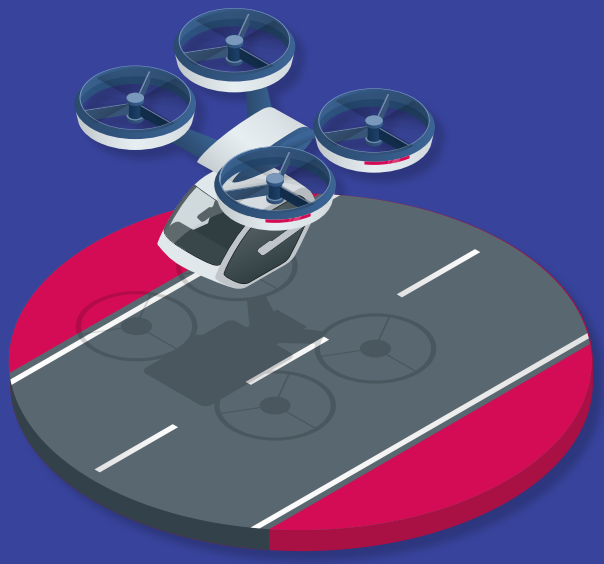
KPMG

Aviation 2030

Disruption beyond COVID-19

Thriving on disruption series



Pandemics and economic downturns expose the volatility of the aviation sector. But other technological and consumer-led changes have longer-term, fundamental implications for aviation. In this piece, we seek to place COVID-19 in longer-term context and also evaluate the potential implications of air taxi ports and revolutionary plane design. We do this through the lens of six key player types.

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About this report

This report combines insights from KPMG member firms' recent and ongoing client engagement with secondary research. Also included are several quotes from conversations with member firm clients in 2020.

"We're very good at clear and present danger, like every mammal is... [but] we don't respond to long-term threats with nearly as much vigor." [1]

In late 2019 KPMG's Global Strategy Group released Aviation 2030 – the first in a series on the implications of long-term technological and consumer-led disruption in the aviation sector.

2020 then brought us the most severe recession for global aviation since the sector's commercial rise in the 1950s. Understandably, the impact of COVID-19, including travel restrictions, has dominated short-term commentary.

The scale of disruption is most significant to the supply side – from operators dropping out or seeing new strings attached to their State bailouts, through lessors having to reshuffle portfolios to manufacturers seeing orders collapse. But the demand side also sees short to medium term impact after such a pandemic. While there are many happy to take an overdue holiday or see loved ones overseas, there are also those that, in the absence of any government restrictions or quarantines, still shy away from travel for health or economic reasons.

But humans have a tendency to exaggerate the significance of shocks, at the expense of gradual developments. Many of the longer-term disruptions in aviation that we explore are indeed dependent on funding and R&D today. With depleted cash reserves, some of the technological innovations we explore in this series of publications may be delayed by a number of years – but the direction of travel is clear, such disruption is a matter of when, not if.

In our opening issue of Aviation 2030, we laid out over a dozen disruptions, focusing on 3:

- alternative energy sources
- maintenance robotics and
- supersonic engineering.

In this issue, we focus on the long-term disruption from:

- COVID-19's legacy
- urban Vertical Take-off and Landing (VTOL) ports
- revolutionary plane design

We do this through the lens of:

- OEMs (original equipment manufacturers) and their supply chain
- Lessors
- Operators
- MROs (maintenance, repair and overhaul (organizations))
- Airports
- ANSPs (air navigation service providers) and regulators

As leading advisors to the global aviation sector, KPMG member firm professionals seek to present a vision of the aviation landscape beyond 2030.

COVID-19 in long-term context

In 2020, the world has been awash with stories on the immediate impacts of COVID-19 on aviation. Some venture mid-decade for their predictions on when we next see a return to 2019 flight volumes. Let's look a little beyond that and consider what legacy COVID-19 could leave on the sector of the 2030s.

OEMs and their supply chain

- The big OEMs often cite the certainty of aviation's long-term growth, outpacing but proportional to global GDP growth. Many of the fundamental drivers of this – such as emerging middle classes in Asia – are still there. But the accelerated acceptance of video conferencing – not a replacement for every face to face meeting but chipping away at marginal cases for business travel – will impact those long-term projections. Combined with Twitterati carbon footprint shaming, we may be seeing a decoupling of aviation's long-term relationship to GDP.
- Even a relatively modest easing of this relationship, say aviation demand growing at GDP rather than double GDP rate, compounds to significant loss of orderbook by the 2030s.
- In 2019 the big two OEMs' 20-year outlooks predicted 39,000-44,000 new deliveries over that timeframe.[2] Instead we could be looking at 30,000.[3] This has significant implications for the supply chain and will only accelerate upstream consolidation, roboticization and the diversification of advanced engineering firms beyond aerospace.

Lessors

- Once lessors have given what payment holidays they can to operators, have handled early termination requests and have been exposed to operator bankruptcies, we will likely see some lessor consolidation.
- Rather than completely go under, consolidation may happen especially around state-backed Asian players. We expect a shorter tail of boutique lessors by 2030.
- Despite that, once asset pricing adjusts, we would expect some new entrants.
- As the value chain player with least direct dependence on physical colocation of staff, lessors (along with I-banking, professional services, etc.) may also have become more virtual as a result of COVID-19 (and ESG initiatives), with smaller office footprints and - beyond headquarters - the lack of any permanent physical office for staff in sales regions.

Operators

- Some exits, but less sector consolidation than may have been thought initially during the pandemic.
- Excess supply of planes won't all end up in retirement – many will inevitably be priced to attract new investors to enter the airline market.
- As OEMs are keen to recover orderbooks, operators may get used to some very competitive pricing – that will set a new expectation among operators for the foreseeable future.
- Expect the proportion of leased aircraft to rise further as operators seek liquidity and flexibility.

MROs

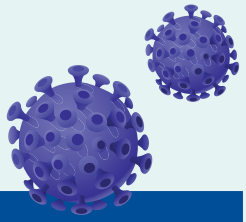
- A recent skills shortage across MRO has been flipped on its head by COVID-19 as demand slumps. People's careers, whether graduate entrants or mid-lifers, cannot easily adjust that fast. By the time MRO is next back to 2019 demand volumes, expect an even bigger talent shortage.

Airports

- Many security measures established in the aftermath of 9/11 are still in place two decades later. Similarly, we predict that most airports will have to keep their new and more visible health screening and sanitation measures in place for years.
- For the cash strapped airport, this means further costs and further queueing when passengers could be in duty free.
- Well managed airports, however, will accelerate the adoption of AI and automation in crowd flow management – like staggered mobile-triggered boarding to avoid 300 persons cramped around a gate. They will collaborate with their retail and restaurant tenants to adapt, bringing the mobile e-commerce and home delivery revolution airside.

