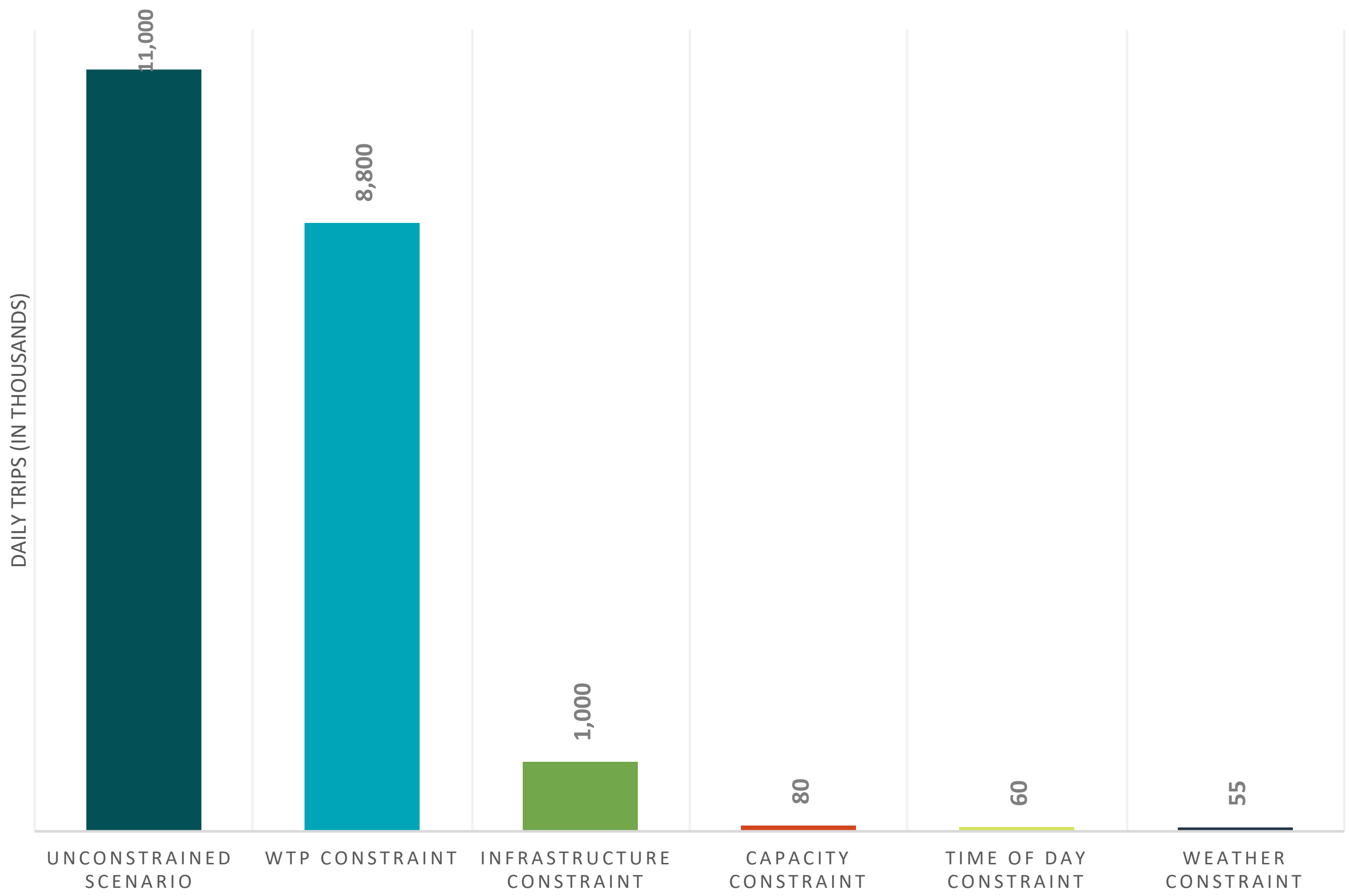
OVERALL MARKET SIZE AND VALUE

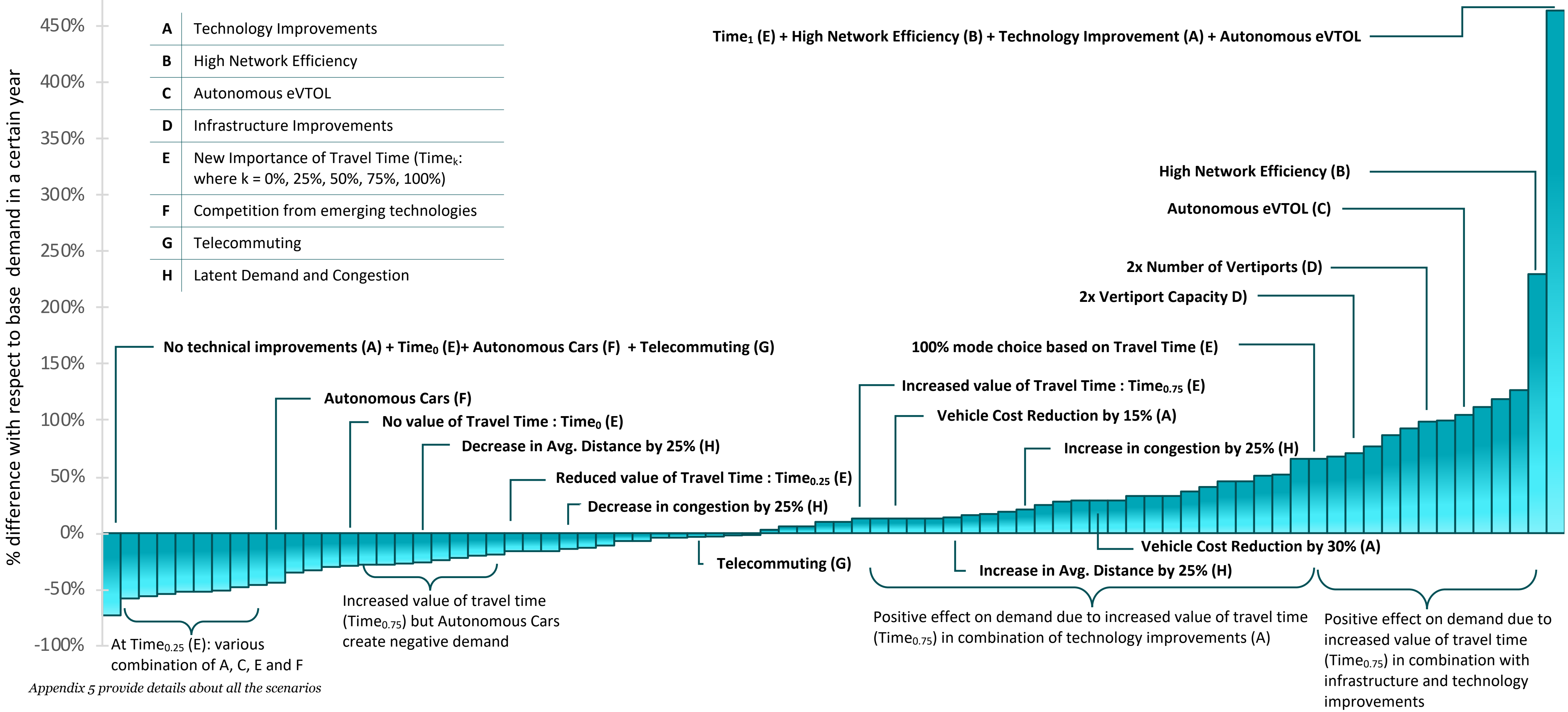
*Air Taxi market has a potential demand of **~55k daily trips** (or ~ **80k daily passengers**) across the US that can be served by **~4k aircraft.** Based on near term market entry assumptions, annual market value is projected to be **~$2.5 bn** for the first few years of operation.*



	Daily Trips	Daily Passengers	Total Number of Aircraft	Annual Market Value (in bn $)
Un-constrained	11,000,000	16, 000, 000	850, 000	500
WTP Constraint	8, 800, 000	13, 000, 000	680, 000	400
Infrastructure Constrained	1, 000, 000	1, 500, 000	80, 000	45
Capacity Constraint	80, 000	120, 000	6, 000	3.6
Time of Day Constraint	60, 000	90, 000	4, 500	2.75
Weather Constraint	55, 000	82, 000	4, 100	2.5

LARGE DEMAND MAY BE ACHIEVED BY HIGH NETWORK EFFICIENCY BUT AUTONOMOUS CARS ARE EXPECTED TO PROVIDE STRONG COMPETITION

- **Autonomous vehicle** and **reduced importance of travel time** may severely **constrain the demand for Air Taxis**. Telecommuting further reduces the demand marginally.
- **High network efficiency**, increased importance of travel time, **autonomous eVTOL**, **technology improvements,** and increased available infrastructure/capacity may all **increase demand.**



Appendix 5 provide details about all the scenarios

CONTENTS

AIR AMBULANCE IS A COMPLEX POTENTIAL MARKET

AIR AMBULANCE OVERVIEW

Definition: The Air Ambulance market includes travel to/from the hospital for emergencies and potentially hospital visits. Both public and private operations are considered.

Selection Criteria: A complex market and likely to highlight technology barriers in terms of technical capabilities needed on board the aircraft, in addition to other legal and regulatory barriers. Air Ambulances have high public acceptability.

