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Urban Air Mobility

eVTOL/Urban Air Mobility TAM Update: A Slow Take-Off, But Sky's the Limit

The MS team decreases the Urban Air Mobility TAM base case to $1tn by 2040, but rolls out projections until 2050, when the TAM is projected to be $9tn. We don't think investors are prepared for the scope of this revolution. However, they must consider a host of regulatory factors that may slow adoption.

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The MS team decreases the Urban Air Mobility TAM to $1tn by 2040, but rolls out projections until 2050, when the TAM is projected to be $9tn. We don't think investors are prepared for the scope of this revolution. However, they must consider a host of regulatory factors that may slow adoption.

Marty McFly: "Hey Doc you better back up. We don't have enough road to get up to 88!"

Dr. Emmett 'Doc' Brown: "Roads? Where we're going we don't need… roads."

- From Back To The Future (Universal Pictures, 1985)

… And the DeLorean DMC-12 takes off into the air and travels through time to the date (get this)… Wednesday, October 21st, 2015.

Following our December 2018 Blue Paper, Flying Cars: Investment Implications of Urban Air Mobility, we undertake our first major revisit of our addressable market analysis and scenario framework. The work in this report is the product of a cross sector collaboration between our US Aerospace & Defense team led by Kristine Liwag, our Transportation and Airline team led by Ravi Shanker and our Autos & Shared Mobility team led by Adam Jonas. We also collaborate extensively across the tech stack of Morgan Stanley Research, including Internet, Semiconductors, Software, Technology Hardware, Real Estate and other industries to better understand the underlying technology and second derivative use cases.

BUT FIRST…. If you want to learn more about flying cars, come join us for the Inaugural (virtual) Morgan Stanley electric Vertical Takeoff and Landing Aircraft/Urban Air Mobility or eVTOL/UAM Summit on May 12. Please reach out to your Morgan Stanley salesperson for more details. You wouldn't want to miss it.

North America Industry View

Autos & Shared Mobility — In-Line

What's new in this report? Four main items:

1. **Updated TAM assumptions, where we allow for a materially slower ramp through 2035 while rolling out the forecast to 2050 (yes, 3 decades from now) to capture the 'inflection.'** Our global base case Total Addressable Market (TAM) is lowered to $1tn by 2040 vs. $1.5tn previously. By 2050, our base case UAM TAM reaches $9tn which is modestly lower than the global TAM of light passenger vehicle mobility/miles traveled market today (>$10tn). This forecast is based on a range of bottom-up estimates from our US Autos and Transport teams, extrapolated to the global market on GDP multipliers. Assumptions incorporate substantial improvements in energy storage, autonomy, growth of final mile business models and imply a significant evolution/curation of the regulatory environment to support such growth.
2. **Adapted our scenario framework of TAM vs. Regulations/Certification.** We want to temper the extraordinarily large addressable market potential with nearer-term hurdles related to regulation and certification. *"A pitcher of Kool-Aid is best served with a side of Curmudgeon"* as one FAA expert

we recently spoke with confessed.

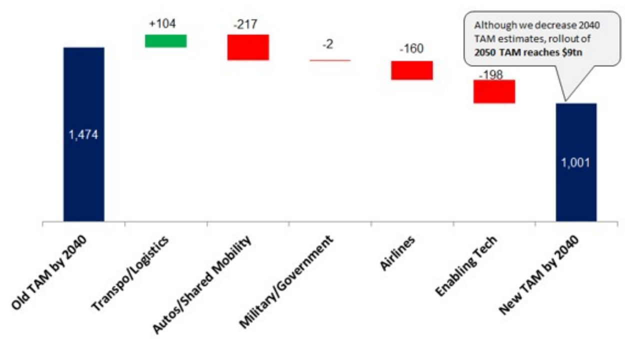
3. **Introduced a deep-dive into the regulatory and FAA certification hurdles.** Our mapping of the regulatory side suggests investors should assume 'horizontal' (pushed to the right) expectations of commercial introduction at least in the early years while leaving the door open for the 'vertical' inflection at some point in the future, which we currently assume is closer to 2040 or beyond rather than 2030. This report includes an in-depth analysis of the regulatory and certification landscape as well as a close look at important historical case studies of eVOTL safety to offer important context of the hurdles and impediments that must be overcome. To quote Elon Musk on innovation: *"Prototypes are easy. Scaling production is hard."*

4. **Explored historical precedents of new transport modalities** and how it transformed the pre-existing models into an entirely new modality. We think eVTOL has the potential to do the same over time. The point we make is that radical changes to transportation modality don't so much 'cannibalize' the current/prevailing form of transport as much as totally re-invent and re-scale the size of the market itself, frequently by orders of magnitude.

Our key message to investors: *Temper your excitement with patience*. The market opportunity for eVTOL/UAM could be far bigger than you think, but we believe it may require decades to reach high volume commercialization. We believe investors may be significantly underestimating the commercial potential of eVTOL/UAM over the long term (think 2040 to 2050 time horizon). At the same time, we would encourage great patience in the early years as the hurdles of certification are also likely underestimated. The combination reveals a balance of the opportunities and risks of this exciting new revolution in transportation that can be considered today. ***In our minds, the birth of eVTOL/UAM at scale is not a matter of 'if' but rather when, how and what must be overcome along the way.***

Exhibit 1:

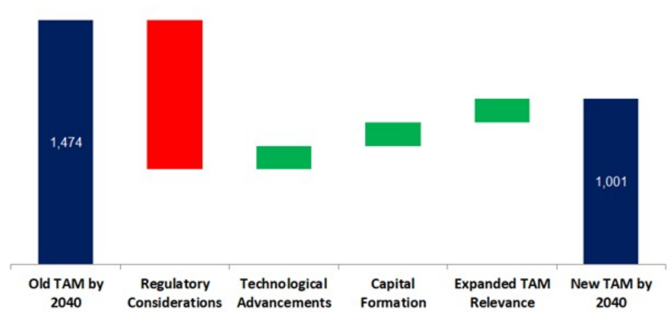
Key Changes to 2040 TAM by End Market ($Bn)



Source: Morgan Stanley Research Estimates

Exhibit 2:

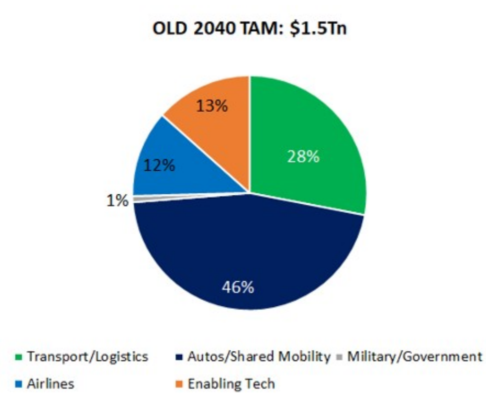
Key Drivers Behind Change in 2040 TAM ($Bn)



Source: Morgan Stanley Research Estimates

Exhibit 3:

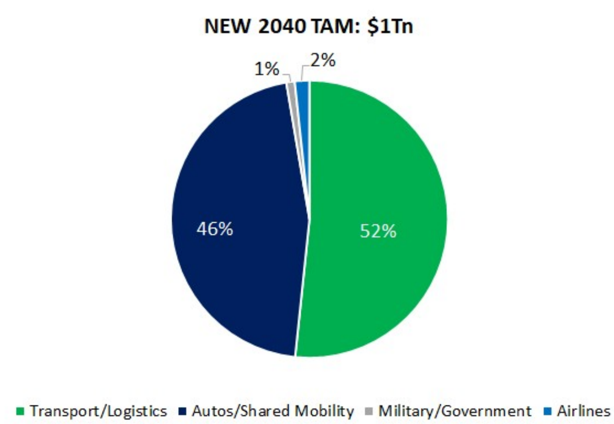
Old 2040 Breakout of TAM by Market (%)



Source: Morgan Stanley Research Estimates

Exhibit 4:

New 2040 Breakout of TAM by Market (%)



Source: Morgan Stanley Research Estimates

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Executive Summary: A Multi-Trillion $ TAM Must Climb a Regulatory Mount Everest and Requires a 30-Year DCF

Striking the balance… As investors enter the world of eVTOL (electric vertical takeoff and landing aircraft) and UAM (urban air mobility) they will face a range of challenges and dichotomies. One must reconcile 'the art of the possible' with the 'buzz-kill of the reality.' Investors must stare into the abyss of a 20 or 30 year DCF (or more) to truly understand the full potential use cases of this next revolution in aviation, while mapping the labyrinth of rules and certifications that shape the aviation market today. A potentially large number of new businesses (both private and publicly listed) will populate this landscape in the very short term, with each offering their own take on their path to technological efficacy, certification and commercial use cases. Many of these scenarios will prove to be too rosy, flying into the realm of the non-disprovable bull case. Many eVTOL companies may never see an aircraft reach commercial service.

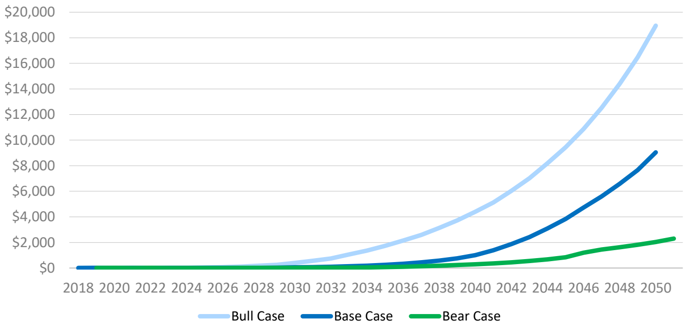
We offer this report and its content as 'open source' to help set the scene of both the opportunity and the risks inherent in what our teams see as an inevitable path to disrupting the mobility market. This report represents the most comprehensive refresh of our assumptions on eVTOL/UAM since the publication of our December 2018 Blue Paper titled **Flying Cars: Investment Implications of Urban Air Mobility** . We have adapted our scenario framework along the orthogonal vectors of Total Addressable Market (TAM) potential and Regulatory/Certification Environment. The interplay between these two vectors, as well as the ever evolving technological substratum (ranging from batteries, propulsion, autonomy, comms, etc…) will shape the curve of adoption in ways that simply cannot be forecasted with specificity today. As such, we present our work across a range of scenarios and have displayed them over a time horizon that extends as far out as 2050. Some investors and industry experts may say 2050 'is too far out,' while others may say 'it's not far enough.' **While the journey to a 'Jetsons-like' future may extend beyond our professional or mortal lives, it's not too early to contemplate the rapidly unfolding investment considerations today.**

Key highlights of this report:

- **Adapted scenario framework.** Our bull-base-bear analysis is based on the overlay of TAM potential vs. regulatory hurdles/enablement through a 2050 time horizon.
- **Regulatory and certification deep-dive.** The regulatory requirements for aviation is one of the most underestimated risks. The high safety standards of aviation were achieved through regulation. Every single aircraft that is in operation in the U.S. must meet FAA standards. Every aircraft that operates in U.S. airspace must follow FAA rules which vary depending on airspace classification. Since the 1960s, aircraft and airspace regulation have matured and standards have increased regarding safety. We explore the safety/fatality evolution in aviation, key regulations (Part 23 aircraft, Part 27 rotorcraft, etc) and lessons from precedents such as the ill-fated New York Airways in the 1960s/1970s.
- **Refreshed TAM assumptions in our global eVTOL/UAM model.** Our 2040 global TAM forecast is actually lowered to $1tn as we made significant reductions to our adoption curve in the early and medium-term years to allow for a greater 'margin of safety' given our understanding of the certification landscape in the US and Europe. For 2030, we reduced our US TAM estimate by nearly 75% to $12bn from $45bn previously. For 2035, we cut our US TAM estimate by 40% to $66bn from $108bn previously. On the other hand, as we rolled out our analysis to 2050 for the first time, we allow for an inflection in TAM adoption for human and parcel use cases which reaches $2.5tn in the US by 2050, extrapolating to $9tn globally.
- **What's changed in the market since our 2018 report.** We are following improvements in battery energy density (impacting range, noise, speed of charge, economics), autonomy (impacting safety and economics), communications systems (5G and LEO sat comms), final mile fleets (accelerated post COVID), far greater levels of capital formation and enhanced national security concerns.
- **Case studies on previous transport disruptions.** Our autos and transport teams go back in time to study the rail, automobile and airline markets to gain a sense of the scope and scale of transport disruption as well as the amount of time required to see it through.

Exhibit 5 :

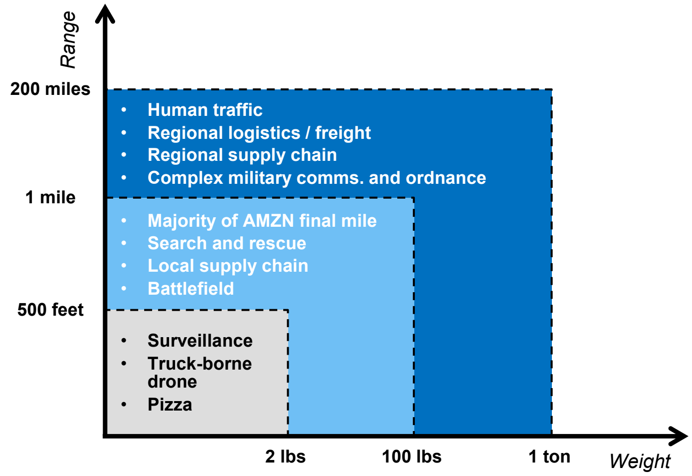
Global TAM Estimates



Source: Morgan Stanley Research Estimates

Exhibit 6 :

VTOL Expected Weight and Range Limitations



Source: Company data, Morgan Stanley Research Estimates

Our thought process and modeling philosophy for eVTOL/UAM begins with a shared mobility model. You can't unlock the true TAM potential without highly compelling economics. Think of a 20-mile Uber or Lyft ride home to the suburbs after a night in the city. At an average speed of 25 mph it takes you 48 minutes to get home at $1.50/mile for a total cost of $30. At 10 trips per shift (a busy day) this can bring in $300 of revenue for the driver or $110k per year. With an autonomous vehicle, that revenue flows to the company. But what if a large drone or autonomous aircraft could make the 20-mile trip at 100 mph and $2.50 per mile? Assuming you'd be willing to pay a premium for speed, you'd be home in 12 minutes for a $50 fee. Faster speeds mean more trips… as many as 40 in an 8-hour shift. Thus $2k of revenue per shift and more working hours could yield close to $1.5 million of revenue per year per flying car.

And on the freight side… most package drone prototypes can carry a maximum of ~10 lbs. Amazon has stated it plans to fly drones weighing 55 lbs at speeds of 55 mph for packages of 5 lbs or less. Sikorsky has begun testing autonomous flying technologies on its helicopters. A military-grade helicopter such as the Sikorsky CH53K, however, has a maximum payload of 15.9 tons and can carry up to 37 soldiers. The chasm between military grade aircraft and urban eVTOL and drone technology exists because battery technology (the primary noise mitigant) is extremely underdeveloped. A 50-fold increase in the global annual production of electric cars by 2030 and as much as $100bn or more of capital investment directed at the mass production of EV batteries (>100 gigafactories by 2040) could reasonably drive technology and costs to levels that significantly enable the eVTOL market.

Key changes to our US TAM forecast vs. our prior assumptions:

Autos: Base case TAM by 2040 lowered to $128bn vs. $150bn previously. This is based on 65b n eVTOL miles travelled (vs. 73bn previously) which implies a 1.5% share of the US vehicle miles travelled (VMT) market. Our bull case is raised to $558bn (vs. $344bn) and our bear case lowered to $10bn (vs. $44bn) representing a widening of our bull-bear spread to allow for greater variability of inputs.

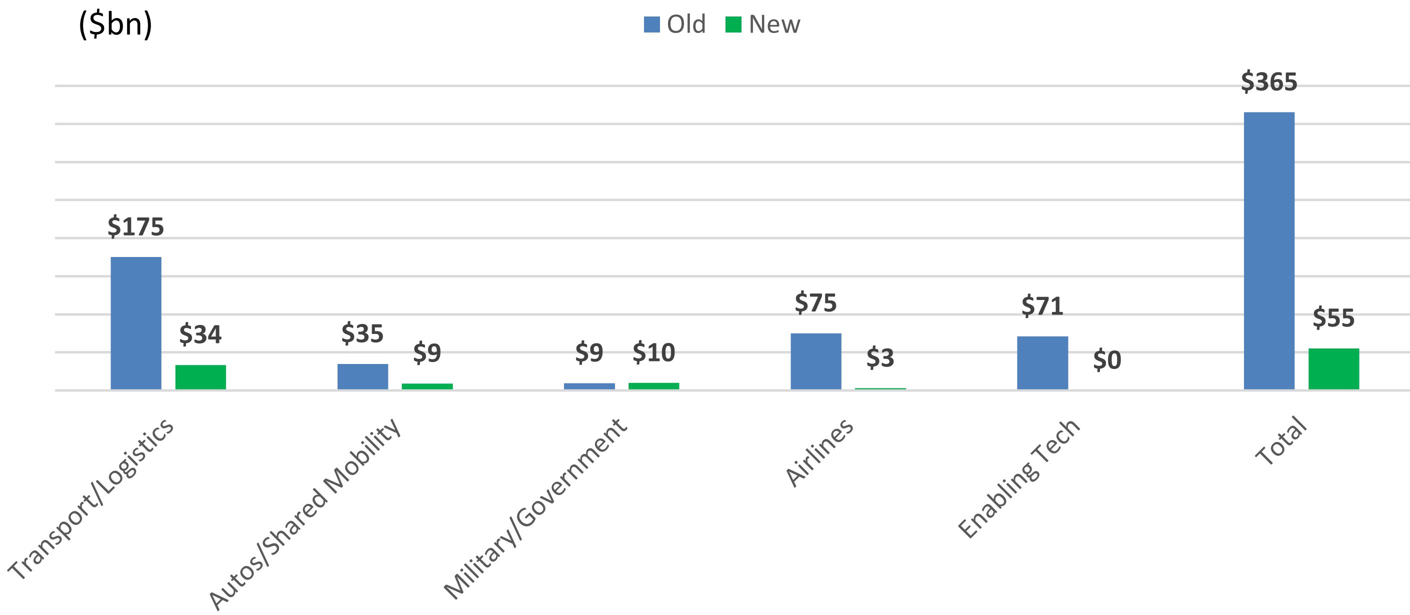
Transport: Base case TAM by 2040 raised to $144bn vs. $92bn previously. Our bull case is raised to $644b n (vs. $149bn) and our bear case rises to $82bn (vs. $64bn). What stays the same: our view of rural and emergency delivery being the first mass commercializable end-market for drone delivery - we estimate this end market for eVTOLs at ~$39 billion around 2040. What has changed: our view of the Urban parcel delivery market is now considerably larger as we have switched our focus from last mile delivery of urban packages to end customers to middle mile delivery of urban packages from DCs to delivery stations/stores close to urban areas. This should permit quicker and easier penetration by eVTOLs while providing a much more powerful use case than Air and Truck today and unlocks a ~ $70bn revenue opportunity around 2040. We have also expanded our scope for heavy freight eVTOL delivery from LTL pickup and delivery to include short-haul truck load (TL) and medium duty truck freight.

