Urban Air Mobility: The Way Forward

Testimony of: Mr. Michael Thacker, Executive Vice President, Technology and Innovation at Bell

Chairman Smith, Ranking Member Johnson, Members of the Committee,

Thank you for inviting me to testify this morning on the subject of Air Taxis and urban mobility challenges.

My name is Michael Thacker, and I am Executive Vice President of Technology and Innovation at Bell. Made up of 7,200 employees, Bell is based in Fort Worth, Texas with facilities in Amarillo, Canada and offices and partners around the globe. Bell is part of **TEXTRON INC,** a $13.8 billion multi-industry company with 36,000 employees.

The future of our nation, and particularly our cities, rests on the ability to expand our footprint in terms of transportation, connectivity, and ease of movement. Today, I will provide an overview of what we at Bell are doing in this regard, raising issues, questions, and arguments for consideration by this body.

At Bell, innovation is in our DNA. Since 1935, we have shaped the history of aviation and delivered more than 35,000 aircraft to customers around the world, including the first fighter aircraft with tricycle landing gear, the first American jet fighter, the first aircraft to break the sound barrier, the first commercial helicopter, and the first tiltrotor aircraft.

As proud as we are of this legacy, we are equally proud of the technology and innovation advancements currently making up half of our business. Today, advances in processing power, flight controls, electric energy storage and electric motors, to name a few, are informing a new breed of aircraft concepts. Concepts that share the tiltrotor's benefits of vertical take-off and landing (VTOL) and high-speed flight, but also concepts that use much simpler propulsion systems, making them affordable enough for large-scale commercial adoption.

The convergence of these technologies is accelerating our ability to achieve real improvements in air mobility and opening new possibilities for flight, such as addressing the issues surrounding transportation congestion in urban areas. Since the first skyscraper was built, cities have been destined to become multi-dimensional, yet we still think, plan and build in a two-dimensional world, limited to places our feet can touch. We've dreamed of flying cars for decades, but until very recently, they've remained flights of fancy. With the rapid pace of technological advancement, however, small, urban aircraft may well play a role where the current solution set has failed to keep up with our needs.

We believe the real solutions to the future of Urban Mobility lie not in the two-dimensional world of roads, buses, and other traditional options, but in new frameworks and partnerships based on multi-faceted ways of thinking about the possibilities. Bell is excited to press forward into these new fronts recognizing the myriad challenges inherent in the journey, including the future of air transportation within our urban areas.

First and foremost, we need to break free of two-dimensional thinking. Space at ground level is limited, constrained by existing buildings and infrastructure. Space below ground is even more so. New, efficient ground transportation solutions still require miles of physical infrastructure to support their operation.

Around the world, tentative steps are being taken into the vertical dimension. Helicopter charter flights in New York City. Commuter gondolas in La Paz, Bolivia and Ankara, Turkey. In Tel Aviv, SkyTran is building a test loop for an elevated maglev personal transit system that, if successful, could be built at one-tenth the cost-per-mile of light rail.

“The only way to get around traffic is to literally go above it,” says SkyTran CEO Jerry Sanders.

At Bell, we couldn’t agree more.

Our Vision of Urban Mobility

We are actively exploring opportunities for air transportation with electric and hybrid VTOL aircraft, including urban air operations. The concept of an “Air Taxi” is nothing new; we have been moving people over urban obstacles for decades with traditional rotorcraft. What is new is the emergence and development of technologies that enable safe, quiet, efficient, affordable urban air operations at scale, using small, heavily automated electric and hybrid vertical lift aircraft.

Our vision of Urban Mobility complements and extends a broader, multi-modal transportation ecosystem. Rather than focusing on just the VTOL aircraft themselves, it is important to first define the operational requirements they must meet, as well as the transportation network they will operate within.