ANSPs and regulators

- ANSPs are variously dependent on flight volumes or government grants for their income. The impact of lower flight volumes will therefore hit different ANSPs differently.
- Anticipated investments in next generation technology to digitise air traffic control (ATC) will be concentrated in those better-funded, and cross-border commercialising players.
- Those already in a poor cash position may go virtual – heralding a cross-border consolidation of ANSP and regulator functions as better positioned, commercialised players become subcontractors for their neighbours.
- Geopolitics and sovereignty are realistic barriers to this, but expect consolidation of some roles to accelerate within Europe.



"No previous aviation crisis compares with COVID-19. Some ANSPs had 2-3 months spare cash, some were better positioned. But none had 2-3 years of cashflow readily available that may now be needed to fund business as usual and continue the necessary technology investments in the sector.

The direct subsidy model may become more prominent and charges per flight may need to be revisited.

The overdue digitalization of air traffic control will have a lack of ready funders. However, some capex has a clearer path to cost savings and might therefore still accelerate during the 2020s – Virtual Towers as an example. With lower flight volumes, now is the ideal time to innovate – if the public funding situation allowed it."

- David Usher,
Head of Customer Relations & Commercial Development at the Irish Aviation Authority.

"In hindsight, the A380 seemed too big for the market. In the post-COVID-19 environment of reduced load factors, the 777 may start to look like the new A380. Perhaps in the short term, the smaller the plane, with sufficient range, the better."

- Norris Tie, Co-founder and CEO at Exosonic, Inc.

Urban VTOL ports

A public fascination with emerging VTOL aircraft technology and the potential for on-demand air mobility distracts from the significant implications for airports, urban planning and real estate.

We have previously explored how VTOLs or air mobility concepts are progressing at pace[4]. Somewhat cocooned from the COVID-19 impacts on aviation at large, dozens of pre-revenue start-ups or partnerships have multi-year funding in place. Hence, we believe, some of the biggest innovation in aviation this decade will come from on-demand, short-haul air mobility. We have previously argued that as VTOL ranges increase, this will have implications for traditional regional aviation. Here we consider the infrastructure side.

"There are two contrasting views on COVID's impact for VTOL. Most ANSPs would like the integration of lower flying air taxis into controlled airspace, but the readiness varies. Some ANSPs have an immediate focus on conventional aviation, they see it suffering and think VTOLs are a distraction in the short-term. Others see today's supressed flight volumes as the ideal time to invest in airspace integration."

- Munish Khurana, Senior Manager at EUROCONTROL.

On average, people in major cities around the world spend ~160 hours in traffic congestion annually – that's 21 days of work lost annually.[5] With global urbanization comes higher ground infrastructure costs,[6] yet airspace remains underutilised. On-demand, short-haul air journeys have the potential to radically improve urban mobility, giving people back time lost in their daily commutes, and not just for those that can afford the skies. An Uber Elevate study argues that urban air transportation has the potential to alleviate ground congestion, modelling ground transport savings of 70-75% in some cities.[7] A network of small, electric aircraft that take off and land vertically, will enable rapid, reliable transportation within cities to suburbs this decade. In the 2030s, we will see intercity connectivity and – where public subsidies step in to support rural connectivity – the leapfrogging of poor ground infrastructure beyond suburbia. (While we are focusing on passenger VTOL here, that is not to disregard the implications of larger VTOL goods transportation.)

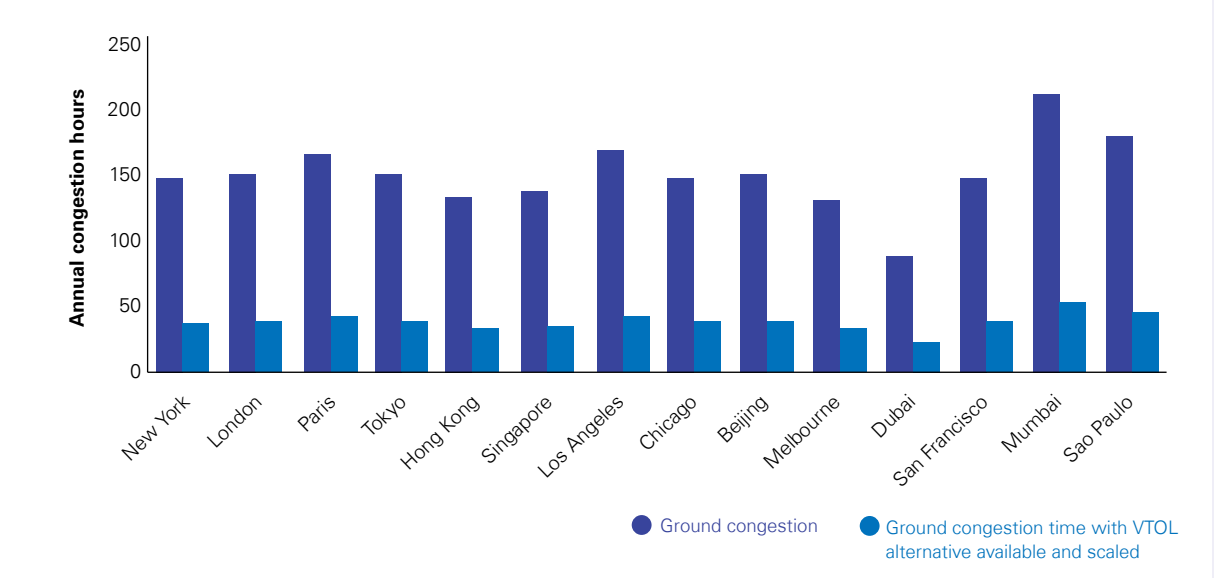
"Airports will be key nodes on vertiport networks. Downtown to/from airport will be one of the key 2-3 routes in most cities. Many airports see that VTOL helps their integration into the city – overcoming distance and bottlenecks. But it will be case by case. Some airports will have VTOL fully airside, others may require some additional security step, but the more seamless the better for the airport and airlines."

- Duncan Walker, CEO at Skyports.

"Safety requirements will likely favour newer and out-of-town airports with available land space. This is because the easiest way to integrate vertiports airside are in new, dedicated terminals, no further removed from the rest of the airport than two terminals might be from each other. An example of this in action is Dallas Fort Worth International. Smaller, urban airports may struggle with available space. Integration onto their terminal roofs in an option but brings its complexities."

- Munish Khurana, Senior Manager at EUROCONTROL.

Figure 1: Comparison of congestion hours saved in urban travel vs current ground mobility



Source: KPMG analysis, TomTom - World Traffic Index, 2019, Uber Elevate

Manufacturers have made progress on the aircraft themselves, but the infrastructure necessary to support and enable transportation of people and cargo is not yet in place. For VTOLs to become a reality, players need to establish ground infrastructure, a robust communication and unmanned air traffic management (UTM) system, and a seamless mobility-as-a-service (MaaS) platform.

