Roland Berger Focus

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Urban air mobility

The rise of a new mode of transportation

Management summary

Driven by increasing urbanization, the worsening bane of road congestion and new advances in aircraft technology and electric propulsion, the time is now ripe for the emergence of urban air mobility (UAM) – the transportation of persons or goods via flying vehicles over urban areas – as a new industry. Close to 100,000 passenger drones could be in service worldwide by 2050.

Over time, advances in electric propulsion, autonomous flight technology and 5G communication networks will spawn on-demand air taxi services, scheduled airport shuttles and intercity flights. Urban air mobility adds a third dimension to the urban transportation matrix. It provides an attractive solution for areas where merely increasing two-dimensional capacity would in no way ease the existing traffic situation. It also creates new opportunities for travelers for whom personal comfort and speed are at a premium, as well as for rescue services and para-public applications. Urban air mobility will gradually be integrated in the existing mobility landscape, bringing a time-efficient mode of travel and a safe, enjoyable flight experience to more and more passengers at increasingly low cost. With flagship pilot projects scheduled to go live in cities such as Dubai, Singapore, Los Angeles and Dallas in the early 2020s, better batteries, new aircraft designs and – as of the late 2020s – autonomous flight technology will bring prices down and spread services to major metropolitan areas around the globe.

The winners in this exciting new market will be those who address its complex, interdisciplinary needs in close collaboration with manufacturers, infrastructure and service providers and the relevant regulatory and urban authorities.

The pivotal success factor is choosing the right use case from the broad array of aircraft/drone concepts. Each has its own benefits and limitations, and not all technologies suit all applications. Yet around this central issue, further success factors will include development of a suitable infrastructure for take-off and landing spots, maintenance, energy supply and communication, the emergence of service providers with robust commercial and operating models, and a regulatory framework to control and govern safety, liability, emissions and a host of other issues.

Contents

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1. From dream to reality

Urban air mobility is poised to become a fast-growing business

Urban air mobility (UAM) is an attractive business proposition. Not too far off in the future, what is currently the exclusive preserve of the ultra-rich – flying over all the traffic jams from one urban location to another – could become common practice. The potential benefits of inner- and intra-city electrical vertical take-off and landing (eVTOL) commutes are genuinely appealing and can be a perfect fit with the needs of customers if this nascent industry can deliver on five key promises:

KEY PROMISE 1
FASTEST TRAVEL OPTION

Saving significant amounts of time compared to taxis and subway lines, for example, would make the use of urban air services highly attractive to passengers. Bearing in mind the time taken for boarding/de-boarding and actually getting to and from a landing hub, eVTOL aircraft need trips to be at least 15 to 25 kilometers in order to deliver genuine time savings and become the fastest urban mobility option. If they do achieve this goal, they can bypass (and potentially ease) the hassle of congestion, while also streamlining the poor connections to airports from which many major cities still suffer today.

KEY PROMISE 2
REASONABLE FARES

In megacities such as São Paulo and New York, ultra-high-net-worth individuals and top executives already commute by helicopter from the airport to the city center, or between points in the city center. By contrast, the switch to electric propulsion and eventually autonomous flight operations will slash purchase prices and running costs for eVTOL vehicles by an order of magnitude, opening up the urban air experience to a much wider target group. Unmanned flights based on autonomous technology will reduce costs still further. Pooling passengers (e.g. from the airport to the city center) could then combine with the above cost reductions to make the urban flight experience available at costs still higher than taxis but much more affordable than today's helicopter services.

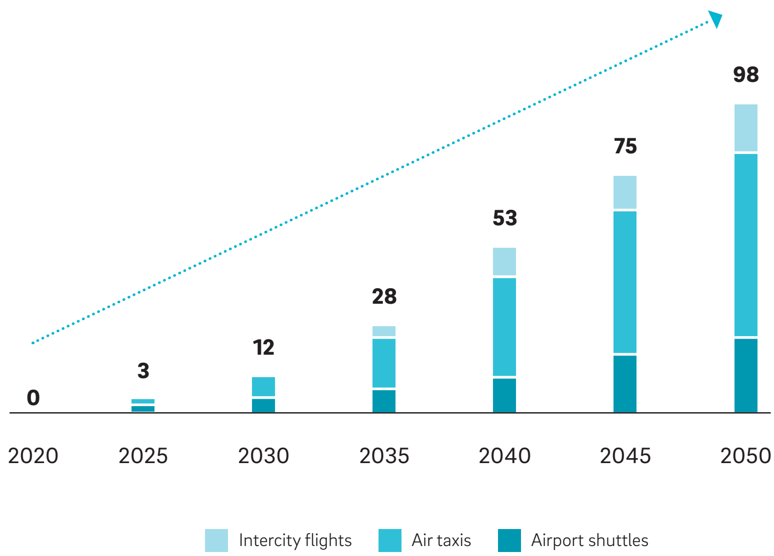
KEY PROMISE 3
SAFE AND ENJOYABLE FLIGHT EXPERIENCE