Airlines: Base case TAM by 2040 *lowered* to $5bn vs. $39bn previously. Our bull case is lowered to $21bn (vs. $85bn) and our bear case falls to $7bn (vs. $9bn). We have lowered our Airline TAM by changing the definition of the end market to be categorized by ASM's flown by Length of Haul. Given short haul flying is only a very small portion of total air travel today (<200 miles is 1% of ASM, 200-500 miles is <10 of ASM). The opportunity here is smaller than we had initially expected. However, this can be upgraded if eVTOLs significantly increase their flying range to 500-1000 miles in the coming years.

Military/Defense: We have not made changes to our Military/Defense addressable market assumptions at this time and note that our base case of less than $3bn in the US, while important, is a relatively minute portion of our overall TAM analysis.

Exhibit 7 :

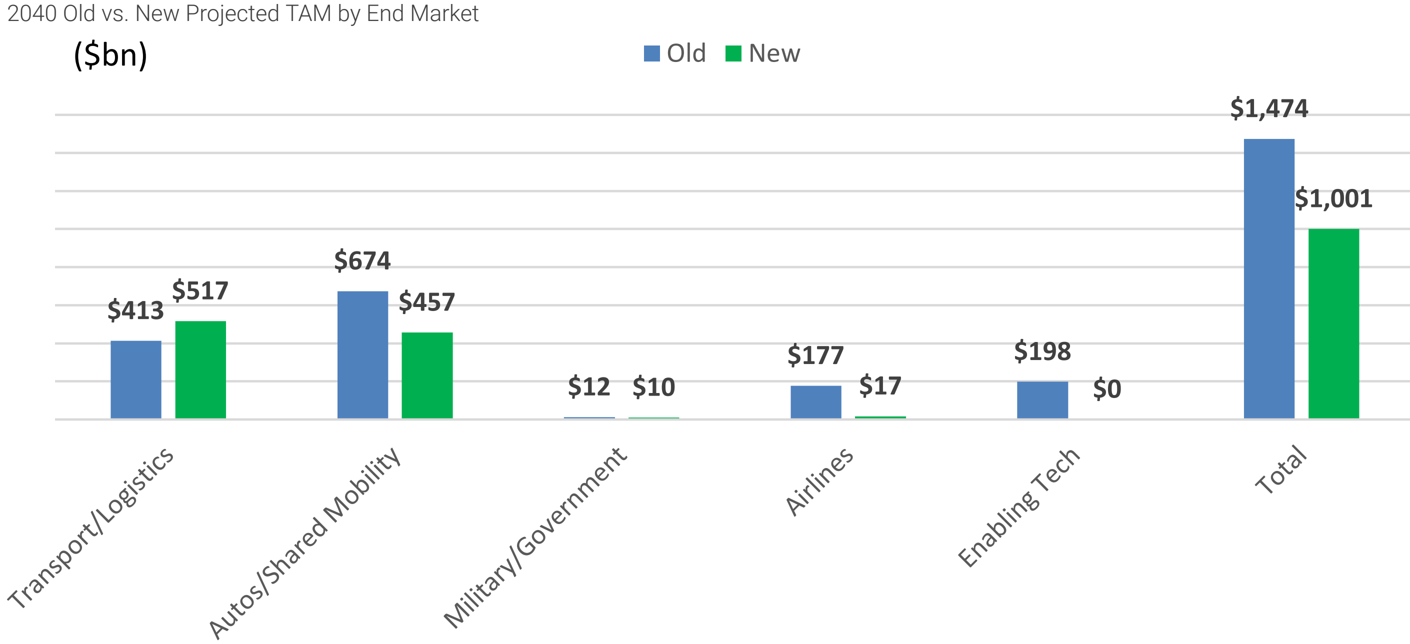
2030 Old vs. New Projected TAM by End Market



Source: Morgan Stanley Research Estimates

Exhibit 8 :

2040 Old vs. New Projected TAM by End Market



Source: Morgan Stanley Research Estimates

Other considerations and assumptions behind our TAM analysis:

The total addressable markets in our base case use conservative estimates, with modest increases in our bull case. Our model embeds the low-end projected speed range of 150 mph by 2040 for both the base and bull case. For logistics, we assume freight payloads of >50 lbs beginning in 2035. Our Autos and Shared Mobility Model assumes steady average growth in occupancy/overall payload through 2040 for eVTOLs , yielding an average occupancy capacity of 3.5 (3.6 in bull case) , slightly more conservative than what aircraft developers project for more mature eVTOL designs. In our "Airlines" model for longer distance flights we assume, by 2040, 15% penetration (30% in bull case) of the <200 miles market, 5% (16% in bull case) of the 200 to 500 mile market, and no share of the 500 to 700 mile market and no share of any route >700 miles (1% of 500-700 miles market in bull case and 0% in 700+ miles marke t).

Battery technology and advanced propulsion architectures such as distributed electric propulsion will be critical to the UAM development . We also consider advances in autonomy from our transport and autos & shared mobility coverage to understand the path to enhanced economics/payback period, greater uptime, reliability and safety for eVTOL/UAM networks. We believe that current Lithium-ion battery technology is largely workable and will near-term be "fit for purpose" to support EV adoption. However, we believe that a material change in battery technology will be needed to achieve the levels of charge rates, cycle life, and capacity that companies are targeting. Potential battery technologies include lithium sulfur or solid state lithium ion batteries, both of which are years away for operation in terrestrial vehicles, let alone electric aircraft. In our view, the push for electric vehicles to reach cost parity with internal combustion engine vehicles will accelerate the demand for advanced battery technologies over the coming decade.

Regulation and a host of other legal and behavioral factors create a formidable and complex set of obstacles. Nevertheless, we see the development and early commercialization of surface transport autonomous networks (shared autonomous cars) as an incubator and accelerator for the framework of regulation, business model and consumer acceptance of flying car tech.

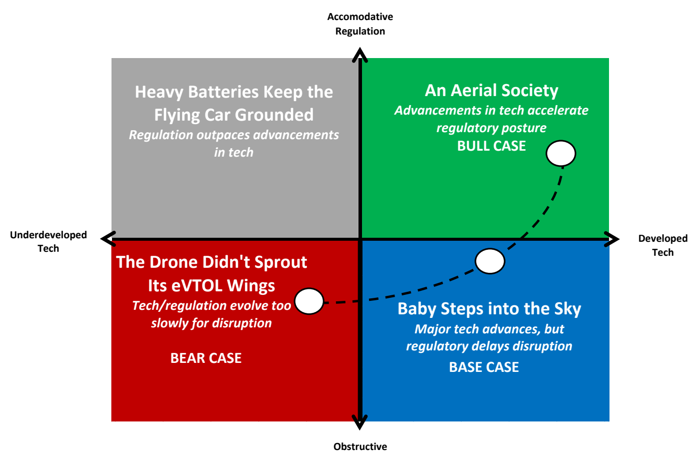
To assess the Global Total Addressable Market for UAM we began with our bottom up forecast of the US Total Addressable Market. Our forecasts are based on scenario analysis with bull, bear, and base total addressable market (TAM) outcomes, given the long-term time horizon and myriad unpredictable technological and policy vectors. We roll these vectors up into two broad parameters: (1) technology and (2) regulation. Our cases reflect several specific areas of technological capability, including payload, range, speed, noise, software, connectivity, battery, and unit cost. A number of regulatory inputs also shape our scenarios, such as state/local/regional government intervention, FAA/EASA oversight, infrastructure barriers, and most importantly public acceptance/acceleration.

To size the addressable markets in each scenario, we focused on three broad end markets: (1) transporting humans, (2) transporting goods and (3) military & defense. More specifically, we look at markets directly relevant to personal urban/suburban transportation, final mile shipping/logistics, short-haul airlines, and defense. We note that, to avoid double-counting, our TAM forecasts are calculated as the services derived from transporting civilian passengers, goods and troops and do not include the hardware and software sold into the supply chain for the manufacture of the vehicles themselves.

We then extrapolated this US only bottom-up model globally to estimate the TAM in China, Europe, and ROW. We did this by taking the relative percentage of GDP our US UAM TAM forecast represents in the US and adjusted across regions for factors such as shared, autonomous, and electric vehicle penetration to arrive at the respective GDP percentages for each region. While we recognize comparing terrestrial ground transportation penetration to UAM may not be entirely apples to apples, we believe they are solid proxies, given the overlap of AV / UAM technologies. **The markets that are relevant to the UAM ecosystem represent just over $1.0 tn of potential global economic value in our base case.**

Exhibit 9 :

UAM TAM Scenario Framework



Source: Morgan Stanley Research

Base Case: Baby Steps into the Sky: Well developed TAM/ economic paybacks gated by highly stringent path to certification. In this case, we envision the technology and capital formation outpacing the certification time line, regulations and infrastructure. Widespread eVTOL/UAM adoption is frustrating ly low through most of the decade even though the technology and pace of pro to typing may make major advances. **Global Total Addressable Market: ~$ 1tn by 2040 and $9tn 2050 (~5 to 6% of projected Global GDP).**

Bull Case: An Aerial Society: Economic rationale more clearly evident and taking a far larger share of surface transport market, bolstered by relatively more accommodative policy and path to certification. eVOTL / drone transportation of goods and people achieves high levels of mass acceptance and adoption, but again with the inflection still closer to a decade away. Technology accelerates and becomes cost effective for both consumers and businesses; it proves more efficient than existing transportation models. Policy is flexible and infrastructure is readily available or easily adapted. Regulatory posture encourag es eVTOL / drone usage and adapts to changing consumer / final mile business demands. **Global Total Addressable Market: ~$4.4t n by 2040 and $18.9tn by 2050 (~11 to 12% of projected Global GDP) .**

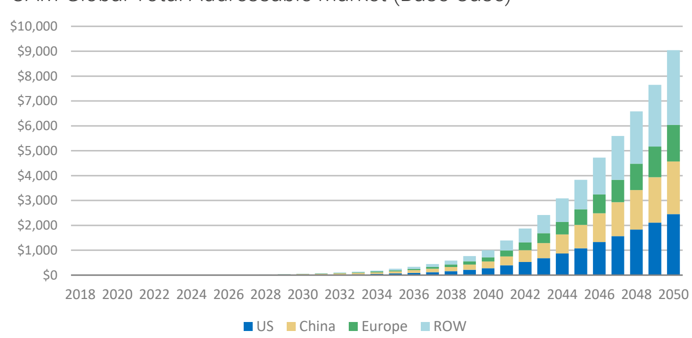
Bear Case: The Drone Didn't Sprout Its eVOTL Wings: Underdeveloped / unsuccessful technology combined with obstructive policy. Mass rejection / minimal adoption of eVTOL / drone transport of goods and people. Technology stagnates as it is not cost effective for consumers or businesses. It is less efficient than current transportation models and encounters critical technological barriers to adoption (weight, noise, range, payload, safety, etc.). Policy is restrictive and infrastructure cannot support adoption. Regulations hinder eVOTL / drone usage and impede widespread global adoption. **Global Total Addressable Market: $ 359b n by 2040 and $2.3tn by 2050 (~ 1 to 1.5% of projected Global GDP) .**

Our base case Global Total Addressable Market of $ 9tn by 2050 assumes significant technological advancement and business model development gated by regulatory/policy hurdles and, ultimately, a supportive government/social response. The breakdown of our 2050 TAM forecast is as follows:

- **Autos and Shared Mobility ($3.7tn) and Airlines ($51bn) – *Transporting humans:*** We assess the opportunity for a growing fleet of electric, shared, and autonomous eVOTL aircraft or other large terrestrial drones. We see the market beginning as an ultra-niche add-on to existing transportation infrastructure, similar to how helicopters operate today. It eventually transforms into a cost-effective, time-efficient method of traveling short to medium distances, eventually taking share from car and airline companies. The market opportunity beyond 200 mile range drops off considerably in our base case, leaving the existing airline market little changed.
- **Freight Transportation ($5.3tn) – *Transporting goods:*** The opportunity is much nearer term than transporting humans, especially with smaller, more lightweight drones. While rural parcel delivery is likely to be the first and most attractive end market for eVTOLs by the middle of this decade, by 2050, the real acceleration in Freight TAM comes from Urban parcel delivery and short-haul heavy freight. As eVTOL capability improves (especially range of 500 miles or more and payload of 1000-10000 lbs), the freight opportunities really open up. We see the opportunity for urban parcel delivery largely coming from the linehaul, middle-mile move (DC to store/delivery station) rather than directly into customer homes in cities, which should reduce the likelihood or running into operational and regulatory hurdles of flying into dense urban areas. We also target short-haul freight and good movement currently targeted by medium-duty trucks and LTL carriers (palletized freight) though we note that this would need upgraded payload capacity by 2050. We see greater size and speed-of-adoption potential in freight vis-à-vis human transport at this stage.
- **Military & Defense ($12bn) – *Transporting troops/supplies:*** The total addressable market for Military and Defense is much smaller than the other sectors because we model the market as a function of US military (DoD) spend. On a relative basis, this is a much smaller revenue pool (~$1bn today) versus the potential for operating a fleet of autonomous aircraft at a cost of $2 per mile. **We still view military and defense applications as an extremely important accelerant for UAM technologies, similar to what DARPA and the military did for autonomous driving in the early 2000s.**

Exhibit 10 :

UAM Global Total Addressable Market (Base Case)



Source: Morgan Stanley Research Estimates

It's All Been Done Before, Is It Any Different This Time?

Vertical lift aircraft to connect urban centers and airports and avoid ground traffic is not just a theoretical concept. New York Airways operated helicopter connections to Wall Street, Midtown Manhattan, and nearby airports for 30 years. It took only 5 minutes to fly from LaGuardia Airport (LGA) to Wall Street, 10 minutes to fly from the PanAm Building (now the MetLife Building) in Midtown Manhattan to John F. Kennedy Airport (JFK), and 16 minutes to fly from JFK to Newark Liberty International Airport (Newark).

Bankruptcy After Helicopter Crash In 1977 and Fuel Crisis

New York Airways is now a distant memory since its last operation was 42 years ago when it filed for bankruptcy in 1979. The airline was unable to recover from the helicopter accident at its heliport atop the Pan Am Building (now the MetLife Building) in Midtown Manhattan in 1977 and the fuel crisis of 1979.

Back To The Future Or Back To 1962?

The debate around Urban Air Mobility today is shaping around the same debate as in the 1960s. Many of the marketing materials of eVTOL companies today echo New York Airways' 1962 commercial: https://vintageairliners.com/the-skyline-route-videos/. The key selling points are short travel times and costs comparable to ground transportation.

The debate from opponents and detractors for urban air mobility is similar to what occurred in 1964 when New York Airways wanted to expand operations to the PanAm Building.

From A New York Times Article In 1964:

"…opponents had charged that the operation would be unnecessary, unsafe, noisy, distracting to motorists, serve private interests and retard other city plans for heliports along waterfront areas."

"The manufacturers accused the opposition of making exaggerated and alarmist statements based on ignorance and misinformation. They described elaborate tests and preparations made to insure the safety of proposed scheduled flights from the roof."

Urban Air Mobility: Flying Cars ARE Coming… but Why Now?

A confluence of economic and technological factors are intersecting, such as improved battery efficiency, artificial intelligence, and satellite communication along with a need for more convenient transportation with zero emissions. These considerations, coupled with large amounts of capital infusion, should accelerate the adoption of autonomous, electrified urban air mobility over our 2050 time horizon.

Ride-sharing and aerospace companies are leading the charge and showing that there are more ways to transport people and goods in a more efficient and economic fashion. **In our view, if you are bullish on autonomous and electric vehicles, then you are bullish on Urban Air Mobility as the technologies are extremely complementary, albeit a different time frame.**

What's changed since our 2018 report? Over the past year we have witnessed a number of drivers that contribute to a greater relevance of the eVTOL/UAM market by investors. Many of our clients may, understandably, chalk the excitement around flying cars to free money and a frothy market environment. Oh sure, that helps… but we believe there are bigger forces at work and worth investor attention today.

Since the publication of our Blue Paper titled Flying Cars: Investment Implications of Autonomous Urban Air Mobility more than two years ago, there have been some significant developments that contribute to accelerate the dawn of commercialization of UAM potentially faster than we originally anticipated. At the same time, however, a deep analysis of the prevailing regulatory frameworks tempers the pace and ramp of the adoption, at least in the early years. We highlight 6 key developments below:

1. **Improved battery energy density…** driven by tens (if not hundreds?) of billions of investment funded by some of the world's most valuable companies. Improvements in WH/Kg are critical to unlocking greater range, lower cost and lower noise. Advancements in DC fast charging batteries (and infrastructure) are also critical.
2. **Improved autonomy.** Autonomy is now being industrialized at automotive scale through improvements in sensors and AI/ML. Advancements in the state of the art of terrestrial autonomy directly apply to pilot removal in UAM which is widely seen as a less difficult environment in airborne navigation vis-à-vis roads.
3. **Final mile as an 'essential service.'** Post-COVID, the role of logistics in e-commerce/software enabled retail is clearly evident. Look for governments assessing sweeping multi-decade infrastructure projects to give greater consideration to UAM transport modalities from heliports, to the grid, spectrum, free air space/ATC, building codes and other regulations. We look for movement of non-human cargo in early years to trail-blaze the eventual business models of human UAM transport.
4. **Development of 5G/LEO sat comms.** The role of players like SpaceX, Kuiper and a host of other mega-satellite constellations (for comms and EO/metrology/next gen GPS) is a key enabler for the safe, redundant, resilient and cybersecure communication with a proliferating number of airborne vehicles.
5. **The climate/ESG revolution.** As cars, trucks and delivery vans undergo a rapid transition off of fossil fuels, the next frontier for sustainable propulsion is seen as aviation. Major tech firms developing their own in-house drone/UAM logistics ecosystems (i.e., Amazon Prime Air which got FAA approval to carry out drone delivery last year) will seek zero-emission solutions.
6. **Enhanced national security considerations.** Do we really need to elaborate here? Let's just say the words 'dual-purpose' and leave it at that.

What Developments We Monitor

In addition to these recent developments, we watch and monitor four items: 1) Aircraft Technology, 2) Safety Concerns, 3) Regulatory Hurdles, and 4) Profitability/Business Model.

1) Aircraft Technology

Electric Aircraft and Improvement in Batteries

Noise concern about operations in an urban area is the same this time around vs. in the 1960s. However, we've seen key improvements in aircraft technology, particularly with electric motors. Electric motors are quieter than combustion engines, but low battery density historically limited the application of electric motors in aviation. Battery evolution is enabling the practical use of electric motors in aircraft as increased battery density is increasing range and payload of electric powered aircraft. The shift to electric motors plus improvements in rotor design paved the way for quieter aircraft. Some Urban Air Mobility aircraft are promising a 20 decibel reduction in noise compared to conventional helicopters. There remains a debate on whether the battery density and weight advancements are enough to operate these electric aircraft within FAA standards for the routes marketed.

Better Field Performance

Helicopters initially were not designed to have frequent starts and stops. Helicopters from the 1960s were operated to minimize starts and stops in order to have operational efficiencies. Modern helicopters have overcome many operational reliability issues regarding frequent starts and stops on engine cycles. However, an Urban Air Mobility aircraft that is purposefully designed and optimized for frequent starts and stops and short turn-around times could provide better field performance.

Advancements in Materials, Software, and Manufacturing

In the past 60 years, we have seen significant advancements in aircraft technology since the beginning of the jet age with advancements in aerospace grade materials like carbon fiber, automation in flight control systems, fly-by-wire instruments, more efficient manufacturing processes, etc. These advancements could mean that aircraft could be lighter and more energy efficient and easier to manufacture.

