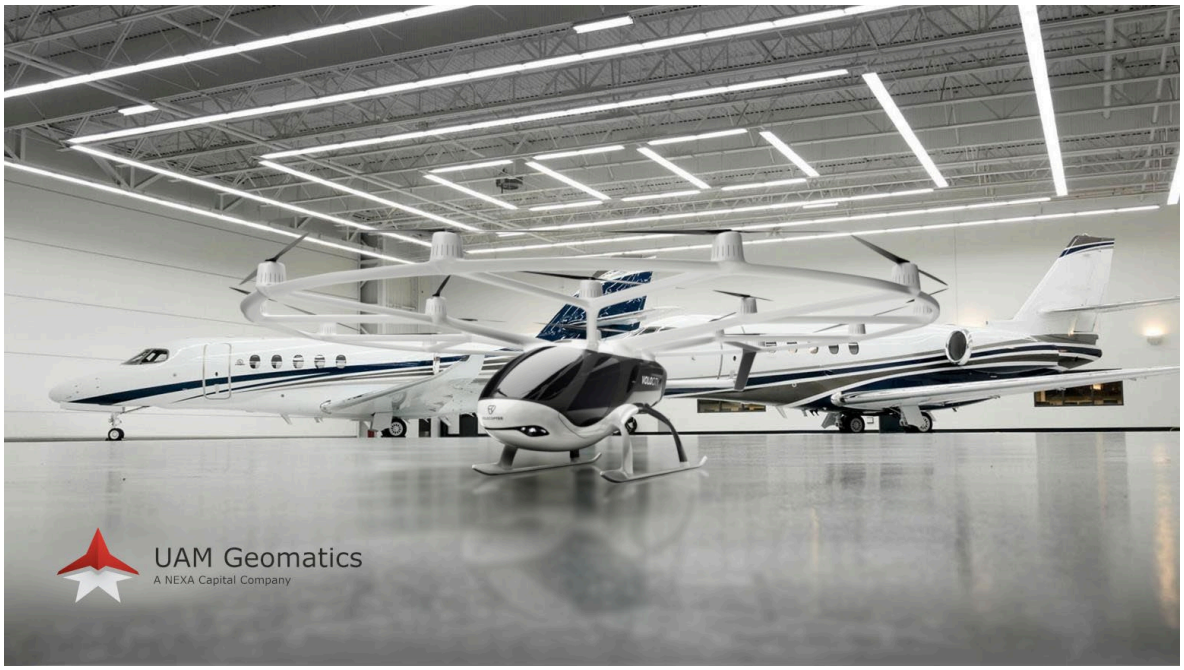
# UAM Study Prospectus

## For New Subscribers

Spring 2020




## New Update Spring 2020

# Urban Air Mobility -

## Economics and Global Markets

**Detailed and Actionable Forecasts for**
**75 Metropolitan Areas: 2020 – 2040**

**Information and Analysis for Infrastructure and Corporate Investors**

UAM Geomatics, inc.
A NEXA Capital Company

# Six Benefits of Subscribing:

## *Interpreting Investment Opportunities*

Where should a company or financial institution make strategic investments in the rapidly growing, constantly changing UAM industry? Which opportunities will pay off sooner rather than later? Which cities and countries will be leaders in the field, and which will be latecomers? Which technologies and business models will yield early and substantial returns on investments? In an industry beset by many unknowns, the UAM Market Study is designed to help your company make wise investment choices.

## *Recognizing Infrastructure Needs*

New Infrastructure will be key to UAM viability: vertiports, UATM infrastructure services, passenger facilities, lighting and weather systems, airspace planning, and certification. How much will this cost? How many vertiports will each city require in the next five to twenty years and how will they be phased in? How much existing infrastructure—such as helipads and heliports—already exists in each city? Where will new vertiports be built? Who will pay for infrastructure, and how will investors recoup their investment?

## *Understanding UAM Obstacles and How to Overcome Them*

Before investing in any aspect of UAM, the prudent investor must understand obstacles in the path of a large-scale production and even city-wide operation. Technological developments, such as vehicle design, longer-lasting batteries, and hydrogen cells, are just one concern. How will the burgeoning UAM industry deal with regulatory barriers, safety issues, noise concerns, privacy matters, and public perception?

## *Distinguishing First UAM Users*

Who will first fly eVTOL aircraft? We take a hard look at the transitioning of current helicopter routes to eVTOL aircraft, emergency/medical rescue, business aviation, airport to airport shuttles, and knowledge essential to any UAM business development strategy.

## *Advantages for City Managers and Economic Development Agencies*

Before cities agree to provide the space for vertiports and regulatory framework for eVTOL flights, they must understand the social and economic advantages such as reduced congestion, jobs, new industries, and tax revenues. Our City Sponsors receive in-depth analysis of their unique urban landscape, with tailored information “content in context.”

## *Do-It-Yourself Modeling*

With over 30 data layers, our interactive city data sets allow subscribers to analyze their own investment opportunities and business case, an unparalleled tool in today’s emerging UAM market. In addition, sponsors may request information on specific areas of particular interest. Our data sets will be constantly updated and available to subscribers without further cost for the next 5 years.

## *Our Goal? To Accelerate Investment into UAM Markets.*

This report has been researched and written to accelerate investment into UAM markets. City by city. For infrastructure funds, vehicle manufacturers, CNS/ATM developers and most importantly, future eVTOL operators serving the flying public.

# About the Underwriting Sponsors

**UAM - Economics and Global Markets** is a joint undertaking by respected aerospace industry organizations, researchers, big data miners, publishers and financial advisors. The comprehensive work herein requires the deep expertise that these organizations enthusiastically bring together. The lead underwriting sponsor is UAM Geomatics, a new entity spun off from NEXA Advisors, a NEXA Capital company with a well known record performing "Multi-Client" research for the aerospace sector.










Version 3, printed January 24, 2020

**For Further Information please contact:**

**Eleanor Herman**
Principal Editor
UAM Geomatics, Inc.
Tel: 202-499-5056
Email: eleanor@nexaadvisors.com
Web: www.nexaadvisors.com

**Michael Dyment**
Managing Partner
NEXA Capital, LLC
Tel: 202-321-0389
Email: michael.j.dyment@nexacapital.com
Web: www.nexaadvisors.com

# UAM Study Prospectus - Table of Contents

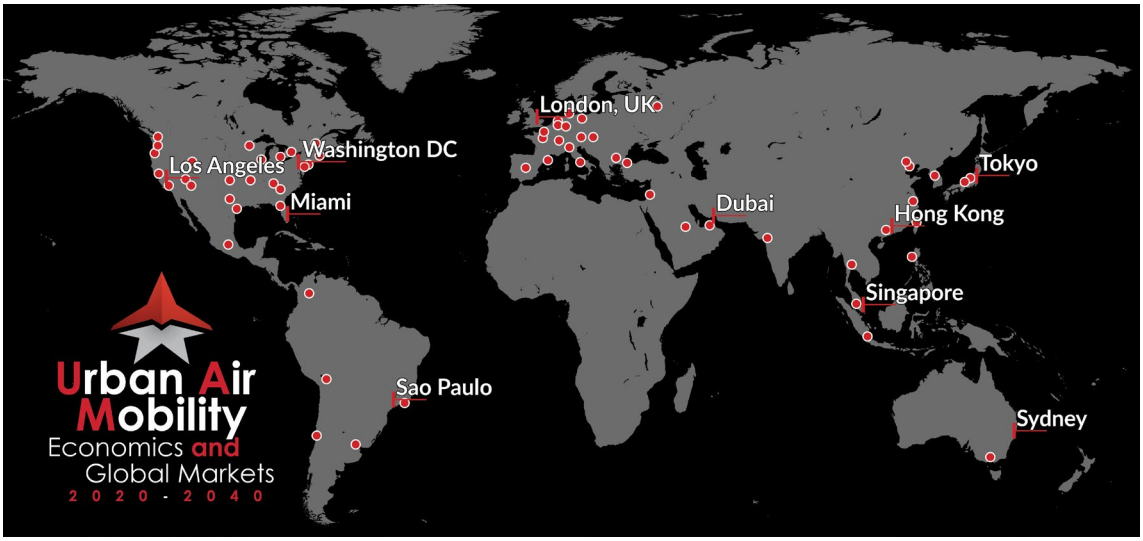
# EXECUTIVE SUMMARY

**We can imagine** cities of the future and clearly see Urban Air Mobility. This Study is a ground-breaking investigation into how the future meets the present. How does our society transform urban mobility from the now—the astonishing electric vehicle prototypes, the conferences and summits, the thousand-and-one speculations—into that future of highways in the sky, the future we clearly know is on the way? It is a crucial question, not just for societal benefits—reduced congestion, greater mobility for those who require it, new technical jobs, and tax revenues—but also because tens of billions of investment dollars are riding on it.

This Study has found the answer, and it is… Well, the answer is that it depends on the highly distinctive characteristics of urban areas themselves. Because each metropolitan area has a unique DNA, a complex blend of current transportation issues, congestion, population density, airports, transportation infrastructure, regulation, business aviation, GDP, local politics, per capita income, and a host of other factors that contribute to the likelihood of it being an early or late user of eVTOL aircraft. We haves analyzed 75 cities around the world and found that despite the many differences, even the smallest cities will eventually create sustainable and profitable UAM services for their communities.