Anyone who has ever flown over a city in a helicopter will have experienced the jaw-dropping excitement and joy such a flight can deliver. The human desire to fly is an appeal that should not be underestimated, even though safety is naturally more important and must be guaranteed at all times. Crucially, passengers must also perceive this mode of transport as safe and reliable, and a robust regulatory framework will go a long way to allaying passengers' fears. In the early stages, for example, flight attendants made available by the flight operator firms could likewise help many people overcome their understandable psychological reservations about autonomous aircraft in particular. The fact that electric propulsion will play a part in reducing carbon emissions in cities is another issue that will add to both the real and perceived attraction of this mode of transportation. However, it is not just the technical aspects that will make flights safe and enjoyable for passengers. Particular attention will need to be paid to environmental aspects, such as harsh weather conditions that would make the flight uncomfortable or even unsafe.

KEY PROMISE 4
INTEGRATED MOBILITY SOLUTION

Attractive eVTOL solutions will dovetail with other local mobility services, giving passengers seamless connections from their location to the departure hub and from the arrival hub to their final destination. That alone will mark a major step forward from the complex, disjointed mobility chains we know today. Online booking apps

A: Passenger drone operations forecast
Number of passenger drones in UAM operation worldwide ['000]



Note: Estimated that ~100 cities will have UAM operations in 2050
Source: Roland Berger

will arrange reservations and handle payment for whole journeys (e.g. calling a ride-hailing service to pick up and bring the passenger to the eVTOL hub, as well as buying a subway ticket for the last-mile journey at the other end). In this way, a vastly superior door-to-door customer experience will be guaranteed.

Intelligent marketing that educates customers will nevertheless need to spell out these benefits. That will be vital if urban air mobility is indeed to become a fully integrated and widely accepted mode of transportation. Initially, eVTOL will be positioned as a high-end product, gradually morphing into an integrated public transportation offering over time.

KEY PROMISE 5
PASSENGER-WINNING SERVICE

At the end, the winners will be the ones who create truly passenger-winning services. Convenience will be a key metric for customer adoption of eVTOL services. For example, take-off and landing locations will have to be strategically positioned at areas of interest and easily accessible for travelers. This includes the already mentioned connection to other mobility services as well as quick access to landing pads, e.g. with dedicated elevators to rooftop pads. Waiting times also will have to be kept to a minimum, which would be optimized through intelligent booking and dynamic passenger demand forecast algorithms.

Aerospace companies and startups alike have joined the race to translate the vision of flying taxis from science fiction into reality before 2025. Many of the concepts under development even plan to do so without a pilot on board. This study examines promising technical concepts and paints a picture of the emerging eVTOL ecosystem with its stakeholders and key success factors. We also highlight where we see major challenges and how they can be overcome. → A

MARKET POTENTIAL

Our research (see "Methodology" on next page), corroborated by numerous interviews with experts in the industry, indicates that close to 100,000 passenger drones could be in the air worldwide by 2050. Something like 100 cities worldwide will have implemented drone services to provide a variety of passenger transport services by then, with on average 1,000 passenger drones in operation in each city. However, there will be a large spread of drones per city ranging in 2050 from 60 drones for the smallest metropolitan areas to more than 6,000 in the largest ones. Based on this scenario, drones will become an integral part of urban (and supra-urban) mobility offerings over the next three decades. In the first few years, we foresee passenger drones mainly being used as airport shuttles. While this service remains an important use case going forward, the majority of passenger drones will later assume the role of point-to-point air taxis. Drones for longer-distance intercity flights will complement the passenger drone market. These three use cases are described in detail in chapter 2.

We will see the first commercially used urban air mobility routes starting in 2025. First pilot tests are expected to start as early as around 2020.

Methodology

How did we calculate market potential?