Defining and developing Urban Mobility solutions is a complex undertaking, requiring coordination and collaboration across industries, regulatory agencies and other communities of interest. Establishing broad agreement on the requirements, standards and regulations of Urban Mobility will accelerate the path to unlocking the benefits of aviation for all of us and, ultimately, the reshaping of our urban environments.

To realize this vision, Bell sees four areas of focus:

Physical infrastructure

The foundation of this solution is a network of vertiports, designated take-off and landing areas where aircraft will pick up and drop off passengers or cargo. These vertiports act as nodes in the network, and can be built on top of buildings and parking structures, limiting the need for ground-level real-estate. Unlike ground-based or ground-tethered transportation options, vertiports will not require miles of physical infrastructure. This makes them highly cost-effective to deploy and allows for substantial freedom in expanding and optimizing the air mobility network without disrupting and displacing existing ground-based activities.

On-demand transportation

VTOL aircraft will travel, on-demand, from vertiport to vertiport, providing fast, quiet, comfortable transportation over crowded urban landscapes. A model informed by current ride-sharing systems will help ensure availability and convenience, while making ridership cost-effective for all. We are currently partnering with groups like Uber who will help define, develop and pilot these on-demand mobility (ODM) operating models. Similar operating models will also augment existing package logistics systems.

Flight control systems

Aircraft will use predetermined flight paths to travel from vertiport to vertiport. Along the way, autonomous flight control systems will engage with each other to manage traffic flow, avoid collisions, and ensure safe, secure, efficient flights. This will require seamless operation between aircraft flight control systems and airspace control software. Existing airspace system infrastructure, along with developing systems, like those in design by NASA in partnership with the FAA, should develop ensure the needs and considerations of urban air mobility are represented to allow for the future of this ecosystem.

Aircraft technology and design

On-demand mobility will require new breeds of aircraft, employing new technologies to fulfill the mission. These aircraft will need to be lightweight, cost-effective, and employ simple, reliable propulsion systems. Because they are intended for use in urban environments, where air quality and noise pollution are important considerations, they will employ electric or hybrid distributed propulsion systems and new, quiet proprotor solutions. Aircraft will continue to evolve in design over time, and regulations must evolve to enable innovation in the service of community needs without sacrificing safety expectations.

Urban Mobility and the Air Taxi

Bell has a strong legacy of breaking new ground in aviation, from America's first jet fighter, the P-59 Airacomet, to the first supersonic aircraft, the legendary Bell X-1, and the first tiltrotor aircraft, the XV-15 and V-22 Osprey. Each required the development of new technology and new approaches to previously unknown obstacles.

The challenge we face today is developing a new breed of distributed propulsion aircraft that target the same benefits as a tiltrotor – namely the combination of VTOL (vertical takeoff and landing) capability and high-speed flight – but that employ much simpler propulsion systems and an imperative to make them affordable enough for large scale commercial use.

As we create new aircraft and concepts of operation, Bell is focusing on our customer communities, to develop solutions that enable air mobility to be more than a simple movement from point A to point B, but rather an opportunity to move across societal barriers, bringing us closer together through safer, more universal access to flight.

Part of our role is to invest in technologies and products to implement this vision of the future. Along the way, we must engage with communities of interest to ensure both acceptance and real benefit. As one of the organizations with the most experience bringing these complex systems to market, we are uniquely positioned to ensure safety, practicality and marketability.

To overcome key gaps in the current system, Bell is advancing across four integrated frameworks – operational, regulatory, technology and manufacturing.

Operational Framework

While it is tempting to leap straight to all the amazing new vehicle technology, we must start with the operational framework. How will the system work? What is the mission that needs to be accomplished? What environment will we be working within?

First, we plan to be operating in urban areas, in and around a lot of people. This comes with a safety expectation that protects both passengers and people on the ground, even in failure scenarios. It will also require an affordable solution accessible by most people. This is critical to acceptance – why would people accept aircraft operating in their neighborhood if they can't take advantage of them?