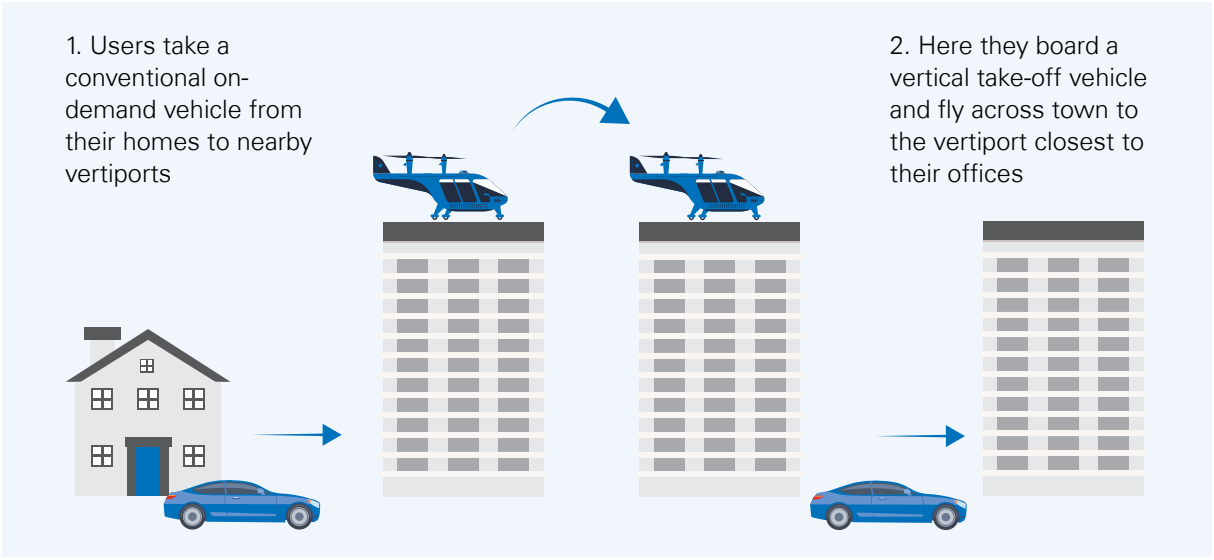
"To be economical, you want 3-4 gates at most downtown vertiports. That limits the available locations. Existing transport hubs are an obvious one, they have the connectivity, energy infrastructure for eVTOL, and neighbours used to the bustle. We are currently working on VTOL integration onto the roof of German rail stations, for example. But beyond that there is an opportunity for first mover advantage among other commercial landlords. Safety regulations will likely limit the density of buildings with a permitted vertistop, so future proofing major urban regeneration projects, or converting existing helipads early on makes sense. It locks in local access to VTOL."

- Duncan Walker, CEO at Skyports.

"European ANSPs and regulators generally want to get standards for unmanned drone use established first – such as medical supplies transport. Meanwhile 'smart cities' are making the case for faster adoption of air taxis. However, it is disproportionately ANSPs and regulators from South Asia, South America and Africa that are keen to leapfrog the Western path for aviation and ground infrastructure and explore how passenger VTOLs can serve local needs this decade."

- Munish Khurana, Senior Manager at EUROCONTROL.

Figure 2: Initial commercial use case



Source: The Times UK

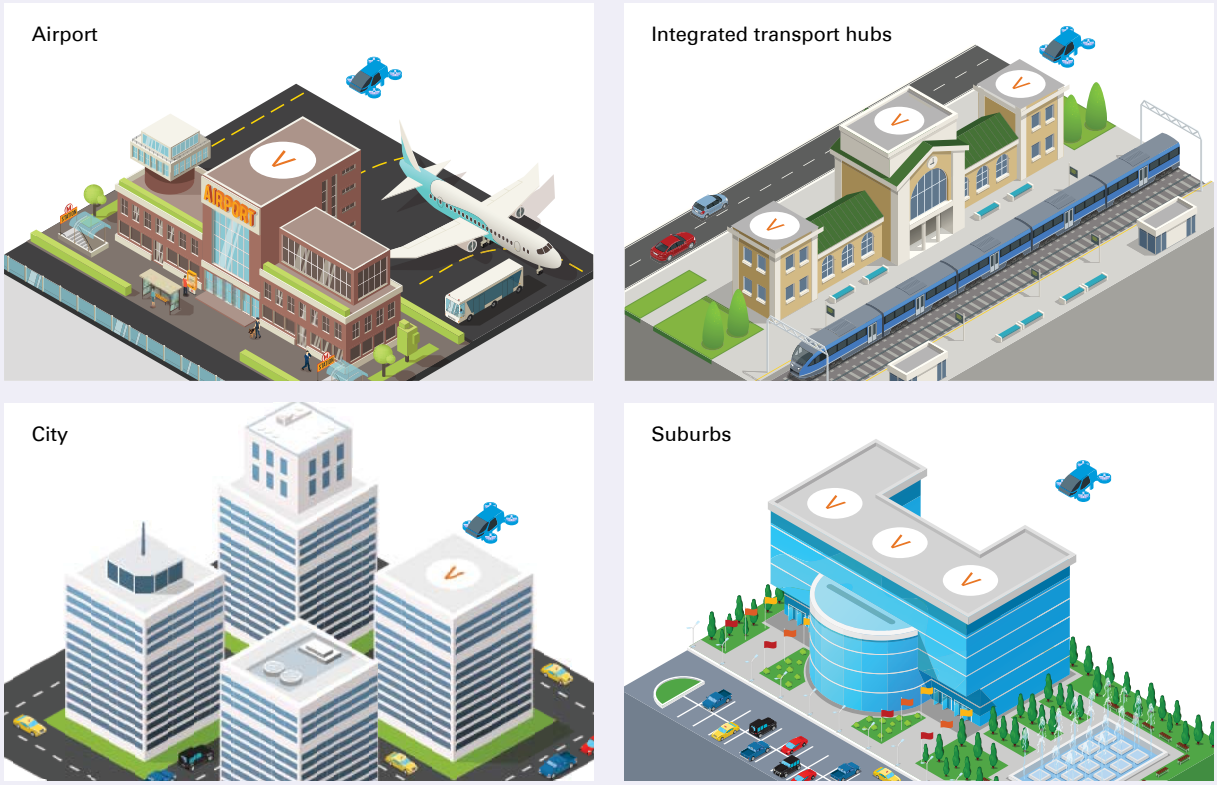
Ground based infrastructure can be classified into two categories:

- Vertiports or Skyports: these would be large multi-landing locations that can simultaneously serve multiple vehicles. They will host fast recharging / refuelling facilities, support personnel, basic security checkpoints, and the capacity to carry out minor MRO operations. They are likely concentrated downtown, at key suburban nodes like rail stations, as well as at conventional airports and harbours.
- Vertistops: these would often be single vehicle landing locations, where no support facilities are provided, but where VTOLs can quickly drop off and pick up passengers without parking for an extended time. This category can include retrofitted parking lots (e.g. at malls or secondary urban centres) and existing helipads.[8]

"We see excessive land costs, limited sites of suitable size and significant safety issues in the early days for downtown 'Skyportz'. It makes more sense for first movers to be city fringe sites, larger business parks outside of the cities, existing helipads and regional airports. These sites will deliver a safe introduction to VTOL with limited impacts on amenity and acceptable infrastructure costs."

- Clem Newton-Brown, Director at Skyportz.