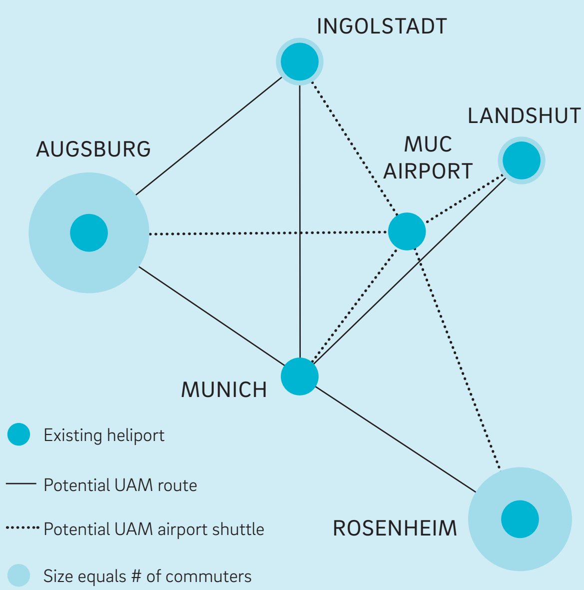
The market potential is estimated based on bottom-up calculation of the number of urban aircraft required to offer viable eVTOL services in major cities.

Four case study cities – Los Angeles, Munich, São Paulo and Singapore – were chosen as the point of departure for this study. They reflect four distinct categories or "urban archetypes" in terms of population density and surface area: Singapore has by far the highest population density in nearly the smallest urban area, while Los Angeles has the lowest population density and the largest surface area.

For each of these cities, potential urban air mobility routes linking key traffic nodes (such as airports) to points of interest (city centers, shopping malls etc.) were identified based on the urban architecture. One important factor was either the availability of helipads or space to build new infrastructure sites. This issue was assessed with the aid of Google Earth, to see where new ground infrastructure could potentially be built, in conjunction with data available in the public domain regarding existing helipads.

We then postulated the number of passengers for urban air mobility services based on available commuter data as well as percentages for switching to this new service based on our interviews with numerous industry experts. The number of drones per route was then determined by the maximum number of passengers per hour at peak times. → B

B: Greater Munich metropolitan area
Example of estimated passenger demand based on available commuter data



Potential UAM routes	Distance	Commuter demand [# of commuters] [outbound / inbound]
Munich - Augsburg	80 km	~2,000 per day ~9,100 per day
Munich - Ingolstadt	80 km	~1,800 per day ~2,300 per day
Munich - Landshut	73 km	~450 per day ~3,900 per day
Munich - Rosenheim	67 km	~1,100 per day ~8,400 per day
Augsburg - Ingolstadt	78 km	~170 per day ~170 per day

Potential UAM airport shuttle	Distance	Potential demand per route per day [# of travelers]
MUC - Munich	40 km	~34,000
MUC - Augsburg	85 km	~6,600
MUC - Ingolstadt	71 km	~3,300
MUC - Landshut	41 km	~1,600
MUC - Rosenheim	100 km, 75 km direct	~1,400

Source: Statistik Arbeitsagentur, Munich airport, Google maps, press research, Roland Berger

The above assumptions and findings were extrapolated for a total of 98 metropolitan regions worldwide, each with at least two million inhabitants and high GDP per capita. Depending on their population density and surface area, these cities were assigned to one of the four urban archetypes reflected by the four named cities. This approach resulted, for Munich for example, in about 100 drones being in service for the three use cases in 2030 and up to 800 drones in 2050. The switching rate increases over time and reaches on average 5% in 2050 but varies per use case as well as per analyzed potential route.

WHY IS NOW THE RIGHT TIME?

The dream of urban aviation is not a new one. Yet as urban sprawl increases and road traffic congestion worsens, several distinct technological advances are putting the long-held dream of escaping from all this madness and taking to the air within our reach:

Electric propulsion will make eVTOL cheaper than current models.[1] Once the production of electric aircraft reaches maturity, the upfront cost of buying or leasing an eVTOL will be lower because electric powertrains are simpler than gas turbines. Battery costs too are dropping thanks to the scale afforded by automotive manufacturing, and running an urban air taxi on electricity is more cost-efficient than running a conventional helicopter on kerosene. Electric powertrains also have lower maintenance costs due to their simplicity, although technical services have to be able to deal with high voltage. The total cost of ownership of eVTOL is therefore expected to be lower overall. By exactly how much will depend to a large extent on eVTOL architectures and configurations, as well as on local fuel and electricity costs. In the final analysis, the business case for eVTOL needs to be made in comparison to both traditional helicopters and taxis. Today, the available battery technology only allows short flight times for eVTOL applications. As energy and power densities improve, however, flights speeds and distances will increase accordingly.

Autonomous flight technology is the second factor that will lower operating costs by rendering pilots obsolete. The extra free seat in each craft will also boost potential by facilitating a significant increase in the payload.

5G communication networks are a further technological enabler for the realization of air taxis. Whereas GPS-based satellite reception can be poorer because of high-rise buildings, 5G will allow the ultra-precise navigation that is needed for urban air mobility.