Those cities who will become UAM early birds possess significant existing UAM infrastructure: heliports, which can be rapidly retrofitted for UAM. Curiously, UAM infrastructure is often overlooked by industry studies and the aviation press, who understandably concentrate on the breathtaking variety of eVTOL designs rather than slabs of concrete. Yet even the most advanced vehicles aren't much use without a place to take off and land. When attempting to discover heliports in the US and around the world, the authors of this Study found an appalling lack of accurate information. Using a program called ArcGIS, along with the world's most advanced satellite imagery, we zoomed into 75 cities and individually counted them, more than 4,267 of them, assessing some US$4 billion in existing infrastructure ready for remediation and retrofit.

**Urban Air Mobility - Economics and Global Markets** has been researched and written to accelerate investment into UAM markets, city by city. We offer information for decision-making, for infrastructure funds, vehicle manufacturers, CNS/ATM developers and most importantly, future eVTOL operators serving the flying public. We forecast the overall 20-year potential for the 75 cities at a value exceeding US$318 billion.



### *This Study offers 75 City Reports*

We examined detailed data on each city, including existing infrastructure to help determine each city's UAM readiness.

- Per capita GDP (PPP)
- Population density
- Mobility substitutes
- Current transportation systems – all modes
- Traveling distances among airports, city center, suburbs, etc.
- Existing heliports and airports
- Fortune Global 1000 Companies
- Hospitals

### *This Study Provides Analysis and Forecasts*

- Interactive ArcGIS maps to start UAM airspace design
- Cumulative UAM Passenger Demand Growth Analysis of each city in four phases from 2020 to 2040
- Analysis of City Readiness vs. 20-Year Projected Passenger Revenues
- UAM Readiness Analysis for On Demand Air Taxi, Regional, Business Aviation, Emergency, and Airport Shuttle
- Cumulative UAM Revenues, Market by Market Analysis for On Demand Air Taxi, Regional, Business Aviation, Emergency, and Airport Shuttle
- Total operator revenues
- Total infrastructure costs
- Total UAM traffic management costs
- Total estimated vehicle and fleet costs
- Business aviation presence
- CIMI capital human index
- Livability
- Airport Originating and Departing Traffic
- Vertiport buildout timeline

### *This Study Presents Global Findings*

- Detailed, city by city and country by country lists helicopter operators and contact information
- Business aviation fleets in each city, indicative of corporate UAM use
- Economic development contact lists for 75 cities
- Four critical supply chains:
  - UAM Ground Infrastructure Supply Chain: Who designs and builds vertiports, who can perform environmental studies, etc.
  - UATM CNS/ATM traffic Management Systems Supply Chain: Who can design airspace, who can provide geo-fencing services, where to go for UATM automation, etc.
  - UAM eVTOL Manufacturers: Which manufacturers are well along in electric eVTOL, hydrogen cell designs, Medevac capable vehicles, etc.
  - UAM eVTOL Manufacturing Supply Chain: Suppliers of electric motors, propellers, avionics systems, hydrogen fuel cells, recharging systems, etc.

### *This Study Projects Total Vertiport Infrastructure Expansion Needs*

in multiple phases from 2020-2040:

- Remediation of existing heliports
- Unserviced Vertipads
- Serviced Vertiports
- Urban Multiports
- Urban Multiports (Electrified/Fuel)
- Airport Multiports
- MegaPorts

# URBAN AIR MOBILITY - ECONOMICS AND GLOBAL MARKETS STUDY OBJECTIVES

As Aerospace Companies rush to develop products and services for the next frontier in transportation - urban air mobility - very few executives or investors know the business case. Cities also want to attract new forms of transportation for improved livability, job creation and economic development. **UAM - Economics and Global Markets** will give these decision-makers the information they need to make appropriate investment decisions.

## *Overview*

Air transportation provides a service highly favored by a global economy: mobility. Assets have to move. Information, people, knowledge, capital, resources—in a global economy, everything has to flow, from one site to the next, one market to the next, one organization to the next, one country to the next. For a company's most important asset—its people—mobility typically means air travel. For the people who make business work— executives, engineers, customers, suppliers, and specialist teams—the quality of that mobility impacts their success navigating the global economy.

The final frontier in air mobility remains urban centers, long captive to heavily congested surface transportation from automobiles, buses and mass rail transit. Never sitting still, driverless autos promise to further cripple areas where congestion is already a plague.

Rapid development of enabling technologies including miniaturization of power systems, lighter weight batteries, powerful electric motors, automation and artificial intelligence-based control systems are helping make the jump to urban shuttle services and urban air taxis using "electric vertical take off and landing" (eVTOL) craft. The revolutionary concepts and

There is currently a yawning gap of market and economic intelligence in the rapidly evolving urban air mobility sector. **UAM - Economics and Global Markets** answers these critical questions (and much more) for investors:

- What is the outlook for 75 of the largest UAM metropolitan areas globally, and what market, technology and financial issues will individually define market success?
- What is the expected size of UAM markets over the next 20 years, but especially the next 5? Which cities are attractive bets?
- What are the key drivers that are absolutely essential for UAM market expansion?
- City by city, what is:
  - The passenger demand for price elastic **airport shuttle**, **on demand air taxi** and **regional (200 mile)** UAM services?
  - The outlook for less elastic market segments including **business aviation** and **emergency services**?
  - The cost and timing to deploy infrastructure, including vertiports, new airport facilities, and UATM?
  - The size and type of vehicle fleets that can begin to serve this demand?
  - The needed interface between UAM operators and other surface mobility modes such as on-demand ride hailing services?

Figure 1 – Critical Questions are Answered

systems in development today have the potential to transform our modern world, boosting the livability of our cities, and improving our way of life. This new wave in aviation brings to mind the last such leap, some ninety years ago, when aviation consisted almost solely of military and mail planes, and visionaries such as the Guggenheim family wanted to develop the first passenger airlines. The path was strewn with fierce resistance in many circles. Obstacles included funding, political, regulatory and safety issues. Similar barriers stand in the way today, and must be resolved for aviation to take the next leap to Urban Air Mobility.

**UAM - Economics and Global Markets** performs the heavy lifting. It provides comprehensive opportunity assessments of UAM markets in 75 urban centers and countries within each of ten UNSD regions (Figure 2). Of tremendous value, the report lays out the new economics of UAM finance. This study is a must-have for top executives, providing the factual foundation for answering key questions to support their strategic decision-making.

## UAM Market Segments

To improve the fidelity of our findings, we examined various operator market segments with different passenger demand and cost assumptions. Our analysis places the 20-year revenue opportunity for the five markets below at just over $244 billion.

### Airport Shuttle Services

Tying city centers to airports will become a high-value application of UAM. This Study examined specific airport infrastructure needs and costs. A well-run airport will be looking towards capitalizing UAM

| Rank | City | (B) GDP in mil PPP | Rank | City | (B) GDP in mil PPP |
|---|---|---|---|---|---|
| 1 | Tokyo | $ 1,616,792 | 39 | Phoenix | $ 207,065 |
| 2 | New York | $ 1,403,463 | 40 | San Diego | $ 202,490 |
| 3 | Los Angeles | $ 860,452 | 41 | Vienna | $ 183,712 |
| 4 | Seoul | $ 845,906 | 42 | Manila | $ 182,842 |
| 5 | London | $ 835,658 | 43 | Melbourne | $ 178,392 |
| 6 | Paris | $ 715,080 | 44 | Abu Dhabi | $ 178,256 |
| 7 | Osaka-Kobe | $ 671,295 | 45 | Rio de Janeiro | $ 176,630 |
| 8 | Chicago | $ 563,188 | 46 | Lima | $ 176,447 |
| 9 | Moscow | $ 553,318 | 47 | Baltimore | $ 173,747 |
| 10 | Rhine-Ruhr | $ 485,218 | 48 | Kuala Lumpur | $ 171,772 |
| 11 | Houston | $ 483,184 | 49 | Santiago | $ 171,436 |
| 12 | Washington, DC | $ 442,212 | 50 | Barcelona | $ 171,032 |
| 13 | Sao Paulo | $ 430,510 | 51 | Denver | $ 169,737 |
| 14 | Hong Kong | $ 416,047 | 52 | Riyadh | $ 163,476 |
| 15 | Dallas-Fort Worth-Arling | $ 412,674 | 53 | Rome | $ 163,243 |
| 16 | Mexico City | $ 403,561 | 54 | Hamburg | $ 161,437 |
| 17 | Singapore | $ 365,928 | 55 | San Jose | $ 160,339 |
| 18 | Nagoya | $ 363,751 | 56 | Bogota | $ 159,850 |
| 19 | Boston | $ 360,110 | 57 | Portland | $ 158,544 |
| 20 | Istanbul | $ 348,721 | 58 | Berlin | $ 157,706 |
| 21 | Philadelphia | $ 346,455 | 59 | Montreal | $ 155,905 |
| 22 | San Francisco | $ 331,024 | 60 | Tel Aviv | $ 153,297 |
| 23 | Taipei | $ 327,295 | 61 | Mumbai | $ 150,853 |
| 24 | Jakarta | $ 321,315 | 62 | Charlotte | $ 140,923 |
| 25 | Amsterdam | $ 320,600 | 63 | Tampa | $ 130,314 |
| 26 | Buenos Aires | $ 315,885 | 64 | Vancouver | $ 109,805 |
| 27 | Milan | $ 312,108 | 65 | Nashville | $ 94,968 |
| 28 | Bangkok | $ 306,765 | 66 | Las Vegas | $ 93,858 |
| 29 | Atlanta | $ 294,420 | 67 | Dubai | $ 82,867 |
| 30 | Toronto | $ 276,313 | 68 | Salt Lake City | $ 73,836 |
| 31 | Seattle | $ 267,473 | 69 | Raleigh-Durham-Chapel H | $ 69,302 |
| 32 | Miami | $ 262,697 | 70 | Reno | $ 49,634 |
| 33 | Madrid | $ 262,335 | 71 | Toulouse | $ 47,384 |
| 34 | Brussels | $ 254,327 | 72 | Geneva | $ 43,980 |
| 35 | Sydney | $ 223,413 | 73 | Syracuse | $ 40,576 |
| 36 | Munich | $ 219,943 | 74 | Wichita | $ 33,840 |
| 37 | Minneapolis-St. Paul | $ 211,398 | 75 | Plovdiv | $ 10,995 |
| 38 | Detroit | $ 207,538 | | | |

Figure 2 - Detailed Examination of 75 Cities

to maximize the utility and convenience of its facilities. Airports are the logical point of ingress for eVTOLs into an urban transportation network.