COTS vs. In-House Design

New York Airways operated off the shelf FAA certified helicopters that already had their histories of operations. New York Airways flew the Boeing Vertol V-44, Boeing Vertol 107, and the Sikorsky S61. What is different with the UAM companies today is that most are developing their own aircraft. Many of UAM companies today do not have any history in aircraft certification.

2) Safety Concerns

Considering that the FAA and New York authorities permitted the use of the helipad atop the PanAm Building, the onus is now on the industry to prove the safety of operating aircraft in an urban environment. Safety concerns regarding frequent flights in dense population areas remain a significant concern for urban air mobility providers just as it was a concern for New York Airways. Not only will the focus be on aircraft and passenger safety, but also the safety of people in the flight path. Public support for Urban Air Mobility providers could wane if the industry were to see another accident like in 1977.

Aviation today is the safest mode of public transportation. The industry's safety record is attributed to strict regulatory standards on aircraft capabilities and aviation, which we will discuss in the Regulatory Hurdles portion. If Urban Air Mobility operators eventually replace significant ground transportation travel, the industry could shift from a niche mode of travel to that of mass transit.

What's the Accepted Level of Risk?

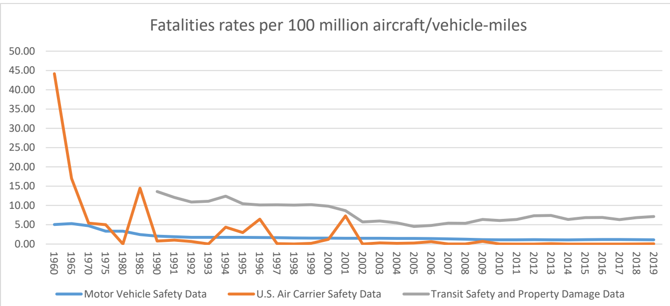
In this case, the key question is, what's the accepted risk rate for urban air mobility in the long-run? Will the industry be held to the same standards as aviation today or will the industry be held to the safety standards similar to automobiles?

The Safety Evolution of Air Travel

In 1960, it was safer to travel by car than travel by commercial flight. According to data from the U.S. Bureau of Transportation Statistics, the fatality rate in 1960 was 44.16 per 100 million aircraft-miles travelled with U.S. Air Carriers vs. 5.06 per 100 million vehicle-miles in cars. However, travelling by airplanes has become significantly safer today. In 2019, the fatality rate per 100 aircraft-miles for U.S. carriers was 0.05 vs. 1.11 per 100 million vehicle-miles for cars. This is a particularly impressive feat considering that aircraft-miles traveled grew 7 fold in that period. Aviation transformed from the least safe mode of travel to the safest mode of travel.

Exhibit 11:

Fatalities per 100 Million Aircraft/Vehicle-Miles



Source: Bureau of Transportation Statistics

3) Regulatory Hurdles

The regulatory requirements for aviation is one of the most underestimated risks. The high safety standards of aviation were achieved through regulation. Every single aircraft that is in operation in the U.S. must meet FAA standards. Additionally, every single aircraft that operates in U.S. airspace must follow FAA rules. FAA rules vary depending on airspace classification. Since the 1960s, aircraft and airspace regulation have matured and standards have increased regarding safety.

FAA Aircraft Certification

Just because an experimental aircraft can take off, fly, and land safely does not necessarily mean the aircraft is airworthy for passenger use. The onus is on the manufacturers to prove to the FAA that their aircraft is safe for passenger use.

The FAA requires the manufacturers to understand the normal operating performance of their product and for the product to meet industry standards on safety. This requires understanding the aircraft's capabilities and limitations. Manufacturers must prove what is normal operating performance for the aircraft and that its performance conforms with industry standards. The manufacturer must prove that a single failure in the aircraft system does not prevent continued safe flight and landing of the aircraft.

The certification could include testing of the aircraft's operating performance like the aircraft's flight performance (takeoff performance, climb requirements, landing, etc), flight characteristics (controllability, trim, stability, stall characteristics, vibration, buffeting and high speed characteristics, performance in icing conditions, etc), structure characteristics (structural load, aeroelasticity, etc), etc.

One important aspect of certification is that manufacturers need to decide if they are certifying their Urban Air Mobility aircraft as a fixed wing or as a rotorcraft. Depending on this path, there are different certification requirements. See below more details on Part 23 Aircraft Certification and Part 27 Rotorcraft Certification.

Part 23 Aircraft

Fixed wing aircraft that weigh 19,000 pounds or less and with 15 or fewer passenger seats must be certified under the FAA's Part 23 Airworthiness Standards for normal category airplanes. The safety parameter for Part 23 is a one in a ten million chance of an accident.

For more details of the requirements - see here.

Part 27 Rotorcraft

Rotorcraft with maximum weights of 7,000 pounds or less and nine or fewer passenger seats must be certified under the FAA's Part 27 Airworthiness Standards for normal category rotorcraft.

For more details of the requirements here.

EASA Special Condition for eVTOL

EASA provided its Special Condition for eVTOL and Means of Compliance. Historically, EASA has been more stringent regarding operations in urban environments for rotorcraft and single engine piston aircraft. It is no surprise that it has taken a stricter view on eVTOL due to expected operations in dense urban areas. The safety parameter under EASA is similar to large commercial aircraft transport with a one in a billion chance of an accident. For EASA's proposed means of compliance, see here.

Airspace Challenges and Air Traffic Control

All US airspace is regulated. There is no such thing as unregulated airspace. However, rules around different airspaces vary depending on location. Since the 1970s, air traffic has now become a mass form of transportation. Busier skies mean that regulating air traffic has become more mature. Lessons learned from historical accidents have led to regulation changes in order to improve safety. For lessons learned from civil aviation accidents, see here.

Challenges Around Dense Urban Environment

Areas near airports and dense urban environment are generally classified as Class B airspace. In the New York area, Class B airspace encompasses almost the entire New York metro area including parts of New Jersey and Connecticut. All operations in Class B airspace require Air Traffic Control (ATC) Clearance. Class B airspace is visually like an upside-down tiered cake. Navigating the air space restrictions in order to offer convenient flights to passengers will be a challenge for the Urban Air Mobility providers.

Air Traffic Control Clearance

Unlike the auto industry where drivers can freely travel from Hoboken to Manhattan without seeking permission from the Department of Transportation, depending on the flight path and altitude of operations, an aircraft operating the same route may need specific ATC permission for every flight. Additionally, the current ATC system is not equipped to handle the expected volume predicted by Urban Air Mobility companies.

Visual Flight Rules (VFR)

However, there are lower altitudes 5 miles outside of airports that may be accessible under Visual Flight Rules (VFR) or Special Visual Flight Rules. This is currently how helicopters operate today without ATC clearance. Under VFR, the pilot can operate the aircraft with visual reference to the ground and avoiding other obstructions and other aircraft visually. Pilots also need to have statute miles visibility and at least 1,000 foot ceilings. Operating purely on VFR could be challenging in areas where visibility is challenged due to bad weather.

Fixed wing and rotorcraft that operate in the VFR corridor do not need to have ATC clearance. However, at any point that the aircraft enters Class B airspace, Class B airspace ATC rules apply.

Exhibit 12:

US Airspace Classification

Source: Federal Aviation Administration

Understanding VFR Corridors

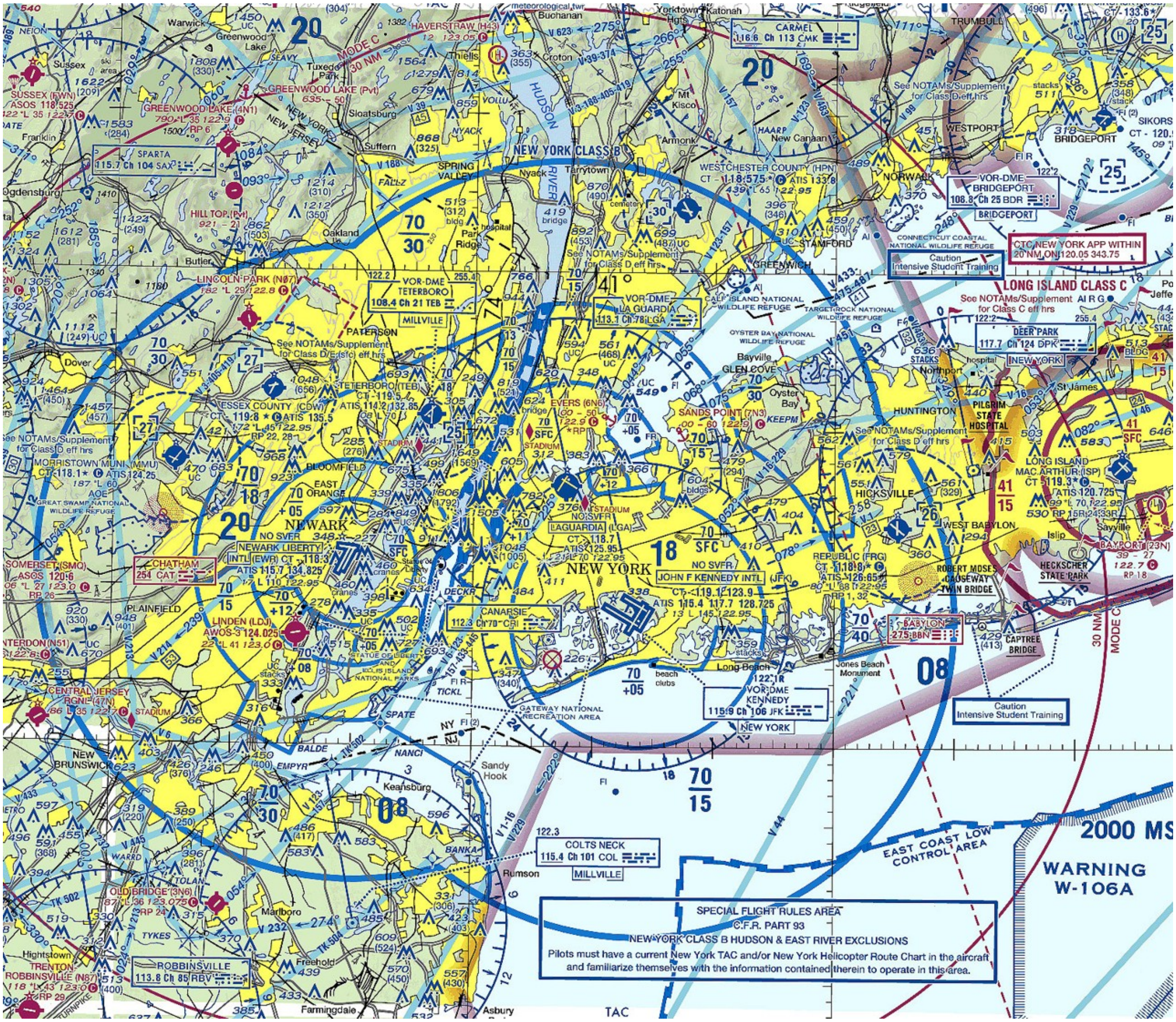
For illustrative purposes, see the Terminal Area Chart (TAC) for the New York Area on the following Exhibit. What this chart shows in the large circle overlays is the Class B Airspace. The numbers on the chart direct where VFR could operate. For example, the area around Governor's Island is encompassed in a section labeled 70/13. This means that aircraft in the region cannot fly above 1,300 feet in altitude without entering Class B airspace. Additionally, some areas also fall under Special Flight Rules Area (SFRA).

Minimum Altitude Requirement

Depending on the area, there may also be a minimum altitude requirement. The general rule is 500 feet above the surface. However, over open water or sparsely populated areas, the aircraft must not be closer than 500 feet to any person, vehicle, vessel, or structure. In congested areas or open assembly of people, the minimum altitude is 1,000 feet above the highest obstacle and 2,000 feet horizontal radius. These rules could vary for fixed wing aircraft and rotorcraft depending on the location of operations.

Exhibit 13:

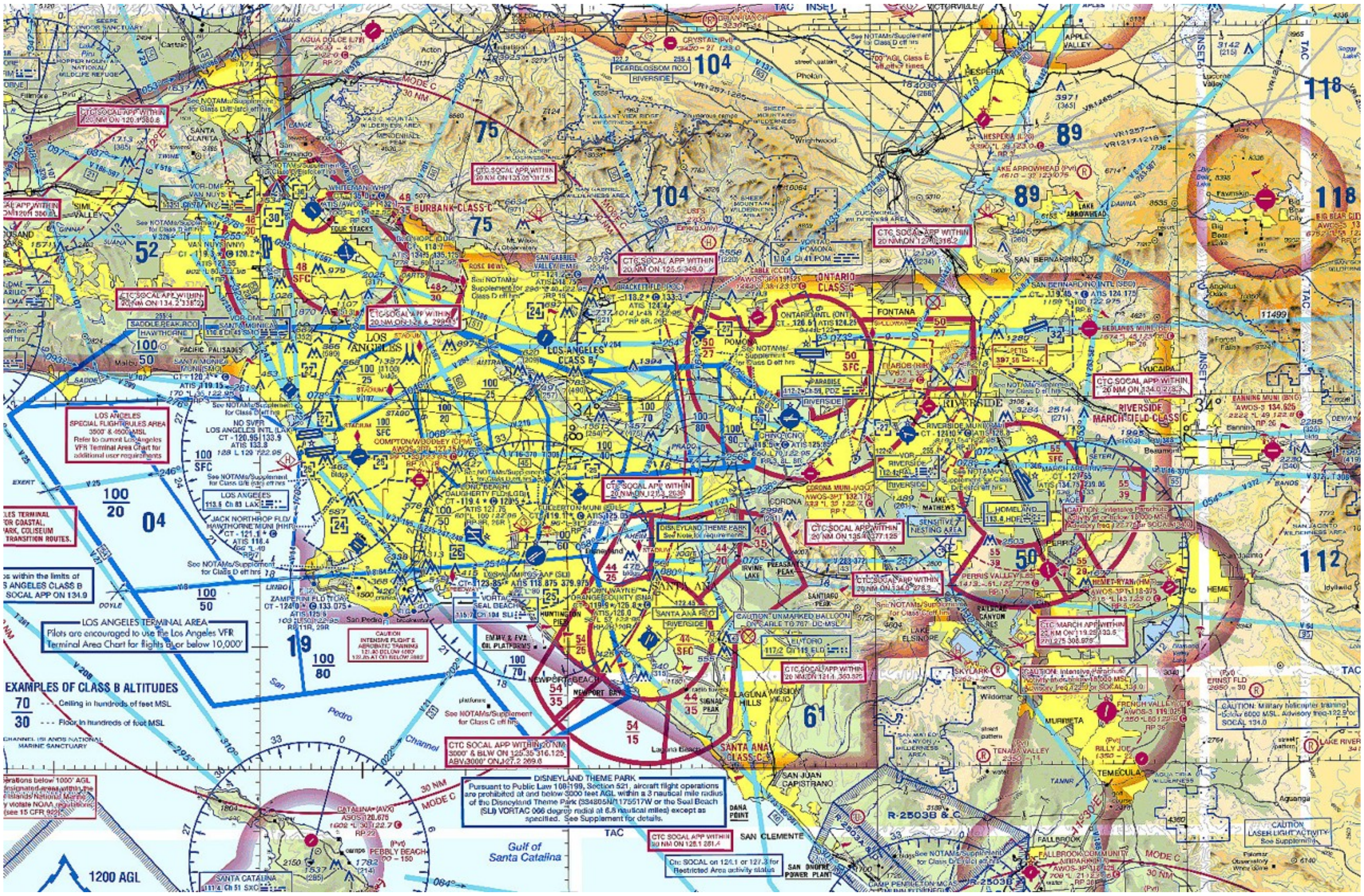
Terminal Area Chart for New York



Source: Federal Aviation Administration

Exhibit 14:

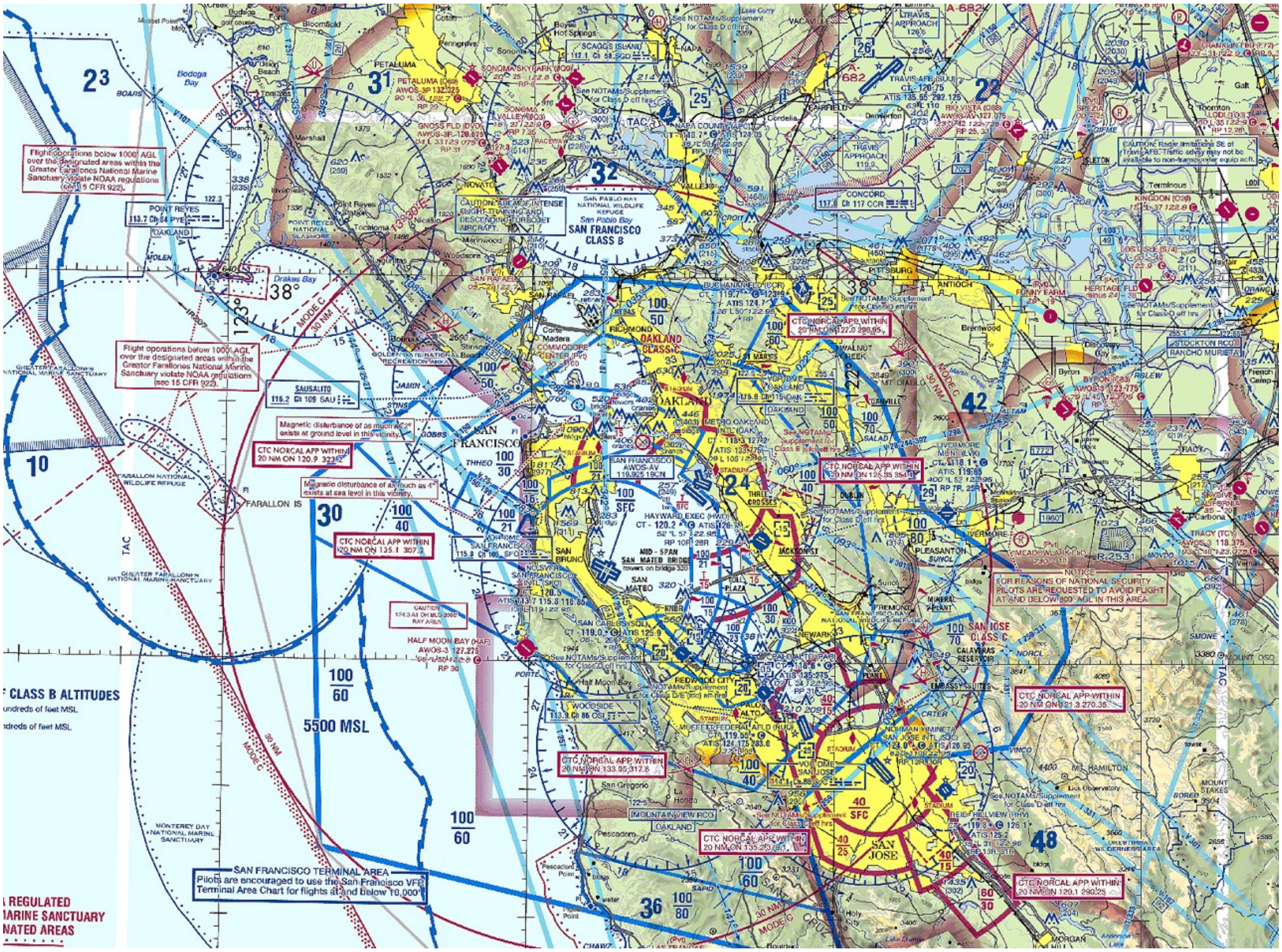
Terminal Area Chart for Los Angeles



Source: Federal Aviation Administration

Exhibit 15:

Terminal Area Chart for San Francisco



Source: Federal Aviation Administration

Exhibit 16:

FAA Requirements for Airspace Operations

Class Airspace	Entry Requirements	Equipment*	Minimum Pilot Certificate
Class A	ATC clearance	IFR equipped	Instrument rating
Class B	ATC clearance	Two-way radio, transponder with altitude reporting capability	Private-(However, a student or recreational pilot may operate at other than the primary airport if seeking private pilot certification and if regulatory requirements are met.)
Class C	Two-way radio communications prior to entry	Two-way radio, transponder with altitude reporting capability	No specific requirement
Class D	Two-way radio communications prior to entry	Two-way radio	No specific requirement
Class E	None for VFR	No specific requirement	No specific requirement
Class G	None	No specific requirement	No specific requirement

Source: Federal Aviation Administration

Zoning for Heliports/Vertiports and Flight Paths

Another regulatory challenge for Urban Air Mobility operators is the zoning for the location of heliports/vertiports and approval of their flight paths. State and local government will need to provide permission for takeoff and landing sites and municipalities and other stakeholders like landowners would need to be consulted. Additionally, any accidents that highlight the safety risks of living in flight paths could change the possibility of community acceptance and state and local government approval.