Although these factors make now the time to press ahead with urban air mobility, this disruptive development will not be implemented overnight. The speed at which the above technologies progress limits the pace at which the UAM market can evolve. Moreover, working services and an attractive customer experience have yet to be created.

[1] See Roland Berger's Think:Act publication on "Aircraft Electrical Propulsion" (https://www.rolandberger.com/en/Insights/Global-Topics/Electric-Propulsion/)

2. What form will UAM take in the future?

Three use cases

The technological developments that are now making urban air mobility a realistic possibility and the benefits this fledgling new mobility offering promises to deliver (see above) lead us to distill three main use cases for passenger drone services – air taxis, airport shuttles and intercity flights – each with its own distinctive technological and operational requirements:

AIR TAXIS

Like conventional ride-hailing services, this use case will provide on-demand flights between any available landing pads within a defined area. To carry one or two passengers and their light hand luggage (up to 20 kg in total) over distances of between 15 and 50 kilometers, the aircraft technology would have to be able to cope with journeys of between 35 and 70 kilometers to ensure a safety margin of roughly 20 kilometers on all flights. Landing pads would be spread around the city to service key points of interest, with charging facilities ideally in place at each station. Service providers would allow air taxi rides to be booked on demand. Predictive traffic management systems would enable aircraft to be dispatched based on passenger demand patterns and forecast demand at different landing pads. → C

C: Use case 1: Air taxis

On demand point-to-point operations

→ On-demand point-to-point non-stop service from one destination to another
→ Optimally used under the following circumstances:
- Short distance between two landing sites
- Fluctuating medium/high demand between two landing sites

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→ High network coverage
→ Fastest travel times between two points

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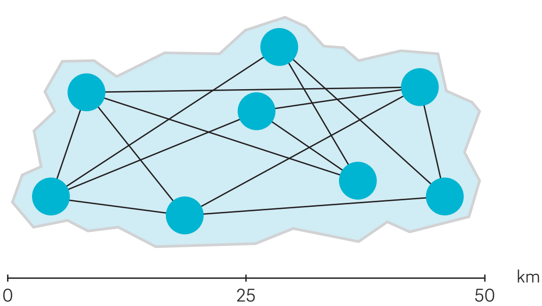
→ Schedule frequency depending on # of air taxis
→ High number of routes to cover all points
→ Large amount of landing sites required to create network
→ Sufficient air space (no restrictions) required to make use of direct point-to-point network



UAM landing site   Metropolitan area   — On demand service

Source: Roland Berger

AIRPORT SHUTTLES

Covering similar as well as longer distances compared to air taxi services, airport shuttles would offer scheduled (rather than on-demand) flights between various landing pads and the airport. The aircraft technology would need roughly the same range as for air taxis, but would be upsized to carry between two and four passengers and between 50 and 80 kg of luggage. Landing pads would be located at strategic locations around the city and, obviously, at the airport. Charging facilities would be concentrated primarily at the airport, but with some at the other landing pads as a function of distance and aircraft travel range. Passengers could book seats for fixed routes on a scheduled flight, completely eliminating the need for demand forecasts and making aircraft location and demand at each station entirely predictable. → D

INTERCITY FLIGHTS

Intercity flights would likewise be based on scheduled services between specified cities that are too close to be viable for regular aviation links. The technology would have to be able to carry two to four passengers and 20 to 40 kg of hand luggage over distances of between 50 and 250 kilometers, plus a safety margin of an extra 50 kilometers. Charging facilities would be installed at each

D: Use case 2: Airport shuttles
Scheduled short-range operations

- → Scheduled operations with fixed flight plans and pre-booked flights
- → Flight schedule adjusted to arrival and departure times of airport
- → UAM landing sites strategically located very close to terminal and gates

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- → Fastest transportation option between airport and city
- → Transfer from plane to UAM on air-side of airport possible (very short transfer times)

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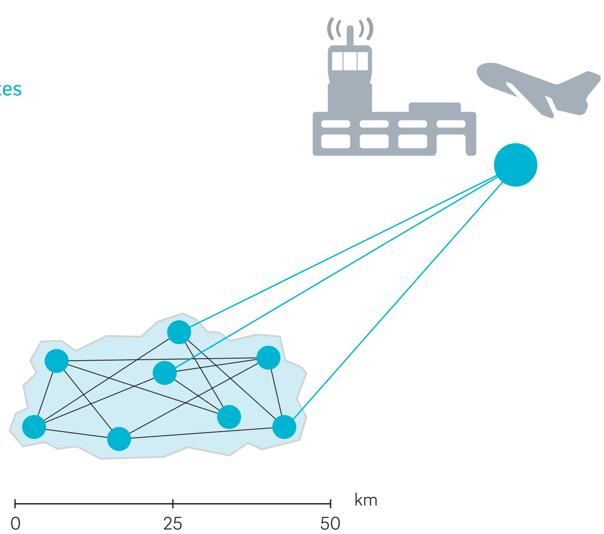
- → Interference with commercial airline operations problematic
- → Scheduled operations



