

*This white paper examines the critical need for an integrated national approach to supply chain management for the emerging Advanced Air Mobility Sector (AAM). Nations around the world are engaged in a highly competitive race to achieve technological superiority and market dominance with electric Vertical Take-off and Landing (eVTOL) aircraft. For the U.S. to win this race, it must harness America’s innovative scientific, technical, production, and capital market strengths across products and services unique to AAM. Powerful supply chain tools built around electronic exchange platforms can link Tier 0 American eVTOL developers to their “Best in Class” national suppliers.*

## The Global Race for Advanced Air Mobility

### A Resilient Supply Chain is Key to American Market Leadership

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#### The Trillion Dollar Prize

Advanced Air Mobility (AAM), also known as Urban Air Mobility (UAM), involves the use of revolutionary eVTOL aircraft (Figure 1), which promise to be smaller, lighter, quieter, greener, and far more affordable than traditional aircraft. This new form of aviation offers dozens of new uses for aircraft—from regional shuttles to medical delivery to on-demand air taxis—as well as the promise of less congestion—the bane of modern cities. Key technologies include lightweight composites, lithium-ion batteries, powerful multi-rotor lift and advanced flight control systems.

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*THE REVOLUTIONARY AAM CONCEPTS AND SYSTEMS IN DEVELOPMENT TODAY HAVE THE POTENTIAL TO TRANSFORM OUR MODERN WORLD, BOOSTING THE LIVABILITY OF OUR CITIES, AND IMPROVING OUR WAY OF LIFE.*

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In 2020, Morgan Stanley forecast the size of the AAM market at more than \$1.5 trillion, while a more recent and widely subscribed industry study by NEXA Advisors identified \$350 billion market potential within the world’s 75 largest cities. (Combined, these metropolitan areas represent just 24 percent of global GDP.)



*Figure 1 – Joby has received approximately \$820 million in investment leading up to 2021. Above is the Joby S4 eVTOL Passenger Tilt Rotor prototype funded by JetBlue Ventures, Toyota, Intel Capital and others.*

The 29 U.S. metropolitan areas in the NEXA study are expected to produce over \$84 billion in business activity between now and 2040 (Figure 2). With a revenue-to-infrastructure investment ratio of 2.8, the U.S. remains a highly promising market, ripe for capital market investment<sup>1</sup> in ground vertiport infrastructure, UATM (low altitude air traffic management) systems, and existing Part 135 helicopter operators. It is expected that eVTOL developers will compete for this business from all corners of the globe. We can identify German

company Lilium (planning to set up U.S. operations in Orlando) as an important example of things to come. China-based eHang also has eVTOL vehicles flying demonstrations in the U.S and Canada.

U.S. UAM Category	Parameter
U.S. Metro Areas	29
UAM Operator Revenues	\$61,990,000,000
Ground Vertiport Infra	\$6,904,000,000
UATM Capex, Opex	\$3,626,000,000
eVTOL Vehicle Cost	\$11,759,000,000
Infrastructure R/I Ratio	2.8

This is in part why other nations are hard at work to develop this new aviation sector that promises tens of thousands of jobs in manufacturing, operations, and related industries, as well as increased tax revenues. Figure 3 provides a list of the 417 conceptual or full eVTOL development projects by country. More than one third are U.S. based.

Country	eVTOL Conceptual or Development Programs
<b>United States</b>	143
<b>Germany</b>	39
<b>United Kingdom</b>	39
<b>China</b>	23
<b>Canada</b>	20
<b>Russia</b>	16
<b>France</b>	14
<b>Italy</b>	14
<b>Japan</b>	13
<b>Austria</b>	10
<b>India</b>	8
<b>Australia</b>	7
<b>Hungary</b>	7
<b>Switzerland</b>	7
<b>Rest of World</b>	57

Figure 2 – Approximately 417 Published eVTOL Concepts or Development Programs Listing the Most Prolific Countries: January 2021. Source: Vertical Flight Society

The looming question is: Which countries will facilitate design and production capacity, and thus reap the economic benefits? The answer depends on which nations create an effective and sustainable

supply chain. Without it, widespread implementation of eVTOL aircraft will never get off the ground.