The ArcGIS data sets permit city-by-city modeling of a reasonable number of network nodes the airports could be serviced from/to.

### On-Demand Air Taxi Services

On-demand air taxi services have the potential to radically improve urban mobility. The time lost in daily commutes, or getting from one location to another, is substantial. According to Uber Elevate, just as skyscrapers allowed cities to use limited land more efficiently, urban air transportation will use three-dimensional airspace to alleviate transportation congestion on the ground. A network of small, electric aircraft that take off and land vertically should enable rapid, reliable transportation between suburbs and cities and, ultimately, within cities.

The ArcGIS data sets permit analysis of the development of infrastructure—vertipads and vertiports—to support an urban VTOL network, proving the case that cost-effective new facilities will likely have significant cost advantages over heavy-infrastructure approaches such as roads, rail, bridges and tunnels. As costs for traditional infrastructure options continue to increase, the lower cost and increased flexibility provided by new approaches may provide compelling options for cities and states around the world.

### Corporate Campus Services

**UAM - Economics and Global Markets** carefully dissects and studies how a new branch of business aviation will quickly emerge, driven by the same mobility value formulas that sustain the $150 billion global opportunity represented by organizations such as the National Business Aviation Association and the General Aviation Manufacturers Association.

The world's most successful companies use business aviation for a variety of reasons. Top executives—whose every minute counts—benefit from time savings and improved productivity. Additionally, business aviation offers strategic transaction acceleration, the protection of intellectual property, increased personnel retention, and improved customer relations. The past five years have seen a 34 percent increase in business aircraft operations globally, and experts estimate that flight hours will double over the next 20 years.

Business aviation users, while reaping advantages traveling from one airport to another in their own aircraft, are still stranded on congested roads along with everyone else to and from their airports. The BA community, with funds already earmarked for efficient travel, will be a major early user of UAM. The nation's most important corporations will own their own UAM vehicles for quick trips over jammed roads from downtown offices to the airport where their jets are waiting and, upon arriving at their destination airport, will use another UAM to fly quickly and efficiently to the site they are visiting.

### Regional Air Transport Services

Some manufacturers of eVTOLs are investing in hybrid vehicles that have the ability to gain altitude from a vertiport under electric power, and transition to vertical flight using lift from fixed wings. Powering and recharging batteries using small jet turbine generators while at altitude, these vehicles will have the range and capability to fly point-to-point from one city to another, but using the new UAM infrastructure available at thousands of approved heliport/vertiport locations forecasted in our analysis. A strong preference for short inter-regional travel, (such as DC to Baltimore, LA to San Diego, or San Francisco to Sacramento) finds new demand that airlines cannot serve.

Numerous studies (e.g. Doc 3 BAH) find that using UAM for short inter-regional trips rather than intercity, make time-saving sense. Regional air transport using eVTOLs is also potentially disruptive to today's commercial air transport model.

### Medical and Emergency Operations and Services

An estimated 400,000 patients are transported by rotor wing aircraft every year in the United States alone. These flights comprise a large part of an urban area's daily helicopter operations. But 54 percent of Medivac flights in the US are simple inter-facility transports.

These hospital-to-hospital ferry flights originate and terminate on well-established helipads that would be early candidates for the new generation of eVTOL

aircraft. These ferry operations are also likely candidates for early adoption due to the tremendous amounts of flight information gathered over the thousands of trips previously conducted by helicopter pilots along the exact route.

The benefits of using new eVTOL aircraft, including significantly lower energy (fuel) and maintenance costs, would immediately be seen in these operations. In addition, the low noise and emissions characteristics of eVTOL aircraft make them well suited to serve hospitals located is densely populated areas.

Traditional Medivac flights cost hospitals, (as well as patients, insurance companies and government healthcare providers) thousands of dollars. The average Medivac services today in the U.S. cost on average US$25,000 per flight. Comparatively, an eVTOL alternative would save financially strained hospitals and healthcare systems millions of dollars.

The introduction of advanced avionics and autonomous technology on eVTOL aircraft and sophisticated ATM systems will help improve Medivac aircraft safety and reliability. Nearly 50 percent of all emergency personnel killed on the job in the United States die in Medivac crashes. These new systems would allow for safer flight operations in a wide range of terrain and weather conditions, as well as reducing the hazards associated with landing at an unprepared site to pick up a patient requiring urgent medical attention. Cutting-edge sensors will allow for obstacles in the landing zones and enroute to be detected and avoided.

Response times would also see a dramatic drop when autonomous flights are introduced after collecting data from thousands of Medivac flights. A vehicle could take off within seconds to respond to an incident. Additionally, the public will more readily accept the introduction of UAM for life-saving operations.

## *New Infrastructure Will Be Key to UAM Viability*

UAM infrastructure to support eVTOL operations will become an important enabler to sector success. **UAM - Economics and Global Markets** places significant attention on this association and has estimated the need for new infrastructure in the range of $32 billion. As with other forms of transportation, UAM has specific infrastructure needs, which will also drive economic development and business investment. Our research has shown that this is even more significant in global economies where economic opportunities have been increasingly related to the mobility of people, goods and information. A relation between the quantity and quality of transport infrastructure in urban areas and the level of economic development is apparent. High density transport infrastructure and highly connected networks are commonly associated with high levels of economic growth, market development, and GDP output.

UAM infrastructure costs are a major part of this Study, as they are necessary for a viable ecosystem to be able to sustain itself. We have estimated, for each of 75 metropolitan areas, the entire life cycle costs for sustainable operations. Beginning with the estimate that a single vertiport platform can be built for $500,000, other cost elements include UTM infrastructure service, passenger facilities, lighting and weather systems, airspace planning, and certification cost.

Urban air mobility can provide a wide swath of benefits covering consumers and businesses, and supply chains dependent upon logistics. **UAM - Economics and Global Markets** identifies the requirements and costs for densely placed heliports and vertiports in each of the 75 urban areas, as well as those suburban and exurban areas that will benefit from improved linkages within and between nodes. Importantly, airport elements are identified at commercial, business and general aviation airports, and at seaports and rail merge points.

### Heliports and Vertiports

The development of infrastructure to support an urban eVTOL network should have significant cost advantages over traditional transportation infrastructure, in a day and age when bridges, subways, and highways cost many billions of dollars. Uber Elevate proposes that building rooftops, repurposed tops of parking garages, existing helipads, and even unused land surrounding highway interchanges could form the basis of an extensive, distributed network of “vertiports” (eVTOL hubs with multiple takeoff and landing pads, as well as charging infrastructure) or single-eVTOL “vertistops” (a single pad with minimal infrastructure). As costs for traditional infrastructure

options continue to increase, the lower cost and increased flexibility provided by these new approaches may provide economically viable low-cost options for cities.

Vehicle charging systems will become essential public infrastructure in the future world of UAM. Electric air vehicles will need to move off the landing pad at vertiports to accommodate other eVTOLs if they also need to recharge, or if another passenger trip isn't already scheduled. However, as reported by Uber Elevate studies, if energy is sufficient and if passengers are ready, then the eVTOL will only stay on the pad long enough to deplane and enplane passengers. Achieving a minimum turnaround time may be important to achieve high vehicle productivity. Batteries will need to be recharged or swapped between flights to achieve maximum utilization. The infrastructure to satisfy this requirement poses many questions dependent upon factors such as the vehicle in service, vehicle mix, space adjacent to operations and other things. **UAM - Economics and Global Markets** analyzes these factors closely in its market and economic analyses.

### UTM Traffic Management Infrastructure

UAS traffic management systems necessary to safely sustain Urban Air Mobility are being studied today by NASA and a collection of the world's most capable system integrators. UTM solutions will provide the same functionality of air traffic control systems at higher altitudes. Under current systems, the air traffic controller can effectively talk to about 15 aircraft at a time. The number of eVTOL aircraft projected to be making daily flights will quickly surpass this capacity.

Another component of required infrastructure is a buildout of higher precision tracking systems that work in low-altitude urban environments. These systems must accommodate simultaneous and instantaneous tracking of a high number of aircraft flying in close proximity to one another and to buildings. With the emergence of urban drone usage, separation between the two will be critical.

### eVTOL Capable Airport Infrastructure

An essential early use of UAM will be connecting city centers with airports. Our Study has analyzed the needs and costs to equip airports for UAM services. Early on, airports will be the only locations with ATM systems required for low volume flights. However, as UAM becomes more prevalent, airports will be required to build out vertiport facilities, battery charging stations, and people moving systems, as well as isolating the UAM activity from, and integrating passenger flow, with conventional airport operations.

## *Aerospace Manufacturing as the Economic Engine Driving UAM*

According to the venerable Teal Group[1], the global aerospace industry was worth a staggering $838 billion in 2017. The various sectors, with aircraft and engine OEMs accounting for 28 percent of activity, and aircraft systems and component manufacturing coming in at 25 percent.