Source: Roland Berger

landing pad, which would ideally facilitate direct access to key points of interest in the cities served. As with airport shuttle and regular aviation services, flights at set times and on fixed routes could be booked in advance. Again, operational scheduling requirements would be entirely predictable. → E

WHEN WILL ALL THIS HAPPEN

Though the race to get to market begins now, these three services will not all be implemented at once. Three key developments over the next decade will be instrumental in shaping the evolution of the UAM market: Improvements in battery technology and new forms of electric propulsion will increase flight ranges from 20 to 30 kilometers today to more than 100 to 250 kilometers by 2030. At the same time, advances in automation technology will usher in fully autonomous flights that can carry more passengers and/or luggage. Prices for the end user will gradually come down, with 50-kilometer drone flights costing double or triple the comparable taxi price in 2020, but becoming much more affordable in the years to come. As this happens, the market for urban air mobility services will grow very rapidly. Between five and seven hubs and roughly 30 to 40 vehicles per city will initially be required to launch this kind of transportation service (based on the interviews we

E: Use case 3: Intercity flights

Scheduled medium- to long-range operations

→ Intercity flights to other larger cities close by, which are too close even for regional airlines
→ Fast UAM connection between cities favorable for commuters and business travelers
→ Short travel times let metropolitan areas grow closer

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→ Significantly reduced travel times between two cities
→ The only high-speed travel option without much infrastructure need (compared to establishing high-speed train services)
→ Scheduled operations with predictable demand

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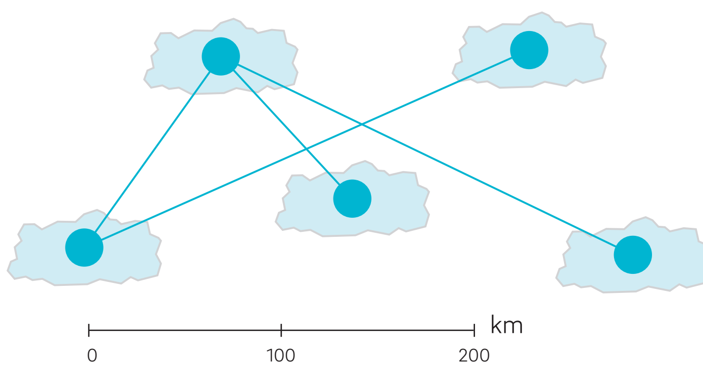
→ Long flight times pose challenges to technology (batteries, motors etc.)
→ Alternate landing sites required along the way in case of emergency



UAM landing site | Metropolitan area | On-demand service | Scheduled service

Source: Roland Berger

conducted). In our opinion, the rough timeline for these developments will look something like this:

Dubai, Singapore, Dallas, Los Angeles and Tokyo, five pioneers of urban air mobility, are keen to provide proof of concept.

INITIAL PILOT PROJECTS IN THE EARLY 2020s

The first pilot projects will get off the blocks in the early 2020s. Dubai, Singapore, Dallas, Los Angeles and Tokyo, five pioneers of urban air mobility, are keen to provide proof of concept, generate publicity and deliver positive user experiences. Dubai commenced test flights in 2017 and has an ambitious goal of launching commercial operations of its Autonomous Aerial Taxi Service in the near future. Which corresponds to RTA's objective of making 25 percent of all public transport modes autonomous by 2030. Uber Elevate project should go live in Los Angeles, Dallas and a third international city starting in 2023. These services will have human pilots, a short range of 20 to 50 kilometers and a focus on intracity mobility.

RANGE EXPANSION AND TECHNOLOGICAL ADVANCES THROUGH 2030

Between 2025 and 2030, eVTOL technology will continue to progress rapidly and expand its geographic reach. Lift and cruise and tilt-wing technologies will combine with more durable batteries to let vehicles fly up to 100 to 250 kilometers and carry three to five passengers. Urban air taxi services will spread to more megacities around the globe and, thanks to their increased range, will also be deployed in the suburban commuting market. Technology, business/operating models and the corresponding infrastructure will continue to improve and regulatory gaps will be closed. Flights should be autonomous to an increasing extent, though commercial passenger drone operators might still keep a pilot on board for safety reasons.

