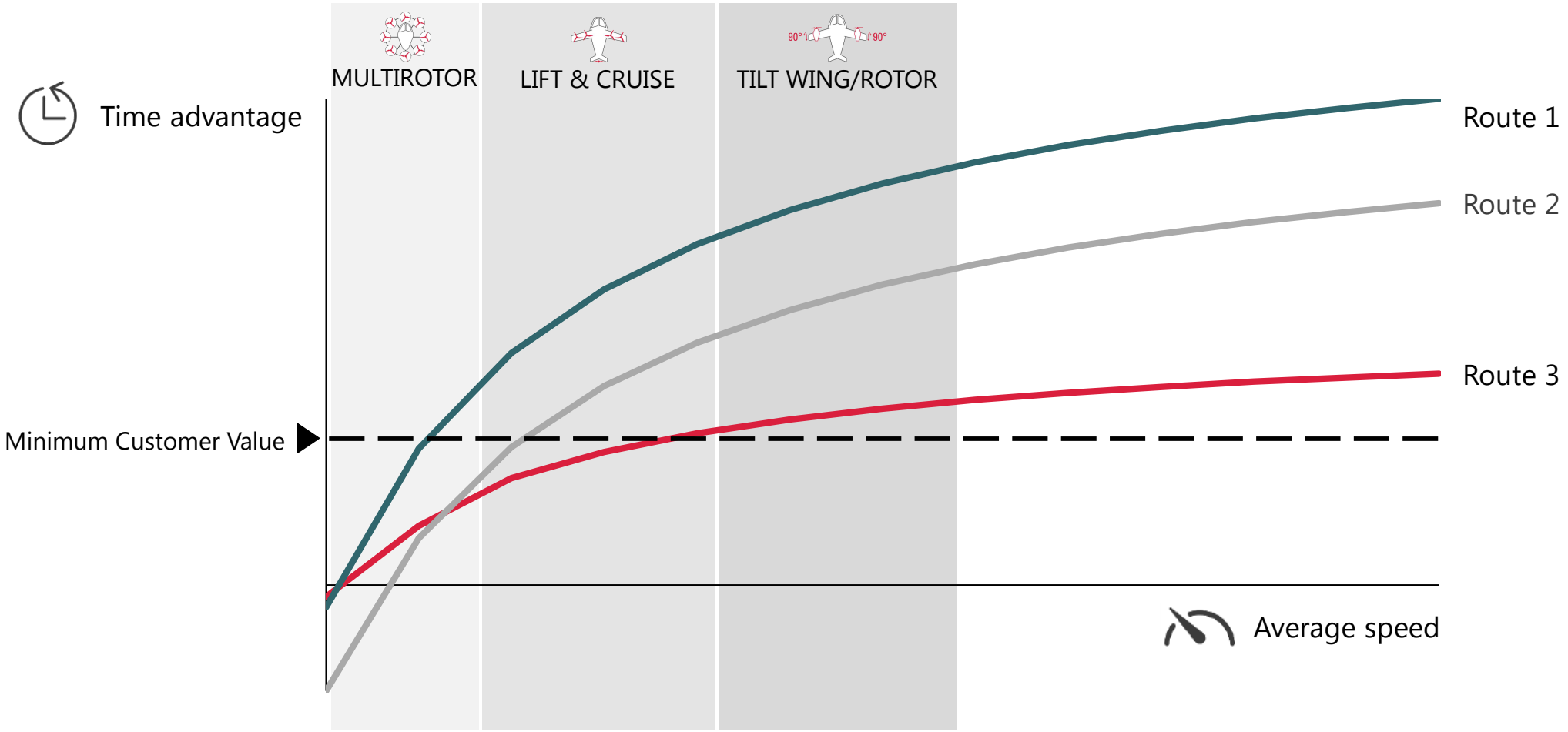
SENSITIVITY ANALYSIS OF AVERAGE EVTOL AIRCRAFT SPEED

ILLUSTRATIVE



Source: FEV

Battery electric concepts make up the majority of eVTOL concepts for air taxi application; battery capacity to be considered for optimized operation