Value Proposition: Lifeline; public safety; reduction of travel time by 1.5-2 times, hence reducing fatalities

Market Dynamics:

- **Market Size:** Relatively limited market; however, the services are of high value
- **Market Drivers:**
    - Events i.e. Accidents, health related events etc.
    - Demographic trends
    - Healthcare legislation
    - Changes in insurance policies
- **Potential Business Models at Play:** Insurance subscription, hospital ownership, fleet operators, pay per ride

Connected Markets: Emergency Response markets such as law enforcement, natural disaster response, and firefighting

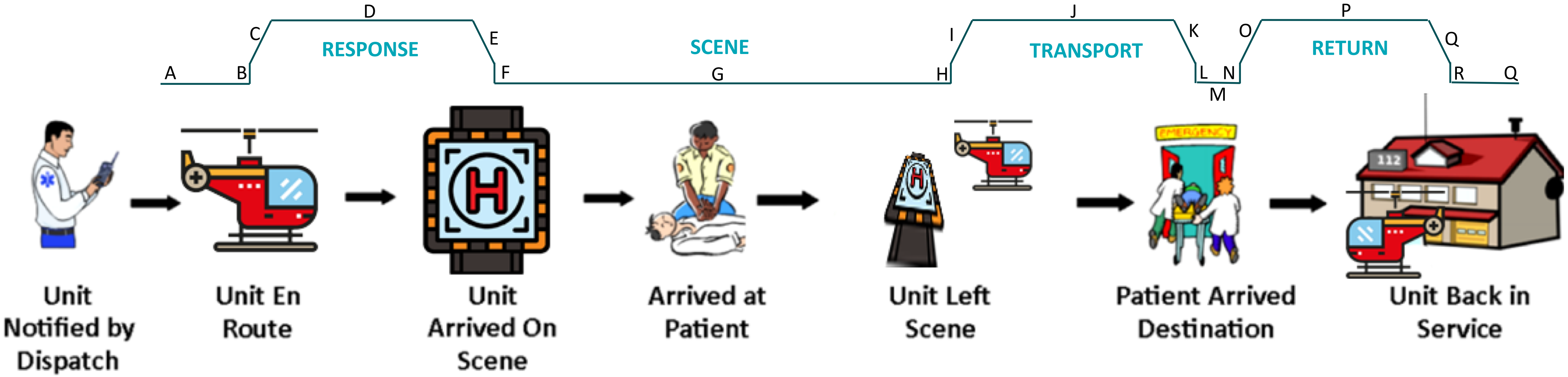
Source: BAH Analysis; Ibis, 2016

TYPICAL AIR AMBULANCE MISSION

A typical air ambulance mission consists of three sub-missions; Response (A-F), Transport (H-M) and Return to Service (N-R). We assume that each of these sub-missions are flown at similar speeds[1] and follow similar profiles i.e., Taxi, Hover Climb, Climb, Cruise, Descend, Hover Descend and Taxi. For the fourth mission (Scene) we assume an air ambulance in Taxi mode. Total Flight time is given by (1).

After completing the transport, the air ambulance returns to its base (N-R) and is prepared for service (R-Q). For this analysis, time required to complete mission N-R is assumed to be 5-15 mins while eVTOL preparation time (R-Q) refers to time required to recharge batteries completely (assuming battery swapping is not possible).

$$\text{Total Flight Time} = \text{Response (B} - \text{F)} + \text{Transport(H} - \text{M)} + \text{Return Time (N} - \text{R).} \qquad ----- (1)$$



[1]Literature suggests that ground ambulances are operated at different speeds for all three sub-missions (i.e., Response speed > Transport Speed > Return to Service speed. However, there is little literature to support a similar trend for Air Ambulances).

Source: NEMSIS, 2018

REFERENCE AIRCRAFT ASSUMPTIONS

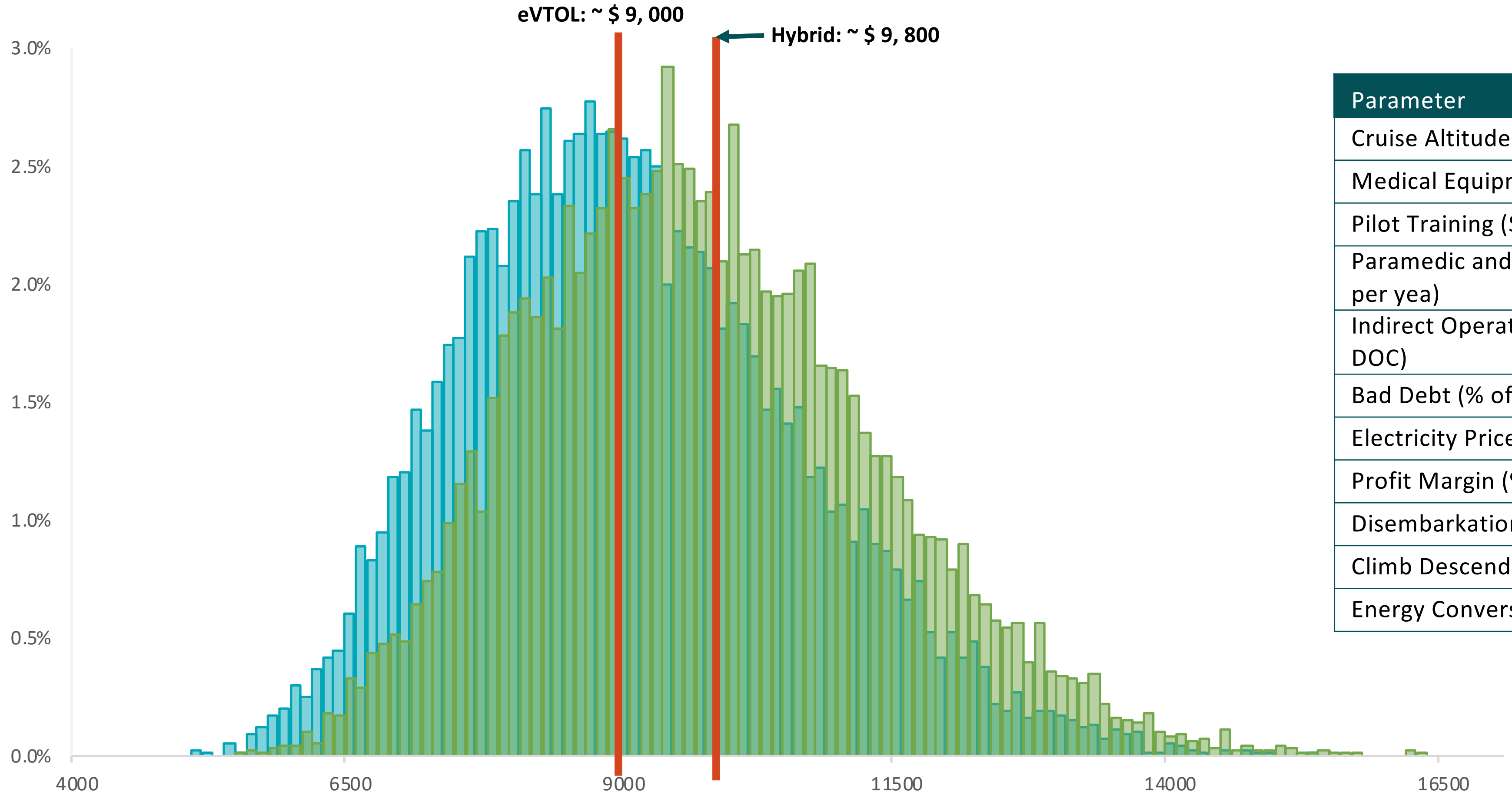
- eVTOL and Hybrid aircraft, like the current rotor wing market, may be used mainly for 1-patient emergency medical transports, both from accident scenes and between hospitals. Therefore, we consider a 5-8 seat size equivalent eVTOL that can fly a **cruise altitude of 500-5000 ft.**
- According to FAA duty hour requirements, a single emergency eVTOL will require **4 full time pilots, 4 full time flight nurses, and 4 full time paramedics** with CAMTS Accreditation. Each crew goes through annual training requirements.

Parameter	Sub Parameter	Minimum	Maximum	Source
Aircraft Assumptions	Cruise Speed (for eVTOL) [1]	125 mph	175 mph	MIT Study
	Cruise Speed (for Hybrid) [2]	200 mph	300 mph	BAH Literature review, XTI Aircraft
	Equivalent Number of Seats[2]	5	8	Helicopter Market Literature Review
	Reserve (mins)	20	30	Part 91 requirements
	Range (miles)	50 + Reserve	200 + Reserve	BAH Assumption
	Battery Capacity (kWh)	100 kWh	150 kWh	Nykvist et al, 2015
	Annual number of Transports[3]	300	400	AAMS, 2017
Crew/Payroll Assumptions	Pilot Salary ($ per year)	$ 60, 000	$ 100, 000	US Bureau of Labor Statistics
	Paramedic ($ per year)	$ 50, 000	$ 75, 000	
	EMT ($ per year)	$ 60, 000	$ 90, 000	
	Mechanic Salary ($ per year)[4]	$ 50, 000	$ 90, 000	

[1]Cruise Speed is use to calculate Trip Speed, which is a parametric function of average distance, LTO speed and Cruise Speed
[2] Based on helicopter market to accommodate one patient
[3]Standard unit for Air Ambulance utilization
[4] Air ambulances generally have one full time mechanic onsite

TOTAL COST PER TRANSPORT

*After performing 10,000 iterations of Monte Carlo, the median cost of operating an eVTOL air ambulance is ~ **$9, 000** per transport and hybrid air ambulance is ~**$9, 800** as compared to ~10, 000 for rotary wing helicopter (source: AAMS) and ~$500 for ground ambulance. About **80% is fixed cost***

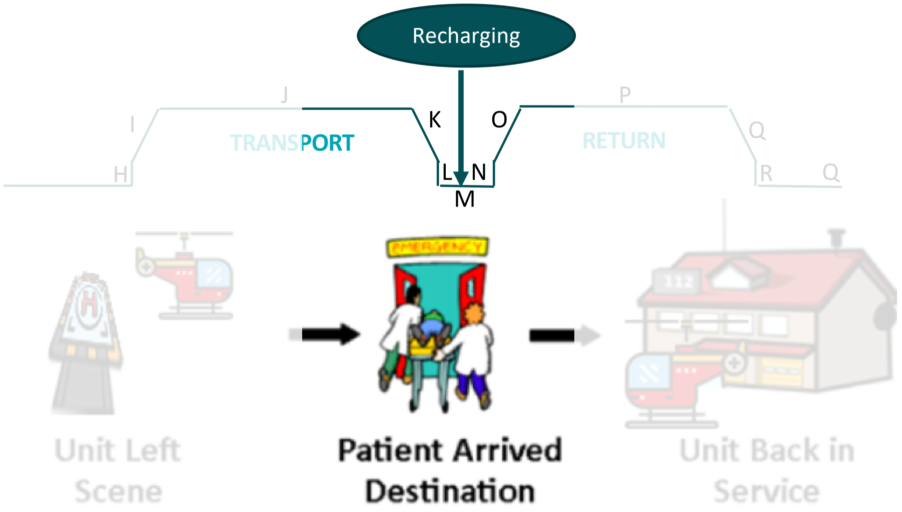


Parameter	Min	Max
Cruise Altitude (ft)	500	5,000
Medical Equipment Weight (lb)	200	400
Pilot Training ($ per year)	10,000	30,000
Paramedic and EMT Training ($ per yea)	10,000	20,000
Indirect Operating Cost (% of DOC)	5%	50%
Bad Debt (% of Operating Cost)	10%	20%
Electricity Price ($/kwh)	0.1	0.3
Profit Margin (% of Cost)	10%	30%
Disembarkation Time (in mins)	3	5
Climb Descend Distance (miles)	1	2
Energy Conversion Efficiency (%)	90%	98%