Another critical component of acceptance is managing the acoustic signature of ODM aircraft. One of the greatest hindrances to vertical lift operations in cities today is noise. To succeed in urban environments, breakthrough reductions in vehicle noise generation are a must.

At Bell, we are building on a 40+ year legacy of acoustic analysis and testing. Together with NASA and the U.S. Army, we have validated open rotor acoustic testing in both traditional helicopters and transformative lift vehicles, such as the XV-15 and V-22. Now, we are focused on fully coupled advanced proprotor modeling for both external and internal noise created by on-demand mobility vehicles. We are currently testing our ODM propulsion drive system to understand this key performance parameter and ensure we achieve our 'good neighbor' acoustic goals.

Beyond the environment driving vehicle and operating requirements, there are myriad operating details to consider, including vertiport locations, charging stations, ground safety protocols, secure passenger identification and access, and more.

We also cannot ignore normal aviation operational requirements for vehicle identification, communication and separation in a potentially more constrained airspace, or standard requirements and practices for maintenance, inspections and continued airworthiness.

Most, if not all, of these operational challenges have been addressed in some form in existing aircraft operations. We obviously already operate helicopters in many urban locations today. The system gaps come due to potential increases in traffic volume, particularly in low altitude airspace, and the increasing use of automation to enhance operational safety and efficiency.

Today, there are numerous efforts underway to outline paths forward.

The FAA recently announced the teams that will proceed with the Unmanned Aerial Systems (UAS) integrated pilot program, which targets data collection to expand unmanned aircraft operations in the national airspace.

The NASA System Integration and Operationalization (SIO) program will integrate state of the art technologies into UAS to inform FAA creation of policies for operating UAS that have Communication, Navigation and Surveillance capabilities consistent with Instrument Flight Rules (IFR) operations.

NASA also has recently announced the Aeronautics Research Mission Directorate Grand Challenge, with high-level goals to demonstrate the potential safety of Urban Air Mobility and provide the opportunity for the community to learn together in relevant and realistic operational environments.

On the industry side, venues like Uber Elevate provide the opportunity to bring stakeholders from across the ecosystem together to address system-level needs. Participants from infrastructure, technology, regulatory bodies, communities, operators and aircraft OEMs have all taken part.

Regulatory Framework

There is significant overlap between all four frameworks, and the operational and regulatory frameworks are in some sense inseparable. Whatever concept of operations we have, we need a regulatory framework that allows us to take off, depart terminal areas, fly, interact with other aircraft, approach, and land.

Bell's top priority in the regulatory framework is working with regulators to establish an integrated approach across vehicle, operational, and air traffic functions. In traditional aviation, these requirements are in many respects separated. For ODM vehicles and operating concepts, we need a holistic approach to ensure we achieve the desired safety outcomes without overburdening any one aspect of the system.

Currently, the FAA, European Aviation Safety Agency (EASA), Transport Canada and other regulators are engaging in a meaningful way to help enable these new mobility concepts. EASA recently released an internal study identifying its view of the gaps for implementing ODM in Europe. The FAA is actively engaging both on existing UAS operations and on new models moving forward. At a recent FAA-EASA international safety forum, innovation, technology, autonomy and on-demand mobility operations were significant elements of the agenda.

Taken together, it is clear much of the regulatory framework for ODM vehicles and operations is already in place. The key areas of discussion moving forward will be the means of showing compliance to our high safety expectations with these new vehicles and operating models.

Manufacturing Framework

Beyond the requirements of the vehicle and operations lies production at scale. For on-demand mobility concepts to succeed, affordability and environmental targets must be achieved, and the manufacturing framework helps address these opportunities.

While the production environment also had regulatory and quality expectations, those are baseline assumptions. The focuses of development in the manufacturing framework are cost, weight and environmental impact.