Figure 3: Anticipated vertiport and vertistop infrastructure

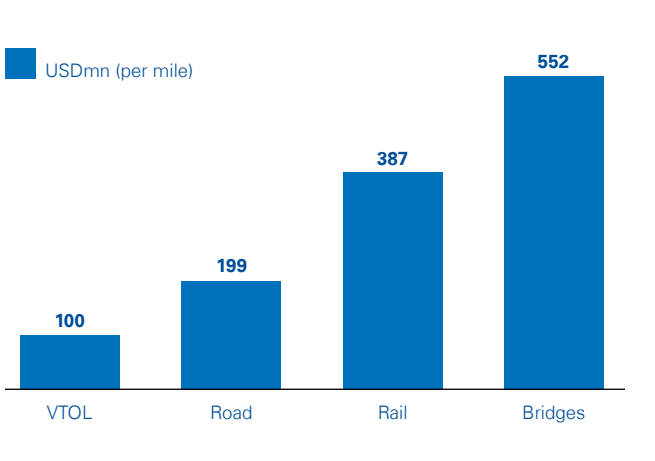


The development of such infrastructure to support a VTOL network will likely have significant cost advantages over heavy-infrastructure approaches such as roads, rail, bridges.[9]

But most vertiport networks will need some building retrofits. It will require careful consideration, co-operation from owners, permitting agencies and flexibility in site agencies.[10]

As costs for traditional infrastructure options continue to increase, however, the lower cost and increased flexibility provided by these new approaches may provide compelling options for cities, local government and states around the world.

Figure 4: Construction cost per mile comparison for ground infrastructure



Estimated infrastructure cost for operating VTOL is approx. 50% of the cost incurred in constructing the cheapest ground infrastructure.

(Source: KPMG analysis based on Uber Elevate, Bloomberg and BBC)

"I think if you look at cars, a massive amount of infrastructure has been built over 100 years, but the sky doesn't need that. If you own the landing sites, the traffic management and capital cost is significantly less than building roads. Urban air mobility services could explode very quickly if we get that all important "community licence" to operate. Having said that, most of the attention to date is about the hardware – what the prototypes look like, etc. But the best aircraft in the world are useless without the landing infrastructure and airspace integration."

- Clem Newton-Brown, Director at Skyportz.

Figure 5: Selected Vertiport partnerships in design and development

			Current phase		
Developer/ Company	**Partner**	**Region**	**Concept/ Design**	**Prototype**	**Construction**
The Related Companies	Uber	United States			
Hillwood properties	Uber	United States			
Skyports	Volocopter	Singapore			
Skyportz	Independent	Australia			
Anonymous	EHang	China			

Source: Uber, Skyports, Skyportz, EHang

Cost effective retrofits will likely make commercial sense but may require the most technical consideration. For example, parking adjacencies, passenger terminals, floor loading, fire and light safety systems, and vehicle charging could all impact practical redesigns and building codes.

For greenfield projects, the pace at which large developers realise the attractions of hosting vertiports will be interesting to observe. Even if the final regulatory specifications are unclear, given the average construction cycle for major urban developments, that impact on design starts now. Future proofing new landmark commercial, residential and mixed-use developments with landing sites for VTOLs will be in the interests of major developers in many cities.

"Space is at a premium in our cities and the business case is far from clear. Partnerships with VTOL manufacturers and real estate developers, along with strong government support, enables a comprehensive network of sites in preparation for the aerial mobility revolution. All the players can sense this is going to be big but are wary about getting burnt as a first mover."

- Clem Newton-Brown, Director at Skyportz.

We now consider implications by stakeholder type.

OEMs and their supply chain

- Existing aviation OEMs face competition not traditionally associated with aviation, including well-financed start-ups, tech companies and car manufactures all eyeing this US$1.5tn market.[11]
- Companies specializing in Drone infrastructure development [12] and operation also create a threat for existing infrastructure players and operators not prioritising VTOL operations.
- Much of the aerospace supply chain in 2020 has had a disruptive reminder of their risk concentration to 1-2 OEMs. VTOLs offer a once-in-a-generation opportunity at revenue diversification.

"OEMs and infrastructure players are taking a multicity approach to ensure that they are in first mover markets. From a city perspective, political stability, regulatory engagement, a quick permitting process, and allocation of public land are all more important to our early business case than overall population or congestion levels."

- Duncan Walker, CEO at Skyports Limited.

"OEMs are looking at more futuristic designs for conventional planes – but now COVID will impact some of that discretionary spend in the short-term. The one area where OEMs know they will lose out is if they start cutting funding in this emerging eVTOL space. The alternative is they pay a premium to buy into successful players down the line. No one is making money out of this anywhere yet and cash is being burnt at the rate of billions per year by the various players. There will be winners and losers, but it is a very exciting game to be in."

- Clem-Newton Brown, Director at Skyportz.

Lessors

- The promise of air mobility is attracting new investors into aviation, thus far primarily on the OEM backing. The question is whether or not existing lessors want to be part of air mobility's value chain, with a customer base spanning tech giants, reimagined automotive brands, transport companies and local government.
- Helicopter leasing hasn't been a profitable business over the last decade. With VTOL's similarities (before it outgrows the role of the present-day helicopter) we could see existing helicopter lessors expanding first into this space and a straight asset substitute.
- We might also see other lessors, those focused on regional jets and turboprops, for example, or the larger diversified lessors, also entering the market given its potential scale. But at least as likely, we foresee a new cohort of VTOL-only lessors emerging which would try to capture the growing market – a mix of private capital and institutional sub-brands.

Operators

- With COVID-19's impact, few operators are currently in the mood to invest in connected mobility. Those that do start to invest in air mobility may be those with strong state backing (e.g. those in the Gulf) or with existing investments in ground MaaS.
- With VTOL's infrastructure cost being ballpark ~20% of high-speed rail (or hyperloop) construction [13], transport authorities in major countries might rethink rail strategies, this could result in public private partnerships to establish and build and operate mass market VTOLs.
- We also see JVs between ground mobility/ tech companies and airline operators bridge the expertise and required skillset between urban mobility and air travel.
- Once VTOL ranges increase, regional carriers will see direct threat of substitution.

MROs

- With most VTOLs being electric, there will be less complexity in engine maintenance. Yet with lower altitude flight there will be greater corrosion and drag potential, although this could be somewhat mitigated with materials choice. Additionally, exposure to ad hoc vertistops may increase the chance of wear and tear. Airframes may therefore need more maintenance per flight hour than a conventional plane.
- The workforce will need to be upskilled and their processes redesigned to manage VTOL maintenance in airports and vertiports, with increased volumes and faster turnarounds.
- Much of the maintenance opportunity may be on the vertiport side itself, with high frequency turnarounds and urban operating environments meaning more intensive maintenance and repair budgets per m^2 when compared with traditional airports.