DEMAND SCENARIOS: REVISED CONOPS AND BATTERY SWAPPING

Scenario 1: Revised ConOps

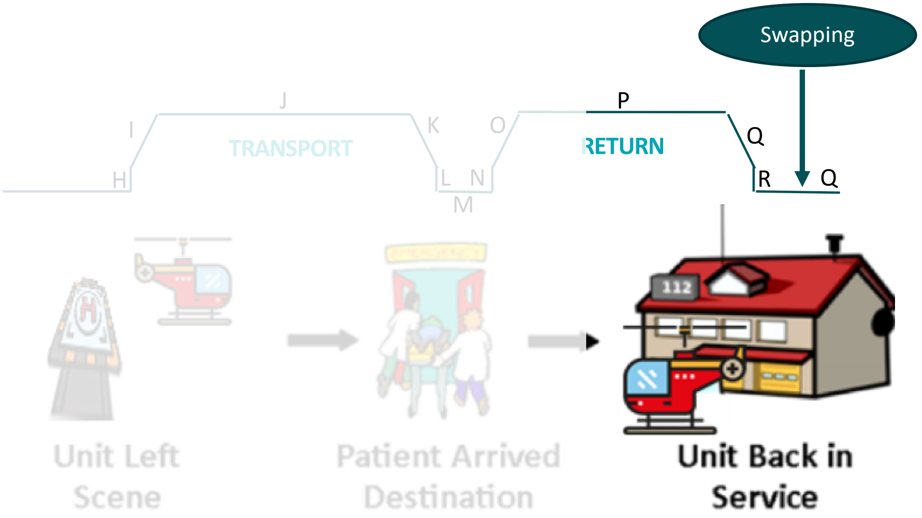
- Under Transport phase, patient is transported from the scene to the medical facilities. Our analysis explores charging during patient disembarkation **(~ 5 mins**) to reduce range requirement (hence, battery requirement) combined with fast recharging from scenario 1. This phase is represented by ‘M’ in the figure below.



- Under this scenario, total range required reduces to 30-180 miles as opposed to 50-200 miles. Average battery weight reduces to ~3, 200 lb (as opposed to ~3, 500 lb).

Scenario 2: Battery Swapping

- Given high re-charging times, air ambulances may rely on swapping batteries when eVTOL returns to the base after each mission to reduce the total call time (increasing dispatch reliability). Battery swapping is expected to take **~5 minutes** (Georgia Tech Study).

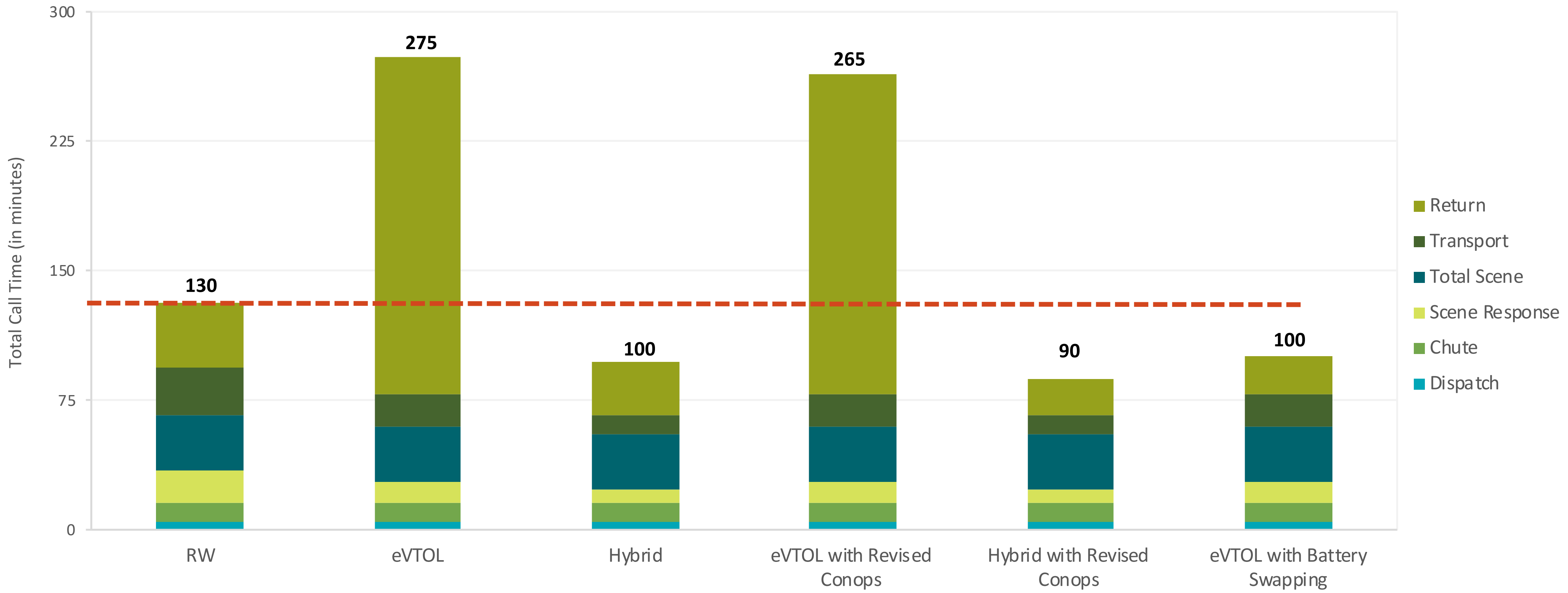


- Median price of battery cost per transport was calculated to be **~$300**, which will be added to the operating cost. Staff and equipment required to swap the batteries can be considered as a part of indirect operating costs.

BOTH EVTOL AND HYBRID AIRCRAFT HAVE HIGH RETURN TIMES DUE TO HIGH BATTERY RE-CHARGING TIME

Dispatch, Chute and Scene time remains the same for RW and eVTOL/hybrid while scene response and transport time changes due to differences in speed. Return time increases significantly for eVTOL due to high battery recharging times.

Total call time in Battery swapping scenario is comparable to current Rotary Wing market while total call time for all other scenarios far exceeds to that of RW.



DISPATCH RELIABILITY VS NUMBER OF TRANSPORTS

- Air Medical Transport follows a certain dispatch protocols that considers the need of minimization of time, weather considerations, availability, safety etc. before deploying a RW aircraft.
- Cost per transport of air ambulances **decrease significantly** as number of transports increases. However, increased use of an air ambulance (i.e., less availability) decreases dispatch reliability.
- **Dispatch reliability** is calculated at an event interval of one hour assuming that an RW Air Ambulance total call time ~2 hours:

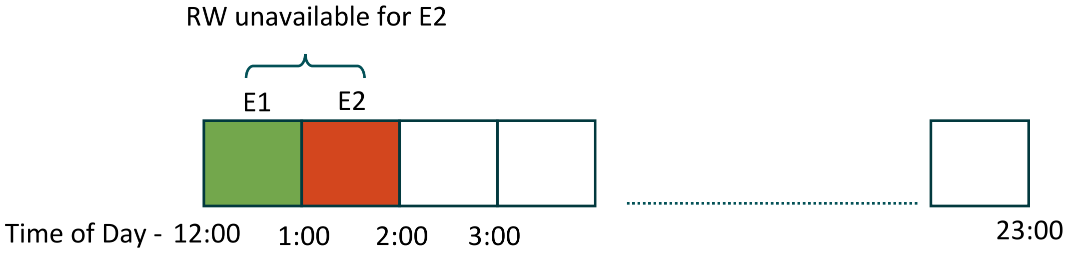
$$\text{Dispatch Reliability} = \frac{\text{Number of events for which ambulance is available (A)}}{\text{Total number of events (T)}}$$

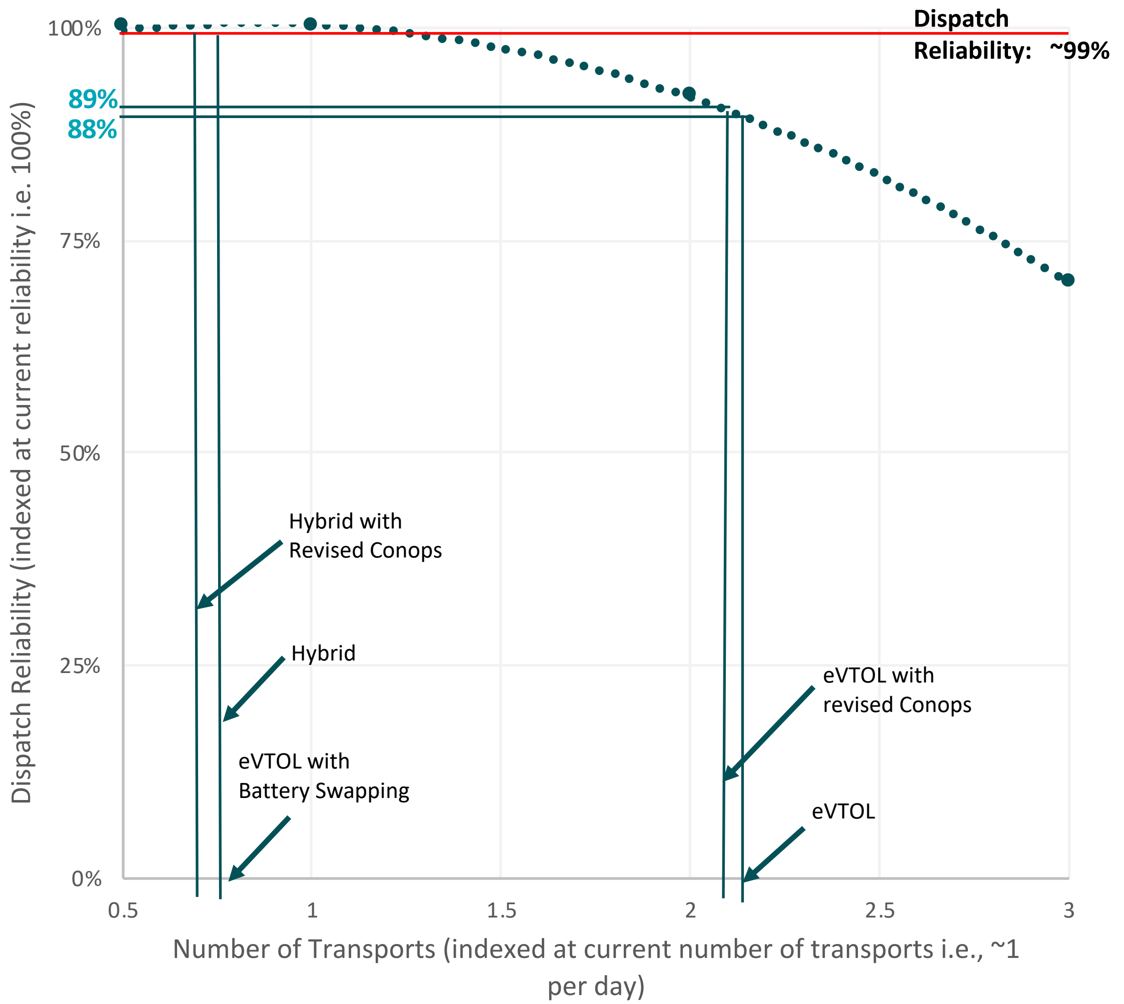
where,

A = T- NA (number of events for which ambulance is unavailable)

e.g. Case of NA

E1 = Emergency event 1 satisfying RW dispatch protocol. RW dispatched
E2 = Emergency event 2 satisfying RW dispatch protocol