AUTONOMOUS FLIGHTS AFTER 2030

The third stage will see autonomous flight technology enabling pilotless drones to navigate urban environments, transforming passenger drones into safe flying robotaxis.

Further increases in vehicle capacity (up to as many as ten passengers) and range (up to 300 kilometers) will sharply reduce operating costs and make urban air taxi services more attractive to a wider audience. Small intercity airline operators could emerge at this time. UAM services will be fully integrated in a city's mobility landscape yet remaining in the premium segment and requiring the fulfillment of multiple success factors.

3. The pivotal success factor

Choosing the "right" aircraft

Choosing the right technology for each use case merits special attention, as it is central to the development of this nascent industry.

Distributed electric propulsion (DEP) gives aircraft design engineers new freedoms to explore the potential of different drone concepts. Traditional designs largely permitted only incremental improvements. Today, however, it is not unreasonable to speak of a third aerospace revolution that will see new use cases made possible by innovative DEP designs.

Yet even as many different aircraft designs are being refined and prepared for certification with more than 75 projects announced and around 20 successfully flight tested so far, there is very little hard data on the validity of the underlying business models or market segmentation. As startups and incumbents scramble to find the next winning design and translate their concepts into actual commercial services, care must therefore be taken to identify and measure the opportunities and limitations inherent in each design. This study identifies five basic electric aircraft architectures that we see as of prime importance: highly distributed propulsion concepts, quadcopters, tilt-wing aircraft, winged VTOL craft and new hybrid concepts.

The technologies that underpin these five concepts have varying strengths and weaknesses. Propellers tend to deliver superior hovering and stability but lower speeds, whereas ducted fans prove more effective for forward speed than for hovering and stability. As a result of this trade-off, the different concepts are better suited to different use cases among those described in chapter 2.

AIR TAXIS (INNER-CITY POINT-TO-POINT SERVICES)

Multicopters (highly distributed propulsion aircraft) and quadcopters might become the solutions of choice for this use case. Their low downwash speeds are kinder to and safer for urban environments, avoiding damage or injury caused by gravel or sand projection on small landing pads. High gust stability could also prove advantageous where skyscraper helipads are used, thereby maximizing up-time even in harsh weather conditions.

AIRPORT SHUTTLES (SUBURBAN TO URBAN SERVICES)

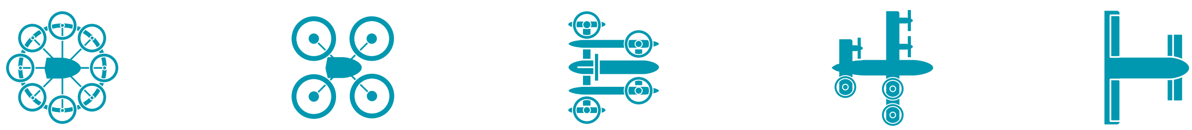
Concepts with higher forward speeds may be better suited to covering longer distances, although poorer hovering efficiency, higher downwash speeds and more noise mean they will require dedicated and better-developed landing areas. Tilt-wing/convertible aircraft concepts, hybrid concepts as well as fixed-wing vectored thrust concepts might become predominant for this business model.

INTERCITY FLIGHTS (INTERREGIONAL SERVICES)

The longer the distances flown, the more important forward speed becomes. Here again, dedicated landing areas will be essential, while 4D unmanned traffic management systems should keep hovering times to a minimum. Fixed-wing vectored thrust will be the most efficient solution for this use case and the solution of choice for this segment. → F