We are developing numerous advanced manufacturing technologies to enable our future factory to be safe, efficient, flexible and accurate. One area of study is the application of rapid prototyping techniques to full-scale production. These include the application of augmented and virtual reality to prototype and full production design, universal component specifications to ensure precise tolerance, streamlined production and efficient field replacement, and 3D printing for rapid design iteration and efficient production for some parts. These techniques hold the potential to enable faster, more efficient production and to bring costs down, as well as the flexibility to design and produce aircraft variants for different applications using common technologies and components.

Technology Framework

The technology framework underpins and enables the others, but it also requires the guidance of the other frameworks to focus and refine efforts.

The innovations being created at Bell are the foundation for a new era of flight. The technology framework for tomorrow's on-demand mobility aircraft includes autonomy and artificial intelligence, electric or hybrid distributed propulsion, and advanced algorithms for integrated aero-acoustic, propulsive and flight controls.

These engineering challenges are being addressed aggressively, but we are at the same time mindful of the lessons we learned while creating the first operational transformative flight vehicle, the V-22. We fully expect new discoveries and new challenges to refine our efforts going forward.

Technology Framework – Man-Machine

One key technology focus area is the man-machine interface. Rapid progress in autonomy will change the way we fly, and ultimately what it means to be a pilot or aircraft operator. In reality, this change has been ongoing for many years, with the move from simple analog gauges to digital displays to today's full glass cockpits, and from mechanical flight controls to fly-by-wire and fly-by-light controls and flight control systems that intelligently manage flight and compensate for aircraft failures.

Today, safe, unmanned operations are already possible. Bell has safely and successfully deployed autonomous technology for 18 years. In many ways, autonomous aircraft are more feasible than autonomous cars, which must contend with the unpredictable variables of human-operated vehicles, pedestrians and wildlife. We fully expect to progress to autonomous flight with passenger-operators in the future.

Beyond autonomous flight, it is also critical to consider remote monitoring and fleet management. In the ODM model, individual aircraft may be fully automated, but they will need to communicate seamlessly with air traffic controllers and with other aircraft. This is an area where we are collaborating closely with partners to develop robust, secure airspace and fleet control solutions.

Technology Framework – Propulsion

Propulsion systems have been a key enabler for nearly every breakthrough in aviation. For on-demand mobility, Bell is developing or working with partners to develop both electric and hybrid-electric distributed propulsion systems.

We have recently announced our collaboration with Safran on the development of an innovative hybrid-electric propulsion system. This hybrid system will support our ODM vehicle at approximately 6,000 pounds maximum takeoff gross weight (MTOGW), with range extension opportunities 3-4 times greater than current all-electric solutions.

While our initial flight demonstration vehicle will employ hybrid-electric propulsion, Bell's engineering teams continue to work the parallel path of all-electric architectures. The limiting factors today are battery energy densities and rapid charging capability without significant life degradation.

In the future, the selection and vehicle integration of these systems will depend on technology maturity and specific operational requirements.

Technology Framework – Science and Technology Opportunities

For this committee, Bell sees numerous opportunities to make an impact on the ability of the US to lead in this emerging aviation field. There are several key technology areas common to almost all of the concepts for vehicles and operations.

Energy storage: The ability to achieve commercially viable combinations of payload and range will require energy densities beyond the current state of the art. Battery energy densities have increased dramatically over the last years, but still lag significantly behind hydrocarbon fuels. Key areas for research include new chemistries or even storage systems for improved energy density, rapid recharge capability and reduced life degradation with recharge cycles.

Electronic hardware: Communication, navigation, separation and other key system functions are driven by electronic hardware and software. Low cost, low weight, high reliability sensors and electronic hardware can help enable these power and weight sensitive vehicles while ensuring safe operation in the airspace.

High voltage electrical power distribution and control: This research area is driven by the high-power requirements for vertical takeoff and landing combined with the need for light weight and high efficiency in the generation and distribution of the electrical propulsion power.

Artificial intelligence and man-machine teaming: For the vehicle, the airspace system and for manufacturing, optimizing the use of man with machine can unlock new capabilities and efficiencies.