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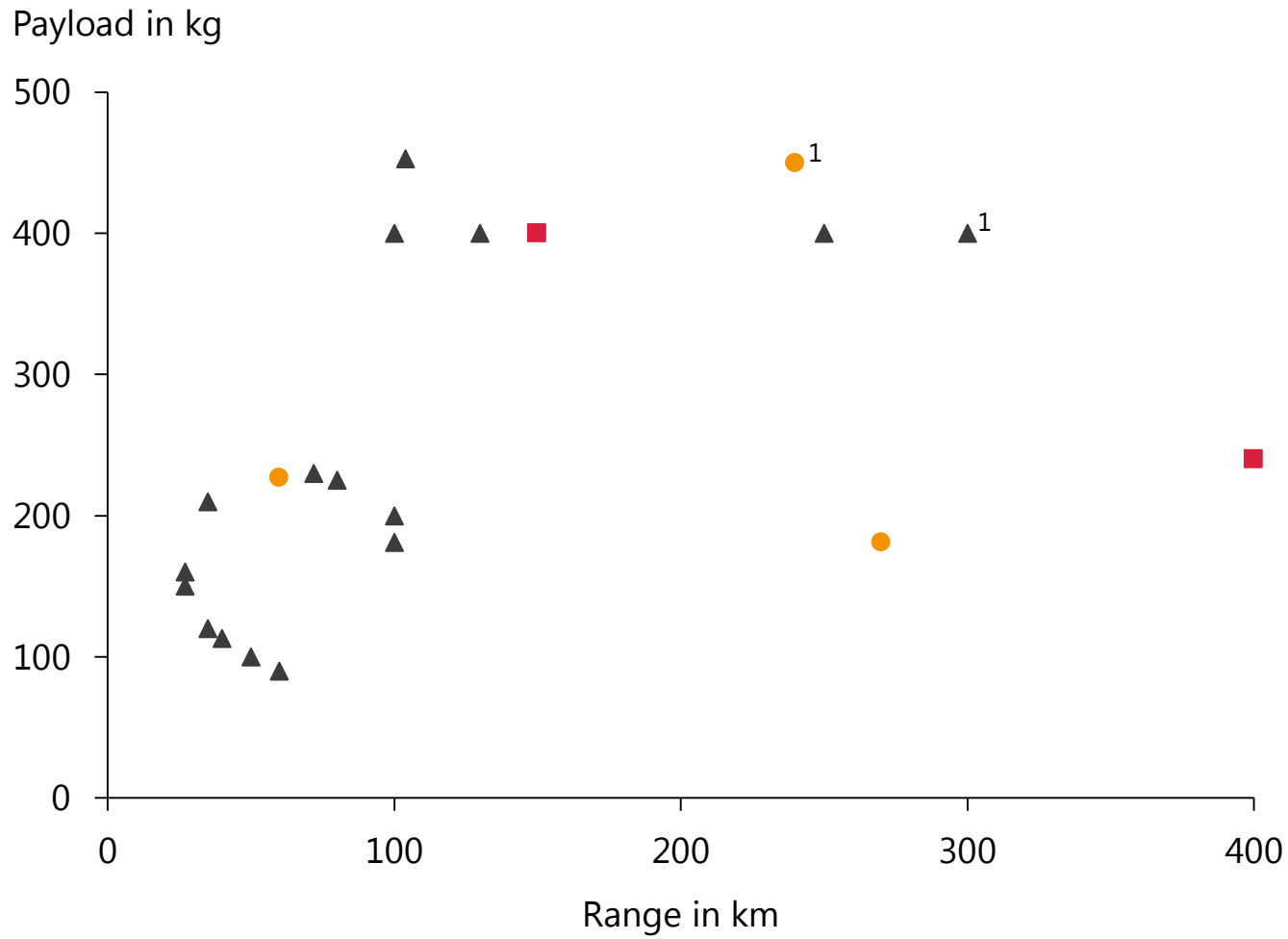
OVERVIEW PAYLOAD OVER RANGE BY PROPULSION SYSTEM