F: Landscape of electric aircraft architectures

Comparison of technical specifications and characteristics



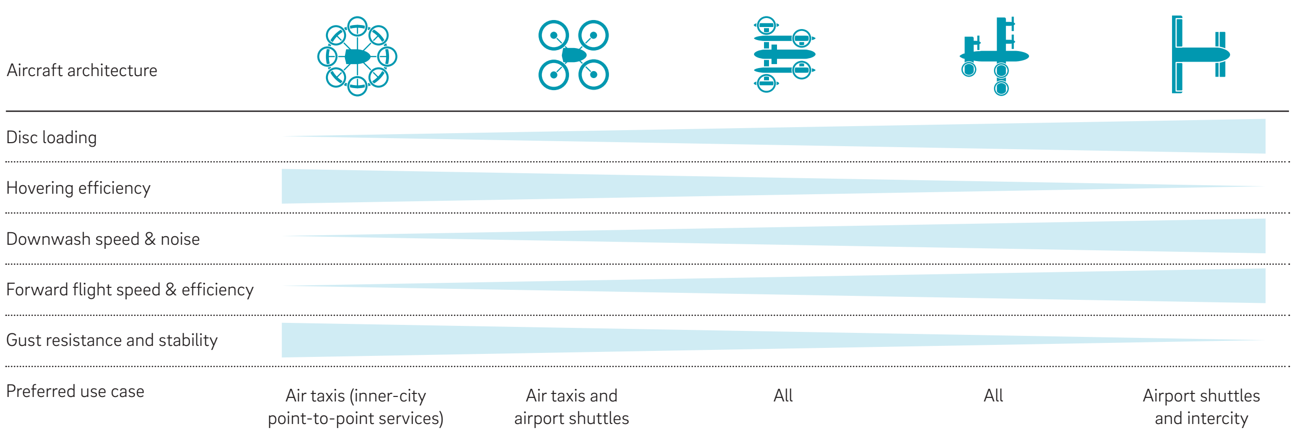
Highly distributed propulsion concepts (multicopters)
This term designates wingless aircraft concepts with more than four fixed propellers. These aircraft cater to between 2 and 4 passengers and can reach maximum speeds of 80 to 100 km/h. One example of this technology is the Volocopter.

Quadcopters
These wingless aircraft concepts with four fixed propellers, possibly arranged as four sets of push-pull propulsion groups, can carry between 2 and 6 passengers at speeds of 120 to 150 km/h. Examples of these concepts are eHang 184, CityAirbus and Pop.Up Next.

Hybrid concepts
These concepts center around aircraft with fixed forward-facing propellers for forward movement and upward-facing/ retractable propellers to generate lift during the take-off and landing phases. Between two and four passengers can fly at speeds of 150 to 200 km/h in these vehicles. Uber Air is an example of this approach.

Tilt-wing/convertible aircraft concepts
These aircraft have several propellers or ducted fans that can be tilted at different angles for fixed or tilting wings to achieve the different configurations needed for take-off, landing, flying and hovering. These aircraft cater to between 2 and 4 passengers and can reach speeds of 180 to 250 km/h. Airbus's Vahana is one example.

Fixed-wing vectored thrust concepts
Winged vertical take-off and landing jets are equipped with variable-direction fans. They too can accommodate 2 to 4 passengers and can fly at 200 to 300 km/h. One example that recently completed its maiden flight is Lilium.



Source: Roland Berger

4. It's not just about drones!

Other key success factors for the UAM market

While choosing the right aircraft technology for the right applications is obviously vital, four additional factors likewise remain essential to the success of any venture into urban air mobility:

INFRASTRUCTURE

It is one thing to build suitable and reliable vehicles, but it is entirely another thing to establish the infrastructure without which the vehicles themselves cannot operate. eVTOL landing sites, charging infrastructures and maintenance facilities must all be set up as key enablers for successful operational business models. Failure to do so will create bottlenecks that could nip the nascent UAM market in the bud and stunt its growth.

Using both ground-based facilities and rooftops for take-off and landing might appear the obvious way to go for urban aviation. However, urban aircraft need a safe landing zone that is unobstructed by buildings and/or trees, which could make this strategy hard to implement in densely populated areas. Other issues include noise and the air turbulence created by the aircraft. On rooftops, the physical aspects are less of a problem. On the other hand, luxury hotels and high-end office buildings are likely to charge exorbitant fees – assuming they are willing to let passenger drones use their helipads at all – as they naturally want to avoid upsetting the wealthy guests who populate penthouse suites and the top executives who work from the upper floors of their office blocks.

On the safety front, a robust 5G cellular network will be imperative to enable communication among eVTOL aircraft, between eVTOLs and other flying objects, and between eVTOLs and control centers. Especially for on-demand services, predictive air traffic management will be key to ensure smooth and efficient operation of the entire eVTOL system. The control center will also take care of both route management and contingency management.

SERVICE PROVIDERS

Service providers will form the link between all stakeholders and will ultimately be responsible for ensuring that urban air mobility services run safely, efficiently and (ideally) at a profit. They will operate the predictive traffic management systems and handle highly granular monitoring to maximize utilization of the network as a whole and of charging infrastructures in particular. At the same time, service providers will take care of aircraft cleaning and maintenance – possibly using off-site hangars, depending on geographical and economic constraints. Downtime will have to be scheduled for off-peak passenger demand periods, again in the interests of optimizing capacity utilization.

PUBLIC ACCEPTANCE

Focusing solely on the benefits of a few wealthy individuals – much as conventional VTOL does today – will prevent urban air mobility from realizing its full potential. The obvious benefits of speed, economy, a safe, enjoyable and environmentally green experience and integrated mobility (see above) must be clearly demonstrated if a broader public as well as city authorities are to accept the potential downside created by the visual and noise pollution caused by passenger drones. In this context, para-public applications (emergency services, traffic and infrastructure monitoring etc.) will be essential tools to communicate the benefits of urban air mobility even to those members of society who will not necessarily use it themselves.