Beyond these basic research areas, continued support of FAA and NASA aeronautics research particularly in airspace integration of UAS and other ODM vehicles is critical to successful launch and operation of these platforms.

Extensibility of Integrated Frameworks

While the primary focus of this testimony has been on passenger carrying systems, the integrated frameworks that enable an air taxi also enable numerous other on-demand mobility applications. Autonomous, electric or hybrid electric, distributed-propulsion VTOL aircraft could serve many roles across many industries, including logistics, shipping, manufacturing, and first responder support for search and rescue, medical transport, disaster relief and more.

One vehicle concept we are actively developing is called Autonomous Pod Transport (APT). While we envision this VTOL transport aircraft as a tailsitter that rotates into level flight, a different mode of operation than our current air taxi concepts, we see many opportunities for shared technology development, including distributed propulsion systems, quiet, efficient rotor systems and autonomous flight control systems.

Furthermore, we anticipate the commercial technologies developed for ODM to have potential for our military customers as well. Bell is working with U.S. armed forces on multiple projects, and can envision numerous applications for similar technology in the field, from scouting and forward air control to maritime patrol, light personnel and cargo transport, and medevac operations. Autonomous or semi-autonomous flight reduces risk for military personnel, as do reduced acoustic signatures. Distributed propulsion systems may also offer a higher degree of redundancy and survivability compared to traditional platforms.

Concept Designs and Development Timeline

Bell has been developing air taxi concepts, along with the technology and infrastructure to enable them, for quite some time. While we are not sharing all of our designs or timelines, we believe viable commercial operations could begin as early as the mid-2020's.

Regulatory Barriers and Gaps

Bell and our partners are working aggressively to bring this set of ODM solutions to life. As we do, it is clear that the existing safety system framework encompasses all of the elements needed for these new aircraft and concepts of operation. However, the existing standards will need to be adapted, and new means of compliance will need to be accepted. Traditionally, airworthiness standards have been largely a collection of lessons learned and best practices. While that has advantages in some respects, it has left us with prescriptive rules that fit yesterday's technology better than future technology.

The on-demand mobility ecosystem will require flexibility to accommodate multiple technology and vehicle types. Numerous developments are already underway, and will continue as the needs of the audience, environment, and overall mission evolve. The path for ODM vehicles already has been helped by amendment 64 of Part 23. Bell believes Part 23 plus special conditions, either unique or from Part 27 or other existing policy and guidance material, can provide a reasonable basis for vehicle certification. At amendment 64, most of the prescriptive means of compliance were moved into consensus-based industry standards leaving the true safety objectives within the Part 23 requirements. This format provides a more adaptive framework to define and accept new means of compliance associated with different technologies and configurations. Extending the Part 23 performance-based approach to Part 25, 27 and 29 would further enhance the path to safe integration of technologies across aircraft platforms and specifically for transitional ODM vehicles.

The regulatory opportunity, however, extends beyond certification of the vehicle. For ODM operations to be success, we need an integrated solution across vehicle certification, flight standards and air traffic control. Today, safety is managed across the system with risks mitigated in each area. However, we have traditionally treated the areas as silos. With increasing automation and the unique attributes of many ODM configurations, risk mitigation and safety outcomes will be managed across the silos rather than within them. We need a holistic approach to ensuring our expected safety outcomes without inappropriately burdening the aircraft or any other individual part of the system based on assumptions that no longer apply.

In this regard, we were pleased to see FAA leadership begin to engage industry with all elements of the FAA team involved in the conversation. This is a positive step toward understanding the overall safety system for ODM and ensuring that we proceed together to define viable solutions.

In addition to aircraft and operating standards, ODM landing sites within urban airspace will require consideration for standards related to landing zone requirements, refueling, secure air fields, and related issues. Each city will have some unique needs based on zoning and the skyline profile and altitude dynamics of that location, as well as density and traffic demand, flow patterns, on-demand operators, and other aircraft in the area. ODM guidelines will need to account for the flight environment and dynamic area in which urban flight takes place, but also plan for growth and expansion into other solution areas that may have completely different needs, like industrial parks, agricultural areas, remote manufacturing, tourism, or other future solutions.