MARKET SIZE CAPTURE UNDER DIFFERENT OPERATION SCENARIOS

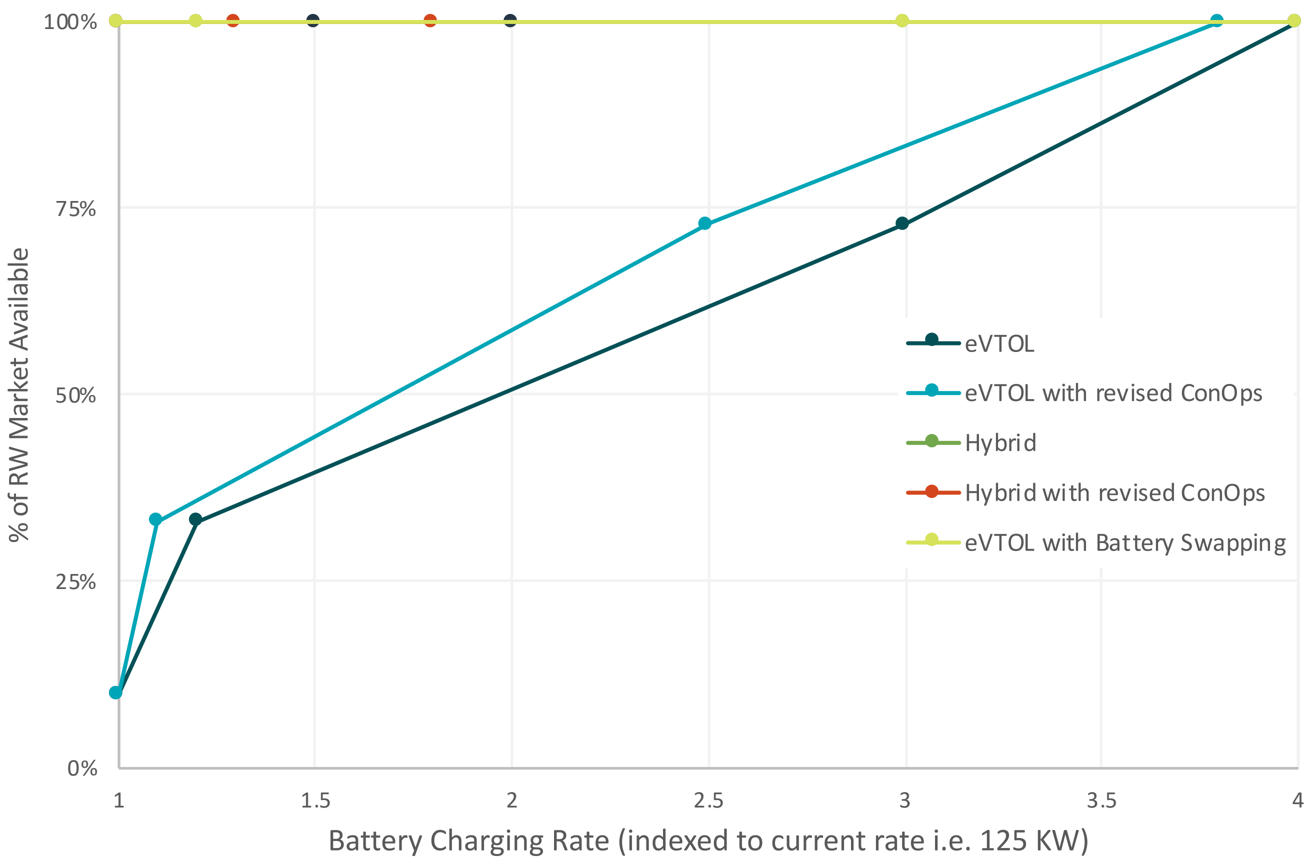
Due to high recharging time, dispatch reliability of eVTOLs for 90% of the market may be below the acceptable standard. Therefore, under current technology, eVTOLs may not be an attractive option for air ambulances. Fast Recharging and Battery Swapping capabilities may propel the capture of available RW market for eVTOLs.

Fast Recharging:

- Assumes a scenario where battery recharging rate increases with respect to current rates
- On increasing Battery recharge rate **approximately 4 times to current rate**, eVTOLs may address the total available RW market because of the following
  - Dispatch reliability similar to current RW market achieved
  - Cost per transport less than current RW market

Battery Swapping:

- **~100% of RW market** is available for eVTOLs with Battery Swapping capabilities



CONTENTS

CONCLUSION - SUMMARY OF KEY FINDINGS

UAM markets have strong potential but face significant challenges and constraints that could severely limit the available market. Our results suggests the following:

- Airport Shuttle and Air Taxi markets are viable markets with a significant total available market value of $500 bn at the market entry price points in the best case unconstrained scenario
- In the near term, a 5-seat piloted eVTOL will cost ~$6.25 per passenger mile. However, in the long term, high operational efficiency, autonomy, technology improvements may decrease the cost by ~60%
- Infrastructure availability and capacity combined with high cost is a major barrier to fully capture the available demand
- Air Ambulance market served by eVTOLs is not a viable market due to technology constraints. Hybrid VTOL aircraft is a more attractive option to serve air ambulance markets
- Legal and Regulatory analysis found all markets share the same regulatory barriers
- Public perception is a large obstacle. Safety is the greatest concern with “unruly” passengers, “lasing” of pilots, and aircraft sabotage being main contributors
- Weather poses significant challenges to UAM operations at several focus urban areas with low visibility, strong winds, and storms being the most frequent adverse conditions

APPENDIX

APPENDIX 1: SAG MEMBERS - FEDERAL GOVERNMENT

NAN SHELLABARGER
Executive Director
FAA Aviation Policy & Plans Office

- Responsible for setting direction and overseeing operations for FAA'S Policy organization
- Previously the Manager of the Planning Analysis Division at FAA where she was responsible for facilitating agency-wide strategic planning, developing long range aviation forecasts, and analyzing airline delays

DR. KARLIN TONER
Director of Global Strategy
FAA Office of International Affairs

- Provides executive leadership in the development, implementation and evaluation of program policies, goals, and objectives for US international aviation
- Master's Degree and Ph.D. in Aerospace Engineering along with honorary Ph.D. in Science
- Oversees the development of a data-informed process to enable the FAA to most effectively prioritize future international engagement

EARL LAWRENCE
Director
FAA UAS Integration Office

- Director of the UAS Integration office responsible for the facilitation of all regulations, policies, and procedures required to support FAA's UAS integration efforts
- Previously served as the Manager of the FAA'S Small Airplane Directorate where he managed airworthiness standards, continued operational safety, policy, and guidance for small aircraft, gliders, light sport aircraft, airships, and balloons

DR. JIM HILEMAN
Chief Scientific and Technical Advisor for Environment
FAA

- Ph.D. and Master's Degree in Mechanical Engineering
- Previously the Principal Research Engineer within MIT's Department of Aeronautics and Astronautics and its Associate Director, Partnership for AiR Transportation Noise and Emission Reduction
- Research focused on modeling the impacts of alternative jet fuel and innovative aircraft concepts on efficiency, noise, air quality and global climate change

CHRISTOPHER HART
Former Chairman
NTSB

- Former Deputy Director of Air Traffic Safety Oversight Service at FAA
- Former Assistant Administrator for System Safety at FAA
- Former Deputy Assistant General Counsel to DOT
- Former Attorney with the Air Transport Association
- Master's Degree in Aerospace Engineering

JULIET PAGE
Acoustics & Sonic Boom Expert
Volpe (DOT)

- SME in the field of acoustics / aerospace engineering including sonic boom, atmospheric propagation, aircraft, rotorcraft, tiltrotor, space and launch vehicle noise
- Experience conducting scientific research, regulatory standards and model development and validation for air and ground based transportation systems through analytic development, experimentation and measurements

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - STATE AND LOCAL GOVERNMENT

BASIL YAP
UAS Program Manager
North Carolina DOT

- 9+ years of experience in airport development
- 4+ years experience in UAS Program Management
- UAS SME
- Designs, establishes, and conducts studies and makes recommendations relative to the UAS policies, programs, methods and procedures currently in place

DARHAN DIVAKARAN
UAS Program Engineer and Geospatial Analyst
NCDOT Division of Aviation

- Unmanned aviation expert with expertise in unmanned flight operations, flight safety, remote sensing, geospatial analysis and project management
- Experience developing best practices and procedures for safe and efficient unmanned aviation operations
- Previously Research Associate – Flight Operations with NGAT and AirTAP at the ITRE in NC

MEERA JOSHI
Chair and CEO
NYC'S Taxi & Limousine Commission

- Previously served as the Frist Deputy Executive Director of the NYC Civilian Complaint Review Board, an agency tasked with investigating complaints of police misconduct
- Responsible for initiation of a landmark prosecution program that resulted in the agency's ability to independently prosecute founded complaints against police officers

ALEX PAZUCHANICS
Assistant Director
Department of Mobility and Infrastructure – City of Pittsburgh

- Policy Advisor for Pittsburgh Mayor William Peduto
- Led Pittsburgh's response to the USDOT Smart City Challenge
- Manages the City's designation as an Autonomous Vehicle Proving Ground and is a member of the PennDOT Autonomous Vehicle Policy Task Force

MARK DOWD
Executive Director
Smart Cities Lab

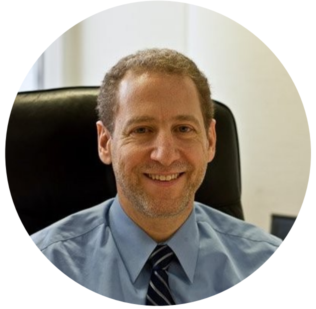
- Previously worked for the White House as the Senior Advisor for the Office of Management and Budget
- Responsible for creating and executing the USDOT'S Smart City Challenge that changed the way cities use technology and innovation to drive change and solve problems related to mobility
- Broad experience in policy development and implementation related to technology, mobility, smart cities, public-private partnerships, energy, and environmental issues

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - STATE AND LOCAL GOVERNMENT

ADRIENNE LINDGREN
Economic Policy & UAS/UAM Integration
LA City

- Oversees the implementation of public-private partnerships for industrial innovation and cluster development, in partnership with the U.S. Departments of Energy and Commerce
- Leads the development of testing and demonstration zones for urban aviation, including the integration of UAV and AV policy strategy, in partnership with the Los Angeles Department of Transportation, LA Fire Department, the Port of LA, Los Angeles World Airports, and the Federal Aviation Administration.