### Developers of eVTOLs and Hybrid Vehicles

Currently about 100 companies are developing eVTOL for commercial or personal use. Vehicle design types include multirotor, ducted fan, fixed wing with rotors, vectored thrust, and others, mostly with all electric or hybrid-electric propulsion systems. All vehicles designed for UAM are capable of vertical takeoff and landing, or eVTOL, to ensure suitability for helipads and dense urban environments. Most vehicles aim to seat 2-6 passengers and come in various configurations, with some designs opting for a modular build that allows for greater flexibility among travel needs. Vehicles can satisfy distances as short as 10 miles, but many can accommodate longer distances in the hundreds of miles on a single journey or battery charge.

Manufacturers range from established aerospace manufacturing companies like Boeing and Airbus, to automotive companies like Aston Martin, to start-ups like XTI Aircraft or Vickers, and even government agencies like NASA and DARPA. Many manufacturers do not plan on operating their UAM vehicles at scale but aim to become part of a larger UAM ecosystem, such as the Uber Elevate initiative. This

[1] ***The Global Aerospace Industry – Size and Country Rankings***, The Teal Group, Fairfax, VA, USA, July 16, 2018

diversity in manufacturers and in vehicle designs adds complexity to the UAM ecosystem from a supply chain and technological governance standpoint, furthering the need for standardization of UAM concepts and specifications.

**UAM - Economics and Global Markets** provides detailed analysis of the anticipated UAM applications and opportunities vehicle developers are driving toward. In particular, the study team has examined, by vehicle development maturity level:

- Vehicle performance characteristics by market application (and customer type)
- Technology strengths and dependencies
- Special supply chain and support needs

The results are presented to inform potential operators and other customers of near-term partnering opportunities.

### eVTOL Supply Chain

Advances in aerospace technologies and manufacturing have allowed for the possibility of UAM to happen at scale, and there remain supply chain challenges and high barriers to entry for aerospace manufacturing.

The UAM supply chain will include third party suppliers of motors, batteries, flight control systems and other eVTOL technology. This supply chain is a new aerospace business opportunity. Because electric propulsion is new, the OEMs will probably play a much greater role in maintenance, repair and overhaul (MRO) of new eVTOL fleets. New MRO support methods and on-board diagnostics systems will ensure high UAM aircraft dispatch, reliability, and on-time performance.

Those UAM vehicle manufacturers without existing aerospace manufacturing capabilities or infrastructure are at a disadvantage, pressured to produce aircraft with revenues generated from pre-sales and/or investor capital. Their development strategies often require proprietary processes, material sourcing, or strategic subsidies to remain economically viable while prototypes are being produced, tested and certified. If they can survive the initial research and development cycle to produce a fully-certified and economical aircraft, they should begin to benefit from economies of scale. This landscape is studied in detail in **UAM - Economics and Global Markets.**

Operators of eVTOL fleets will need to support them to the highest safety level possible, and likely in accordance with regulations including FAR 121, 135, 145 or their equivalents. The analysis of such supply chain capabilities are an important part of **UAM - Economics and Global Markets.**

### Electric Propulsion is Key

If the future were a color, it would be green. Cities already struggling with poor air quality will only welcome urban air vehicles with minimal emissions. Currently, transportation emissions represent the largest source of U.S. greenhouse gas emissions, some 28.5 percent, or more than 1.8 billion metric tons. Over 90 percent of the fuel used for transportation—cars, trucks, buses, ships, trains, and planes—is petroleum based. Currently, aviation fuel is the largest source of U.S. lead emissions. Electric propulsion promises a significant reduction in maintenance costs and energy costs (fuel) resulting in direct operating costs that are up to three to four times less than today's small aircraft and helicopters. Additionally, each short UAV trip will remove one or more gasoline-powered, ground-based vehicles from the roads for a more significant time period.

Some of the problems with all-electric flight are nearing their solution: Instruments, wiring and monitors are becoming smaller every year, while materials to build interiors, like carbon fiber, are lighter yet stronger. Other factors are somewhat behind these: higher powered electric propulsion systems are still too heavy to use in large passenger or freight aircraft.

NASA has been at the forefront of electric propulsion research for UAM operations and has shared extensive amounts of technical data from its X-57 Maxwell project, an all-electric propulsion experimental research plane, for UAM manufacturers to study and use. NASA has already begun working with regulators to determine how electric propulsion systems for UAM can best be certified by the FAA. The analysis of such supply chain capabilities is an important part of **UAM - Economics and Global Markets.**

### Batteries and Charging Systems

A major component of the hybrid-electric or all-electric propulsion systems for UAM vehicles is the batteries and charging systems that will power flight on individual trips and throughout the day. While electric vehicle batteries have made significant strides over the past decade and benefitted from research and development expenditures from major auto manufacturers like GM, Ford, Toyota, Nissan, and most notably, Tesla, there are still concerns about the cost of operation, speed of charging, cost of replacement, and raw materials required to make electric batteries at scale efficient from both cost and operational standpoints.

Increases in range for electric vehicle batteries can alleviate some of the concerns for operators, but they still face decisions on how to best implement the battery technology: should batteries be replaced on vehicles as they lose charge, or should they be tied to individual aircraft and re-charged like current electric cars?

Particularly exciting are recent Department of Energy (DOE) investments which support eVTOL priorities. The DOE Battery 500 project is spending $50 million over the next few years to develop high capacity batteries and chargers. This collaboration between DOE labs and universities is focusing on lithium-metal batteries, overseen by an industry panel board including Tesla, IBM, and PNNL to ensure manufacturable solutions. If new cost thresholds can be achieved, the cycle life would be highly acceptable.

Trends in battery development and timelines for availability of nascent but promising technologies are carefully analyzed in **UAM - Economics and Global Markets.**

## *UAM Passenger Demand Modeling*

**UAM - Economics and Global Markets** carefully examines the implications and the business case support for UAM tied to specific urban populations, mobility factors and benefitting industries. According to the United Nations, in 2018 some 55% of the world's population lived in urban areas, a proportion that is expected to increase to 68% by 2050. The urban population of the world has grown rapidly from 751 million in 1950 to 4.2 billion in 2018.

Projections show that urbanization, the gradual shift in residence of the human population from rural to urban areas, combined with the overall growth of the world's population, could add another 2.5 billion people to urban areas by 2050, with close to 90% of this increase taking place in Asia and Africa. Future increases in the size of the world's urban population are expected to be highly concentrated in just a few countries. Together, India, China and Nigeria will account for 35% of the projected growth of the world's urban population between 2018 and 2050. By 2050, it is projected that India will have added 416 million urban dwellers, China 255 million and Nigeria 189 million. The final frontier in last-mile mobility remains urban centers, and with slowing investment in roads and rail, these centers are experiencing heavily congested surface transportation from automobiles, buses and mass rail transit.

Figure 3 summarizes factors we took into consideration when analyzing city-by-city UAM passenger and urban air service demand for price-elastic markets. Many factors provided data or context for our projections, such as per capita city income, air service affordability, transportation substitutes, congestion, cost of living and educational levels. Applied through the lens of economic theory, and then adjusted by constraints, each city yielded a separate demand elasticity model for urban air passenger growth assessed for future promise.

| | Demand Input | Demand Input Description |
|---|---|---|
| **1** | Airport O/D Traffic | The Airport O/D input weighted cities according to the level of originating and departing passenger traffic. The total commercial passenger "Enplanement" traffic was gathered for all active airports within the wider city metro areas. A tier was then found for each city to determine how much of the passenger traffic was originating to or departing from the city, eliminating connecting traffic. Further data on average ticket prices and business traveler concentration were used. |
| **2** | Mobility Substitutes | The Mobility Substitutes input ranked a city's willingness to accept a new UAM transportation option. The rank was derived from five scores, all weighted accordingly, including on-demand taxi cost, public transport cost, vehicle ownership cost, electricity and gas cost. The higher the cost (except for electricity), the better the city scored for the new UAM services. |
| **3** | Per Capita GDP | The per capita GDP (PPP) input weighted cities according to the most up-to-date gross domestic product (PPP) of each city. |
| **4** | Distances and Congestion | The Distances and Congestion input weighted cities according to average traveling distances. The rank was derived from ranking the distance from the main airport to the city center, and the total area of the city itself. The higher the congestion, the greater weight this factor played. |
| **5** | CIMI Human Capital Indicator | The CIMI Human Capital input weighted cities according to the human capital indicator of the IESE Cities in Motion Index (CIMI), 2019. The CIMI comparatively analyzed 174 different cities. The human capital score was derived from 10 different factors, including higher education levels of the population, available universities, and per capita expenditure on education. |
| **6** | Population Density | The Population Density input weighted cities according to their density and proximity to city employment areas. The gravity model determined how likely the factor was able to influence UAM demand. |
| **7** | Livability | The Livability input ranked cities according to its livability, focusing on disposable income. The costs of living in each city was derived from Expatistan.com, and then inversed. That rank was combined with the average monthly net salary (after tax) of each city, and the two scores were averaged together. The higher the salary and the lower the cost of living, the higher the cities were ranked for UAM usage. |
| **8** | Fortune 1000 Presence | The Fortune Global 1000 Corporations input weighted cities according to commercial business environment. To determine the importance of this factor on passenger demand, we identified the total count, total enterprise value, and total employees of Fortune Global 1000 company headquarters. The three scores were ranked and averaged to influence UAM usage. |
| **9** | Business Aviation Activity | The Business Aviation arrivals/departures input weighted cities according to their business aircraft arrivals and departures. The data was derived from multiple sources and databases. Business aviation fleets were considered through JETNETS registrations. |
| **10** | Existing Heliports and Fleets | The Existing Heliports input weighted cities according to their sunk investment in heliport infrastructure. The best available data for heliports is considerably inaccurate, so UAM Geomatics proprietary data and research tools were developed and used to increase the accuracy. |

Figure 3 – Demand Elasticity Model Selected Drivers

### Traffic Management Systems

There is perhaps no greater complexity of the proposed UAM ecosystem than that of traffic management at scale across cities. Unmanned Aircraft System Traffic Management governing low altitude airspace will be crucial to ensure the safety of all participants and residents of urban areas. UTM must consider not only the UAM vehicles, but other commercial and civilian drones, commercial aircraft, business and general aviation aircraft, emergency response aircraft, and anything else that could occupy low altitude airspace, as well as weather conditions and large-scale events.