Despite these local integration needs, it is important that standards for the aircraft and for operations are common across the US and preferably across the globe. To that end, it is important that Federal preemption for the FAA in the area of aviation is respected legislatively and judicially.

Close coordination and cooperation with governments and regulatory agencies is critical for the development of appropriate regulation that provides a clear path to compliance and authorization to operate with guardrails, rather than roadblocks. Furthermore, the FAA, EASA and other regulators should work together to develop a globally coordinated safety system expectations through agreed-upon consensus standards that ensure the viability of reciprocal airworthiness acceptance. We are encouraged in this regard by recent progress, including the activity of the General Aviation Manufacturers Association Electric Propulsion Innovation Committee (GAMA EPIC), which has brought both voices to the conversation together, and we encourage both agencies to seek opportunities for continued collaboration.

When considering this space and the diversity of flight platforms in development, there are many 'correct' solutions to provide safe, efficient, effective transportation in various forms. Standards must allow for and encourage smart development and problem-solving as industries come together to address these challenges. Limiting tomorrow's solutions with yesterday's design and testing rules not only prevents creative technology, it reduces interest in the field from the greatest minds and can inhibit overall development.

The goal, ultimately, is to create a regulatory approach that allows good ideas in while at the same time ensuring safe and effective operation.

Public-private cooperation has helped establish regulatory approaches in the past. At Bell, our depth of knowledge and experience across regulations provides a strong foundation for working with regulators to define appropriate paths forward for showing compliance.

We are already engaged with the FAA and look forward to working with them to help chart the paths toward safe and compliant ODM operations.

Safety and Security

Beyond the hype and excitement, to be successful, these new systems must be safe and secure to warrant the public confidence and widespread usage. Bell expects these new systems to produce safety outcomes that are equivalent or better the today's aviation system expectations for similar aircraft. As noted above the regulatory system needs to be flexible enough to rapidly enable these new aircraft and operating concepts, but robust enough to ensure we maintain our high expectations of aviation safety.

Summary and Conclusion

Creating a real, viable Urban Mobility network isn't something that is going to happen tomorrow, but this future is closer than many people realize. Across private entities like Bell and our partners, as well as government agencies including NASA and the FAA, this future is being actively, aggressively pursued.

The Bell focus, detailed in the above testimony, is framed through four integrated frameworks that help define the Urban Mobility model, develop the enabling technologies, chart a path for regulatory support and ultimately inform aircraft design and operating requirements.

Many of America's greatest accomplishments—from the Manhattan Project to the space program to the internet—were only possible through effective public-private partnerships. The promise of another great American accomplishment, true Urban Mobility in the vertical dimension, now lies before us, and along with it the promise of carrying on America's long legacy of leadership and innovation in aviation. We are pursuing the technology that will make this dream a reality, but we need your support to help drive basic science and technology investments and to create a framework of regulation and oversight that allows for rapid and even radical innovation while ensuring safe, effective deployment and operation.

As we speak to this Committee today, all the issues we have addressed are viewed through a solutions-oriented lens. We are, after all, a solutions-oriented company, driven to find not just any answer to a given challenge, but the right answer, especially when it requires innovative thinking, breakthrough technologies, or developing entirely new classes of aircraft.

Today we are presenting the conceptual approaches we believe will work not only for a more mobile, more functional American future, but that will create more freedom and efficiency in how we work and live. Opportunities that can create a cleaner, quieter, more efficient urban environment, and advanced technology solutions that offer any number of job opportunities in our US-based facilities or with one of our many talented partners. We are committed to a stronger, more mobile future, and will do our part to bring it to life.

Thank you to Chairman Smith, Ranking Member Johnson, members of the Committee, our fellow speakers, and everyone in attendance for the opportunity to speak with you today.