4) Profitability/Business Model

One of the key questions for the Urban Air Mobility providers is if they can lower the operating cost enough and build a profitable business model. New York Airways offered helicopter rides cheaper than taxi fares.

According to Bloomberg, in 1962, riders could go from Newark to Wall Street by helicopter for just $6 as opposed to an $8 cab ride or from Newark to Idlewild (now JFK) for $9 instead of paying $19 for a cab. New York Airways received subsidies from the U.S. federal government. New York Airlines filed for bankruptcy in 1979 as the company was unable to recover from the 1977 PanAm Building accident and the 1979 fuel oil crisis. Similarly, many Urban Air Mobility providers are targeting prices comparable to an Uber Black ride.

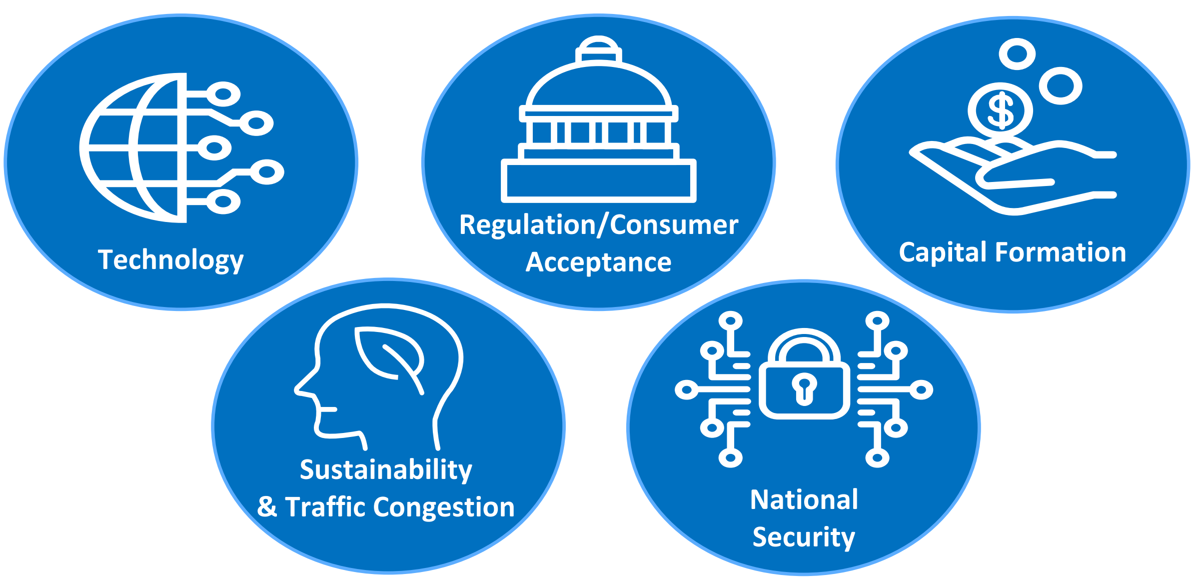
What's surprising to us is that we did not see any successors to New York Airways. In our view, this reflects the challenges in operating this business model and it remains to be seen how newer players will be different. That said, the ride sharing evolution could change the long-term business model of the Urban Air Mobility industry.

While it may take decades to fully develop the UAM economy, we believe it is not too early for investors to contemplate the considerations right now. In many of our simulations, we can come up with more miles traveled than cars and potentially more units sold than cars over time. While Tesla CEO Elon Musk has historically dismissed UAM transport modality (citing truly legitimate concerns of noise, privacy and general annoyance) we would not bet against Tesla unveiling a concept in the UAM arena in the near future. In fact, we see it as a natural extension for sustainable electric transport and autonomy. But again, to our knowledge, the company has not commented recently on this topic.

Morgan Stanley has assembled a cross-sector research team to track key developments on the UAM market and will continue to monitor events closely. **Urban Air Mobility adoption comes down to 5 primary drivers:**

1. Technology (Autonomy, 5G, Energy Storage)
2. Regulation/Consumer Acceptance
3. Capital Formation
4. Sustainability/Building Road Congestion
5. National Security

Exhibit 17:
The 5 Core Drivers of Urban Air Mobility Acceleration



Source: Shutterstock, Morgan Stanley Research

Gating Factors for Urban Air Mobility – What Do We Need and Where Are We Now?

Exhibit 18:

UAM Key Accelerants

Source: Morgan Stanley Research

Technology

Unmanned aircraft technology has been a domain for military application for decades. In recent years, there have been a rapidly growing number of startups and efforts by established aerospace and technology firms who have directed resources towards all-electric unmanned aircraft. To our knowledge, battery technology as applied in drones and unmanned aerial vehicles is near parity with the cost, safety and energy density of lithium-ion battery technology used in electric cars. However, the force required to move a car on wheels and axles against its 2 primary forces of friction (rolling resistance and aerodynamic resistance) enable rather massive batteries to provide power and range. In short, if you want to add range to an electric car… just add a bigger battery (with cost… or financial friction… being the primary barrier).

For aircraft, batteries are an unorthodox choice of stored energy because the energy density of gasoline is roughly two orders of magnitude higher than lithium-ion batteries. The energy required to lift the same mass of a car off the ground vertically (without Bernoulli's principal in an airfoil) are far higher than to move a car along a road. As such, today's applications for electric flying cars are only in the development stage, with small payload (parcel delivery) and short distances (line of sight). Advancements in solid state battery technology (2x the power/50% of the mass of current lithium ion batteries), battery chemistry, and software are eking out improvements in battery technology in likely a non-linear manner. Electric motor size, weight, and advanced propulsion techniques are meant to help compensate for the inherent disadvantages in battery energy density vs. gasoline that are more limiting in aircraft applications than in automotive applications. Sensors, compute power, and software are much further developed, to our knowledge, due to military applications, and current advancements in autonomous vehicle technology.

In aviation, two additional differences versus cars are weight requirements and reserve energy requirements.

Weight of the aircraft is very important in aviation as it is one of the forces acting on an aircraft. Weight pulls the aircraft downward due to the force of gravity. The heavier the aircraft, the more lift the aircraft needs to generate in order for the aircraft to fly. This could require a larger airframe. A heavier aircraft may also need more propulsion and currently, increased thrust generally means more weight. Therefore, the weight of the battery is even more important in aviation than in autos.

Cars can pull over if it runs out of energy. Meanwhile, aircraft need to be able to land safely. Aviation regulation is structured to provide safety for passengers and also for bystanders. Therefore, there are additional safe operating parameters and reserve energy requirements for aircraft to ensure that if something were to go wrong, the aircraft could land safely. This means that the compliant operating performance of an electric aircraft could be significantly below the maximum capacity.

This leaves the problem of noise, which is a function of all aspects of the aircraft's design, including mass, number of rotors, rotor design, rotor material, propulsion, speed, altitude, etc.

In summary, we would describe the current state of technology for electric autonomous aircraft as still far from fully mature, but rapidly improving in areas of pilot substitution, safety, and efficiency. While limited by battery technology, which may need to improve to a level significantly greater than that of conventional EVs for road transport over the next 10 years, we believe that the pathway to widespread adoption is clear, with billions in public and private investment set to occur over the next few years.

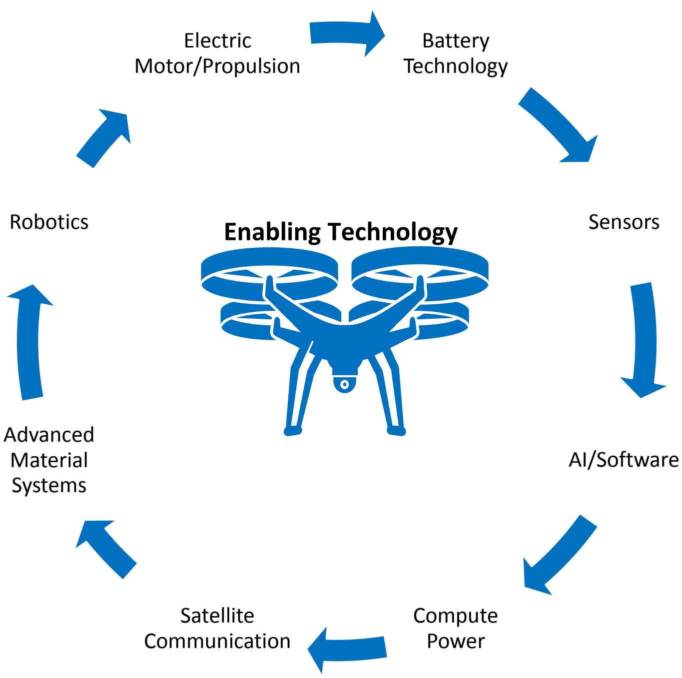
In order for heavily adopted, economically feasible, electric, autonomous Urban Air Mobility, many advancements need to be made technologically. Below, we have identified 8 core technologies that, in our view, are currently "gating factors" for bringing Urban Air Mobility to the masses, while making it both time and energy efficient.

A Word on 5G...

While 5G connectivity is an important input in an eVTOLs sensory/connectivity suite, we do not believe lack of a widespread network will be an obstacle to rolling out an eVTOL network, especially outside of urban areas. We have already seen commercial drone use in rural areas and continuous network / data access is not needed for the aircraft to operate. As such, we believe the bulk of regulatory focus is likely to remain on the airworthiness of the aircraft and scalability of the business model.

Exhibit 19:

Enabling Technologies



Source: Shutterstock, Morgan Stanley Research

Exhibit 20:

Urban Air Mobility Tech Developments

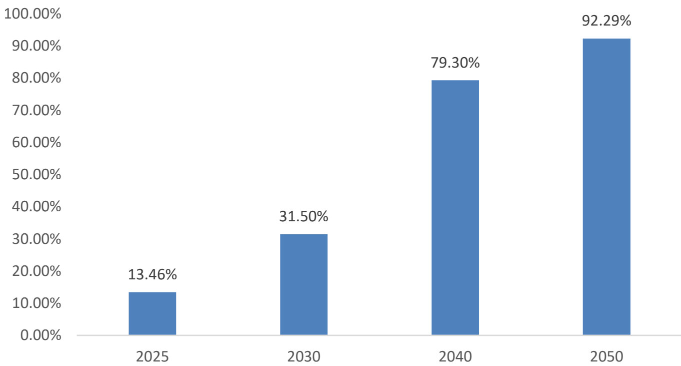
UAM Technology Developments	
Technology	**Developments**
Satellite Communication	• Launch costs falling dramatically • Rising demand for bandwidth • Significant levels of capital formation • Estimate Space economy to be $1.1tn by 2040
Compute Power/ Availability	• Price of processing power and memory at all-time lows • Increased speed and capacity likely coming from new 5G infrastructure • Moore's Law
AI/Software	• Large amount of investment and development in autonomous driving • AI derived business value is expected to reach $3.9 trillion by 2022
Sensors	• Increased usability/cost efficacy of LiDar and other sensor technology • Companies using sensors in a range of use cases, such as smart cities or autonomous driving/flying
Advanced Material Systems	• Becoming a cheap and practical method of manufacturing complex parts • This technology can create lighter and more durable parts that are not possible with traditional metalllurgical methods
Battery Technology	• $/kWh coming down steadily - target of $50/kWh by 2030 • Increased EV adoption accelerating need for better battery technology
Electric Motor	• Cost, weight, and volume decreasing significantly with improved performance • Cost targets for 2022 50% below current prices
Robotics	• Companies continue to develop different use cases for robotics, combining developments in AI/machine learning • Allows for faster assembly of more complex mechanics systems

Source: Shutterstock, Medium, Dept. of Energy, Morgan Stanley Research

Many questions still remain for battery advancement, which leads to our additional concerns around the range and safety of urban electric aircraft. A key message to investors is that we believe the advancements in technology, manufacturing, form factor and cost that will be driven from the scale production of BEVs in the light vehicle market may very likely drive innovation that could be applied to electric aviation.

Exhibit 21:

Global BEV Sales Penetration (Milestone years)



Source: Morgan Stanley Research Estimates

Distributed Electric Propulsion (DEP)

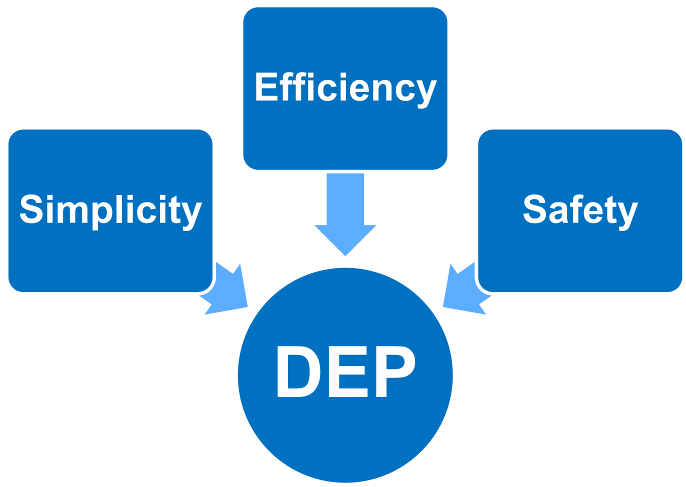
Distributed electric propulsion has important ramifications for safety, efficiency, and reliability of Urban Air Mobility. There are many different designs ranging from aircraft with 10+ medium sized rotors to aircraft with no rotors at all. Rotors are the primary cause of noise on helicopters today, which is why in San Francisco, out of the 40 helipads in the city, *only 1* is active (except for emergencies).

DEP provides three main components that are imperative to the realistic use of small, commercial aircraft in dense city centers: **(1)** Simplicity, **(2)** Efficiency, and **(3)** Safety.

- **Simplicity –** DEP allows electrical systems architectures to interact well without relatively more complex mechanical parts. Using a fully electrified system allows controls to be far simpler than what helicopter or plane controls are today, which means less certification requirements for pilots. The goal is for pilots (if there is a pilot) to have to only control the vehicle in a situation such as poor weather. Coordination of the powertrain and autonomous functionality will be crucial for economic efficiency, safety, and technological improvement such as payload weight and maximum trip distances.
- **Efficiency –** DEP allows aircraft designers to use several smaller motors rather than one large one, but also allows the mechanical architecture to increase the total number of electric motors without a trade-off in terms of weight. Each motor produces enough thrust to compensate for its own weight as they are positioned in such a way that allows the aircraft to achieve the optimal level of thrust spread across the aircraft. Studies by NASA and Joby Aviation show that DEP has reached levels of power similar to helicopters but with nearly 3x the efficiency.
- **Safety –** The number one cause of helicopter accidents today is engine failure. DEP creates an interlinked network of electric motors, controls, and battery architecture that allows redundancy across the aircraft. This level of redundancy allows the vehicle to lose efficiency in the event of a failure, but "fail gracefully" and mitigate the risk of accidents. DEP, in turn, will allow electric aircrafts to become much safer than helicopters today.

Exhibit 22:

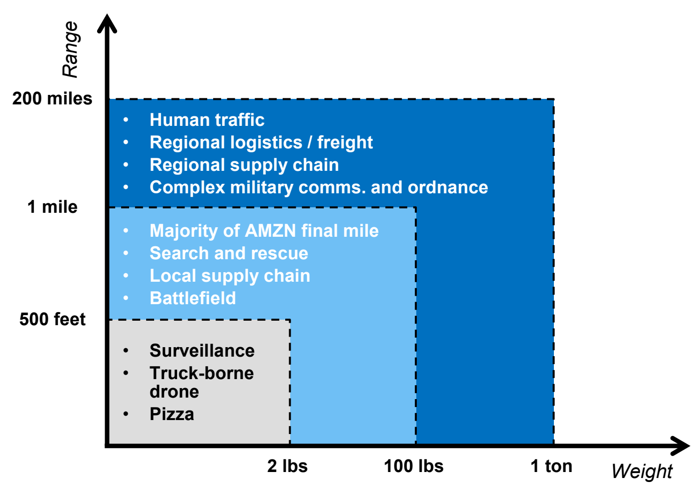
Benefits of DEP



Source: Joby Aviation, NASA, Morgan Stanley Research

Exhibit 23:

VTOL Expected Weight and Range Limitations



Source: Company data, Morgan Stanley Research Estimates

Exhibit 24:

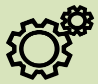
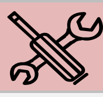
Levels of Autonomous Flying

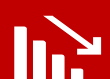
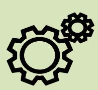
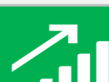
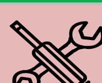
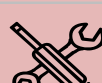
Levels of Autonomous Flying	
L0	Human pilots responsible for safe operation of aircraft. Spacious, well defined distances in which planes can fly near eachother. Drones allowed to fly in visual line of sight (VLOS) of the pilot.
L1	Computer systems assist human pilots - automation is introduced in the form of autopilot, navigation in form of GPS/navigation aids. Drones can be used commerically, but with limited access to airspce.
L2	Onboard automation systems control the majority of activities. Pilots supervise the systems/take over when it is necessary. Aircraft/drones coordinate using ground based systems to coexist at low density levels.
L3	Automation systems perform the entirety of flight operations. Pilot control when certain performance conditions cannot be met. Drones and aircraft can operate in proximity with each other (i.e. near airports).
L4	Supervisors monitor fleets that coordinate amongst themselves rather than requiring a pilot for an individual aircraft. Drones can fly in large, automated fleets, while commercial aircraft is capable of flying with one pilot. Automation systems actively assess risk and provide advanced notice to human supervisors.
L5	Autonomous systems are certified for use in all conditions and during all phases of flight. Drones coexist with all forms of aviation in complex urban areas. Onboard systems combined with service providers determines when and how the airpsace is used.

Source: Airbus, Morgan Stanley Research

Exhibit 25:

Technology: What does development look like – what are areas that need improvement?