Beyond visual line of sight (BVLOS) flight, aircraft communications and surveillance, aircraft security, the buildout of infrastructure, and heliport capacity management are all challenges UTM must address as well. Many experts believe that artificial intelligence will be used to autonomously solve these problems as they arrive and plan UAM travel to a degree that solves or minimizes many issues, in ways similar to how air traffic control handles commercial aviation. NASA is currently undertaking an extensive study into UTM, going through four "Technological Capability Levels" (TCL) of increasing complexity with industry and academic partners, detailing their research results with the expectation of handing them over to the FAA in late 2019 for further testing.

**UAM - Economics and Global Markets** extensively reviews and analyzes options for developing (and funding) UTM at the national and metropolitan levels, with due consideration to ideas and models that delegate capability from the central to the vehicle level.

## *UAM Infrastructure Investment*

One of the biggest questions surrounding the various UAM initiatives around the world is who will pay for extensive infrastructure needs. On the ground, there is the need to build heliports – places where mass passenger exchange can take place – as well as the need for additional localized helipads and drop-off/pick-up vertiports in dense urban areas. Additionally, sensors, radars and monitoring technology will need to be installed and operated in the UAM airspace to ensure safety of passengers and residents alike.

We believe that infrastructure costs can be contained by embracing modern materials like composites, and as well, smart city approaches to transportation. Special analysis has been undertaken to treat these topics in **UAM – Economics and Global Markets.**

Yet the business case has eluded analysis. While there are many potential sources of investment – from the leaders of initiatives themselves like Uber or Airbus, to local or federal governments – a business case must be made that stands up to professional scrutiny.

Innovative financing solutions or "systems-as-a-service" funded by groups of third-party investors, including prominent investment banks and private equity firms, are possible. Each metropolitan area will need to determine its overall cost of investment, adopting its own approach to financing the needed infrastructure. **UAM - Economics and Global Markets** organizes an approach to infrastructure financing that tackles the business case and identifies the most likely sources of funding for these cases to proceed.

# URBAN AIR MOBILITY - ECONOMICS AND GLOBAL MARKETS STUDY APPROACH AND METHODOLOGY

## *Study Audiences*

**UAM - Economics and Global Markets** focuses on, and provides value to, a wide range of audiences in several industrial sectors identified as the urban air mobility ecosystem.

## *Research Methodology*

The UAM Geomatics research program is built on our years of experience supporting business investment and strategic planning for institutional investors and some of the largest aerospace companies in the world. We apply this approach to ensure that subscribers achieve a balanced view of the global marketplace and can make informed strategic decisions to reach their business and investment objectives. The method of market research chosen for **UAM - Economics and Global Markets** identifies major issues and trends in a market characterized by technological innovation, competition, industry standards, government regulation, global economic and political turmoil, public perception, and impacts from fluctuation in factors such as energy prices. We present data quantitatively so that the analysis results can be used to judge the impact of policy, finance, market and industry trends on UAM business strategies and tactics.

Our research for **UAM - Economics and Global Markets** focuses on the following dimensions:

- **Technical:** Technology and systems information that examines existing as well as emerging UAM technologies, new R&D programs, technology forecasting and supporting analysis.
- **Economic:** In-depth research focused on timely and critical global, regional and country-specific trends, including the political, demographic and socioeconomic landscapes that influence or impact UAM developments.
- **Market:** The Study provides UAM market drivers and restraints, market trends, regulatory changes, competitive insights, growth forecasts, industry challenges, end-user perceptions and strategic recommendations. Seventy-four metropolitan areas in all ten UNSD regions are included.
- **Financial and Investment:** The Study considers new capital models – engines of investment for UAM infrastructure that power opportunities in the sector by metropolitan area.

The mix of primary market research, secondary market research, and supporting analysis, is explained below.

### Primary Market Research

Primary market research included the collection and analysis of industry and market data from industry and informal expert interviews. Always an important part of our methodology, we hold these research sessions and interviews with a cross-section of academics, government agencies/ANSPs (federal, local and international), aerospace and defense experts, regulators, equipment suppliers, private/public funding and international financial sources.

### Secondary Market Research

Secondary market research includes investigations that focus on secondary sources of information, such as census data, econometric studies, technical and market literature, trade journals, syndicated databases, etc. Topics of relevance in the international context were analyzed by user or industry benefits, with the most detailed data summarized.

- **Syndicated Data Sources:** Secondary research sources are varied and rich in facts as they pertain to all aspects of the global UAM markets and industries. Critical to this part of the research is the participation of **Aviation Week Network**, which owns some of the industry's largest and deepest databases exist. Also, **JETNET** offers one of the aerospace sector's most comprehensive datasets on aircraft and helicopters.

- **Physical Libraries:** We reached out to academic institutions and trade associations for studies and data that provided further clarity for our analysis. We researched the World Bank and affiliated economic repositories. In addition, we sought the latest available data from the libraries of the FAA, the U.S. National Center of Excellence for Aviation Operations Research (NEXTOR), NASA, ICAO, IATA, SESAR and other organizations whose resources are relevant.

## *Market and Economic Forecasts*

Market outlooks and forecasts are essential to provide strategic understanding of the long-term trends and perspectives within **UAM - Economics and Global Markets**. UAM Geomatics and its partners including Aviation Week Network forecast the emerging trends and global market opportunities in UAM vehicles, systems, services and infrastructure. We explored new concepts in UAM products and services, and develop future revenue forecasts. The study used econometric forecasting to determine the size, composition and probity of the markets by country and urban area.

### UAM Geomatics Toolset 1 – Analytical Forecasting Model

The analytical framework for UAM – Economics and Global Markets is presented in Figure 4 below. Key to this analysis tool are the three "Business Case" models in the center of the diagram. The tool accepts assumptions used for input drivers of each model:

- Vehicle Operators: Airport shuttle, On-Demand Air Taxi, Regional Transport, Corporate Campus to Destination, and Medical/Emergency Services
- Public Private Partnership model for urban air mobility ground infrastructure
- Public Private Partnership model for Urban Air Mobility Air Traffic Management (UATM) infrastructure

The investment thesis we use is this: in order for a city market to reach sustainable UAM revenue activities, operators and infrastructure investors must achieve profitability break-even success or as a better outcome, profitable bottom line. Passenger demand is one of the most important inputs for the model, and for this forecast, the study team carefully developed supply and demand assumptions based upon a dynamic range of elastic and inelastic ticket prices.

Some of the fundamental questions cannot be answered by standard financial and economic analysis yet remain central to the UAM business case. For example:

- Will the public embrace these new services, finding sufficient value from improved urban air mobility thus offsetting ticket prices?
- Will an extensive network operation involving dozens of vehicles flying above residential areas, generating noise and visibly daunting, find acceptance?