JUSTIN ERBACCI
Chief Innovation and Technology Officer
Los Angeles World Airports

- Responsible for implementing LAWA's overall Information Technology vision and strategy, in addition to leveraging innovative technologies and processes to enhance operations at Los Angeles International (LAX) and Van Nuys general aviation airports.
- Prior to his appointment with LAWA, he served as Vice President of Customer Experience & Technology for Star Alliance, a global airline network comprised of 28 airlines serving 640 million passengers annually

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - LEGAL AND REGULATORY

GRETCHEN WEST
Senior Advisor in the Global Unmanned Aircraft Systems

Hogan Lovells

- Policy advocate for the commercial drone industry over a decade working to reduce barriers to entry
- Works with companies to assist in understanding market trends and develop strategies for market growth
- Co-leads the Commercial Drone Alliance, a non-profit association
- Previously served as AUVSI's Executive VP overseeing AUVSI's global business development initiatives and government relations efforts for the unmanned systems and robotics industry

LISA ELLMAN
Co-Executive Director of Commercial Drone Alliance

Hogan Lovells

- Co-chair of firm's UAS practice
- Counsels businesses and trade groups on UAS issues in industries ranging from newsgathering, aerial photography, energy, precision agriculture and insurance, higher education, drone technology, to construction
- Held variety of positions at top levels of executive branch at the White House and the U.S. Department of Justice (DOJ)

DAVID ESTRADA
Chief Legal Counsel

ZEE Aero

- Previously VP of Government Relations at Lyft and helped establish a legal and regulatory framework for TNCs in the US
- Previously held Legal Director role at Google X, leading the legal efforts behind Google's self-driving cars, Google Glass, and drone delivery program
- While at Google, helped create the first state laws and regulations governing self-driving cars in Nevada, California, and Florida

MATTHEW DAUS
Partner, Chair of Transportation Practice Group

Windels Marx LLP

- Practice focuses on transportation law, counseling clients on a wide range of matters including regulatory compliance, strategic planning, procurement, litigation, regulatory due diligence, expert witness testimony and reports, administrative law and public policy
- Previously served as Commissioner and Chairman of NYC TLC
- Formerly served as General Counsel to the Commission and Deputy Commissioner for Legal Affairs
- Served as Special Counsel to the TLC Chair – supervising over 75 lawyers and Administrate Law Judges

MARK AITKEN II
Senior Policy Advisor

Akin Gump Strauss Hauer & Feld LLP

- Leads advocacy for the inclusion of association priorities in House and Senate versions of FAA reauthorization and associated appropriation measures
- Influences to safely expedite the US framework for integrating UAS into the NAS for commercial opportunities
- ACRP 03-42 Panel Member

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - EDUCATIONAL INSTITUTIONS

JOHN HANSMAN
T. Wilson Professor of Aeronautics & Astronautics

Massachusetts Institute of Technology

- Head of the Humans and Automation Division at MIT
- Director of the MIT International Center for Air Transportation
- Current research interests focus on advanced cockpit information systems, including Flight Management Systems, Air-Ground Datalink, Electronic Charting, Advanced Alerting Systems, and Flight Crew Situational Awareness

PARKER VASCIK
Ph.D. Candidate, Aeronautics and Astronautics

Massachusetts Institute of Technology

- Conducting research in collaboration with the NASA On Demand Mobility and UAS Traffic Management (UTM) programs
- Research areas include Unmanned Aircraft System Traffic Management, On-Demand Mobility Aviation, Design for Ilities under Uncertainty, and Technology Infusion Analysis

JESSIE MOOBERRY
Technologist

Peace and Innovation Lab at Stanford

- Expert in humanitarian UAV design and operations
- Built and served as VP of Uplift Aeronautics, first cargo drone nonprofit
- Founded SwarmX, an enterprise drone company
- Commercial drone pilot
- Mentor for Ariane de Rothschild Social Enterprise Fellowship

BRIAN J. GERMAN
Associate Professor

Georgia Tech

- Ph.D. in Aerospace Engineering
- Senior Member of the American Institute of Aeronautics and Astronautics
- Research areas are multidisciplinary design, multi-objective optimization, and decision methods applied to air vehicle design and systems engineering
- Also conducts research in aerodynamic, propulsion, subsystem, and performance models suitable for aircraft concept studies

DR. JUAN ALONSO
Professor, Department of Aeronautics & Astronautics

Stanford University

- Founder and director of the Aerospace Design Laboratory where he specializes in the development of high-fidelity computational design methodologies to enable the creation of realizable and efficient aerospace systems
- Research involves manned and unmanned applications including transonic, supersonic, and hypersonic aircraft, helicopters, turbomachinery, and launch and re-entry vehicles
- Ph.D. in Mechanical & Aerospace Engineering

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - MANUFACTURERS

DR. BRIAN YUKTO
VP of Research & Development

Aurora Flight Sciences, a Boeing Company

- Responsible for Aurora's R&D business unit which advances Auroras capabilities in the areas of autonomy, next generation, air vehicle design, advanced electric propulsion, and operations of intelligent flight systems in the national airspace

DR. ERIC ALLISON
CEO

Zee Aero

- Previously served as Zee Aero's Director of Engineering
- Thesis covered ultrasonic propulsion
- Ph.D. in Aeronautics and Astronautics from Stanford University

TRAVIS MASON
VP Public Policy

Airbus

- Master's Degree in Public Policy
- Leading Public Policy for our future of flight projects across A^3 by Airbus, Airbus Aerial, the Corporate Technology Office urban air mobility group and with Airbus Defense & Space

DR. CARL C. DIETRICH
Co-founder and CTO

Terrafugia

- Focused on development of future product concepts and establishment of new R&D center for Terrafugia
- BS, MS and Ph.D. from the Department of Aeronautics and Astronautics at MIT

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - MANUFACTURERS

PETER BERGER II
Director of Innovation, Silicon Valley

Embraer Business Innovation Center

- Former CEO of Contact IQ, Alitora Systems and Topicmarks
- Advised numerous startups and Fortune 500 companies such as Orange Telecom and Qualcomm
- Undergraduate degree from California Polytechnic and a law degree from Rutgers University

DAVID ROTTBLATT
Business Development Director

Embraer

- Experience in large multi-national corporations
- Recent projects have focused on business model design and execution, strategic marketing, market development and international project management
- Developed in-depth knowledge of aviation market and customer needs to identify new ventures for Embraer to pursue

BOB LABELLE
CEO

XTI Aircraft Company

- 25+ years experience in top-level aviation management and strategy, aircraft development and operations
- Responsible for development of the TriFan 600 aircraft
- Led the drive to incorporate hybrid-electric propulsion in the TriFan 600 and championed other enhancements in order to better position the aircraft in the future
- Former Chairman and CEO of AgustaWestland North America

JOEBEN BEVIRT
Founder

Joby Aviation

- Master’s Degree in Mechanical Engineering Design from Stanford
- Founded Joby Aviation to develop a compact electric personal aircraft designed for efficient high speed flights
- Former Co-Founder of Velocity11 which developed high-performance laboratory equipment
- Former Director of Engineering of Incyte Corporation where he built a team to develop robotics to improve the throughput and efficiency of Incyte’s laboratories

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS

OPERATORS

MARK MOORE
Engineering Director of Aviation
Uber Elevate

- Mark D. Moore worked for NASA for over 32 years before joining Uber, the entire time focusing on conceptual design studies of advanced aircraft concepts.
- His research focused on understanding how to best integrate the emerging technology area of electric propulsion and automation to achieve breakthrough on-demand aviation capabilities

JUSTIN ERLICH
Head of Policy, Autonomous Vehicles & Urban Aviation
Uber Elevate

- Subject matter expertise includes transportation, sustainability, smart open data, and smart cities, with an academic background in law, government, and behavioral science
- Previously worked on the leadership team of former California Attorney General (currently Senator) Kamala Harris managing technology policy, strategy, and operations

INTERNATIONAL

CHRISTOPHER PETRAS
Legal Officer at the ICAO Legal Bureau
International Civil Aviation Organization (ICAO)

- Provides legal advice to ICAO's Secretary General on international law, air law, commercial law, labor law and related issues
- Former Chief Counsel for International Law for the U.S. Air Force's Air Mobility Command and NORAD
- LL.M. in Air and Space Law (McGill University)

RESEARCH ORG.

MATTHIAS STEINER
Director Aviation Applications Program
NCAR Research Applications Laboratory

- Expertise in mitigating weather impacts on the aviation industry
- Leading efforts to understand weather sensitivities and requirements for the rapidly growing interests in urban air mobility and using unmanned aerial systems for wide-ranging applications and safe integration into the national airspace system.