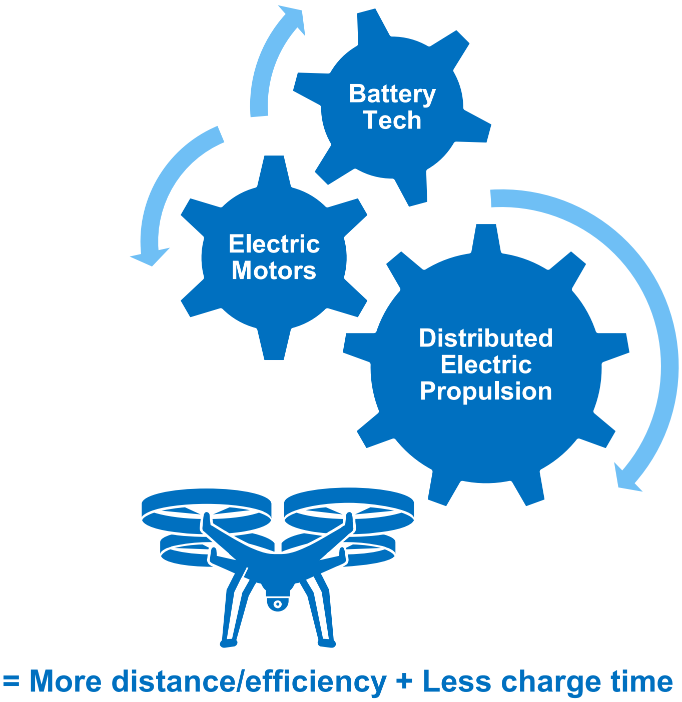
Development Framework System	
Relative Development	**Description**
	**Extremely developed technology**
	**Moderately developed technology**
	**Highly underdeveloped technology**
	**Moderately underdeveloped**
	**We cannot accurately say**

Key Technologies		
Technology	**Rating**	**Rationale**
Battery Density/Fast Charging		Currently represents, in our view, the largest technological barrier to UAM adoption in the near term. According to our European Chemicals team, it will require a significant technological breakthrough to reach range specifications UAM companies are targeting.
High Power Electric Motors		Electric motor architecture is fairly robust relative to other technologies on this list. Distributed electric propulsion provides enough redundancy to mitigate penalties for the failure of one motor. Even today, 3-4x more efficient than ICE powertrains.
3D Manufacturing		3D manufacturing allows companies to more easily create parts with complex geometric structures. This technology has rapidly evolved over the past 5 years and is already being used in the design of many aircraft parts.
Advanced material systems (weight + weather)		Advanced materials are not as talked about as technologies such as batteries or autonomous systems, but designing an ultra lightweight super strong composite will be very important for making every ounce count and extending the range of electric aircrafts, especially if there is a pilot.
Comms Infrastructure		On a relative basis, we believe current comms infrastucture is relatively sufficient for connected aircraft and secure operating systems
Cybersecurity		We believe that due to future regulatory concerns surrounding UAM aircraft, cybersecurity will have to improve by orders of magnitude before a significant number of aircraft are allowed to fly at once
Autonomous Systems		A large amount of investment and resources are going into the advancement of autonomous driving systems, which is why we are ultimately constructive on autonomous aviation systems - the overlap between the two is immense, autonomous tech overall is still in its early innings.

Source: Morgan Stanley Research

Exhibit 26:

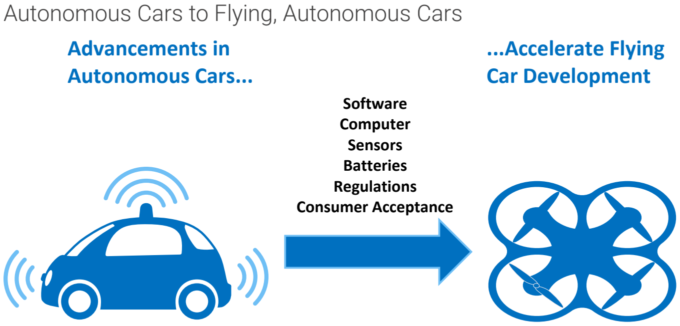
The Electric Propulsion Evolution



Source: Shutterstock, Morgan Stanley Research

Exhibit 27:

Autonomous Cars to Flying, Autonomous Cars



Source: Shutterstock, Morgan Stanley Research

Regulation

Similar to our views on autonomous vehicles – we believe that the Urban Air Mobility Market will be one that is highly regulated by two primary agencies: the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) – organizations that control 50% and 30% of air traffic, respectively.

When looking at aerial regulation, it is important to note the differences in certification processes for everything from the development to the infrastructure to the actual operations. Regulation is also in part determined by the type of aircraft that is being examined, whether it be a small hobby drone or a 747.

FAA Part 23 or Part 27 Certification

For operations in the US, these short-haul aircraft fall under the FAA FAR Part 23 Certification for small airplanes and FAR Part 27 Certification for rotorcraft. The safety parameter under these certification is to have a one in a ten million chance of an accident.

EASA Special Condition for eVOTL

Comparatively, the EASA provided its Special Condition for eVOTL and Means of Compliance. Historically, EASA has been more stringent regarding operations in urban environments for rotorcraft and single engine piston aircraft. It is no surprise that it has taken a stricter view on eVOTL due to expected operations in dense urban areas. The safety parameter under EASA is similar to large commercial aircraft transport with a one in a billion chance of an accident.

New Technologies Need Approval

Historically, aviation legislation and certification processes have been largely incremental, step-by-step processes, but technologies such as Distributed Electric Propulsion and autonomous sense and avoidance technologies will need to be addressed as they become fully developed. Companies such as Uber Elevate are constantly in contact with regulators to ensure a smooth transition from helicopters or airline flight today to a service where hundreds to thousands of trips per hour are being fulfilled. However, aviation regulators move slowly as the focus is on high standards of safety.

Exhibit 28:

DoD UAS Group Descriptions

Group	Classification/Description	Weight (lbs)	Altitude (ft)	Speed (kts)
5	Penetrating	>1,320	> 18,000	Any
4	Persistent	> 1,320	< 18,000	Any
3	Tactical	< 1,320	< 18,000	<250
2	Small Tactical	21 - 55	< 3,500	<250
1	Micro/Mini Tactical	0 - 20	< 1,200	<100

Source: Unmanned Aircraft System Airspace Integration Plan, Morgan Stanley Research

Exhibit 29:

DoT Notional UAS Vehicle Classification and Categorization:

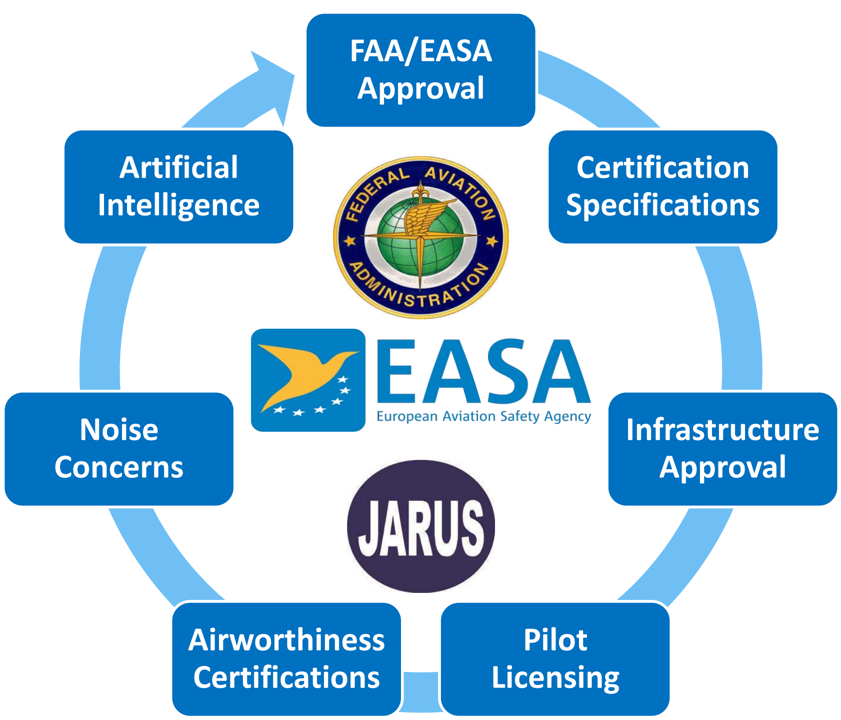
UAS Description	Weight (lbs)	Overall Size (ft)	Mission Altitude (ft)	Mission Speed (mph)	Mission Radius (mi)	Mission Endurance (hrs)
Nano	< 1	< 1	< 400	< 25	< 1	< 1
Micro	1 - 4.5	< 3	< 3,000	10 - 25	1 - 5	1
Small UAS	4.5 - 55	< 10	< 10,000	50 -75	5 - 25	1 - 4
Ultralight Aircraft*	55 - 255	< 30	< 15,000	75 - 150	25 - 75	4 - 6
Light Sport Aircraft*	255 - 1,320	< 45	< 18,000	75 - 150	50 - 100	6 - 12
Small Aircraft*	1,320 - 12,500	< 60	< 25,000	100 - 200	100 - 200	24- 36
Medium Aircraft*	12,500 - 41,000	TBD	< 100,000	TBD	TBD	TBD

Source: Unmanned Aircraft System (UAS) Service Demand 2015-2035, Morgan Stanley Research

Besides the aircrafts themselves – we have concerns around air traffic/airspace management systems. How will Urban Air Mobility services be able to handle the added capacity of hundreds to thousands of low to the ground, close proximity aircraft in dense urban environments? What are the cybersecurity and terrorist implications? These are all items that need to be addressed. **We forecast 830,000 drones/eVTOL aircraft in the skies in the US alone by 2040 and recognize the significant regulatory risk that comes along with this.**

Exhibit 30:

UAM Regulatory Considerations



Source: FAA, EASA, JARUS, Morgan Stanley Research

A New Kind of TAM: Expanding the Pie

Much of our TAM analysis of the Auto, Transportation, Airline and A&D revenue opportunity for eVTOLs has been driven by the share that we believe technology can take from the existing market. But what if, in addition to this, eVTOLs can grow the pie or create a new pie?

Imagine living in NYC and going to a dinner at a hot new restaurant in Boston before coming back home to sleep in your own bed in Manhattan. Imagine visiting a friend or relative living in a neighboring state for a day-trip. Imagine living in upstate NY, a 3-hour drive from your nearest international airport, but being able to connect to your international flight in under 30 min. These are all use-cases that would not exist or be very difficult to achieve using existing modes of transportation with existing infrastructure. However, all of these possibilities could become a reality with eVTOL. As such, we do not believe that the size of the eVTOL TAM should be framed by the existing passenger and freight transportation modes - we believe the new and unique capabilities offered by an entirely new means of transportation could unlock revenue opportunities that are not possible today.

This has happened before. There is precedent to new methods of transportation unlocking new TAMs before – twice. With the introduction of the passenger automobile at the end of the 19th century and its subsequent mass production early in the 20th century. We not only saw the passenger car take share from horse drawn carriages and railroads as existing means of transportation, but vehicle miles traveled by passengers - in total - soared as people had a convenient new way to quickly travel reasonably long distances on their own schedule, reliably and safely, that was likely not practical or possible by horse or rail before that.

In the year 1900, there were approximately 20 million horses in the United States… and approximately 4,000 automobiles. I can imagine the financial analysts of that time hosting dinners with institutional investors in cigar-smoke filled oak paneled rooms discussing the potential of this radical new technology (enjoyed by only a select few wealthy 'motorists'). I can imagine discussions about the TAM (Total Addressable Market) of the automobile. How much of the horse market could it eventually replace?

The hegemony of the horse-linked TAM was so pervasive that the early automobile was, of course, referred to as the 'horseless carriage.' Today, 113 years after the Model T was introduced, we still refer to the power output of a modern car as 'horsepower.'

If we assumed the average horse traveled 10 miles/day in 1900, this would reveal a prevailing equestrian TAM of approximately 60 billion 'horse miles.' Sounds like a big number, right?

While the horse and the automobile frequently shared the road for the better part of 25 years (from the late 19th century until around 1920), we of course saw changes that vastly exceeded the expectations of the market at the turn of the 19th century. According to the FHA, the number of motor vehicle miles traveled (VMT) increased from just 100 million miles in 1900 to 3.6 billion by 1910.

But things really started to change in 1913 when Henry Ford installed his first moving assembly line which drove a dramatic reduction in the cost to acquire an automobile. By 1920, automobile VMT had matched the previous 1900-level horse-mile TAM of around 50 or 60 billion miles and things compounded from there. Today there are approximately 3 trillion vehicle miles travelled or conservatively 50x that of the horse-mile market over a century ago. The automobile achieved the elimination of one living being in the transportation ecosystem (the horse). But it still required another living being (the driver). In our investment lives, we will witness this next change.

With respect to autonomous and shared mobility… ***is it time to think outside the horse?***

The point we make is that radical changes to transportation modality don't so much 'cannibalize' the current/prevailing form of transport as much as totally re-invent and re-scale the size of the market itself, frequently by orders of magnitude.

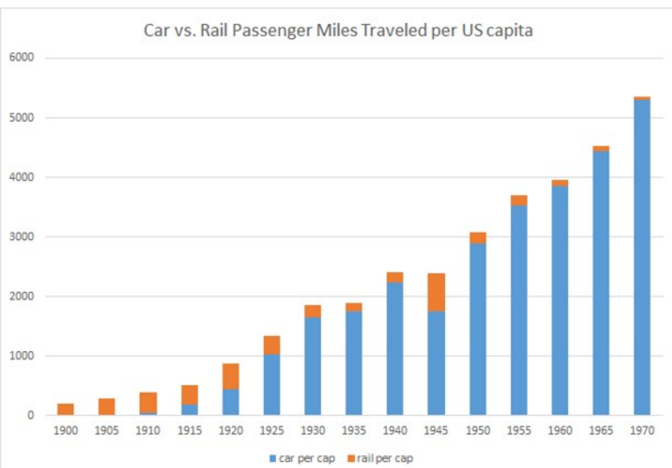
Another example of this lies in aviation. For many years after the Wright Brothers achieved the 'first flight' in 1903, people believed the fixed wing aircraft could never be safe/reliable enough for long haul transportation. Indeed, it was the dirigible/zeppelin market of its day that was seen as the future of air travel. Could the airplane ever achieve a big chunk of the airship market? Between 1910 and WWI, the largest German airship operator called Deutsche Luftschifffahrts-Aktiengesellschaft had transported 34,000 passengers over 1,500 trips. Were 'zeppelin miles' the bounding TAM for aviation back in the day?

With respect to eVTOL/UAM… ***is it time to think outside the zeppelin?***

Between 1900 and 1920, total passenger miles traveled by car and rail in the US rose from 16 billion to over 200 billion (CAGR 13%) and topped 350 billion by 1940 before WW2 (1900-1940 CAGR 8%). VMT settled into a normal growth pattern after WW2, growing from almost 500 billion in 1950 to 1,150 billion by 1970 (a CAGR of 5.7%). The new transportation model also gained share in this period with Rail going from almost 100% share in 1900 to <10% share in 1940 and 1% by 1970. Perhaps the best indicator of the growth of travel brought on by the new transportation mode comes from looking at per capita travel, which increased from ~200 miles in 1900 to ~900 miles in 1920 to ~2,500 miles per year by 1940, a 12x increase in 40 years.

Exhibit 31:

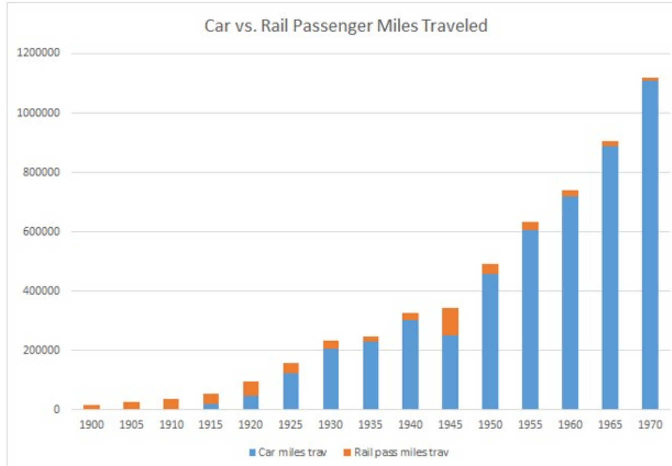
Car vs. Rail Passenger Miles Traveled per US Capita per Year



Source: US Census Bureau

Exhibit 32:

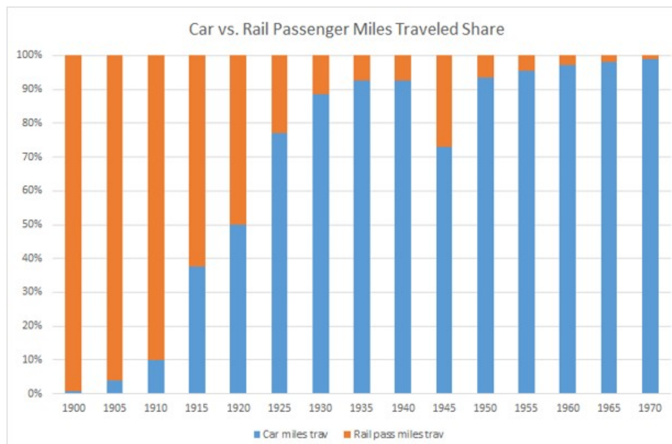
Car vs. Rail Passenger Miles Traveled (Millions)



Source: US Census Bureau

Exhibit 33:

Car vs. Rail Passenger Miles Traveled Share (%)

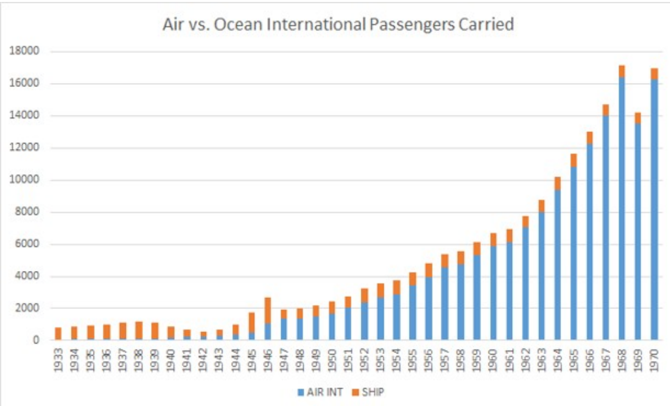


Source: US Census Bureau

This happened again after WW2 in the long-haul travel space with the launch of commercial airlines. What commercial airlines did to steamship travel is similar to what passenger cars did to horse-buggies and railroads half a decade earlier. Total international passengers that arrived in the US by Ocean increased from <800,000 in 1933 to almost 3 million by 1946, but after WW2 ramped from just over 2 million in 1950 to almost 18 million by 1970 – almost 10x in 20 years. Air market share of these passengers grew from 10% in 1933 to 70% by the late 1940s and 95% by the late 1960s. Similarly US per capita international travel increased 10x between the 1940s and 1960s, with global per capita travel increasing a similar percentage.