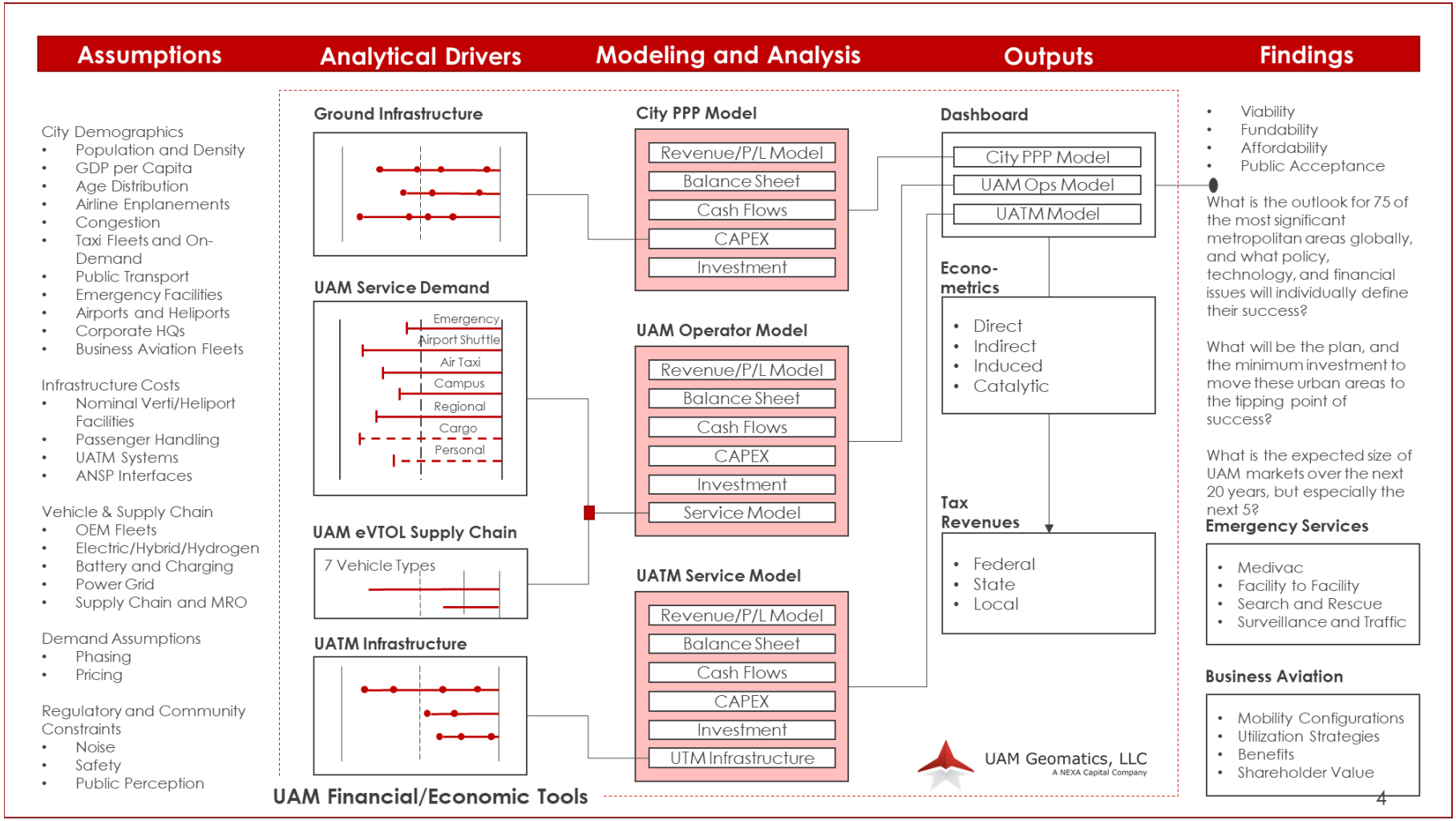



Figure 4 – UAM Analytical Toolset for Urban Air Mobility – Economics and Global Markets

## UAM Geomatics Toolset 2 – ArcGIS

ArcGIS, produced and maintained by ESRI, is a geographic information system (GIS) used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides the complete data analysis infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web. ArcGIS includes capabilities for data manipulation, editing, and analysis.

spatial data. A geodatabase is a "container" for holding datasets, tying together the spatial features with attributes. The geodatabase can also contain topology information, and can model behavior of features, such as road intersections, with rules on how features relate to one another. When working with geodatabases, it is important to understand feature classes which are a set of features, represented with points, lines, or polygons. With shapefiles, each file can only handle one type of feature. A geodatabase can store multiple feature classes or type of features within one file.


**Figure 5 – For a close look at ArcGIS layers for New York City, Click on the Link Embedded Above**

Upon entering the UAM Geomatics Web Portal (www.nexa-uam.com), individual cities can be accessed for many purposes, such as geographic relationship modeling, and further analysis of urban air mobility needs and features. Subscribers have the option of downloading the extensive geo-coded information for analysis and other needs (Figure 5).

ArcGIS is built around a geodatabase, which uses an object-relational database approach for storing

## *Most Cities have Over 30 Layers of Data*

| Layer | Description | Embedded Data Sets | Notes |
|---|---|---|---|
| **1** | Political boundaries/road networks | All features labeled, zoomable | <One meter resolution |
| **2** | Waterway boundaries | All features labeled | <One meter resolution |
| **3** | Existing heliports (registered) | Heliport ID codes, etc. | Owner data, code |
| **4** | Existing heliports (Unregistered) | Limited data | Lat/Long |
| **5** | Airports – Commercial air transport | Passenger O/D traffic | O/D and enplanements |
| **6** | Airports – General and business aviation | Business aviation fleets/operations | Registered fleets, A/D |
| **7** | Hospitals with heliports | Hospital name, address | |
| **8** | Hospitals without heliports | Hospital name, address | |
| **9** | HQ's of Fortune 1000 corporations | Company name, # of employees | |
| **10** | Major local employers | Company name, # of employees | |
| **11** | Major sports venues | Facility name, address, etc. | |
| **12** | Major shopping centers | Facility name, address, etc. | |
| **13** | Water and shipping ports | Facility name, address | |
| **14** | Major music venues | Facility name, address | |
| **15** | Military bases and airports | Facility name, address | |
| **16** | Government facilities – Federal, Local | Facility name, address | |
| **17** | Subways and Metro stations | Facility name, address | |
| **18** | Rail networks | Facility name, address | |
| **19** | High voltage transmission lines | Voltage, type (underground, etc.) | |
| **20** | High voltage substations | Street address, ownership | |
| **21** | Restricted airspace | Class A, B, C, D, G etc., special use | |
| **22** | Airspace-responsible ATM facility | ARTCC, TRACON ID, etc. | Most cities |
| **23** | Helicopter restricted airspace | Geographic fencing | |
| **24** | Phase 1 vertiport expansion model | Involves mainly existing heliports | All airports included |
| **25** | Phase 2 vertiport expansion model | User selected | Initial data inserted |
| **26** | Phase 3 vertiport expansion model | User selected | Initial data inserted |
| **27** | Phase 4 vertiport expansion model | User selected | Initial data inserted |
| **28** | Phase 5 vertiport expansion model | User selected | Initial data inserted |
| **29** | Areal drawing layer | User selected | |
| **30** | Line drawing layer | User selected | |
| **31** | Population density heatmap | | Some cities |
| **32** | Workforce employment density heatmap | | Some cities |
| **33** | Street peak hour traffic congestion | | Most cities |

# URBAN AIR MOBILITY - ECONOMICS AND GLOBAL MARKETS STUDY AUTHORS

**UAM - Economics and Global Markets** is sponsored by several of the aerospace sector's most capable and insightful analysis and market forecast companies.

## *Underwriting Sponsors*

### About UAM Geomatics

In March 2013, UAM Geomatics was spun off from NEXA Advisors to focus exclusively on Urban air Mobility. NEXA Advisors is the analytics and research subsidiary of NEXA Capital Partners LLC, an investment bank and financial advisor serving the aerospace industry. Founded in 2007, NEXA has provided structured finance services for companies and projects, from M&A to capital project financing. With expertise in aviation infrastructure, NEXA helped finance the Aireon satellite system, a billion-dollar project which used the SpaceX launch vehicles to provide global ADS-B navigation coverage. Through ITT/Exelis, NEXA arranged financing for the FAA ADS-B network, which provided the 550 broadcast stations to blanket the U.S. and serve airline and GA customers. NEXA was also the founder and sponsor of the NextGen Equipage Fund and the NextGen GA Fund, using federal loan guarantees to secure financing to accelerate NextGen equipage.

In 2018 NEXA provided consulting support and expertise to the National Aeronautics and Space Administration, to advance its commercial understanding of the long-term potential of UAM markets. Among many other topics, NEXA's team researched the investment and regulatory hurdles facing UAM and the drone sector in the United States.

NEXA's 2012 **"Air Traffic Infrastructure Global Markets 2012"** examined market opportunities for CNS/ATM and air traffic infrastructure for over 50 countries. This multi-client Study was sponsored by 20 leading aerospace companies including Lockheed Martin, Harris Corporation, Serco, Thales ATM, Rockwell Collins, Airbus and others. NEXA has also developed special analytics used to justify capital investment in business aircraft, on behalf of the National Business Aviation Association.

### About Aviation Week Network

The Aviation Week Network (AWN) is a division of Informa Inc., an information services and marketing company with decades of market intelligence experience. The Aviation Week Network is best known for its flagship magazine, ***Aviation Week & Space Technology***. A multi-channel service provider, decision engine and marketplace, with deep databases and integrated workflow tools that support action, the Aviation Week Network brings the industry the power to prevail in a challenging and fast-paced industry.

AWN's global staff of more than 50 editors and analysts delivers an unsurpassed portfolio of information products and services for all sectors of the aerospace and defense industry. The AWN provides intelligence that informs and enables the global aviation, aerospace and defense industry and provides professionals with a strategic business advantage.

### About JETNET

Business aviation is a critical dimension studied as part of **UAM – Economics and Global Markets**. JETNET researchers capture, on average, 500 major database "Research Event" changes per day, working worldwide to maintain records, spec sheets, documents, and photos for about 6,500 aircraft. Evolution Marketplace is JETNET's flagship web-based information service designed for the active researcher, dealer, broker, or financial professional. Marketplace LIVE instantly enables the UAM Geomatics team to access the crucial market intelligence needed to make well-informed decisions as urban air mobility begins its journey into the business aviation sector.

### About National Business Aviation Association

UAM has valuable potential for NBAA's 11,000 members on a number of practical levels. Specifically, it is clear that UAM could boost the efficiency of business

travelers' "final miles" – the ones employees must drive to and from airports – often, over very congested roadways – to reach their aircraft for traditional business aviation missions. NBAA well recognizes this reality: in the past year alone, the association has explored the matter in its bimonthly magazine, at its annual convention and in its focus on how congressional lawmakers are considering UAM from a policy perspective. NBAA has connected companies that are developing plans to operate UAM with business aircraft flight department leaders to discuss synergies, perceived risks/concerns, and opportunities. Through its work with NEXA in support and sponsorship of **UAM – Economics and Global Markets,** NBAA intends to continue building on the organization's thought-leadership role in this space, and the new UAM Geomatics Study offers a valuable opportunity to do so. NBAA recognizes NEXA as a leading world expert in business aviation and shareholder value creation. At a strategic level, the Study looks carefully at the implications of UAM technologies for companies relying on business aviation to meet their transportation needs.