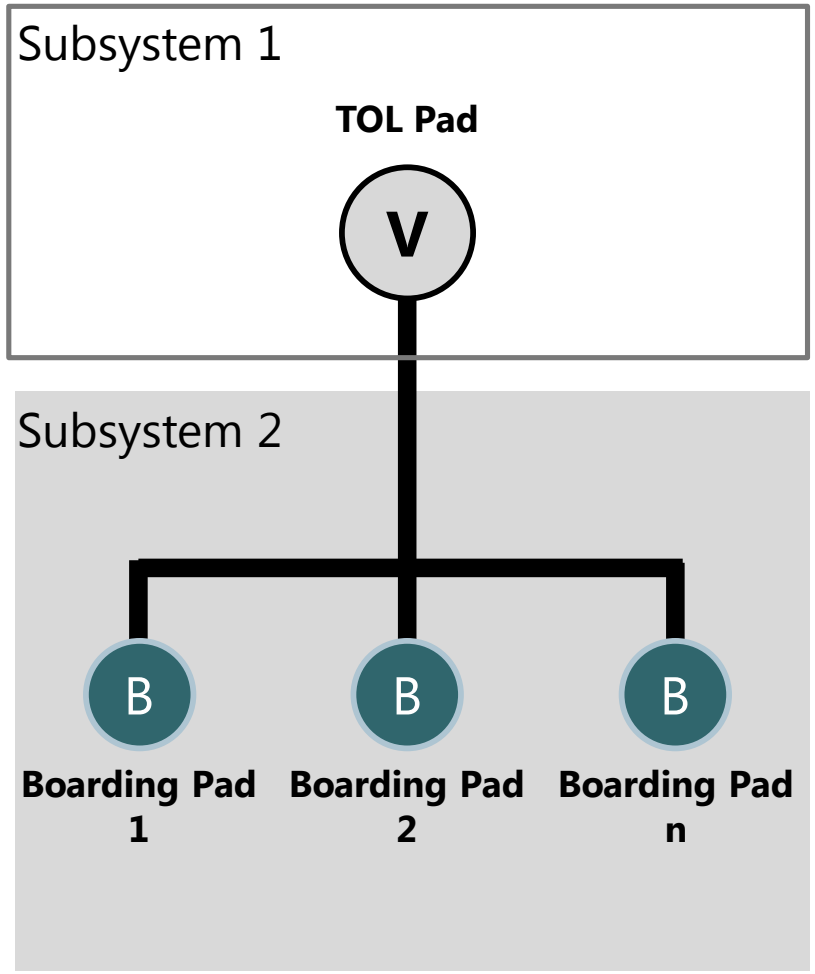
Note: Based on published information

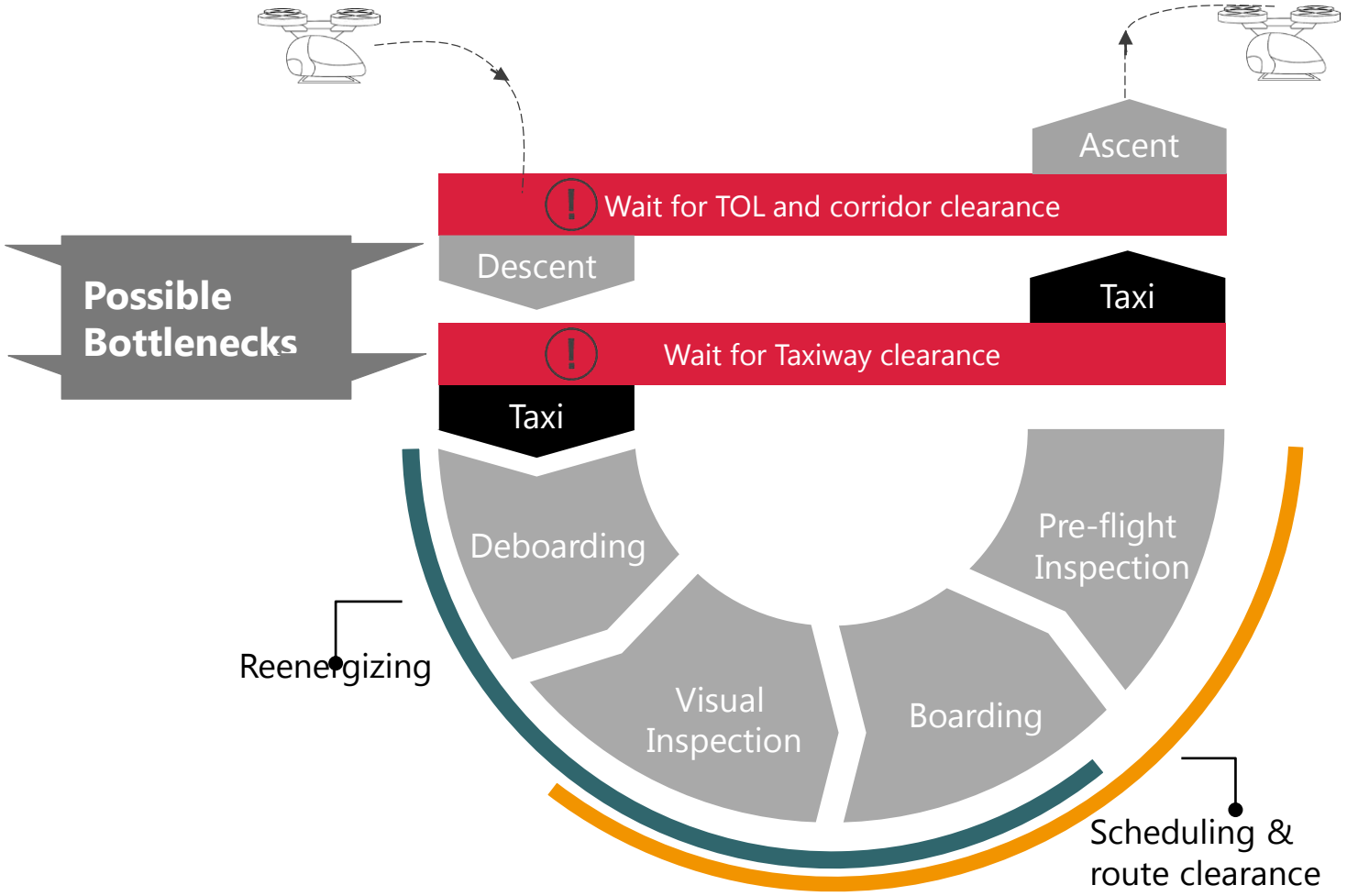
1) estimated payload, manufacturer only provide information on # of passengers

Source: FEV

Each of the subsystems at a Vertistructure can become a bottleneck; a process analysis must be performed for optimized PAX throughput

PARALLELIZATION OF THE PROCESSES AT A VERTISTRUCTURE





1
2
3
4

Source: FEV

We defined functional requirements for the vertistructures and derived multiple vertistructure concepts

SELECTED FUNCTIONAL REQUIREMENTS FOR A VERTISTRUCTURE

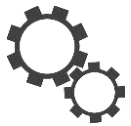
Protected Boarding Pads / Areas

AAV recharging at high temperatures

Protected parking of AAVs

High passenger comfort through temperature controlled boarding

TOL Pad to Protected Boarding Pad ratio optimized for PAX throughput



Facilities for security, maintenance and logistics, areas for multimodal integration

1
2
3
4

Source: Collective project result from:

Urban Air Mobility has a great potential; however, the entire ecosystem needs to be properly defined as a basis for a successful implementation

SUMMARY

1 Urban Air Mobility can become a game changer for public transportation, having great potential to save significant time in people's life

2 Urban Air Mobility is more than just the aircraft; key success factors for the entire Ecosystem need to be considered

3 Interdependencies within the Ecosystem can impact the use-case, routes/locations, but also the definition of suitable aircrafts

4 For an efficient operation, vertistructures need to be throughput optimized to allow a financial viable service

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