Airports

- Current airports are built to serve traditional aircraft. We foresee smaller, less profitable airports doing cost-conscious retrofitting of existing perimeter infrastructure, like parking lot conversions, to serve VTOLs arriving from the catchment area.
- More ambitious, larger airports will want to connect people airside arriving for regional/ secondary cities. Newbuild terminals can start incorporating vertiport design today, while existing operations will need to factor in the required build work to minimise disruption.
- While some downtown vertiports could conceivably check passengers in for international connections, with full airside integration at the airport, many airports will still likely require security checks before passengers fully merge airside.
- Given the small size of VTOLs, heavy luggage for onward travel is impractical. Therefore, expect the roll-out of integrated luggage services already prominent in some parts of the world. For example, drop your checked luggage in advance at the local shop or post office, for collection at your end destination.

ANSPs and regulators

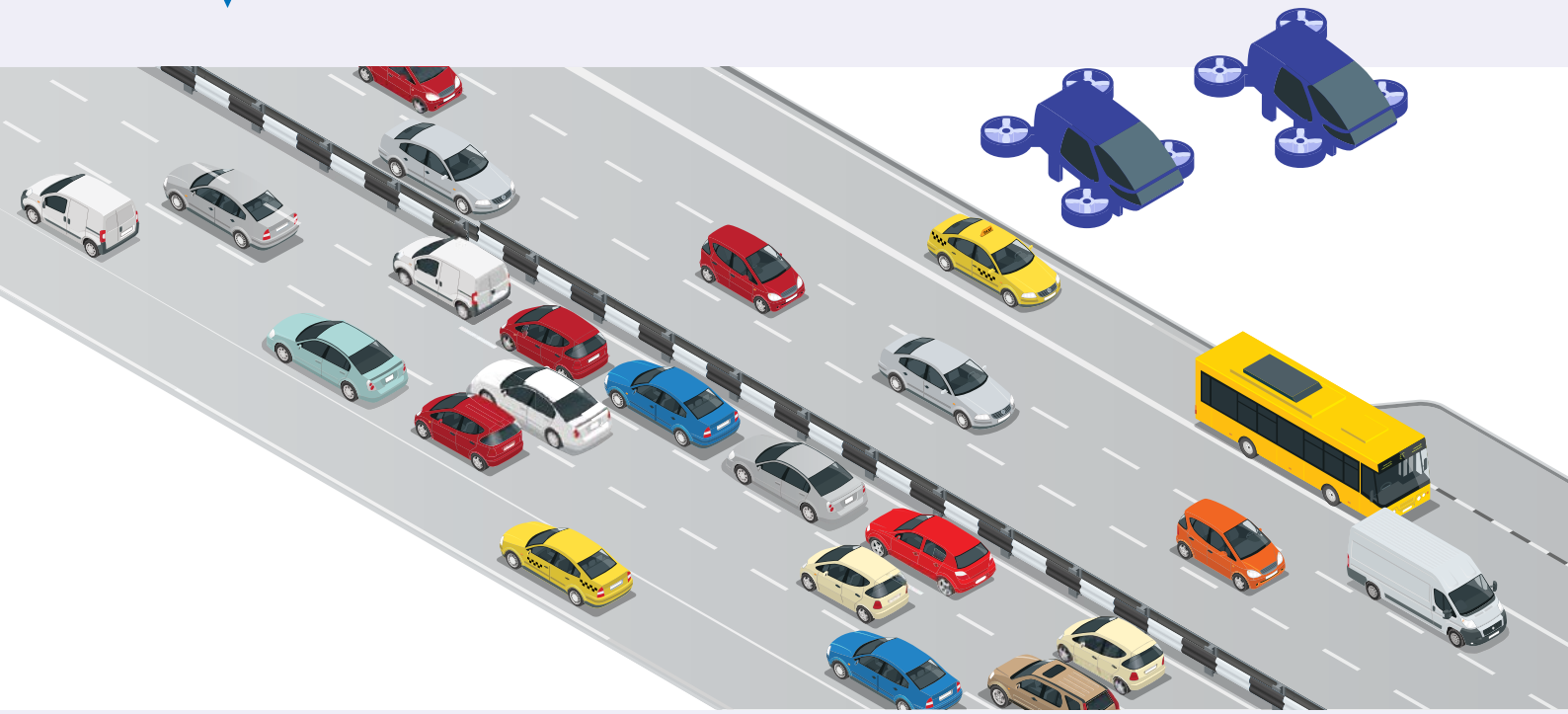
- We will see a new cohort of players from tech, independent start-ups and Space agencies entering the UTM (Unmanned Air Traffic Management) market.
- Revenue opportunities from the provision of trainings, licensing and consultancy work in the area of airspace designs, systems integration and operations set-up, as well as UTM services to VTOL operators.
- Global guidelines may be implemented very differently in each country. Regulators can make or break the commercial viability of VTOL operators.
- The key question for cash strapped ANSPs, however, is what does it cost to monetize this opportunity? COVID-19 impacts on finances aside, leading ANSPs would like to increasingly digitize their offering this decade, with increased use of AI. But upgrading core systems at scale is tough – would it be better to trial automation in air traffic control first on UAVs, then passenger VTOLs? Once the system works, it can be scaled back up to conventional airspace. The investment in VTOLs would therefore not be an additional cost, but rather a lower risk approach to core ATC upgrades.

"U-Space service provision will likely remain separate from traditionally controlled airspace, whether provided by ANSPs or new entities. However, the latter would complicate the integration of VTOLs into airside airport operations."

- David Usher, Head of Customer Relations & Commercial Development at the Irish Aviation Authority.

"With battery range and cross-border regulatory approvals, the VTOL business case really takes off – where total journey times can be reduced 50+%, say a route like downtown Singapore straight to a beach resort on Bintan, or downtown London to Brussels."

- Duncan Walker, CEO at Skyports Limited.