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - INSURANCE AND REAL ESTATE

BRYANT DUNN
Assistant Vice President

Global Aerospace

- Experience in aviation insurance, underwriting, aircraft and airport operations, market research, marketing, sales, finance, and flight instruction
- Specialized in corporate flight department hull & liability program, aviation manufacturer products liability, airport liability, and unmanned aircraft systems

TOM PLAMBECK
Underwriter

Global Aerospace

- Active Pilot
- Expert in underwriting of drones and light aircraft
- Bachelor's Degree in Aviation Management

ERIC ROTHMAN
President

HR&A Advisors

- 20+ years in transportation planning and transit-oriented development
- Expertise in strategic planning, transportation planning and development, economic development, capital program management, financial management, and program implementation
- Leads the firm's work creating transit-oriented development strategies anchored by station redevelopment across the US

Bios of the members were last updated in April 2018

APPENDIX 1: SAG MEMBERS - VENTURE CAPITAL

FRANCOIS CHOPARD
CEO
Starburst Aerospace Accelerator

- 20+ years of experience in strategy consulting, entrepreneurship, and business development
- Specializes in the Aviation Aerospace and Defense industries featuring high stakes technology and has developed a wide experience of innovation-related issues
- Works on topics like future trends, product strategy, open innovation for companies mainly from the aerospace industry as well as investment funds
- Master’s Degree in Electrical Engineering

VAN ESPAHBODI
Aerospace Ventures / International Business Development
Starburst Aerospace Accelerator

- Bringing technology + investment + design together to improve the way aerospace infrastructure operates
- Focus areas include: Corporate and Strategy Development, Corporate Venturing and Open Innovation, Partnerships & Alliances, International Sales, Government Affairs, Competitive Intelligence Analysis

KEN STEWART
Entrepreneur in Residence
GE VENTURES

- 20+ years of business development, strategic planning, sales/marketing, and product development/line-of-business management experience

BARRY MARTIN
Senior Manager - Business Development & Strategy
The Boeing Company

- Coordinates internal functional groups (Legal, Contracts, Intellectual Property, Supplier Management, Communications) to place agreements with customers/partners/suppliers
- Previously Avionics Integration Project Manager at Boeing and responsible for managing cross-functional teams for various F/A-18 avionics system upgrades

Bios of the members were last updated in April 2018

APPENDIX 2: TYPE CERTIFICATION COMPARISON TABLE

	Fixed Wing	Rotary	Hybrid Or Special	Engines	Propellers
FAA	**Part 21** – Certification Procedures for Products and Parts **Part 23** – Small Fixed Wing **Part 25** –Transport Category Airplanes	**Part 27** – Small Rotorwing **Part 29** –Transport Category Rotorcraft	**Part 21.17(b)** – Designation of applicable regulations	**Part 33** – Aircraft Engines	**Part 35** – Aircraft Propellers
EASA	**CS-22-**Sailplanes and Powered Sailplanes **CS-23**- Normal, utility, aerobatic, and commuter aeroplanes **CS-25** – Large Aeroplanes	**CS-27** – Small Rotorcraft **CS-29** – Large Rotorcraft	**CS-VLA-** Very light aircraft **CS-VLR**- Very Light Rotorcraft	**CS-E** - Engines	**CS-P** -Propellers
NATO	**STANAG 4671** – UAV System Airworthiness Requirements (USAR), Fixed wing aircraft weighing 150kg to 20,000 kg **STANAG 4703** – Light unmanned aircraft systems	**STANAG 4702** – Rotary wing unmanned aircraft systems	**Draft STANAG 4746-** Vertical Take-off and landing (VTOL)	Referenced in **STANAG 4703** **STANAG 3372**	Referenced in **STANAG 4703**
Comparison	Terminology such as: proof of structure FAA Fixed and rotary aircraft factor in additional engine part certification (Part 33) **EASA CS -25** vs **FAA Part 25** Large aeroplanes vs Transportation category airplanes Comparison: i.e. Proof of Structure terminology - The wording of Part 25 is different from CS-25 and this has resulted in different interpretations on the need for and the extent of static strength testing, including the load level to be achieved.	**STANAG 4702** is based on Parts 23, 27, and CS-23	**CS-VLA** has similarities to PART 21.17B **Draft STANAG 4746** is based on EASA Essential Airworthiness and is Harmonized with STANAG 4703. 4746 and 4703 Use **EASA CS-VLR** as a basis; Includes Electric Propulsion Certification Requirements	**CS-E** shares similar standards to **Part 33**- Testing covers all thrust ratings Development assurance for software & airborne Electronic Hardware under policy draft review	**CS-P** shares similar standards to **Part 35**: Bird Impact-Both require demonstration that the propeller can withstand the impact of a 4-pound bird for all airplanes.

APPENDIX 3A: SOCIETAL BARRIERS - FOCUS GROUPS METHODOLOGY

Process

- The Washington D.C. and Los Angeles focus groups were completed on June 7 and June 14, 2018 respectively
- A total of 15 people participated in both focus groups
- A written summary of findings is included in final report

Focus Group Structure

Focus group protocol followed the following structure:

- Pre-Focus Group Questionnaire
- Familiarity with Air Taxi and Urban Air Mobility
- Thoughts and Impressions about Urban Air Mobility
- Automation and Electrification
- Ownership versus Sharing
- Security and Safety
- Privacy
- Concerns as a Non-User

APPENDIX 3B: SOCIETAL BARRIERS - FOCUS GROUPS

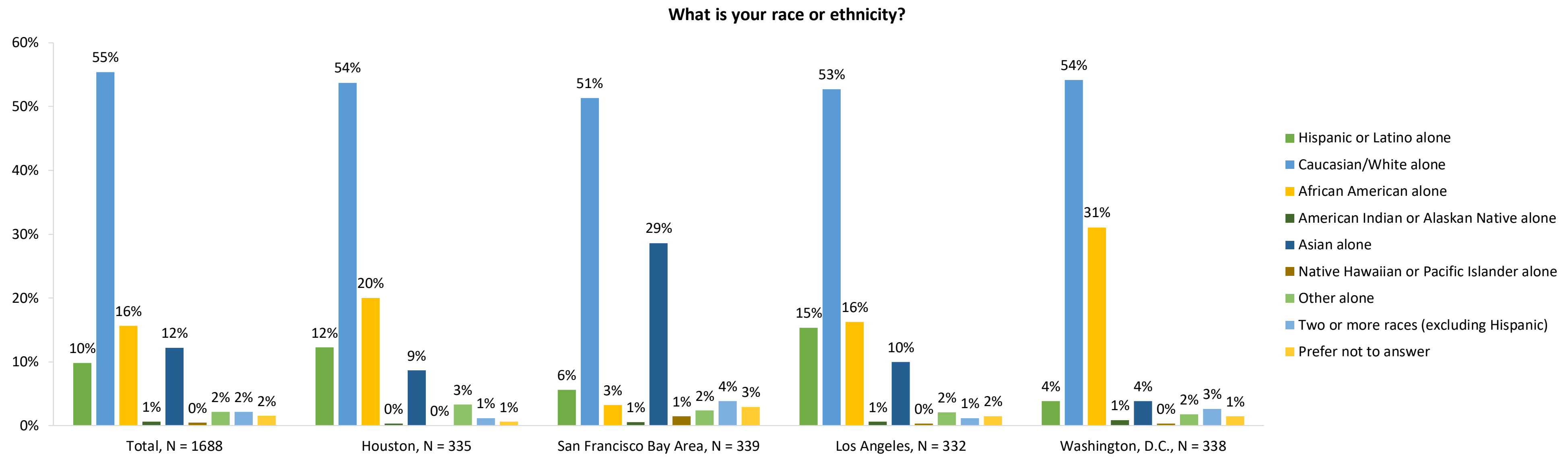
Overview of Participant Demographics

- **Income:** Both focus groups contained a small number of very low-income participants with household incomes of less than $15,000 per year and larger numbers of middle-to-upper income participants earning more than $75,000 per year
- **Highest Level of Educational Attainment:** 60% of participants had a college degree; the remaining participants were evenly split between those with a high/school diploma or vocational training and those with some post-graduate studies
- **Age:** 47% of participants were 18 to 29 years old; the median across all focus group participants was 33 (average age 36)
- **Gender:** 60% Female; 40% Male
- **Race and Ethnicity:**
  - Los Angeles - 67% of the focus group participants were Caucasian compared to just 17% in Washington D.C.
  - Washington D.C. - 50% of focus group participants were African-American compared to 0% in Los Angeles

APPENDIX 3C: SOCIETAL BARRIERS - SURVEY DEMOGRAPHICS

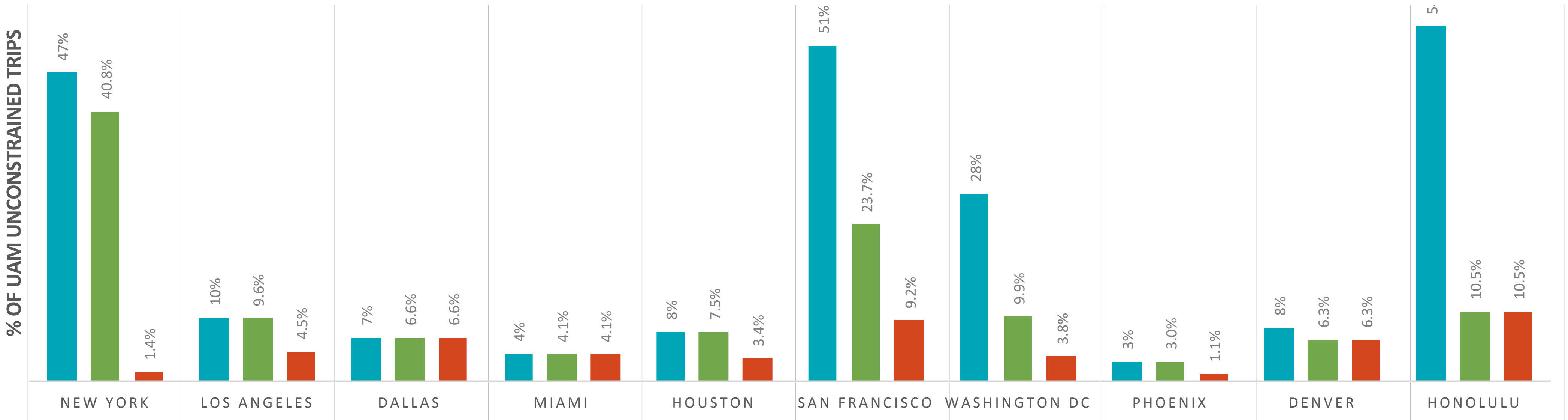
Overview of Participant Demographics

- **Income:** Income distribution of respondents representative of present populations across the cities; closely matched the 2016 American Community Survey distribution
- **Age:** Wider age distribution than focus groups. 51% of respondents were over the age of 45.
- **Gender:** 57% Female; 43% Male
- **Highest Level of Educational Attainment:** More than 60% of participants had a college degree, with more than 30% either currently in the process of obtaining or possessing a graduate degree
- **Race and Ethnicity:** Slight underrepresentation of Latinos, ~14% overrepresentation of Caucasian/White alone across cities