Urban air mobility will not replace any part of the existing mobility landscape. But it will become a pivotal element of future mobility in and around major cities.

REGULATORY LANDSCAPE

One of the key hurdles right now is the absence or very immature status of regulations worldwide. As things stand, there is no dedicated body of law in place to govern the operation of drone taxis. Yet a comprehensive regulatory framework will be essential to guarantee the safety of people, infrastructure facilities and third-party property. This will clearly be another crucial success factor if the UAM market is to take wing.

Such a regulatory framework should, in our opinion, address four key safety concerns: avoidance of possible mid-air collisions, prevention of injuries to people and damage to properties as an outcome of possible crashes, and avoidance of privacy breaches. Its inevitable objective is therefore to regulate the certification of vehicles, operators, air traffic management (ATM) and, indeed, the entire airspace for UAM services.

Urban aircraft will themselves require certification to share public airspace with larger (manned) aircraft, to fly over urban areas and to comply with noise and emissions regulations.

The management systems used for conventional and unmanned air traffic will likewise require clear rules to avoid conflicts and, potentially, collisions with police or rescue helicopters, for example. Responsibility and liability for mid-air collisions, damage to property and so on must be clearly allocated to manufacturers and operators, who will also need adequate insurance for all the safety aspects referred to earlier.

Busy European airspace is already heavily regulated, especially in the vicinity of major airports. Here, the challenge will be to adapt existing laws and regulations to accommodate the peculiarities of UAMs and permit congruent operation of both sets of aircraft in the same airspace. At least in the US and the EU, numerous areas of existing law lend themselves as a point of departure for any such regulatory moves.

Given that UAM vehicles will fly much closer to the ground (only a few hundred meters up, compared to several kilometers for current aircraft), there will also be a need to explicitly protect personal privacy (e.g. by prohibiting/preventing drone passengers from taking photos from above).

Ultimately, the emergence of an appropriate body of regulations, and the transparent and open communication of how compliance with these regulations is certified and ensured, will play a critical role in driving broad acceptance of this new means of urban mobility.

5. Conclusion

HOW TO IMPLEMENT UAM SUCCESSFULLY

The beginnings of the ecosystem described in this study are already visibly taking shape. Right now, this embryonic market is open to potential players from a variety of backgrounds, and it is far from clear who will run the farthest with this vision. Aircraft manufacturers and automotive OEMs are obvious choices and could attach primary or secondary importance to different aspects (from drone production to infrastructure development to navigation, ticketing and air traffic management systems, just to take a few examples). Yet mobility service providers are equally keen to get in on the act, as are no shortage of technology startups.

Given the sheer complexity of the road ahead, though, what is clear is that "going it alone" will not be an option for any of these players. Extensive development is still needed in all the relevant areas: aircraft technologies (in particular energy density in batteries and autonomy), infrastructures and regulatory frameworks – not to mention business and operating models. This fact alone calls for an interdisciplinary approach that brings incumbent and startup aircraft manufacturers, operators and service providers together with local, regional (and possibly national) authorities. Collaborative consortiums such as the Urban Air Mobility (UAM) initiative, launched by the European Innovation Partnership and backed by the EU Commission, are already showing one way forward.

What recently still seemed a distant dream is now taking its first determined steps toward reality – complete with real and promising business opportunities in the years ahead. The winners of tomorrow will, to a very great extent, be determined by the preparation done today. In concert with reliable, potent partners and advisors, would-be market players must therefore move now to map out a clear strategy, commit to technologies that will best serve the segments they plan to serve, and invest commensurate resources. The business stakes are high, because a long-held human dream is about to take wing.

"Going it alone" will not be an option for any of the players. The key success factor is the strong collaboration between manufacturers, operators, infrastructure providers and regulatory authorities.

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WE WELCOME YOUR QUESTIONS, COMMENTS AND SUGGESTIONS

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About us

Roland Berger, founded in 1967, is the only leading global consultancy of German heritage and European origin. With 2,400 employees working from 34 countries, we have successful operations in all major international markets. Our 50 offices are located in the key global business hubs. The consultancy is an independent partnership owned exclusively by 220 Partners.

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Roland Berger has been helping its clients to manage change for half a century. Looking forward to the next 50 years, we are committed to supporting our clients as they face the next frontier. To us, this means navigating the complexities that define our times. We help our clients devise and implement responsive strategies essential to lasting success.

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