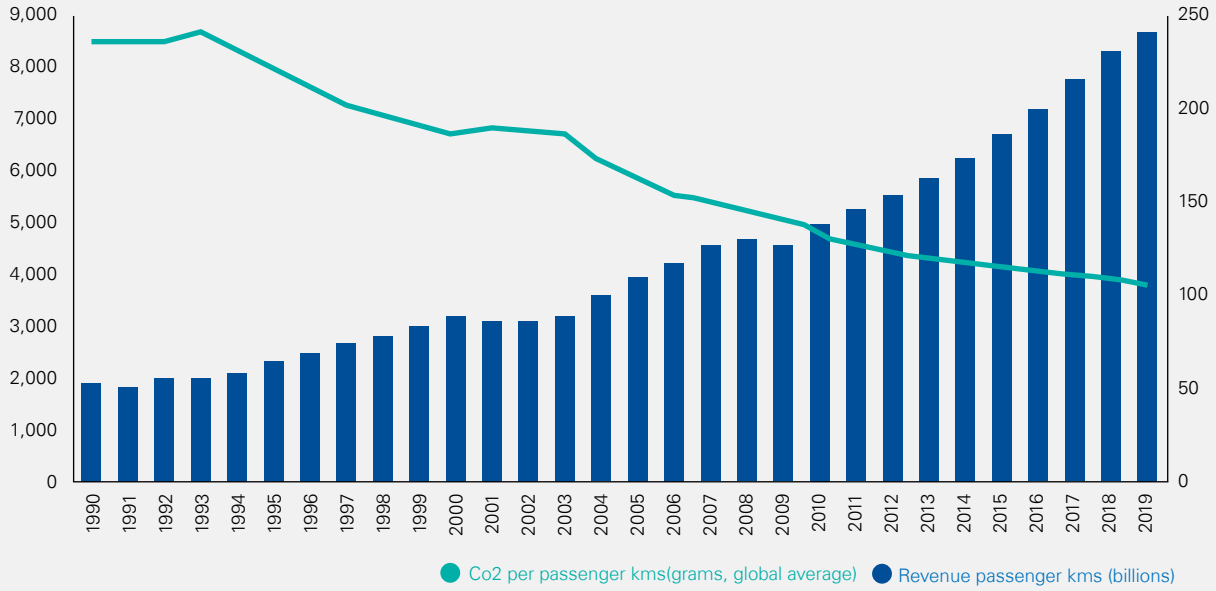


Revolutionary aircraft redesign

Aviation's ability to decarbonize is usually seen through incremental efficiency gains and the promise of electric, hybrid or biofuel propulsion. But does fundamental plane design – untouched for decades – need to remain a bottleneck?

In 2009, the aviation industry agreed to an ambitious set of goals for its carbon emissions. The combined fleet of commercial aviation aircraft would improve its fuel efficiency by an average of 1.5% per year through to 2020, with further goals set to cap net CO2 emissions from 2020, halving them by 2050 based on 2005 levels. More recent figures indicate the short-term goal is on track, with current analysis showing a 2% improvement on a rolling average – an efficiency improvement of 21.4% since 2009.[14] These efficiency levels have been achieved with some significant changes in plane and engine design – such as the introduction of turbofan engines – coupled with year-on-year incremental improvements to engine design and operation.[15] Volatile fuel costs have made it economical to retire older aircraft at higher rates further contributing to fuel efficiency performance. We have seen this trend continue with the early retirements of Airbus A340-600s and Boeing 747-400s worldwide, for example, triggered by COVID-19.

Figure 6: The decline in CO2 per passenger kms



Source: IATA Economics/Air Transport Action Group

There is a direct link between aircraft emissions reductions and improvements in propulsion, aerodynamic, material and structural technologies.

Propulsion technologies offer the greatest amount of reduction in fuel consumption and consequently CO2 emissions. We have seen engine makers bring engines on the latest wave of single aisle aircraft (A320neo, B737MAX, E2) which provide a 15% reduction in fuel burn relative to earlier engines. Meanwhile, latest generation engines for new production twin-aisle aircraft (A330neo and B777-9) can deliver up to 10% fuel-burn reduction relative to 2014 in-service reference.[16]

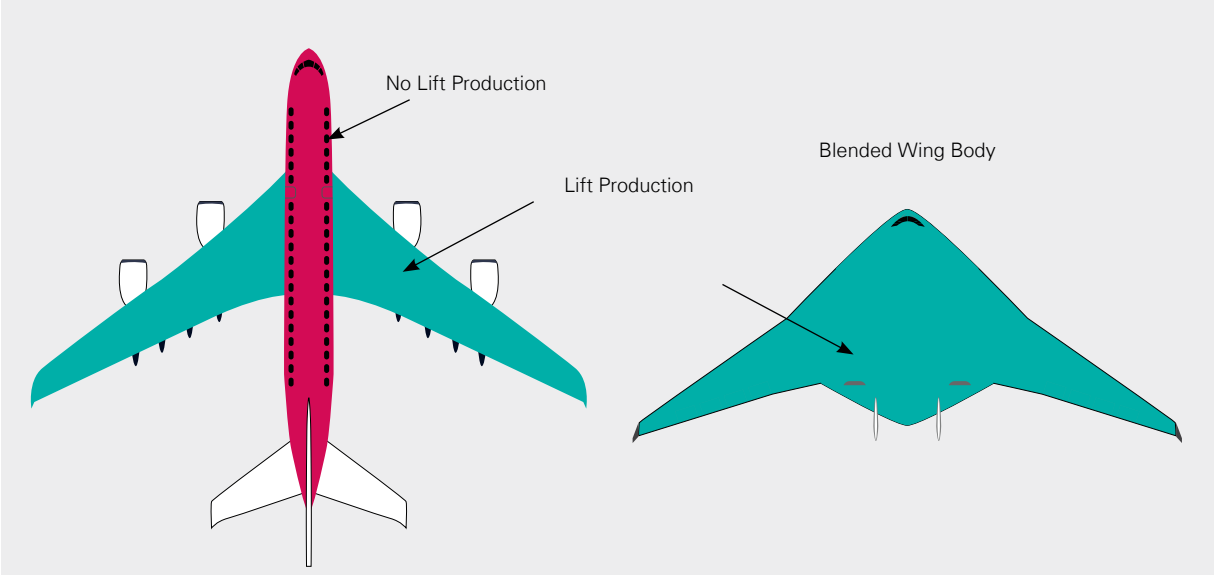
Research programmes are further developing propulsion technologies. The US national research program CLEEN (Continuous Lower Energy, Emissions, and Noise) has demonstrated a 20% fuel burn reduction. Europe's Clean-Sky 2 Joint Technology Initiative builds on validating more radical engine architectures, including Open Rotor concept, providing up to a 30% fuel burn reduction and supporting flight-testing planned for 2023.[17]

"The advancements brought by supersonic commercial aircraft development may introduce new technologies that benefit the commercial aviation industry. These could include the increased proficiency of large-scale manufacturing with carbon composites, more advanced flight software capabilities, and higher temperature engines."

- Norris Tie, Co-founder and CEO at Exosonic, Inc.

Reducing the effects of lift-dependent drag and skin friction are also key to improving an aircraft's aerodynamic efficiency. In addition, increasing lift could require more radical aircraft configuration concepts such as blended wing bodies (BWB) or strut-braced wings. Although these concepts could appear complex and costly, in the case of BWB, they have over two decades of research and development and draw on military aircraft designs, including the B-2 Bomber, to accelerate research and testing timelines*. The application of modern manufacturing methods to deliver full composite or 3D printed fuselage segments could also be key to reducing skin friction through the removal of fastener protrusions into airflow.

Figure 7: Blended wing comparison



Source: RMIT University

Another opportunity to further reduce fuel burn and CO2 emissions is by decreasing aircraft structural weight. Progress in composite materials and advanced metallic alloys will offer future weight reduction opportunities of up to 8% relative to current state-of-the-art structural configurations.

Considering a typical aircraft lifespan can currently range from 20-35 years, future aircraft technologies can be divided into:

1. Retrofit programmes (short-to-medium term)
2. Production upgrades (medium-to-long term)
3. Radical design concepts (long term)

Figure 8 illustrates future aircraft designs and technologies across the 30-year horizon until 2050. In the 10-year period until 2030, we will see "evolutionary" developments with classical fuselage tube and wing configurations and turbofan engines. The key efficiencies in this decade will be in materials selection, improved aerodynamics and high by-pass engine architectures. A combination of evolutionary technologies will improve fuel efficiency by 25-30%.[18] Examples of this are the GE9X engine or UHBR Clean Sky project and the wider adoption of retrofit programmes for in-service aircraft winglets.