**About Esri and ArcGIS**

Environment Systems Research Institute (Esri) was founded to help solve some of the world's most difficult problems. Esri supports its users' important geospatial work with a commitment to science, sustainability, community, education, research, and positive change. With employees in 73 countries, and 11 dedicated research centers, Esri is the global market leader in Geographic Information Systems, providing powerful software tools including ArcGIS, enabling **UAM – Economics and Global Markets** to examine urban environments with deep and enriched data. ArcGIS is UAM Geomatics' preferred platform to create, manage, share, and analyze spatial data of relevance to UAM, UTM and UAS applications.

**About Blue Raster**

Since 2002, Blue Raster has partnered at the senior level with leading global organizations, helping them share their unique stories through the powerful visual medium of interactive maps. Blue Raster makes organizational visions a reality, moving beyond dots on a map. Blue Raster works with many of the biggest global organizations and government agencies in the fields of Transportation, Urban Design, Conservation, Health, Government, Global Affairs, and Education.

Blue Raster's development and design team is comprised of experienced professionals with a wide range of expertise in web, graphic, and spatial technologies.

Blue Raster works closely with Esri, the world leader in GIS software. It has certified Esri developers on its team and its developers make regular visits to Esri's Redlands, California, campus, where they help shape future Esri products to address customer's needs.

**About Crown Consulting**

Crown Consulting, Inc. (CCI), located in Arlington, VA, features a sophisticated technical infrastructure that provides capabilities important for **UAM – Economics and Global Markets**. CCI sports an analytics laboratory with an array of simulation, modeling, and statistical tools supporting aerospace, defense, space programs (NASA), FAA and aviation clientele generally. Crown serves both private and government organizations in enhancing their performance through providing analytics, information solutions and engineering services.

## *Authors and Editorial Board*

The Editorial Board of **UAM - Economics and Global Markets** has seated three leading thinkers on aerospace trends, manufacturing and supply chain, and sector finance. The Editorial Board set the tone and direction of the editorial policy of **UAM - Economics and Global Markets**.

**Michael J. Dyment, Editor in Chief and Managing Partner, NEXA Capital Partners, LLC**

Michael is the Managing Partner of NEXA Capital Partners, an investment banking and corporate finance advisory firm. A highly experienced transportation, aero-space and defense industry consultant and trusted financial advisor to top management, he has over 40 years operational, M&A and corporate finance experience. Prior to NEXA, Michael was Senior Managing Director with Pricewaterhouse-Coopers LLP, responsible for key aerospace and

defense industry clients. He was also an Officer and Vice President of the Transportation Practice of A.T. Kearney, Inc. From 1996 to 2002 he served in the business consulting unit of Arthur Andersen LLP, where he was the global managing partner of its Aviation Industry Practice. He was an engineer at one time with Shell Exploration, developing advanced electronic and navigation systems for use in the High Arctic. Michael's work in the aerospace supply chain began with Canadian Marconi Company, for whom he was its first GPS Product Manager in 1979. He holds a Master of Science in Aeronautics and Astronautics from the Massachusetts Institute of Technology, and a B.Sc.Eng. in Geomatics Engineering from the University of New Brunswick.

**Mike Hirschberg, Contributing Editor, Executive Director of the Vertical Flight Society**

Mike Hirschberg assumed the duties of Executive Director of the Vertical Flight Society (then known as the American Helicopter Society, Inc.) on June 1, 2011, after 20 years in the aerospace industry, primarily in vertical flight. As the Executive Director, he is responsible for the execution of the strategic direction set by the Society's Board of Directors.

He represents the vertical flight technical community and advocates for the advancement of vertical flight research and technology to the executive and legislative branches of the government. Mr. Hirschberg is the publisher of all society publications, including *Vertiflite*, the *Journal of the AHS*, and the Annual Forum Proceedings.

Mr. Hirschberg was previously a principal aerospace engineer with CENTRA Technology, Inc., providing technical and program management support for over 10 years to the Defense Advanced Research Projects Agency (DARPA) and Office of Naval Research (ONR) on advanced aircraft and rotorcraft concepts. Prior to this, Mr. Hirschberg worked from 1994 to 2001 in the Joint Strike Fighter (JSF) Program Office, supporting the development of the X-32 and X-35 vertical flight propulsion systems.

He served as the Managing Editor of *Vertiflite* magazine from 1999 to 2011, and had been a contributing author since 1997. Mr. Hirschberg is an internationally-known lecturer, frequently presenting on vertical flight at short courses, meetings, conferences and universities, and is the author/co-author of more than 100 publications on helicopter, V/STOL and advanced aircraft developments, including three books.

Mr. Hirschberg holds a B.S. in Aerospace Engineering from the University of Virginia (1991) and a M.E. Mechanical Engineering from Catholic University of America (1996). He completed a Master of Business Administration at the Virginia Polytechnic Institute & State University (Virginia Tech) in 2013. He is proficient in German. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and a Fellow of the Royal Aeronautical Society (RAeS).

**Dan Hubbard, Senior Vice President, Communications, National Business Aviation Association**

Dan Hubbard joined the staff of the National Business Aviation Association (NBAA) on Dec. 1, 2004, as its new vice president, communications, and he was promoted to senior vice president in 2008. He also served as corporate secretary of the Association's Board of Directors from 2007 to 2010.

With experience in grassroots, governmental and political communications, he serves as the senior staff member providing leadership for the Association's tactical and strategic communications program. Hubbard also manages the cultivation and implementation of proactive media and press relations activities directed to NBAA Members, the aviation community and the general public.

Hubbard previously served as vice president at Fleishman-Hillard, one of the world's leading public relations firms. As the deputy director, public affairs for the firm's Washington, DC, office, he focused on

political operations, coalition building and management, crisis communications, and media relations. While at Fleishman-Hillard, much of Hubbard's client work focused policies affecting the commercial aviation and aerospace industries.

Hubbard came to Fleishman-Hillard after six years of campaign and Capitol Hill employment. In each of his capacities, his work emphasized grassroots activation and third-party validation to highlight the issue positions and accomplishments by candidates and elected officials.

In his political positions, Hubbard provided media relations support for the George W. Bush 2000 Missouri presidential primary campaign, Senator Christopher Bond's (R-MO) 1998 re-election campaign, Senator Bob Dole's (R-KS) 1996 Missouri presidential operation and Senator Sam Brownback's (R-KS) 1994 congressional campaign. Hubbard's political work concluded with his service as communications director for Senator Bond.

Hubbard holds a Bachelor of Science degree in broadcast journalism from the University of Kansas.

# URBAN AIR MOBILITY – ECONOMICS AND GLOBAL MARKETS: REPORT TABLE OF CONTENTS

Below is an abbreviated table of contents of the written report for **UAM - Economics and Global Markets**. Because our research continues we reserve the right to modify, and add to, this report and therefore, table of contents. For the latest version of the table of contents, please send an email request to administrator@nexaadvisors.com.

Note:

The accompanying web portal www.nexa-uam.com contains thousands of pages of relevant UAM Sector facts, data and information, assembled as a complement for the report itself, and easily accessible by subscribers.

# PRICE LIST AND SUBSCRIBER ORDER FORM

## *Product Descriptions*

The **UAM Economics and Global Markets** report and associated web portal contain a rich assortment of information, analysis modules and functions, more fully described in the study Prospectus.

The descriptions below can help to navigate the Price List on the following page.

**The UAM Web Portal** – The URL for the web portal is www.nexa-uam-com and is accessible through permission granted by UAM Geomatics. This portal contains the downloadable Final Report, as well as extensive files and maps for each of the 75 cities.

**Cities Profiled** – UAM Geomatics has detailed the UAM profiles of 75 global cities. When accessed through the www.nexa-uam.com web portal, each has an information-rich profile providing content-in-context for UAM planning purposes. Cities can be explored to understand matters such as expected UAM demand and price elasticity and other and ranked for such valuable information as cost of infrastructure, etc.

**City-to-City Benchmarking** – This powerful tool permits "Big Data" analysis of cities as they compare with each other using over 25 factors such as "readiness", per GDP capita, business concentration, education levels, existing heliports, etc.

**Web Application Maps** – These export maps contain up to 33 layers of information accurately portrayed by city and surrounding area;

**ArcGIS Geo-Coded Maps** – All layers are accurately coded by geocoordinates at a resolution of less than 1 meter. While these look similar to the Web Application Maps, data sets are high resolution and feature-rich. For example, commercial airports denote passenger O/D traffic and general aviation airports denote business aircraft fleets residing at those locations.

**Supply Chain Data Sets** – Over 2,000 companies have been profiled for the following supply chains, meticulously mapped through Tiers 0 to 3:

- UAM Ground Infrastructure Supply Chain: Who designs and builds vertiports, who can perform environmental studies, etc.
- UATM CNS/ATM traffic Management Systems Supply Chain: Who can design airspace, who can provide geo-fencing services, where to go for UATM automation, etc.
- UAM eVTOL Manufacturers: Which manufacturers are well along in electric eVTOL, hydrogen cell designs, Medevac capable vehicles, etc.
- UAM eVTOL Manufacturing Supply Chain: Suppliers of electric motors, propellers, avionics systems, hydrogen fuel cells, recharging systems, etc.

**Top Infrastructure Funds** – Information on the world's leading infrastructure funds.

**Part 135 (or equivalent) helicopter operators** - Those currently operating helicopters through charter services in each of the 75 cities today, along with fleet composition and contact information.

**Updates**

Report and datasets are constantly being updated. A subscription will guarantee that comprehensive quarterly update reports are available free of charge for a 5-year period or until December 31, 2024.