Exhibit 34:

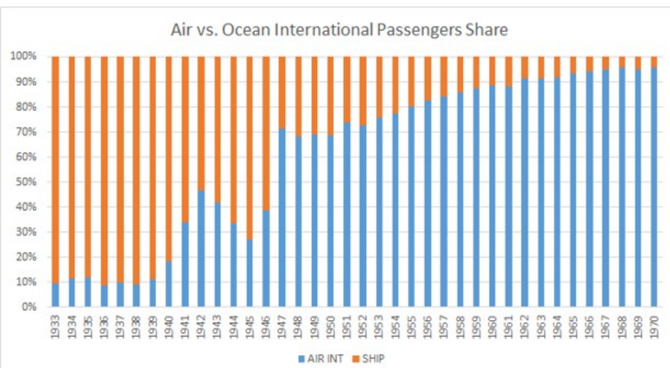
Air vs. Ocean International Passengers Carried (Thousands)



Source: US Census Bureau

Exhibit 35:

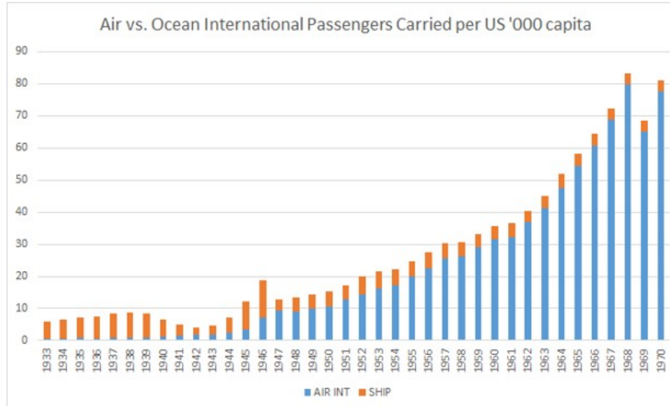
Air vs. Ocean International Passengers Share



Source: US Census Bureau

Exhibit 36:

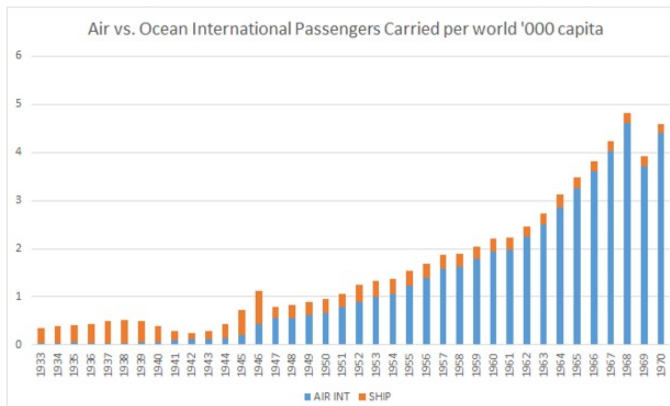
Air vs. Ocean International Passengers Carried per US '000 capita



Source: US Census Bureau

Exhibit 37:

Air vs. Ocean International Passengers Carried per world '000 capita



Source: US Census Bureau

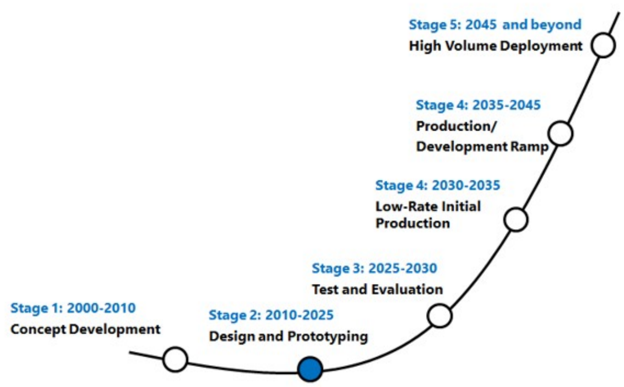
There is no way to tell for certain if eVTOLs can replicate this growth. The world is now a much more connected place than it used to be and travel in general – both long and short haul – is a more mature industry. However, *if* this were to happen and eVTOLs can replicate what the passenger automobile and commercial airline did (by growing domestic and international miles traveled by 12x and 10x, respectively in a 40 and 20 year period), the TAM would be considerably larger than what we have estimated. Increasing current US VMT by 10x in a 30 year period (between 2020 and 2050) will drive an incremental revenue opportunity of $30 trillion in the US alone (at ~$0.50 per mile), which would be incremental to our bull case TAM.

Scenario Introductions – Assessing the TAM for Urban Air Mobility

What Do the UAM Sector Adoption Curves Look Like?

Exhibit 38:

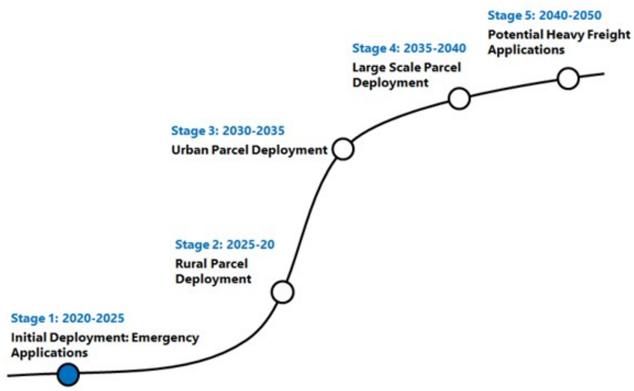
Adoption Curve for Military and Defense Usage



Source: Morgan Stanley Research

Exhibit 39:

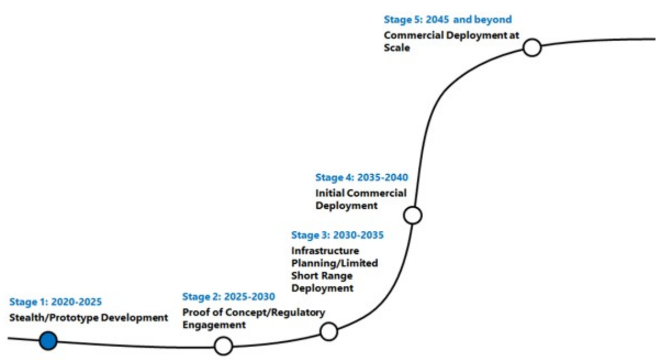
Adoption Curve for Transporting Packages and Freight



Source: Morgan Stanley Research

Exhibit 40:

Adoption Curve for Transporting Humans – A slower, but more logarithmic S-curve



Source: Morgan Stanley Research

Urban Air Mobility comes down to performing 2 core functions: *transporting goods and transporting humans.* While the gating factors for each use case are relatively similar, we view the adoption curves for each differently, due to the uncertainties surrounding regulation and overall societal acceptance.

1. **Transporting goods:** Transporting goods, in our view, will have significantly greater near term adoption because of the lower degree of technological barriers (weight, size, etc.) as well as fewer regulatory hurdles (especially in rural areas) regarding safety and redundancy that human transportation will have to overcome. Small and large eVOTL aircrafts can be used for many things such as last-mile delivery, fertilization of crops, and emergency transport. Companies such as Amazon (covered by Brian Nowak), JD.com (covered by Grace Chen), and Alphabet (covered by Brian Nowak) have had autonomous drone programs for years in order to capitalize on the potential cost savings and incremental revenue opportunities. Technologically speaking, drone technology has advanced rapidly, but barriers still exist. The primary driver of drone adoption and usage will be the level of autonomy, speed, and efficiency that shipping drones are able to operate under.
2. **Transporting humans:** The second, and longer-term use case is transporting humans in electric, autonomous, and urban eVOTL aircrafts. We estimate the 2040 addressable market for the human transport (categorized by Airlines and Autos/SM in our model) market to be $474bn**,** stealing share away from cars, planes, and public transit. The UAM market is precipitated by the increasing adoption of ride sharing and we see urban air mobility operating in a multimodal, ride-share fleet model. Urban Air Mobility represents business opportunities within infrastructure, fleet management, software, hardware, and content, much like the market opportunity for AVs. We see the UAM ecosystem

building off of existing EV as well as helicopter infrastructure. Initially, UAM services will likely start off as a complementary method to already existing modes of transportation, with operations primarily at airports and in dense city systems. But over time, we see infrastructure evolving to a point with more dense vertiport buildout across cities, with trips becoming progressively longer, driving cost per mile down to more affordable levels.

Total addressable market analysis: Scenario framework ranges from $2.3tn in our bear case to $19tn in our bull case by 2050.

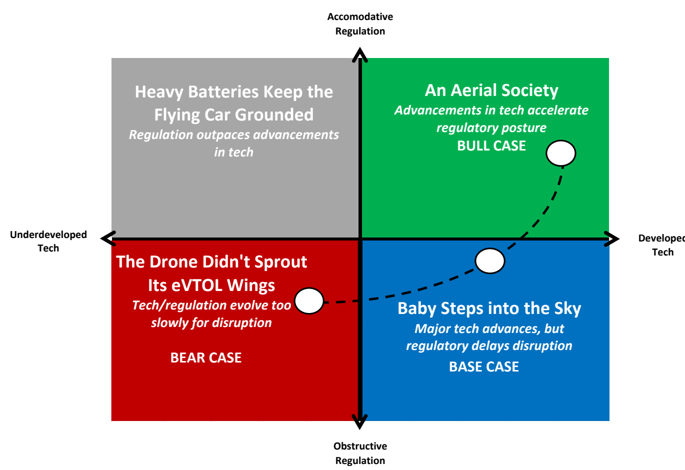
Given the extremely wide range of outcomes, the unpredictable evolution of enabling technology, and the consumer acceptance/regulatory issues that are not possible to model, we resort to scenario analysis to help frame investor thinking on the adoption and TAM of the flying car model. **The autos, transport/logistics, airlines and aerospace, and defense teams considered a number of vectors when determining the bear and bull case ranges for the TAM including:**

- **Battery technology.** Improvement in battery energy density is critical to enabling range, payload, and mitigating the emission of noise from the aircraft. Improving power to weight through lighter and more powerful batteries enables a greater magnitude of freight and/or numbers of human passengers for any distance of flight. Increased payload and range unlocks larger portions of addressable market to be exploited. A super heavy flying car with room for 1 passenger and a range of 1 mile would offer only novelty/limited commercial application. An unmanned passenger aircraft with a 50 mile range and room for only 3 passengers would require large numbers of aircraft in operation at any one time, which would compound ATC complexity and erode the economic payback periods.
- **Regulation/Societal acceptance.** Flying cars will be subject to a host of regulations and permitting/licensing considerations, including FAA/EASA approval, crashworthiness, software and hardware certification, infrastructure development, and environmental standards around emissions, noise, and privacy. We acknowledge that the realization of even our base and bull cases will require a substantial development of regulatory and operating standards from today's level. We see the development and early commercialization of terrestrial autonomous networks (shared autonomous cars) as an incubator and accelerator for the framework of regulation and consumer acceptance of flying car tech.
- **Other factors.** Beyond technological and regulatory factors, we believe macro-economic factors and the pace of private investment by companies and governments will impact the pace of adoption and the ultimate level of penetration. We see NASA's early involvement as a great positive for UAM ecosystem funding and organization. Dual-purpose and national security concerns may also play a role.

We have divided our scenarios for the Global UAM TAM into Bull, Base, and Bear cases. **Our framework to derive our scenarios is primarily driven by 2 primary vectors: (1) Technology and (2) Regulation.** Our cases assume a number of specific areas of technological capability (payload, range, speed, noise, software, connectivity, battery, unit cost, etc.). We also assume varying levels of regulatory inputs (local government, FAA/EASA, infrastructure, and public acceptance).

Exhibit 41:

UAM TAM Scenario Framework



Source: Morgan Stanley Research

We separated our bottom-up Urban Air Mobility model into 4 sections, which drive our estimates for the US Total Addressable Market in our Bull, Bear, and Base cases.

The sections are as follows:

1. **Autos and Shared Mobility:** Transporting humans shorter distances in heavily populated urban environments, such as a commute to work
2. **Airlines:** Transporting humans longer distances along more traditional short-haul airline routes, allowing for potentially larger, noisier aircraft.

3. **Freight Transportation:** Transporting goods, small and large, in both urban and rural environments
4. **Aerospace and Defense:** Using eVOTL aircraft on the battlefield for the transportation of troops and supplies.

We then extrapolated this US only bottom-up model globally to estimate the TAM in China, Europe, and ROW. We did this by taking the relative percentage of GDP our US UAM TAM forecast represents in the US and adjusted across regions for factors such as shared, autonomous, and electric vehicle miles penetration to arrive at the respective GDP percentages for each region. While we recognize comparing terrestrial ground transportation penetration to UAM may not be entirely apples to apples, we believe they are solid proxies, given the overlap of AV/EV and UAM technologies.

Bull Case: An Aerial Society

Advanced / Developed Technology and Accommodative Policy:

- Mass adoption / acceptance of transportation of goods and people by eVOTL / drone
- Technology accelerates – it is cost effective for both consumers and businesses; it is more efficient than current transportation models
- Policy is flexible and infrastructure is readily available / amendable – regulations permit “easy” eVOTL / drone usage and adapt to changing consumer / business demands
- **Global Total Addressable Market: $18.9tn by 2050 (~11 to 12% of 2050E Global GDP)**

Bear Case: Baby Steps into the Sky

Underdeveloped / Unsuccessful Technology & Obstructive Policy:

- Mass rejection and fear/ minimal adoption of transportation of goods and people by eVOTL / drone
- Technology stagnates – it is not cost effective for consumer or businesses; is less efficient than current transportation models; encounters critical technological barriers to adoption (weight, noise, range, payload, safety, etc.)
- Policy is restrictive in nature and infrastructure is unable to support adoption – regulations hinder eVOTL / drone usage and impede widespread adoption.
- **Global Total Addressable Market: $2.3tn by 2050 (~1 to 2% of 2050E Global GDP)**

Base Case: The Drone Didn't Sprout Its eVOTL Wings

Advanced Technology & Obstructive Policy:

- Technology outpaces regulation / infrastructure / budget capabilities;
- VTOL / drone adoption is affected by red tape and falls on legislative priority list, hindering usage though technology is readily available
- Some societal concerns surrounding autonomous aerial control contributes to restrictive policy
- **Global Total Addressable Market: $9tn by 2050 (~5 to 6% of 2050E Global GDP)**

Morgan Stanley eVTOL/UAM Total Addressable Market Model

We believe that the opportunity in Urban Air Mobility is going to be substantial. To size the Total Addressable Market in the US, we focused on three broad end markets + the supply chain: (1) transporting humans, (2) transporting goods and (3) military & defense. More specifically, we look at markets directly relevant to personal urban/suburban transportation, final mile shipping/logistics, short-haul airlines, and defense.

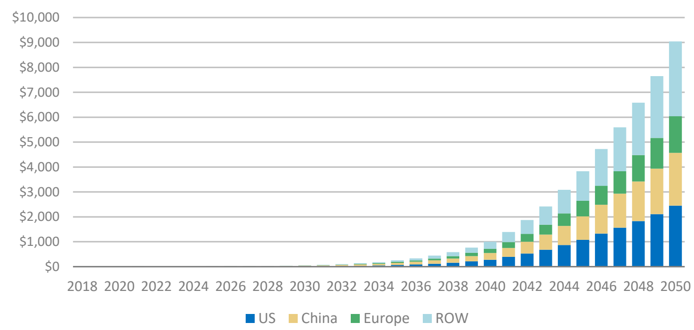
Our TAM analysis is limited to the end market services only (excluding hardware/content). This report does not include the components, sensors, compute, and software – the so called "arms dealers" of the autonomous aircraft ecosystem – which one can estimate via bottom-up forecasts for the three primary end markets.

We believe that our US TAM model provides a relevant illustration of the economics behind UAM ecosystem. To arrive at a Global TAM, we extrapolated our US TAM model using relative percentages of GDP, while adjusting for factors across China, Europe, and ROW such as shared, autonomous, and electric vehicle mile penetration. We believe that these factors are a good proxy for UAM penetration across regions since the technologies are highly complementary.

Global Total Addressable Market Summary

Exhibit 42:

Global Total Addressable Market ($bn)



Source: Morgan Stanley Research Estimates

Exhibit 43:

Global Total Addressable Market ($bn)

Model Summary	2020	2025	2030	2035	2040	2045	2050
US (Revenue $bn)							
Base	$1	$2	$12	$66	$279	$1,081	$2,450
Bull	$1	$6	$86	$446	$1,228	$2,661	$5,134
Bear	$1	$1	$5	$24	$96	$336	$626
China (Revenue $bn)							
Base	$1	$6	$26	$89	$268	$941	$2,120
Bull	$1	$20	$188	$605	$1,178	$2,316	$4,442
Bear	$1	$5	$11	$33	$92	$293	$542
Europe (Revenue $bn)							
Base	$2	$1	$8	$41	$168	$623	$1,466
Bull	$2	$5	$59	$277	$738	$1,533	$3,072
Bear	$2	$1	$4	$15	$58	$194	$375
ROW (Revenue $bn)							
Base	$4	$2	$10	$60	$285	$1,189	$3,006
Bull	$4	$6	$74	$405	$1,253	$2,929	$6,298
Bear	$3	$1	$4	$22	$98	$370	$768
Global Total Addressable Market ($bn)							
Base	**$8**	**$10**	**$55**	**$255**	**$1,001**	**$3,833**	**$9,042**
Bull	**$8**	**$37**	**$407**	**$1,733**	**$4,397**	**$9,439**	**$18,946**
Bear	**$8**	**$9**	**$24**	**$94**	**$343**	**$1,193**	**$2,310**

Source: Morgan Stanley Research Estimates

US Bottom-Up Model Summary

Our bottom-up US Model, in our view, provides a reasonable representation of the different revenue opportunities and business models that will make up the UAM ecosystem.

Exhibit 44:

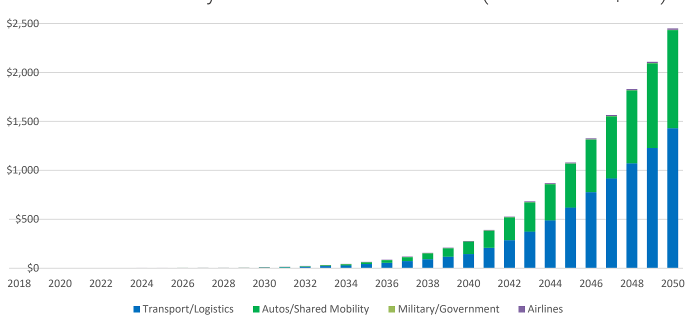
US UAM TAM Model Revenue Breakdown by Core Sectors ($bns)

Revenue Breakdown ($bn	2020	2025	2030	2035	2040	2045	2050
Transportation/Logistics							
Base	$0.0	$0.6	$7.1	$42.9	$144.3	$619.7	$1,431.3
Bull	$0.0	$4.5	$64.1	$292.5	$643.5	$1,096.4	$1,723.9
Bear	$0.0	$0.6	$2.7	$19.4	$81.7	$291.3	$492.2
Autos/SM							
Base	$0.0	$0.1	$1.9	$17.5	$127.6	$449.0	$1,001.5
Bull	$0.0	$0.6	$17.1	$139.7	$558.4	$1,524.7	$3,361.5
Bear	$0.0	$0.0	$0.3	$1.9	$10.6	$38.8	$123.3
Airlines							
Base	$0.0	$0.1	$0.6	$2.9	$4.8	$9.0	$13.9
Bull	$0.0	$0.2	$1.9	$8.6	$20.5	$33.9	$41.6
Bear	$0.0	$0.1	$0.8	$1.5	$2.3	$5.4	$9.5
Military/Defense							
Base	$1.1	$0.9	$2.1	$2.5	$2.7	$3.0	$3.3
Bull	$1.1	$0.9	$3.2	$4.9	$5.4	$6.0	$6.6
Bear	$1.0	$0.7	$1.3	$1.2	$1.1	$1.0	$0.9

Source: Morgan Stanley Research Estimates

Exhibit 45:

US Urban Air Mobility Total Addressable Market (Base Case - $bns)



Source: Morgan Stanley Research Estimates

Autos & Shared Mobility (US)

The business model of autonomous aircraft has the potential to be far more economically superior to much of the terrestrial ride-sharing model.