APPENDIX 4A: AIRPORT SHUTTLE BASE YEAR DEMAND COMPARISON FOR ALL URBAN AREAS

- On average **~4.5% of daily unconstrained trips are captured** after applying constraints.
- **San Francisco, Denver and Dallas** are potential urban areas of high daily demand. New York demand capture is highly restricted due to current airport capacity constraint



	NEW YORK	LOS ANGELES	DALLAS	MIAMI	HOUSTON	SAN FRANCISCO	WASHINGTON DC	PHOENIX	DENVER	HONOLULU
Un-constrained	21,000	12,000	13,000	10,000	11,000	14,000	11,000	7,000	11,000	2,000
Infra + WTP Constrained	9,900	1,100	900	400	900	7,100	3,100	200	900	1,000
Capacity Constraint	8,600	1,100	900	400	800	3,300	1,100	200	700	200
APT capacity Constraint	310	530	870	410	390	1,290	410	80	690	190

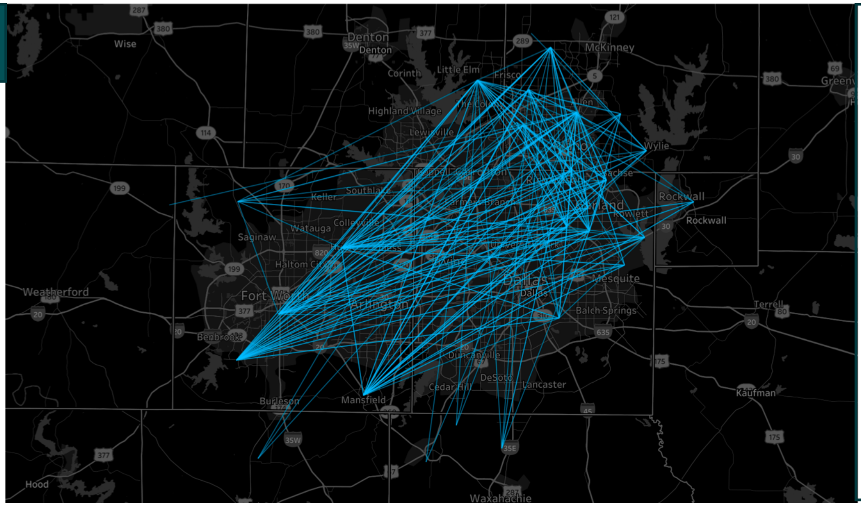
APPENDIX 4B: OVER AT LEAST 85% OPERATIONS MAY BE FLOWN IN CONTROLLED AIRSPACE

Our first order assessment shows that more than 85% of the operations in most urban areas may be flown[1] under controlled airspace. Existing air traffic control may not have sufficient capacity to administer the large amount of operations. ***New technologies like UTM*** *will be needed to serve the Air Taxi market.*

Urban Area	Not Controlled Airspace (A)	Controlled Airspace (B)
New York	10%	90%
Los Angeles	10%	90%
Dallas	15%	85%
Miami	5%	95%
Houston	16%	84%
San Francisco	12%	88%
Washington DC	22%	78%
Phoenix	13%	87%
Denver	36%	64%
Hawaii	11%	89%

[1] Our analysis assumes that a mission is completed on a great circle track. We simply add detour factor to take into account deviation in flight tracks based on airspace, noise, weather constraints etc. However, airspace design is a complicated process as shown by active researches done at MIT, NASA etc.

A



In this case, O-D infrastructure are outside the controlled (B-E) airspace (CA). Since flight path may still intersect CA, operators can make a detour (captured under detour factor) and not fly great circle track to avoid CA.

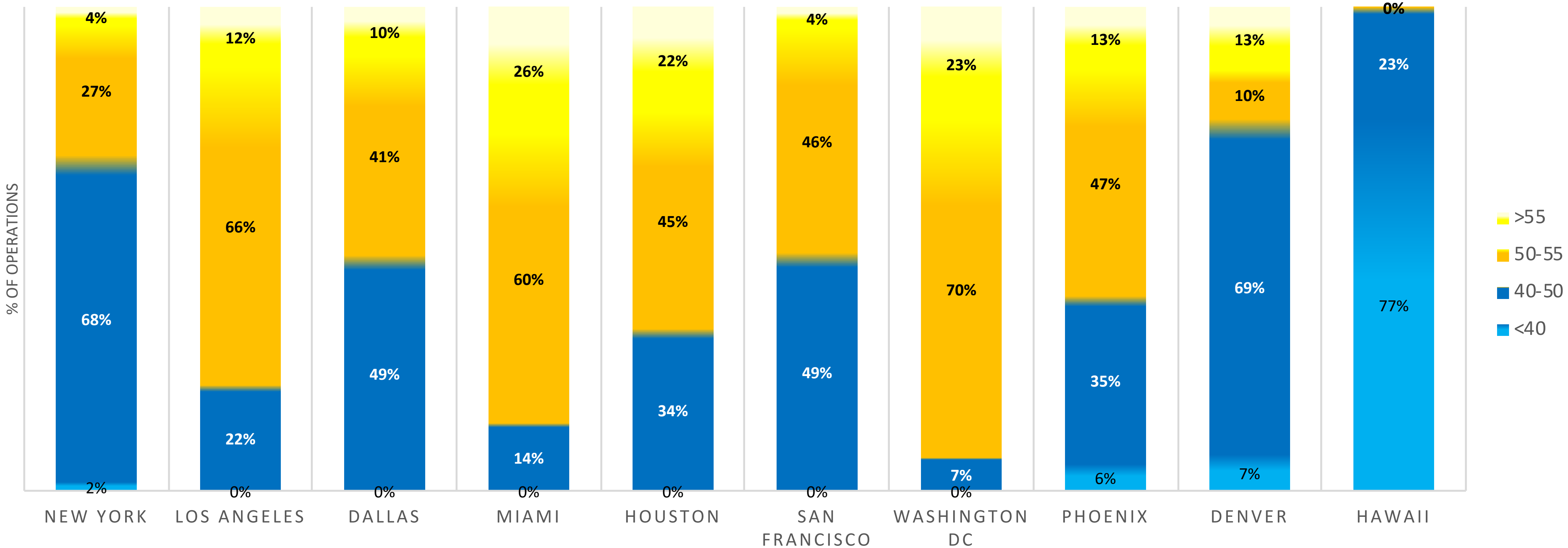
B

In this case, either origin or destination infrastructure are in the controlled (B-E) airspace (CA). Therefore, CA cannot be avoided using detours or other track efficiency metrics.

Note: Subset of the trips (>~1 trip/hr per infrastructure) shown for Dallas in the above figures

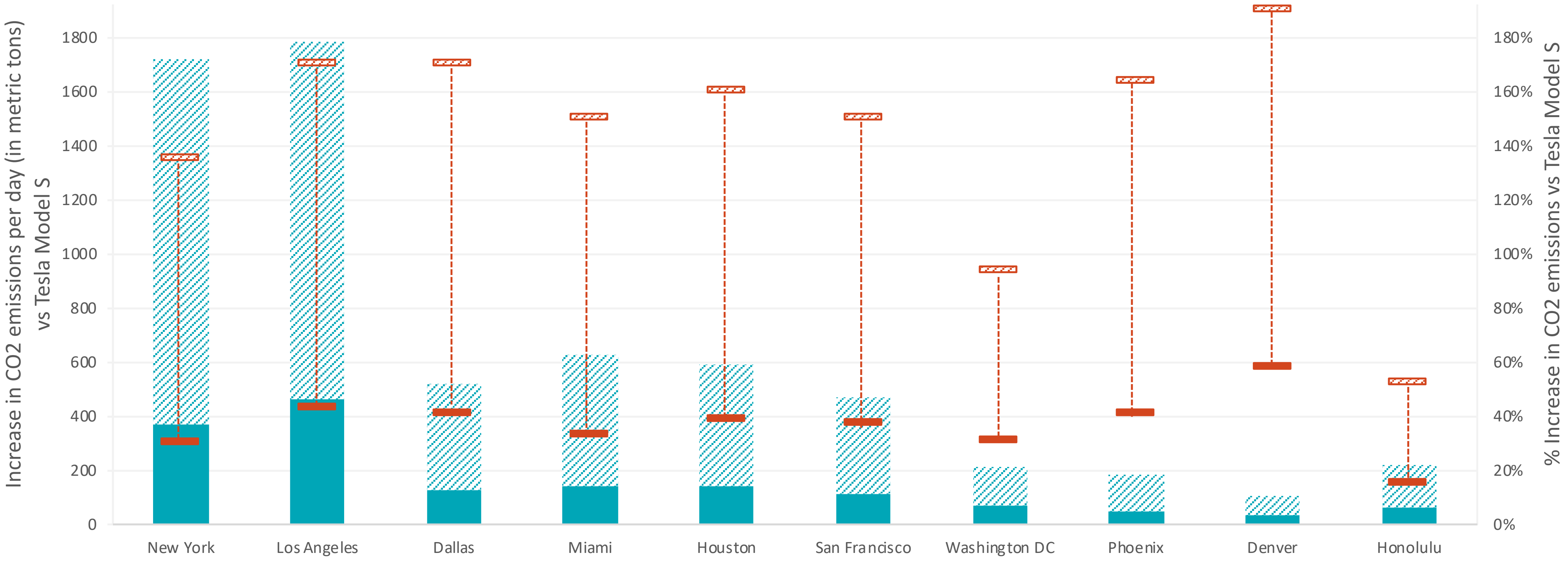
APPENDIX 4C: LARGE PERCENTAGE OF OPERATIONS ARE IN THE AREAS OF LOW BACKGROUND NOISE

- Our preliminary first order noise analysis (available in 'Air Taxi Interim Deliverable') showed that **noise exposure is expected to be more severe near the take-off and landing areas**. Also, there are may be ways to mitigate noise impacts while in flight by choosing routes and flying altitude of minimum impact.
- Urban areas like **Washington DC, Los Angeles and Miami** have most of their **operations in areas of high background noise** (greater than 50 dB as defined by Federal Highway Administration). **Public acceptance** to Air Taxi operations in these urban areas **may be higher** in comparison to New York, Hawaii or Denver