# *Price List*

| Package | Description | UAM Geomat-ics Fi-nal Report | UAM Geomat-ics Web Portal | Cities Profiled | City to City Bench-marking | Web App Map(s) | ArcGIS Geo-Coded Map(s) | Supply Chain Data Sets | Top Infra-struct. Funds | City P135 Oper-ators | One-Time Fee ($US) | Annual Price ($US) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **Full Subscription - UAM Geomat-ics Economics Data and Toolset** | Yes | Yes | 75 | Yes | Yes 75 | Yes 75 | Yes | Yes | Yes | $24,995 | $6,500 |
| **2** | **Single Special City Subscription: Tokyo, New York, Los Angeles, Seoul, London, Paris, Osaka, Chi-cago, Moscow, Rhine-Ruhr, Dal-las, Singapore, or Salt Lake City** | Yes | Yes 1 | Yes 1 | No | Yes 1 | Yes 1 | Yes | Yes | Yes | $9,995 | $2,500 |
| **3** | **Single "Other" City Subscription: Any other from cities list on Page 7 of Report Prospectus** | Yes | Yes 1 | Yes 1 | No | Yes 1 | Yes 1 | Yes | Yes | Yes | $4,995 | $1,250 |
| **4** | **City not on Original 75 City List** | Yes | Yes | 75 | Yes | Yes 75 | Yes 75 | Yes | Yes | Yes | $14,995 | N/A |
| **5** | **Two Day Corporate Level Briefing at Subscriber Site by NEXA Capi-tal's Managing Partner** | | | | | | | | | | $10,000 plus Travel | N/A |
| **6** | **Big Data Network Analysis/City Planning** | Yes | Yes | 75 | Yes | Yes 75 | Yes 75 | Yes | Yes | Yes | $100,000 | |
| **7** | **Special or Custom Studies** | Yes | | | | | | | | | | Please Call |

**Pricing subject to change without notice. For up-to-date pricing please contact a representative.*

# UAM Global Markets Product Descriptions

**UAM Geomatics Final Report** – Go to www.nexa-uam.com for full prospectus for detailed UAM Geomatics Final Report description, including table of contents, data tables, maps, active links to critical information sets, etc.

**UAM Geomatics Web Portal** – The URL for the web portal is www.nexa-uam.com and is accessible through permission granted by UAM Geomatics. This portal contains the downloadable Final Report, as well as extensive files and maps for each of the 75 cities.

**Cities Profiled** – UAM Geomatics has detailed the UAM profiles of 75 global cities. When accessed through the www.nexa-uam.com web portal, each has an information-rich profile providing content-in-context for UAM planning purposes. Cities can be explored to understand matters such as expected UAM demand and price elasticity and other and ranked for such valuable information as cost of infrastructure, etc.

**City-to-City Benchmarking** – This powerful tool permits "Big Data" analysis of cities as they compare with each other using over 25 factors such as "readiness", per GDP capita, business concentration, education levels, existing heliports, etc.

**Web Application Maps** – These export maps contain up to 33 layers of information accurately portrayed by city and surrounding area;

**ArcGIS Geo-Coded Maps** – All layers are accurately coded by geocoordinates at a resolution of less than 1 meter. While they look similar to the Web Application Maps, data sets are high resolution and feature-rich. For example, commercial airports denote passenger O/D traffic and general aviation airports denote business aircraft fleets residing at those locations.

**Supply Chain Data Sets** – Over 2,000 companies have been profiled for the following supply chains, meticulously mapped through Tiers 0 to 3:

- **UAM Ground Infrastructure Supply Chain:** Who designs and builds vertiports, who can perform environmental studies, etc.
- **UATM CNS/ATM traffic Management Systems Supply Chain:** Who can design airspace, who can provide geo-fencing services, where to go for UATM automation, etc.
- **UAM eVTOL Manufacturers:** Which manufacturers are well along in electric eVTOL, hydrogen cell designs, Medevac capable vehicles, etc.
- **UAM eVTOL Manufacturing Supply Chain:** Suppliers of electric motors, propellers, avionics systems, hydrogen fuel cells, recharging systems, etc.

**Top Infrastructure Funds** – Information on the world's leading infrastructure funds.

**City Part 135 (or equivalent) helicopter operators** - Those currently operating helicopters through charter services in cities today, along with fleet composition and contact information.

# *Subscription Agreement*

Please submit pages 4-6 of this Subscriber Order Form, and carefully fill out following the instructions provided, and forward it to UAM Geomatics, Inc.

**Full Subscriber Identification:**

For the **UAM - Economics Data and Toolset** Full Subscriber Edition, please enter the company below as a Subscriber. The Subscriber agrees to abide by the terms and conditions of the UAM Geomatics, Inc. Urban Air Mobility Data and Services Limited License, attached hereto.

_____
Subscriber Company Name

_____
Address

_____
City State/Province Country

_____
Zip/Postal Code Telephone Email address

**Authority:**

On behalf of the Subscriber named above, I certify that I have read and accept the license agreement (page 6) and have the authority to place an order for **UAM Economics Data and Toolset.**

_____
Signature Name (printed)

_____
Title Date Tel.

**Enclosed Payment:**

**ONE TIME SUBSCRIPTION:** Select the package number on page 2 and write it here _____. Check the appropriate square for type of payment:
☐ check
☐ credit card
☐ wire transfer
In the amount of $_____.

UAM Geomatics, Inc. will issue a receipt upon acceptance of this Subscription and of payment. This one-time subscription provides the Subscriber with a five-year license and access to all quarterly report updates without further charge.

**ANNUAL SUBSCRIPTION:** Select the package number on page 2 and write it here _____. Check the appropriate square for type of payment:
☐ check
☐ credit card
☐ wire transfer
In the amount of $_____.
This annual subscription may be renewed upon the sole discretion of the Subscriber upon each anniversary, and includes, for each subscription year, an annual license and access to all quarterly report updates.

**Confidentiality:**

☐ We wish to have our company identity kept confidential as a subscriber to **UAM Economics Data and Toolset.**

| | | | |
|---|---|---|---|
| **Wiring Instructions** | **BB&T Bank USA**<br>**1455 Chain Bridge Rd.**<br>**McLean, VA 22101**<br>**(703) 847-4345** | **Credit to:**<br>**Account #:**<br>**ABA Routing #:** | **UAM Geomatics, Inc.**<br>**1470002932040**<br>**051404260** |

Each subscriber in entitled to five seats. Once payment has been received, we will grant the five participants you designate a password to access the website.

# New Studies

Note that several important markets for Urban Air Mobility have not (as of yet) been included in our analysis. For example, six markets we did not consider include:

| | | |
|---|---|---|
| ☐ | UAM markets outside the 75 city MSA boundaries set herein. | The remaining cities, suburbs and exurbs, and rural regions contribute substantial GDP footprint in relation to the first 75 cities that we analyzed. |
| ☐ | Cargo delivery and Just-in-Time manufacturing, related cargo and freight and oil and gas opportunities that eVTOL vehicles can address. | Including concepts such as centralized warehousing, serving multiple end integrators. The oil and gas sector requires extraordinary mobility solutions for offshore oil workers. |
| ☐ | Markets driven by recreational or tourism applications of eVTOLs. | Markets exist today for helicopter tourism and recreation in most countries. eVTOL promises to open up new sectors and vistas to new uses. |
| ☐ | New and emerging emergency services opportunities. | Applications that will require specialized eVTOL designs await this industry. |
| ☐ | New business models for commercial airlines to link high mileage travelers to their global networks. | Part 121 air carriers are already making use of business aviation platforms to seamlessly integrate business travelers having travel mobility needs in other regions or on other continents. The door-to-door problem can be addressed. |
| ☐ | Military markets, applications and opportunities. | We will be releasing a prospectus on this market application in the fall of 2020. |

UAM Geomatics would like to know if you have interest in either sponsoring or acquiring such additional market research areas. If so, please check the box(es) above and add any comments below so that we may respond:

Thank You.

# UAM GEOMATICS, Inc. Urban Air Mobility Data and Services Limited License

UAM Geomatics shall grant Subscriber and its Affiliates a limited, fair use, non-exclusive, revocable license ("Limited License") to use said UAM Geomatics information, data and services (collectively “UAM Geomatics Services”). Said Limited License shall be limited to employees and Affiliates of Subscriber to be used within the normal course of Subscriber’s business. Subscriber agrees that it shall not use UAM Geomatics' Services for any other purpose nor shall it permit any third party other than Affiliates to use UAM Geomatics' Services unless otherwise agreed in writing by UAM Geomatics. Subscriber agrees that it shall not publish, resell, transmit, broadcast, distribute, or otherwise use any of the UAM Geomatics’ Services in violation of this Agreement. Subscriber agrees that it shall not give access to the UAM Geomatics Services nor will it export UAM Geomatics’ data from nor import UAM Geomatics’ data into any other forum, without written consent from UAM Geomatics. Subscriber agrees that it shall not use UAM Geomatics’ Services in any manner to compete with UAM GEOMATICS in UAM Geomatics' business or for any other purpose not permitted by this Limited License.

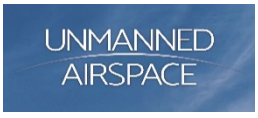
# About the Study Sponsors

UAM - Economics and Global Markets is a joint undertaking by respected aerospace industry organizations, associations, researchers, publishers and marketing and financial advisors. The lead underwriting sponsor is UAM Geomatics, a NEXA Capital Partners LLC company with a proven record performing “Multi-Client” investment-related research for the aerospace sector.









**For Further Information please contact:**

**Eleanor Herman**
Principal Editor
UAM Geomatics, Inc.
Tel: 202-499-5056
Email: Eleanor.Herman@nexa-uam.com
Web: www.nexa-uam.com

**Michael Dyment**
Managing Partner
NEXA Capital, LLC
Tel: 202-321-0389
Email: michael.j.dyment@nexacapital.com
Web: www.nexacapital.com