### Why is AAM Supply Chain Management Important?

For more than a century, strategic industries such as automotive, aircraft manufacturing, and pharmaceuticals have known that a robust, electronic platform-based supply chain is crucial to success. Of the nine drivers of supply chain resilience, the most important are supplier location, country risk/policies, intellectual property protections, supplier innovation, and capital market access.<sup>2</sup>

*“THIS IS A GAME-CHANGER. IMAGINE TAPPING INTO A WORLD OF THOUSANDS OF MANUFACTURERS, AND WITHIN SECONDS FINDING ONES PERFECTLY SUITED TO FILL YOUR NEEDS.”*

– NATIONAL ASSOCIATION OF MANUFACTURERS

Over 400 AAM vehicle development programs are underway in the world today, according to the Vertical Flight Society.<sup>3</sup> Of these, some 140 are U.S.-based (Figure 2). All but a few are under-funded, making it critical for developers to link quickly with partners offering the best-of-breed components and sub-systems, while sources of capital are being sought to finance the most promising of these projects.

Vehicle design types include multicopter, ducted fan, fixed wing with propellers, vectored thrust, and others, mostly with all electric or hybrid-electric propulsion systems. All eVTOL vehicles planned for AAM are capable of vertical take-off and landing, to ensure suitability for helipads within 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.

Manufacturers range from established aerospace companies like Boeing and Airbus, to automotive companies like Toyota and Hyundai, to start-ups like

Joby, Wisk, Lilium or VEA Aviation (a spinoff of Piasecki Aircraft). Some developers plan on operating their AAM vehicles directly and at scale, while others aim to become part of a larger AAM ecosystem. This diversity in manufacturers and in vehicle designs adds complexity to the AAM ecosystem from a supply chain and regulatory governance standpoint, furthering the need for standardization of AAM concepts and specifications.

In the U.S., the Federal Aviation Administration is aerospace’s regulator – be it manufacturing or operations - and has recently reorganized around the complexities of the eVTOL supply chain.

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*HERE IS WHY AN EFFICIENT SUPPLY CHAIN IS SO IMPORTANT TO THE AAM SECTOR: LOWER PRODUCTION COST, GREATER PRODUCT PERFORMANCE, LOWER CERTIFICATION RISK AND FASTER TIME TO MARKET. THE ENTIRE SECTOR AND ECONOMY WILL BENEFIT IN POWERFUL CATALYTIC WAYS.*

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These factors translate into cost savings, rapid market introduction, and improved market share. For the AAM Sector, a 5-8 percent supply chain improvement can translate into billions of dollars in enterprise value for participants, and potentially shave years off product development and certification time.

### **The U.S. AAM Supply Chain Holds Immeasurable Strategic Value**

While there are more than 65 AAM development programs in the U.S. today, companies in the supply chain necessary to support these programs number in the thousands. Consider just these five critical Tier 1 and Tier 2 components of eVTOL aircraft:

- Motors, propellers and power control systems
- Energy storage systems including Lithium Ion and hydrogen fuel cells
- Avionics including flight control, radio and inertial navigation, surveillance, air to ground communications, and pilot assistance
- Composites and aerodynamic structures

- Software, Command and Control and Artificial Intelligence

These Tier 1 and 2 suppliers are themselves hotbeds of innovation. According to data compiled by Aviation Week Network, over 3,000 companies in the U.S. alone can provide these components.<sup>4</sup> But eVTOL developers know very little about the skilled aerospace suppliers that are likely in their own back yards.

For a company developing an Advanced Air Mobility product for manufacture, having an efficient supply chain makes the best use of its resources – financial, human, technological, and physical. Choosing the most strategically valuable Tier 1 or 2 supplier is critical, as by doing so a developer can leverage the most innovative components available, maximize performance, minimizing costs, and reducing time to market. In the AAM arena, most developers have an extremely narrow idea of what is available in their country, let alone down the street.

### **National Security, Defense Production and the AAM Supply Chain**

High-tech industries in the U.S. remain vulnerable to intellectual property theft from the usual competitors – China, Iran, and Russia. Federally driven policies are being formulated to maintain strong national supply chains to reduce exposure and vulnerability to foreign actors. One need only point to the drone sector, where China now dominates supply, on the back of U.S. innovations of earlier years. Another recent example is with PPE availability, which demonstrated U.S. supply vulnerability during the early months of the COVID-19 pandemic.