From 2030 onwards, "revolutionary" new aircraft configurations and propulsion systems are expected to be ready for entry into service (provided global economic conditions are favourable). These radical new aircraft designs include blended wing bodies, strut-braced wings, and hybrid and battery-electric aircraft.

While views are split on the safety compliance of evacuation times for larger BWBs, the current market experience of A380s and 747s suggests the next generation of design will focus on seating capacities more aligned to today's narrowbody market.

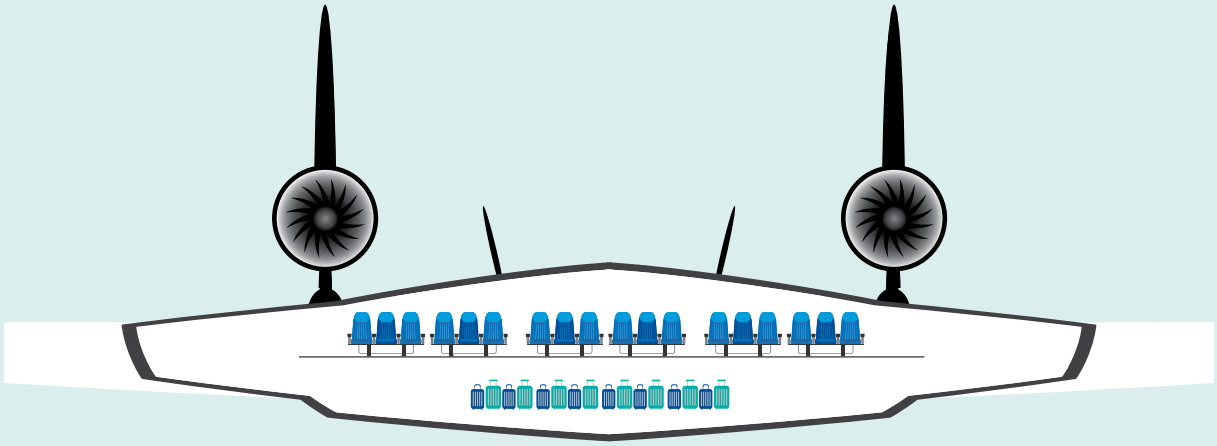
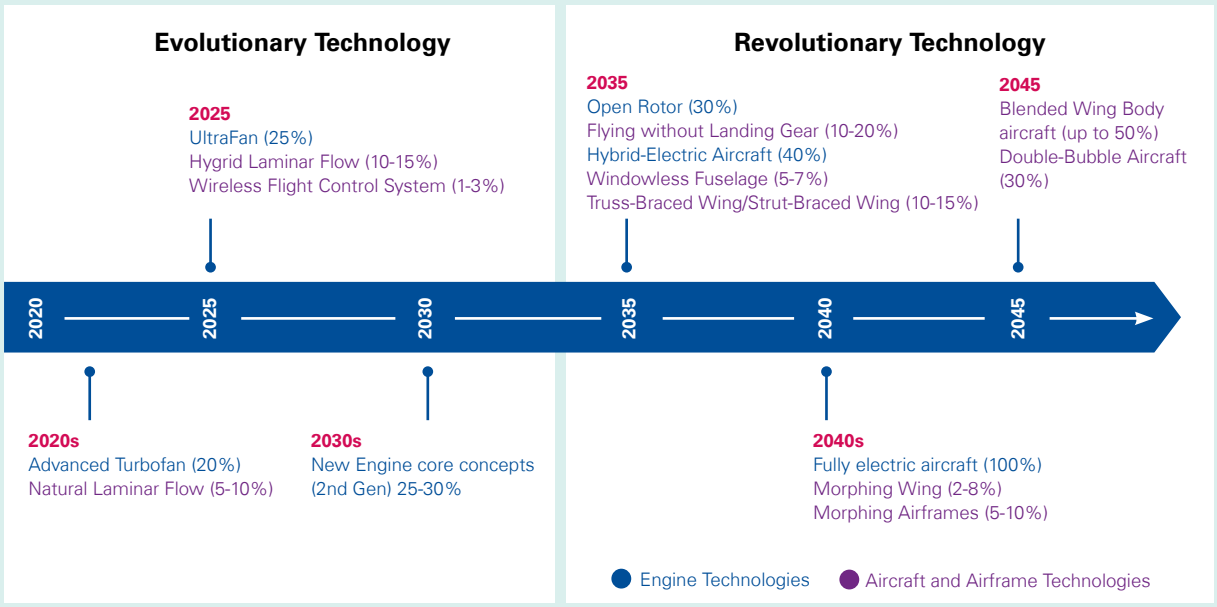


Figure 8: Evolutionary vs. Revolutionary technology (with improved energy efficiency percent potential in brackets)



Source: IATA Technology Roadmap, KPMG analysis

Revolutionary concepts and technologies offer the greatest fuel efficiencies into 2050 when compared with predecessor aircraft or engines. An additional 30-40 % CO2 equivalent reduction potential is expected from future new aircraft in the 30-year timeframe.[19]

Implications will be industry wide, however, OEMs and operators are most obviously impacted.

OEMs and their supply chain

- Given COVID-19's impact, developments in revolutionary technology will slow for 2-3 years due to cash restrictions and lower fuel prices. We foresee increased emphasis being put on currently paused evolutionary engine designs and rectifying issues in LEAP engines before proceeding with R&D spend on newer technologies.
- In the 737MAX aftermath, there is increased safety scrutiny. Since major aircrafts design changes haven't really taken place since the late 1950s, we expect longer safety approval processes which may favour new entrants with a less conventional and more patient investor base.
- Electric aircraft producers and other technology innovators that lack scale and aftersales networks, however, will often partner with (or be acquired by) major players.

Lessors

- Lessors may need to revisit the economically useful life of an aircraft as the pace of innovation accelerates – new depreciation curves will mean rethinking the economics of overhauling older planes.
- Conversely, if new technologies extend the life of an aircraft and present an environmental and economic advantage, there may be a push to overhaul or perform modifications and sooner.

Operators

- Airlines will lobby governments to support local investment in enterprises aimed at advancing aircraft technologies and will themselves form partnerships with such companies.
- Taking ownership of a radically designed aircraft will represent a very large investment and risk, making it essential to ensure the aircraft meets its operational requirements and meets the needs of the broad variety of customers including the need for operational flexibility. Balance sheet risk could be managed with greater use of lessors.
- An increasingly complex fleet (ageing and new generation aircraft) will introduce additional maintenance and inventory burden requiring a specialized engineering workforce and spares holdings.
- LCCs are less likely to pioneer revolutionary designs. Larger flag carriers or those heavily state backed are more likely to be the first customers for newer designs. The exception is where larger LCCs pre-empt environmental lobbying with headline decarbonization projects like all-electric short haul.