APPENDIX 4D: AIR TAXI WILL LIKELY ADD SIGNIFICANT AMOUNT OF WELL TO WAKE GHG EMISSIONS AS COMPARED TO ELECTRIC CARS

- On average, Air Taxi market at the system level is likely to contribute **significant well-to-wake (WTW) GHG emissions**[1] as compared to Tesla Model S 75D when the same Air Taxi mission is performed by Tesla on the ground.
- To serve the near term Air taxi demand in Urban areas like New York and Los Angeles combined can add more than **1, 000 metric tonne of WTW CO_2 emissions** might be added to the atmosphere based on current sources of electricity generation



[1]Shows the uncertainty in vehicle sizing, which affects energy requirement and CO_2 emissions significantly. Solid bars indicate emissions from vehicle sizing methodology that uses Raymer's General Aviation single and twin engine empty weight fractions, while shaded bars shows emissions from vehicle sizing methodology using empirical data available from public sources

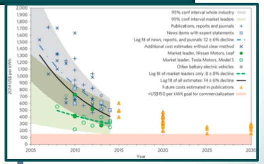
APPENDIX 5A: TECHNOLOGY AND INFRASTRUCTURE SCENARIOS

We outline a set of illustrative technology and infrastructure scenarios to measure the order-of-magnitude implications of improvements and investments in technology and infrastructure proposed to be used for Urban Air Mobility. Each of these scenarios are evaluated independently first and then in an integrated form.

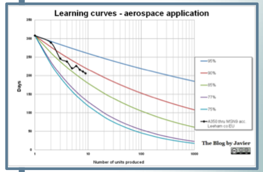
A Technology Improvements

This scenario includes improvements in battery technology and reduction of vehicle cost due to manufacturing learning and experience.

- Li-ion battery capacity specific cost is expected to fall to the **$100/kWh to $150/kWh** price range by 2025 at a $10/kWh annual reduction (Nykvist)
- On average, **vehicle cost reduces by ~15%** on doubling the production (source: NASA). We **double the production every five years.**



Nykvist



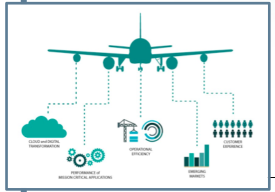
The blog by Javier

B High Network Efficiency

Network efficiency parameters like load factor, utilization and dead-end trips are among the most significant parameters that influences the operating cost (slide 56). We consider following improvements in these factors:

Utilization: ~7 hours/day (from ~4 hours/day) may be possible due to supercharging, higher system capacity, demand etc.
Load Factor: ~80% (from ~65%) similar to commercial aviation
Deadend trips: ~20% (from ~37.5%)

JDA Aviation Technology solutions



Aryaka

Technology and Infrastructure Scenarios

D Infrastructure Improvements

This scenario assumes enhancement to the current air traffic system (or a developed UTM system), which allows in-part an increase of vertiport's operations capacity

Increase in number of vertiports is coupled with increase in capacity. We **double the number of vertiports and operational capacity every five years** to measure new demand.

NASA

Gannett Fleming Image

C Autonomous eVTOL

Most of the vehicles being developed are expected to have the capability to be fully autonomous. Given the pilot shortages facing the aviation industry and the scale of UAM operations anticipated, autonomy may play a key role to fully capture the realized demand. For this scenario we assume the following:

- **Pilot not required**, and therefore **all the seats are available to passengers**
- An **extra ground staff** required to do safety briefings, loading and unloading of passengers.

Bell Helicopters

Uber

APPENDIX 5B: DEMAND SCENARIOS

We outline a set of illustrative scenarios to measure the order-of-magnitude implications of new technologies / concepts like autonomous cars, telecommuting trends and new importance to travel time due to other enabling teleconferencing technologies. Each of these scenarios are evaluated independently first and then in an integrated form.

E New importance of travel time

Continuous advancement in Virtual Reality / Augmented Reality, large screens, new interiors in ground vehicles and other teleconferencing technologies may **enhance the productivity** of the human driver/passenger while in transit. Increased productivity may result in **decrease in value of travel time**, thereby affecting demand of Urban Air Taxis

We evaluate the importance of travel time/cost by introducing a **significance factor in the utility function** (slide 83) and vary it between 0 and 1. '0' represents no importance to travel time and the user is expected to chose the mode entirely based on price, comfort etc.

The Zebra

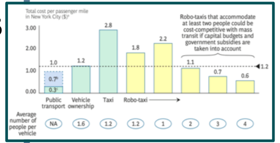
Shutterstock

F Competition from other modes

Autonomous cars, high speed rails and many new or improved existing modes of transportation may pose a potential challenge to the adoption / demand of urban air taxis. Under this scenario, we examine the emergence of fully autonomous vehicles (AVs) only.

BCG U.S. Self-Driving Cars survey 2014 showed **strong willingness** among the American consumers to buy **autonomous cars**. The analysis further shows a **penetration rate of 0.5% and 10% in 2025 and 2035** for full AVs. At an average occupancy rate of ~65% (similar to eVTOL), we use ~$0.9 cost per passenger mile, which is **~35% less than current car ownership / operating costs** in our mode choice model

Strategic Finance



BCG

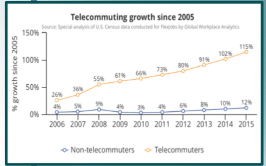
Demand related Scenarios

G Telecommuting

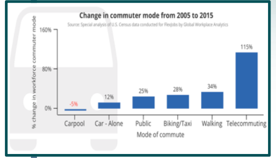
Regular telecommuting grew 115% in the past decade (i.e. ~10% annual), nearly 10 times faster than the rest of the workforce. Current telecommuting population of 3.9 million (3% of total workforce) avoided 530 million trips or 7.8 vehicle miles annually (source: Global Workforce Analytics)

We consider a scenario where **telecommuting continues to increase**[1] **at a rate of ~10% every year** to scope the available demand.

[1]Several researches have shown a possible reverse trend in telecommuting where companies (like IBM) are restricting telework (source: Comcast, Blank Rome LLP, IBM)



Global Workforce Analytics



Global Workforce Analytics

H Congestion & Latent Demand

eVTOLs can induce new mobility patterns including **de-urbanization** i.e. people moving out of the city due to faster transportation options available. We explore such a scenario using parametric analysis by varying average distances for each trip by -25% to +25% at an interval of 10%. Negative percentage indicates increased urbanization.

Finally, mega cities can get **more congested over time**. However, in some scenarios (more pooling, better public transportation etc.), cities can also de-congest. We explore such possibilities by varying average driving speed by -25% to 25% at an interval of 10%. Positive percent indicates increased congestion.

CNBC

V2Gov

APPENDIX 6A: UAM PROJECT TEAM

CHRIS FERNANDO

Senior Associate

Aviation & UAS

- 15+ years of experience in leading projects related to aviation /transportation modeling, analysis, and policy
- Principal Investigator on ACRP 03-42: Airports and UAS
- Extensive knowledge in aviation, data, ATM, and airspace re-design

DR. COLLEEN REICHE

Project Manager

Aviation and Weather

- Ph.D. in atmospheric science from Purdue University
- 10+ years of experience in technical project leadership of aviation research
- Management and technical oversight of a diverse portfolio of FAA and NASA projects related to weather, forecast capabilities, and impact translation

ROHIT GOYAL

Dy. Project Manager

UAM Market Analysis Lead

- Expert in aviation modeling, market analysis, and policy
- Comprehensive knowledge in aviation technology, data, and UAVs
- Advanced studies in Aerospace Engineering from Harvard University and MIT

DR. SUSAN SHAHEEN

Societal Barriers Lead

Sustainable Transportation

- Oversees leading center at UC Berkeley focused on sustainable transportation
- Performs research tasks focused on the future of mobility and emerging transportation
- Authored 60 journal articles, over 100 reports and proceedings articles, nine book chapters, and co-edited two books

DR. PHILIPPE BONNEFOY

Technical SME

Aviation

- Ph.D. in Engineering Systems from Massachusetts Institute of Technology
- 15+ years in aviation modeling and policy analysis with experience in leading projects related to Aviation, Energy, and Environment
- Lead of several groups within the International Civil Aviation Organization (ICAO)

JACQUELINE SERRAO, JD, LLM

Legal and Regulatory

Aviation Law

- 18+ years in leading projects relating to U.S. and international aviation policy, law, and regulations, legal and institutional capacity building
- Comprehensive knowledge of aviation, airport, and UAV laws
- Drafted civil aviation laws, regulations, and/or policies for over 15 foreign governments

APPENDIX 6B: UAM PROJECT TEAM

DR. SHAWN KIMMEL

Transportation

- Ph.D. in Engineering from Colorado School of Mines
- Supporting clients on technical and policy issues related to automation and cyber-physical systems, especially focusing on supporting the Department of Transportation with the integration of automated and connected vehicles.

DR. SARAH NILSSON

UAS Law Professor and Attorney

- SME on aviation and space law, UAS regulations worldwide, flight instruction, aviation safety and education.
- Full-time faculty at Embry-Riddle Aeronautical University (ERAU) in Prescott, Arizona, teaching Aviation Law, Global UAS, Unmanned Aircraft Ground School, Business Law, and Business Ethics

ADAM COHEN

UAM

- SME on the future of mobility, innovative and emerging transportation technologies, shared mobility and Smart Cities
- Conducts global industry benchmarking on shared mobility and co-author of industry market outlooks

DOMINIC MCCONACHIE

Aviation

- 7+ years of experience in leading projects in air transportation and data analytics focusing on economic and environment impact analysis
- Nominated as an expert by the United States to various ICAO Committees on Aviation Environmental Protection (CAEP) groups

ROBERT THOMPSON

Market Analysis

UAM

- Specializes in emerging aerospace markets
- Works with global aerospace OEM on emerging technology strategy across multiple aerospace markets
- Led systems engineering and operations analysis projects on multiple unmanned vehicles
- BS in Astronautical Engineering from Univ. of Wisconsin; Yale MBA

DR. UVEN CHONG

Transportation

- Ph.D. in Engineering from University of Cambridge
- Project lead for ACRP 03-42: UAS and Airports
- Project lead for regulatory analysis in support of viability of UAM for Global OEM
- Analytical expertise in ATM operations and transportation technology analyses.