*“... With Western drone manufacturers floundering and shifting business models, one company’s fortunes are soaring: China’s DJI Technology. Today the Shenzhen-based company dominates the global drone hardware market, which is forecast to surpass \$11 billion by 2020.”*

**CNBC News**

Policies are emerging designed to prevent supply chain weaknesses with AAM. Executive Order 13806, released by the White House and Department of Defense in 2018<sup>5</sup>, calls for the

establishment of resilient supply chains in key industrial sectors. The U.S. government recognizes that in an era of highly-charged international competition, the ability to supply strategic sectors depends on a healthy and resilient national defense and commercial industrial base.

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*A HEALTHY MANUFACTURING AND DEFENSE INDUSTRIAL BASE SUPPORTED BY RESILIENT SUPPLY CHAINS IS ESSENTIAL TO A COUNTRY'S ECONOMIC STRENGTH AND TO NATIONAL SECURITY.*

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The ability of the United States to maintain readiness, and to surge in response to an emergency, directly relates to the capacity, capabilities, and resiliency of its manufacturing and defense industrial base and supply chains.

Modern supply chains, however, are often complex. The ability of the United States to manufacture or obtain goods critical to national security could be hampered by an inability to obtain various essential components, which themselves may not be directly related to national security. Thus, the United States must maintain a manufacturing and defense industrial base and supply chains capable of manufacturing or supplying those items.

The loss of more than 60,000 American factories through 2019, key suppliers, and almost 5 million manufacturing jobs since 2000 threatens to undermine the capacity and capabilities of American manufacturers to meet national defense requirements and raises concerns about the health of the manufacturing and defense industrial base. The loss of additional companies, factories, or elements of supply chains could impair domestic capacity to create, maintain, protect, expand, or restore capabilities essential for national security.

### **Another American Innovation: Electronic Exchange Platforms Benefit Supply Chain**

An important key to a resilient supply chain is the information exchange system that allows sharing of critical data of relevance in support of OEM design

and manufacturing. A eight-year collaborative effort led by i5 Services in partnership with the National Association of Manufacturers and key stakeholders (manufacturers and manufacturing associations) in Utah and Florida has produced a powerful platform that links hundreds of thousands of manufacturers, so that producers can identify Tier 1 and 2 suppliers perfectly suited to fill production needs.<sup>6</sup> The CONNEX MARKETPLACE™ Platform's proven capabilities include:

- Supply chain visualization and risk assessment
- Search by equipment, materials, certifications, products, and more
- Workforce and R&D visualization and directory of capabilities
- Exchange center for RFIs, RFPs, RFQs, other needs
- Blacklist verification of all organizations in the supply chain (top 12 U.S. government blacklists)
- Direct link to national search (single click expands search nationally)

Visualization of the supply chain and identification of supply chain risk are just two key benefits of the i5 solution. For AAM, this platform will be modified to specifically address unique challenges for the eVTOL sector.

### **Benefits of Integrative Supply Chain Approach**

The enormous benefits of a dedicated electronic exchange platform supporting eVTOL developers in the U.S. are many:

**Industrial:** Tier 0 eVTOL developers will be able to locate and leverage the most innovative components, systems and intellectual property available from U.S. sources, that in turn can maximize product performance, minimizing recurring manufacturing costs, speeding certification and reducing time to market. Risk management becomes vastly more achievable. Opportunities to better scale Tier 1 and 2 volumes and provider companies will follow.

**DoD and Industrial Base:** As specified in Executive Order 13806, the DoD can add its commercial contracts to the industrial mix, and can afford protections that will reduce risk and ensure resilience over the long term. National security benefits should automatically accrue.

**National Economics:** Improved revenue growth concentrated in the U.S. will lead to increased aerospace sector and growth in aerospace jobs. The types of these full-time-equivalents are more scientific and technical in nature, and higher paying.

**Capital Investment:** U.S. capital markets will be more responsive and participatory due to the strengthened local dynamics of this powerful supply chain presence (see below).

## U.S. Capital Markets are Poised to Support AAM

Venture capital is a subset of private equity which focuses on relatively small firms perceived to have high growth potential. According to the National Venture Capital Association, deal value for the first 3 quarters of 2020 exceeded \$112 billion<sup>7</sup>. AAM sector development companies have secured almost \$5 billion, and this figure is expected to double by mid-2022, according to NEXA. In addition, some deals will attract significant public capital through the increasing availability of SPACs and PIPEs.