- Compared to today's ride-sharing car, an autonomous electric aircraft can be faster, can do more shifts (higher utilization), and can charge higher revenue/mile. The combination implies strong revenue generation.
- In our scenario analysis, we estimate that flying cars can conduct 4x the numbers of trips per day as a ride-sharing car with 4x the number of miles per trip (100mph for flying car vs. 25mph for rideshare car).
- We estimate the annual revenue for a highly utilized ride sharing car to be around $75k/year. We estimate a flying car can generate as much as 12x this revenue (>$900k/year).
- Assuming a 15% margin for flying cars vs. a 10% margin for terrestrial cars implies the flying car generates 18x the profit per unit.
- We note the economic outcomes of flying cars depend on a range of factors, including vehicle cost, useful life, residual value, interest rate, electricity cost, range (miles/KwH), maintenance cost, hangar/infrastructure costs, parking, SG&A, insurance, licensing, and other fees.

Exhibit 46:

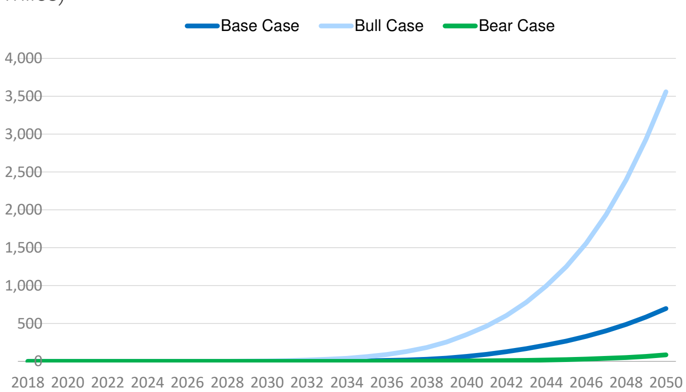
US Autos and Shared Mobility UAM TAM Model Summary

Case Summary	2020	2025	2030	2035	2040	2045	2050
UAM % of Vehicle Miles							
Base	0.0%	0.0%	0.0%	0.2%	1.5%	4.7%	9.0%
Bull	0.0%	0.0%	0.2%	1.6%	8.2%	21.8%	46.1%
Bear	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	1.1%
Production (units)							
Base	40	273	2,208	14,151	76,108	203,823	409,961
Bull	40	845	10,284	49,270	162,631	439,103	1,003,472
Bear	20	63	365	1,963	7,861	25,948	79,186
Hours of Operation/Day							
Base	1	2	3	4	5	5	5
Bull	2	4	6	8	10	11	12
Bear	1	2	2	3	4	4	4

Source: Morgan Stanley Research Estimates

Exhibit 47:

US eVOTL Total Miles Traveled – Autos and Shared Mobility (bns of miles)



Source: Morgan Stanley Research Estimates

Freight Transportation

Freight Transportation, especially for small parcels in rural areas, are the first and most obvious application for eVTOLs. However, as the capability of the aircraft increases - especially with range and payload - and as supply chains evolve to meet the growing need for eCommerce (by getting faster and tighter), the next few generations of eVTOLs can play a much larger role in Freight Transportation by 2040-50 than we had envisioned in our 2018 report.

The three main use cases for eVTOLs in Freight Transportation are:

1. **Rural and high-service parcel delivery.** This is likely to be the first commercial use case for eVTOLs. In fact, this has already begun. In addition to commercial drone deliveries of medical and emergency supplies in parts of Africa and remote areas in North America, commercial (not pilot tests) medical and rural delivery services began in 2019. UPS and Matternet started commercial drone deliveries for the Wake Forest Medical System in NC in 2019, which has since expanded to more routes. Separately, Fedex has partnered with Wing to launch commercial drone operations at a limited scale in the city of Christianburg, VA. We believe medical and rural delivery that fully leverage the speed, cost and operating efficiency of eVTOLs, which existing delivery solutions struggle to replicate, represents an attractive initial use case. Density is the lifeblood of any parcel delivery network and some extra urban areas simply do not have the population density to allow for affordable package delivery, especially in today's same-day delivery world. Our 2018 Alphawise analysis showed that roughly 80% of the US population lives in 28% of zip codes, mostly in urban areas along the coasts. We estimate that the other 20% of the population that lives in the other 72% of the zip codes are rural/extra urban residents for whom eVOTL delivery would make practical sense. Our 2019 deep-dive into AMZN Logistics backed up this number, by showing that roughly 20% of deliveries were to rural areas. As such, we estimate that rural deliveries represent roughly 20% of the parcel TAM. While drone deliveries to rural areas have already launched, we model a slow ramp to 5% of the rural delivery TAM by 2030, growing to 27% by 2040 and 85% by 2050, in our base case. We estimate the rural parcel TAM grows at roughly the rate of GDP growth.
2. **Urban parcel delivery.** While commercial drones can be used for rural delivery, larger cargo eVTOLs can be used for urban parcel delivery. There are clearly some challenges with using flying aircraft for delivery to dense urban areas, largely

as the ground and air density of urban areas makes it challenging to deliver a small package directly to the customer and also because the density makes current parcel unit economics very attractive, reducing the need to find an alternative. However, until urban architecture is updated to have eVTOL delivery landing pads on the roofs of buildings, we believe eVTOLs can become a very attractive solution for the *middle mile* urban delivery before penetrating the last mile. As eCommerce supply chains become shorter, faster and tighter and default service standards increase to one-day or even same day delivery, eCommerce companies are looking to significantly speed up delivery, while also lowering its cost, since customer willingness to pay for delivery has not increased. While Air is the fastest way to connect DCs, it is expensive and cannot reach final mile delivery stations/ stores out of which final-mile delivery occurs. Truck is the best solution today, but the carbon footprint is high and it is not as fast as Air. eVTOLs could be the solution. An eVTOL that can carry several hundred pounds of payload by Air for a 100-200 mile radius from a DC to a delivery station/store in the outskirts of an urban area represents the best of Air and Truck. As such, we estimate that eVTOLs can access 12% of the *middle mile* urban Parcel TAM by 2040 and 65% by 2050, a much later and slower ramp than rural delivery. This adds $70 bn to our Freight eVTOL TAM by 2040 and $903 bn by 2050 and is a new addition to our Freight TAM analysis relative to our 2018 estimate.

3. **Pallet-ized freight delivery.** While Parcels typically weigh between 1 and 50 lbs (average 3-5 lbs), pallet-ized freight (as seen in LTL truck delivery) is 150 lbs+. While early launch multi-passenger eVTOLs should have payload capacity of 500 lbs+ (4-5 passengers), we estimate that this increases to a few thousand lbs by 2035-40 (first generation Cargo eVTOLs are set to have ~1000 lbs payload at launch in a few years). This should allow eVTOLs to rival large commercial vans and medium duty trucks as well as tap into a small portion of the loads carried by LTL (especially pickup and delivery) and TL carriers. As such, we triangulate to the heavy freight TAM by estimating the % of the $800 bn Trucking TAM in the US that is LTL pickup and delivery and short-haul TL as well the % that is delivered by medium-duty truck and short-haul Class 8 truck. We only expect heavy freight eVTOLs to launch after 2035 but ramp up to just under ~$100 bn of TAM by 2050.

Exhibit 48:

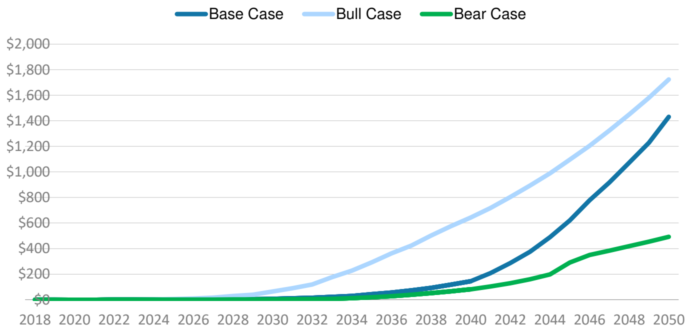
US Freight Transportation UAM TAM Model Summary

Case Summary	2020	2025	2030	2035	2040	2045	2050
Rural Parcel Drone Share (%)							
Base	0%	2%	5%	13%	27%	52%	85%
Bull	1%	20%	38%	50%	60%	60%	60%
Bear	1%	20%	38%	50%	60%	60%	60%
Urban Parcel Drone Share (%)							
Base	0%	0%	2%	7%	12%	41%	65%
Bull	0%	10%	20%	30%	40%	40%	40%
Bear	0%	3%	5%	8%	10%	10%	10%
Freight Market Drone Share (%)							
Base	0%	0%	0%	1%	10%	20%	30%
Bull	0%	0%	0%	6%	20%	20%	20%
Bear	0%	0%	0%	4%	20%	20%	20%

Source: Alphawise, Morgan Stanley Research Estimates

Exhibit 49:

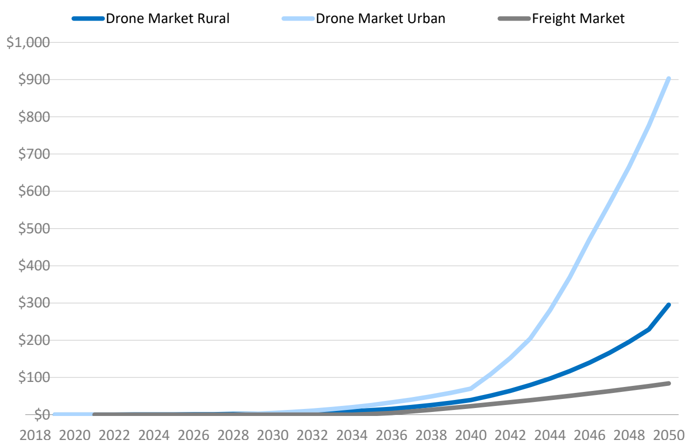
US Freight Transportation Total Addressable Market ($bn)



Source: Alphawise, Morgan Stanley Research Estimates

Exhibit 50:

US Freight Transportation Total Addressable Market (Urban / Rural / Freight – Base Case – $bns)



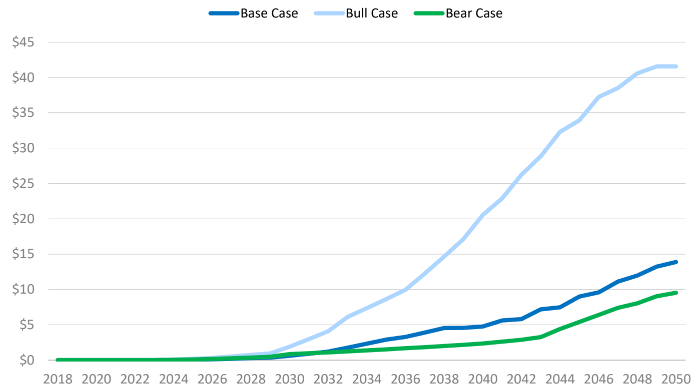
Source: Alphawise, Morgan Stanley Research Estimates

Airlines

In addition to passenger car mobility, eVTOLs likely have the most overlap with short-haul passenger aircraft. This is a relatively small TAM as in 2019 only 1% of the total 877,574mm ASMs (available passenger seat miles or airline capacity) flown by US Airlines was <200 mile length of haul (LoH) and another 10% was 200-500 miles. Nevertheless, we believe this represents an attractive use case for eVTOLs and can add to the TAM. We estimate a RASM of 75c/mile given the short haul nature of the flight (vs. 10-15c RASM for the average US passenger airline today). We believe eVTOLS can replace workhorse "shuttle" flights between popular city pairs like NYC-Boston, NYC-DC, LA-SF, etc., over time. We have a slow ramp in our base case, with only 5% of <200 mile flights operated by eVTOL by 2030, growing to 15% by 2040 and 35% by 2050 with a much smaller penetration still of 200-500 mile LoH flights. This adds ~$3bn to our TAM by 2035 and ~$14bn by 2050. We note that if eVTOL capability accelerates quickly and these aircraft can achieve 500-1000 miles of range, they could be significant threats to passenger aircraft. Our bull case has the airline revenue opportunity topping $40 bn by 2050.

Exhibit 51:

US Airlines Total Addressable Market ($bn)



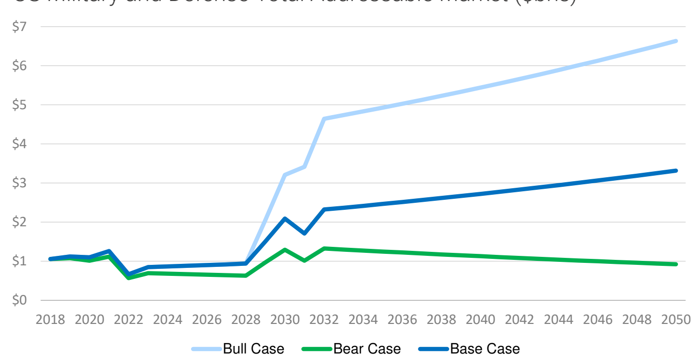
Source: Morgan Stanley Research Estimates

Military & Defense

Although Military and Defense is a very small sliver of our overall Total Addressable Market Model, we see the increased involvement of militaries in the space as paramount to both technological and regulatory advance. The total addressable market for Military and Defense is much smaller than the other sectors because we model the market as a function of military spend (i.e., how much will the military spend on advance eVOTL vehicles in a given year?). On a relative basis, this is a much smaller revenue pool (~$1bn today) versus the potential for operating a fleet of autonomous aircraft at a cost of $2 per mile.

Exhibit 52:

US Military and Defense Total Addressable Market ($bns)



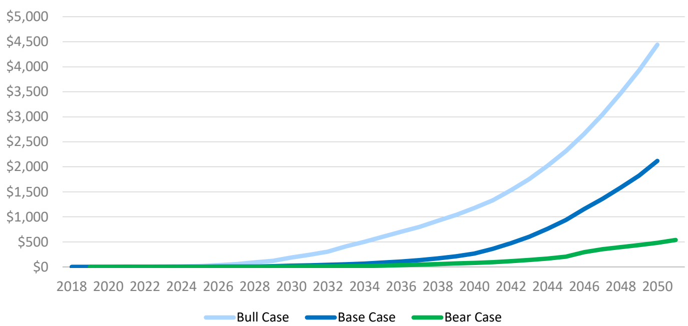
Source: Morgan Stanley Research Estimates

UAM Global Total Addressable Market Extrapolations

While we do not perform a bottom-up analysis for China, Europe, and ROW, we believe our model extrapolation reasonably accounts for differences across regions such as autonomous, electric, and shared mile penetration. Although using terrestrial penetration forecasts for those vectors is not completely apples to apples, they will likely be relatively good proxies to adjust our bottom-up Total Addressable Market estimates across regions. We acknowledge the regulatory, societal, and national security vectors get significantly more difficult to address as you extrapolate globally, especially for a topic like UAM.

Exhibit 53:

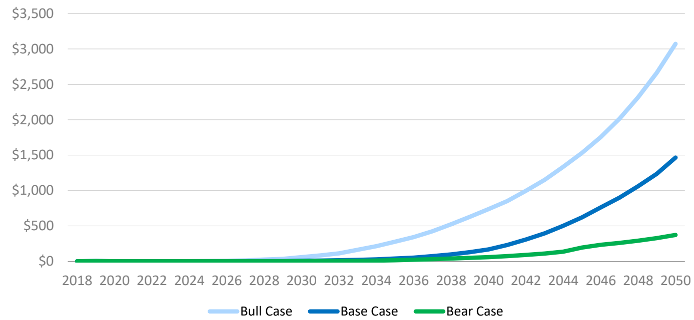
China Total Addressable Market ($bn)



Source: Morgan Stanley Research Estimates

Exhibit 54:

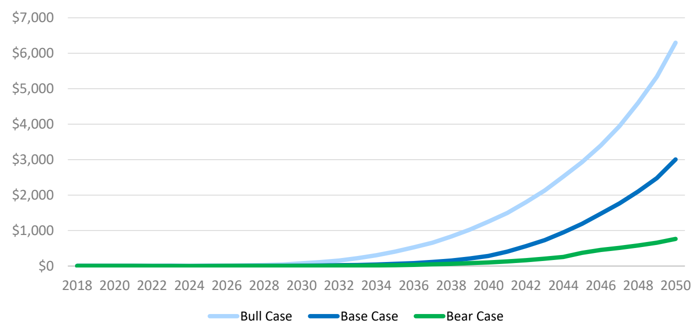
Europe Total Addressable Market ($bn)



Source: Morgan Stanley Research Estimates

Exhibit 55:

ROW Total Addressable Market ($bn)



Source: Morgan Stanley Research Estimates

Case Assumptions

Exhibit 56:

TAM Analysis Case Assumptions

Case	Technology	Regulation	Outcomes
CASE	TECHNOLOGY	REGULATION	OUTCOMES
BASE	**Payload/Range: up to** 750lbs, 150 miles **Speed: up to** 150mph **Noise:** 65-70 dbA, slightly above normal conversation volume **Pilot:** Manual/human **Sensor suite:** lidar, camera, radar, AI/ML, remote supervision **Telecom:** 4G/5G, LEO, V2V, V2X mesh network **Battery:** gen 1 solid state, energy density 0.5KwH/Kg **Unit Cost:** $50k to $2 million **Cost per Mile:** up to $4	**Local Government:** bespoke regulatory posture, mixed **FAA Certification:** status quo certification stds, limits broad deployment **Telecom Infrastructure:** somewhat enabling **EV Infrastructure:** density optimized for city/MSA **Public Acceptance:** mixed, depending on application/region	**Narrative: Baby Steps into the Sky** Tech advances much faster than regulations. Network gets large enough for low cost operation. Jury still out on consumer safety/envonmental impact. **Market Size:** $250bn, 1.5% of US GDP **Use Cases:** parcel delivery esp. in rural and remote areas with small drones followed by commercial launch of multi-passenger short-range eVTOLs **Reality Check:** Passenger eVTOLs may have a hard time getting off the ground due to tech and regulations, use cases may be relativley limited
BULL	**Payload/Range: up to** 2200 lbs, 500 miles **Speed: up to** 250mph **Noise:** 40-50 dbA **Pilot:** Fully autonomous **Sensor suite: lidar, camera, radar, AI/ML, fully independent** **Telecom:** 5G, LEO, DSRC, mesh network **Battery:** advanced solid state, hydrogen/synthetic fuel **Unit Cost:** ~$250k **Cost per Mile:** $1-3	**Local Government:** bends to economic/Fed rulemaking **FAA Certification:** extremely enabling certification stds **Telecom Infrastructure:** AV infrastructure well developed **EV Infrastructure:** density optimized for region/nation **Public Acceptance:** high, visible benefits	**Narrative: An Aerial Society** Major advancements in tech accelerates regulatory posture. Solving noise and range issues were key. Cheaper than today's cars. Proven safety track record. **Market Size:** $700bn, 4% of US GDP **Use Cases:** On the path to taking cars and trucks off the road and putting them into the sky, broad use in middle mile logsitics, short-haul passenger travel **Reality Check:** Still minority of miles traveled (10 to 20%). Requires another decade or two to displace 2D transport.
BEAR	**Payload/Range: up to 10**lbs, 20 miles **Speed:** 50mph **Noise:** 85db, between highway speed cars and helicopters **Pilot:** remote supervision with line-of-sight **Sense & Compute:** camera, radar sensor-fusion **Telecom:** 4G, wifi **Battery:** Tesla-era EV tech, energy density 0.2KwH/Kg **Unit Cost:** $5k to $250k **Cost per Mile:** approx $5 to $10	**Local Government:** more power than Fed rules **FAA Certification:** stricter certification stds in urban areas, bottlenecks **Telecom Infrastructure:** limited to short-range operation **EV Infrastructure:** patchwork/responsibility of private firms **Public Acceptance:** low, environmental/privacy pushback	**Narrative: the Drone Didn't sprout its eVTOL wings** Tech/regulation evolve too slowly for major disruption. Network size too small to achieve economies of scale. Many communities ban on noise and privacy concerns. **Market Size:** $50bn, 0.3% of US GDP **Use Cases: technology and regulation limited to drones with limited passenger applications,** surveilance, entertainment, emergency svcs, line-of-sight delivery. Almost no human traffic. **Reality Check:** Sub 1% level of miles traveled. Moral, legal, ethical and infrastructure impediments.