MROs

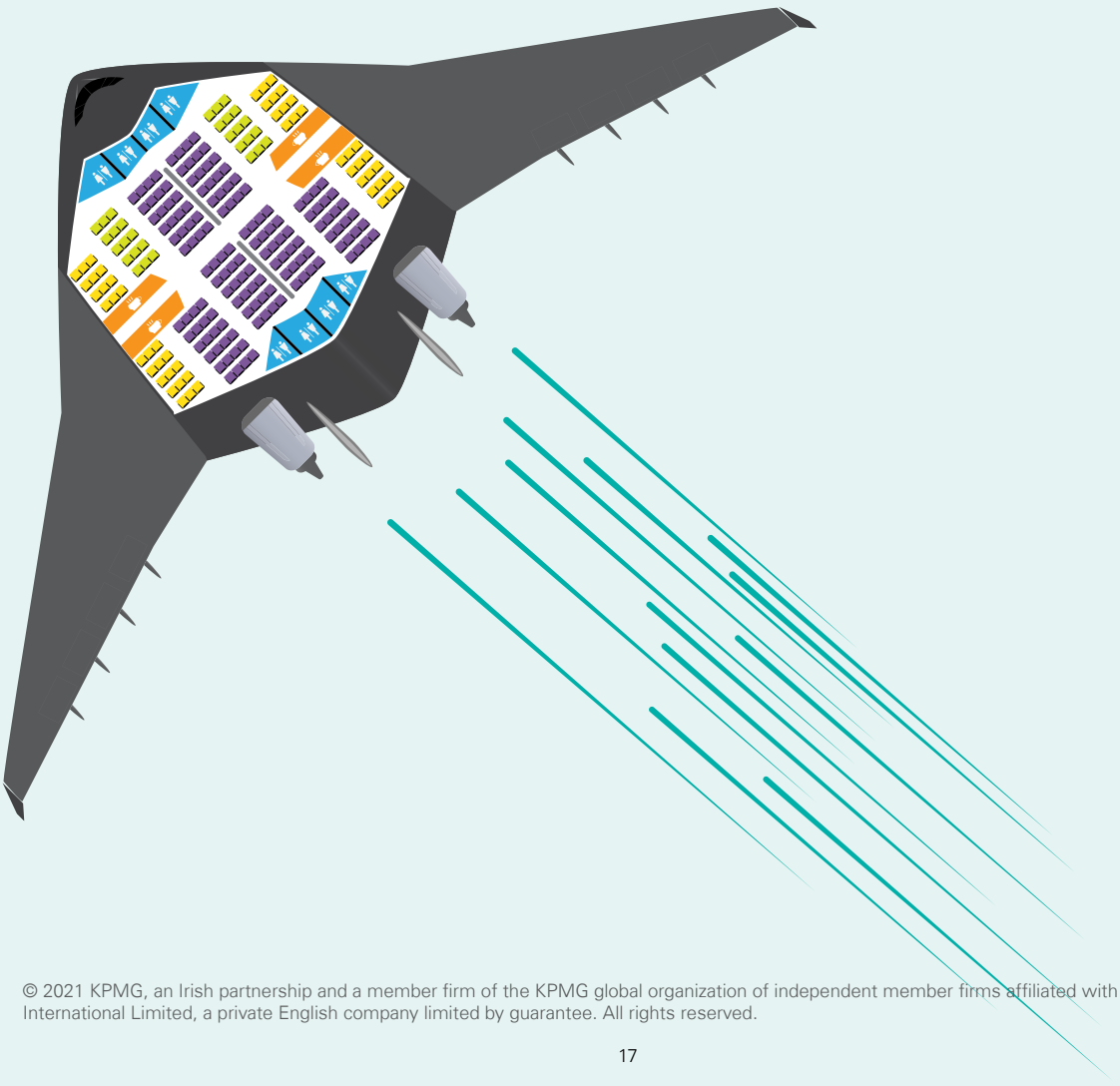
- With increasing skill shortages and cost of human capital within MRO, we see many players innovating around digital means, robotics and AI to perform maintenance more effectively. With NextGen aircrafts equipped with e-Enabled sensors we see the typical operating models of most MROs shifting towards digital and less frequent maintenance.
- OEMs will push to increase MRO presence, especially so for radical designs due to their complexity and sophistication. Airbus' Skywise and Boeing's AnalytX will prove key with seamless integration between aircraft, data and engineering decision making.
- MROs will need to ensure engineers have adequate technical training for new designs, with the cost of this expected to increase.
- With predictive maintenance and the wider adoption of digital twin models of aircraft, the expectation is that maintenance schedules and requirements will change, therefore MROs will have to reshape their skills base to work with these digital capabilities.

Airports

- Airside infrastructure changes will be required to accommodate different aircraft designs, for example cabin access for passengers, ground handling, servicing and line maintenance activities.
- Greater collaboration with OEMs will be needed to determine infrastructure requirements and necessary investment and funding for construction.
- While revolutionary design doesn't necessarily equate with greater speed and shorter flight times, is there a threat to the current airport retail model and passenger flows more generally with new generations of plane? If your intercontinental flight is shortened to just a few hours, do you want to spend 60 minutes airside waiting on a gate?

ANSPs and regulators

- A barrier to radical designs and novel technologies being introduced is certification, especially so for electrification. Regulators will have to revisit existing safety and compliance regulations to adequately assess novel aircraft designs and technologies.
- With the aftermath of the B737 MAX accidents and subsequent reviews of the Federal Aviation Administration (FAA) certification process, important recommendations have been to develop policies or standards on proper visibility, clarity, and consistency of key design and compliance information that is submitted for certification. This is particularly with new design features, requiring early involvement in the type certification process with the addition of feedback paths for aircraft design throughout development and certification.
- Innovations in ATM, associated infrastructure and connectivity with aircraft: Revolutionary plane designs are also likely to be the time to make bigger AI updates and help herald the reduced flying intervals and greater environmental IoT feedback into the ATC system that ANSPs have been anticipating.



Conclusion

The aviation sector has had a sharp reminder of its vulnerability to pandemics and economic shock. The impact of technological changes and public pressure to decarbonize, however, will bring greater change through and beyond 2030.

If we summarize our call to action, across the selected topics, by player type:

OEMs and their supply chain – explore your fit with the VTOL revolution and other opportunities to diversify your revenue stream beyond traditional aviation

Lessors – start considering modelling for shorter asset lifespans and diminished residual values; consider the potential for investment and customer diversification that VTOL brings

Operators – with the quickening pace of energy efficiency and novel propulsions, reconsider your mix of owned vs leased and stress contract agility with lessors as asset flexibility becomes vital

MROs – with the acceleration of design changes comes pressure to keep pace; anticipate bigger investment requirements in tech ahead

Airports – integrate VTOLs airside where possible and grow your operations into the city with them, with external funding and partners where necessary

ANSPs and regulators – ideate your value add to passenger VTOL early on, don't sit on this for another 5 years and then expect to monetize it.

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