Source: Morgan Stanley Research

A Brief History of New York Airways

New York Airways operated vertical lift flights in the New York City area from 1949 to 1979. The company flew the Boeing Vertol V-44, Boeing Vertol 107, and the Sikorsky S61.

In its 30 years of operations, New York Airways served the airports around the New York City area including New York International Airport (now known as JFK), New York LaGuardia (LGA), Newark Airport (EWR), Teterboro, White Plains, and Stamford. New York Airways first used the heliport at West Side Highway at 30th Street and then the Wall Street Heliport. The company also provided scheduled flights using the heliport at the top of the Pan Am Building (now the MetLife Building) in Midtown Manhattan.

Exhibit 57:
Boeing Vertol V-44

Source: Wikimedia

Exhibit 58:
Boeing Vertol 107

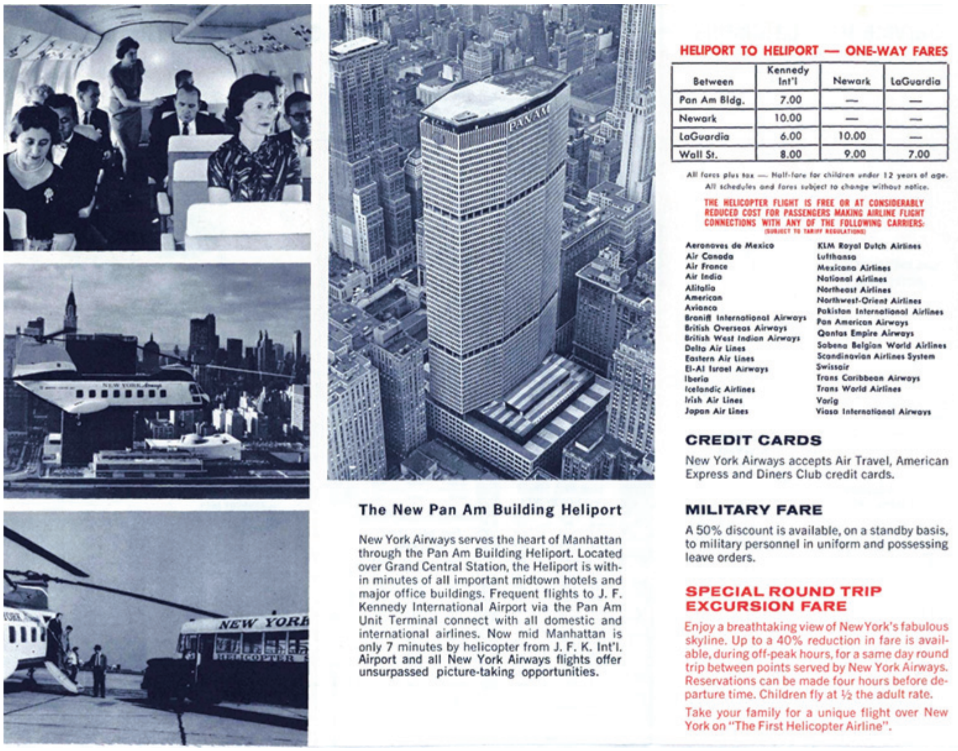
Source: Wikimedia

Exhibit 59:
Sikorsky S61

Source: Wikimedia

Exhibit 60:

New York Airways



The New Pan Am Building Heliport

New York Airways serves the heart of Manhattan through the Pan Am Building Heliport. Located over Grand Central Station, the Heliport is within minutes of all important midtown hotels and major office buildings. Frequent flights to J. F. Kennedy International Airport via the Pan Am Unit Terminal connect with all domestic and international airlines. Now mid Manhattan is only 7 minutes by helicopter from J. F. K. Int'l. Airport and all New York Airways flights offer unsurpassed picture-taking opportunities.

HELIPORT TO HELIPORT — ONE-WAY FARES

Between	Kennedy Int'l	Newark	LaGuardia
Pan Am Bldg.	7.00	—	—
Newark	10.00	—	—
LaGuardia	6.00	10.00	—
Wall St.	8.00	9.00	7.00

All fares plus tax — Half-fare for children under 12 years of age.
All schedules and fares subject to change without notice.

THE HELICOPTER FLIGHT IS FREE OR AT CONSIDERABLY REDUCED COST FOR PASSENGERS MAKING AIRLINE FLIGHT CONNECTIONS WITH ANY OF THE FOLLOWING CARRIERS:
(SUBJECT TO TARIFF REGULATIONS)

Aeronaves de Mexico
Air Canada
Air France
Air India
Alitalia
American
Avianca
Braniff International Airways
British Overseas Airways
British West Indian Airways
Delta Air Lines
Eastern Air Lines
El-Al Israel Airways
Iberia
Icelandic Airlines
Irish Air Lines
Japan Air Lines
KLM Royal Dutch Airlines
Lufthansa
Mexicana Airlines
National Airlines
Northeast Airlines
Northwest-Orient Airlines
Pakistan International Airlines
Pan American Airways
Qantas Empire Airways
Sabena Belgian World Airlines
Scandinavian Airlines System
Swissair
Trans Caribbean Airways
Trans World Airlines
Varig
Viasa International Airways

CREDIT CARDS

New York Airways accepts Air Travel, American Express and Diners Club credit cards.

MILITARY FARE

A 50% discount is available, on a standby basis, to military personnel in uniform and possessing leave orders.

SPECIAL ROUND TRIP EXCURSION FARE

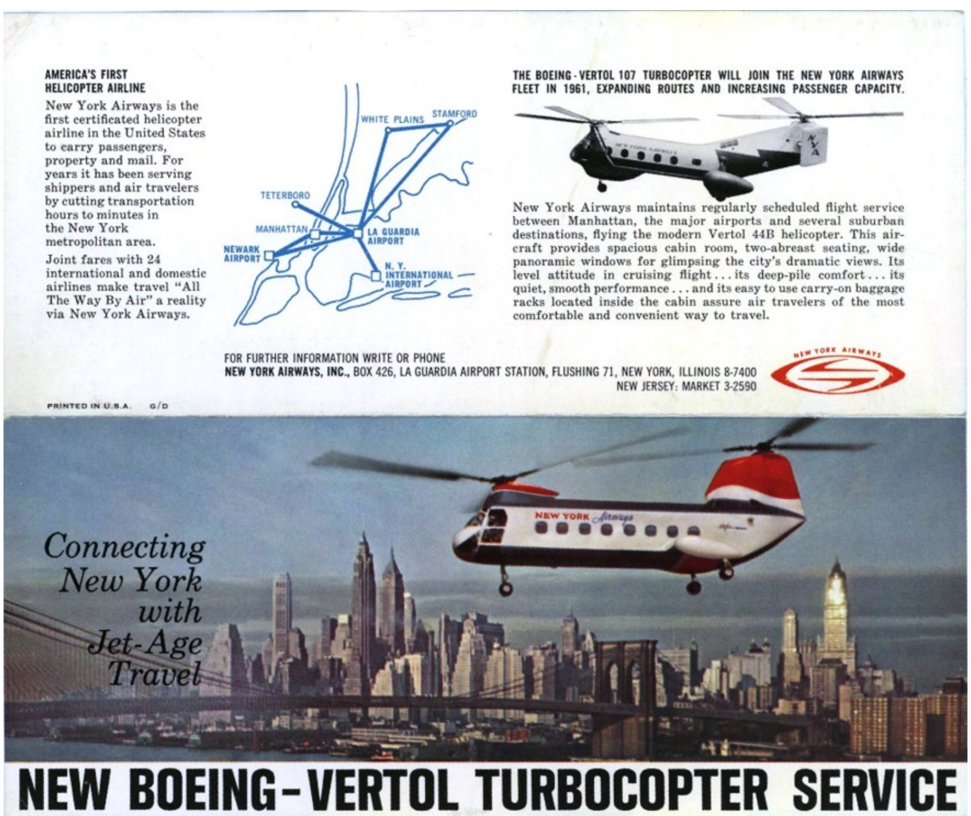
Enjoy a breathtaking view of New York's fabulous skyline. Up to a 40% reduction in fare is available, during off-peak hours, for a same day round trip between points served by New York Airways. Reservations can be made four hours before departure time. Children fly at ½ the adult rate.

Take your family for a unique flight over New York on "The First Helicopter Airline".

Source: National Air and Space Museum Archives

Exhibit 61:

New York Airways



AMERICA'S FIRST HELICOPTER AIRLINE

New York Airways is the first certificated helicopter airline in the United States to carry passengers, property and mail. For years it has been serving shippers and air travelers by cutting transportation hours to minutes in the New York metropolitan area.

Joint fares with 24 international and domestic airlines make travel "All The Way By Air" a reality via New York Airways.

THE BOEING-VERTOL 107 TURBOCOPTER WILL JOIN THE NEW YORK AIRWAYS FLEET IN 1961, EXPANDING ROUTES AND INCREASING PASSENGER CAPACITY.

New York Airways maintains regularly scheduled flight service between Manhattan, the major airports and several suburban destinations, flying the modern Vertol 44B helicopter. This aircraft provides spacious cabin room, two-abreast seating, wide panoramic windows for glimpsing the city's dramatic views. Its level attitude in cruising flight . . . its deep-pile comfort . . . its quiet, smooth performance . . . and its easy to use carry-on baggage racks located inside the cabin assure air travelers of the most comfortable and convenient way to travel.

FOR FURTHER INFORMATION WRITE OR PHONE
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NEW JERSEY: MARKET 3-2590

NEW YORK AIRWAYS

PRINTED IN U.S.A. G/D

Connecting New York with Jet-Age Travel

NEW BOEING-VERTOL TURBOCOPTER SERVICE

Source: National Air and Space Museum Archives

Exhibit 62:

New York Airways

Source: National Air and Space Museum Archives

NTSB Report From 1977 PanAm Building Accident

According to the National Transportation Safety Board (NTSB),

"About 17:35 e.d.t., on May 16, 1977, the right landing gear of a New York Airways, Inc., Sikorsky S-61L; N619PA, failed while the aircraft was parked, with rotors turning, on the rooftop heliport of the Pan Am Building in New York, New York. The aircraft rolled over on its right side and was substantially damaged. At the time of the accident four passengers had boarded the aircraft and other passengers were in the process of boarding.

The passengers and the three crew members onboard received either minor or no injuries; however, four passengers who were still outside the aircraft and were waiting to board were killed and one was seriously injured. One pedestrian on the corner of Madison Avenue and 43rd Street was killed and another was seriously injured when they were struck by a separated portion of one of the main rotor blades of the aircraft.

The National Transportation Safety Board determined that the probable cause of the accident was the fatigue failure of the upper right forward fitting of the right main landing gear tube assembly. Fatigue originated from a small surface pit of undetermined source. All fatalities were caused by the operating rotor blades as a result of the collapse of the landing gear."

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Global Stock Ratings Distribution

(as of April 30, 2021)

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	Coverage Universe		Investment Banking Clients (IBC)			Other Material Investment Services Clients (MISC)	
Stock Rating Category	Count	% of Total	Count	% of Total IBC	% of Rating Category	Count	% of Total Other MISC
Overweight/Buy	1517	44%	413	47%	27%	670	44%
Equal-weight/Hold	1418	41%	373	42%	26%	649	42%
Not-Rated/Hold	4	0%	2	0%	50%	4	0%
Underweight/Sell	529	15%	95	11%	18%	210	14%
Total	3,468		883			1533	

Data include common stock and ADRs currently assigned ratings. Investment Banking Clients are companies from whom Morgan Stanley received investment banking compensation in the last 12 months. Due to rounding off of decimals, the percentages provided in the "% of total" column may not add up to exactly 100 percent.

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Overweight (O or Over) - The stock's total return is expected to exceed the total return of the relevant country MSCI Index or the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis over the next 12-18 months.

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Not-Rated (NR) - Currently the analyst does not have adequate conviction about the stock's total return relative to the relevant country MSCI Index or the average total return of the analyst's industry (or industry team's) coverage universe, on a risk-adjusted basis, over the next 12-18 months.

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Attractive (A): The analyst expects the performance of his or her industry coverage universe over the next 12-18 months to be attractive vs. the relevant broad market benchmark, as indicated below.

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Cautious (C): The analyst views the performance of his or her industry coverage universe over the next 12-18 months with caution vs. the relevant broad market benchmark, as indicated below.

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INDUSTRY COVERAGE: Autos & Shared Mobility

COMPANY (TICKER)	RATING (AS OF)	PRICE* (05/06/2021)
Adam Jonas, CFA		
Adient PLC (ADNT.N)	U (03/17/2021)	$48.29
American Axle & Manufacturing Holdings Inc (AXL.N)	U (03/24/2021)	$9.76
Aptiv Plc (APTV.N)	O (03/30/2020)	$141.46
Asbury Automotive Group Inc (ABG.N)	O (12/07/2020)	$209.17
AutoNation Inc. (AN.N)	U (07/10/2018)	$106.89
BorgWarner Inc. (BWA.N)	U (11/09/2020)	$52.23
Carmax Inc (KMX.N)	O (07/10/2018)	$130.29
Carvana Co (CVNA.N)	O (02/26/2021)	$263.45
Ferrari NV (RACE.N)	O (05/09/2019)	$200.11
Fisker Inc (FSR.N)	O (02/11/2021)	$11.30
Ford Motor Company (F.N)	U (01/29/2021)	$11.74
Garrett Motion Inc (GTX.O)		$5.80
General Motors Company (GM.N)	O (04/09/2018)	$58.72
Group 1 Automotive, Inc (GPI.N)	O (05/06/2019)	$174.90
Lear Corporation (LEA.N)	O (11/09/2020)	$192.21
Lithia Motors Inc. (LAD.N)	U (02/09/2021)	$380.32
Lordstown Motors (RIDE.O)	U (02/11/2021)	$8.06
Magna International Inc. (MGA.N)	E (04/13/2021)	$96.06
Penske Automotive Group, Inc (PAG.N)	O (07/10/2018)	$92.37
Quantumscape Corp (QS.N)	O (02/11/2021)	$30.98
Romeo Power, Inc. (RMO.N)	U (02/11/2021)	$7.56
Sonic Automotive Inc (SAH.N)	E (11/14/2019)	$52.37
Tenneco Inc. (TEN.N)	U (03/30/2020)	$11.35
Tesla Inc (TSLA.O)	O (11/18/2020)	$663.54
Visteon Corporation (VC.O)	U (03/22/2018)	$126.53
Billy Kovanis		
Avis Budget Group Inc (CAR.O)	E (03/15/2021)	$83.91
Harley-Davidson Inc (HOG.N)	U (04/22/2021)	$48.96
Polaris Inc. (PII.N)	O (01/19/2021)	$143.57
Victoria A Greer		
Goodyear Tire & Rubber Company (GT.O)	E (04/16/2021)	$19.54

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Freight Transportation

COMPANY (TICKER)	RATING (AS OF)	PRICE* (05/06/2021)
Ravi Shanker		
ArcBest Corp (ARCB.O)	O (12/10/2020)	$86.58
C.H. Robinson Worldwide Inc. (CHRW.O)	U (06/09/2013)	$98.02
Canadian National Railway Co. (CNR.TO)	++	C$134.02
Canadian Pacific Railway Ltd. (CP.TO)	++	C$471.75
CSX Corporation (CSX.O)	U (12/10/2020)	$102.56
Echo Global Logistics Inc (ECHO.O)	E (03/05/2019)	$35.07
Expeditors International of Washington I (EXPD.O)	E (02/25/2015)	$115.64
FedEx Corporation (FDX.N)	E (06/20/2013)	$310.96
Heartland Express Inc. (HTLD.O)	U (05/06/2011)	$19.11
Hub Group Inc (HUBG.O)	E (02/13/2018)	$69.72
J.B. Hunt Transport Services Inc. (JBHT.O)	E (05/06/2011)	$174.90
Kansas City Southern (KSU.N)	++	$296.31
Knight-Swift Transportation Holdings Inc (KNX.N)	O (12/13/2017)	$48.83

Landstar System Inc (LSTR.O)	U (02/23/2016)	$175.72
Norfolk Southern Corp. (NSC.N)	U (06/03/2016)	$286.97
Old Dominion Freight Line Inc (ODFL.O)	O (03/23/2020)	$264.96
Saia, Inc. (SAIA.O)	U (02/23/2016)	$236.64
Schneider National Inc. (SNDR.N)	O (05/01/2017)	$25.93
TFI International Inc (TFII.N)	O (06/10/2020)	$87.80
Union Pacific Corp. (UNP.N)	E (03/23/2020)	$227.21
United Parcel Service (UPS.N)	U (02/23/2016)	$214.78
US Xpress Enterprises Inc (USX.N)	O (07/09/2018)	$10.73
Werner Enterprises (WERN.O)	O (02/23/2016)	$47.85
XPO Logistics, Inc. (XPO.N)	E (02/19/2019)	$144.35

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Aerospace

COMPANY (TICKER)	RATING (AS OF)	PRICE* (05/06/2021)
Kristine T Liwag		
Boeing Co. (BA.N)	O (01/29/2021)	$229.81
Raytheon Technologies Corp (RTX.N)	O (09/07/2020)	$84.68
Spirit AeroSystems Holdings Inc (SPR.N)	O (03/01/2021)	$44.23
TransDigm Group Inc. (TDG.N)	O (09/07/2020)	$599.04

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Defense

COMPANY (TICKER)	RATING (AS OF)	PRICE* (05/06/2021)
Kristine T Liwag		
General Dynamics Corp. (GD.N)	U (09/07/2020)	$192.68
L3Harris Technologies Inc (LHX.N)	O (09/07/2020)	$216.99
Lockheed Martin Corp (LMT.N)	O (09/07/2020)	$387.34
MDA Ltd (MDA.TO)	E (04/27/2021)	C$15.72
Northrop Grumman Corp. (NOC.N)	O (09/07/2020)	$370.05
Textron Inc. (TXT.N)	E (09/07/2020)	$67.31

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* Historical prices are not split adjusted.

INDUSTRY COVERAGE: Aerospace & Defense

COMPANY (TICKER)	RATING (AS OF)	PRICE* (05/06/2021)
Adam Jonas, CFA		
Virgin Galactic Holdings Inc (SPCE.N)	E (02/01/2021)	$19.18

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