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*IF THE U.S. IS TO COMPETE IN THIS RACE, IT MUST HARNESS AMERICA'S INNOVATIVE SCIENTIFIC, TECHNICAL, PRODUCTION AND CAPITAL MARKET STRENGTHS ACROSS PRODUCTS AND SERVICES UNIQUE TO AAM. POWERFUL SUPPLY CHAIN TOOLS BUILT AROUND ELECTRONIC EXCHANGE PLATFORMS, CAN LINK TIER 0 AMERICAN eVTOL DEVELOPERS TO THEIR "BEST OF BREED" LOCAL SUPPLIERS.*

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With a more secure supply chain strategy providing accelerated benefits to U.S. eVTOL developers and supply chain leaders in AAM infrastructure, capital formation will become easier to achieve. 2021 will be the most significant year ever in capital formation for AAM companies and eVTOL developers.

## NASA and AFWERX are Participants in eVTOL Supply Chain Development

The Air Force recently launched Agility Prime, a non-traditional program seeking to accelerate the commercial market for advanced air mobility vehicles. Leveraging unique testing resources and revenue generating government use cases for distributed logistics and disaster response, the U.S. government plans to mitigate current commercial market and regulatory risks to ensure the IP and technologies remain within our country. Agility Prime also aims to bring together industry (meaning supply chains), investor, and government communities to establish safety and security standards while accelerating commercialization of this revolutionary technology. To be successful, Agility Prime has indicated that the supply chain needs to be visible and accessible to U.S. companies in a sustainable and resilient way.

The NASA Aeronautics Research Institute (NARI) in support of NASA's Advanced Air Mobility (AAM) Project is collaborating with Agility Prime through the AAM Supply Chain Working Group. The overall goal of this working group is to ensure that the aerospace supply chain will meet the demands of new and current vehicles with regards to resiliency, production targets, and competitiveness.

## Putting it Together

An industrial consortium has been assembled to complete the development of an electronic supply chain solution customized for the U.S. eVTOL sector. Led by NEXA Advisors, i5 Services, the Vertical Flight Society, Crown Consulting and Apicem Analytics, this team is developing the program, and will have the needed financial commitments in place to initiate the project by May 31, 2021.



**i5 Services:** For the last 8 years i5 has worked to develop a robust tool – CONNEX MARKETPLACE™ – for national and regional supply chain, workforce, and R&D connections. The solution provides public, member, and confidential data that is accessed through secure, role-based permissions. The supply chain visualization, risk assessment, and exchange center connections (surplus materials, RFI's, RFP's, RFQ's and other needs) have set the solution and i5 apart as pioneers and leaders in the industry.

**VFS:** The Vertical Flight Society is the World's premier scientific and technical organization for vertical flight -- including leading eVTOL advocacy efforts since 2013 -- and provides collaborative and technical resources for eVTOL developers across the supply chain. As a 501(c)(3) educational not-for-profit, VFS will manage an important operational and maintenance role for this new supply chain capability and tool.

**Apicem Analytics:** Apicem Analytics has deep experience in supply chain strategy, process and workforce optimization and procurement management. Apicem will lead in work needed to implement the most effective and efficient supply chain strategy.

**Crown Consulting:** Crown has worked with NASA for over 20 years, and is familiar with its mission, multiple priorities and many processes. It will bring this expertise to the effort to ensure that NASA is fully represented during the electronic exchange platform project.

**NEXA Advisors:** NEXA Advisors is a world-leading advisor for the AAM sector, and has developed comprehensive supply chain strategies and listings for all four critical aerospace supply chains directly tied to long term success of Advanced Air Mobility.

## Next Steps

The authors have laid out the vision, tasks, project organization and execution of a program to implement this resilient supply chain solution:

Phase 1 – Complete the consortium process, to include funding for platform development.

Phase 2 – Vision, strategy including needed outreach to the supply chain to identify key implementation goals and features.

Phase 3 – Expand the platform to align with AAM needs. It will be operated by i5 and the Vertical Flight Society.

Phase 4 – IOC, enrollment of member suppliers and eventual full deployment.

The activities behind these four work phases can be found in a comprehensive proposal available upon request, through NEXA Capital Partners, LLC. Funding is expected to come from aerospace sector members and investors beginning Q2 of 2021.

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<sup>1</sup> Urban Air Mobility: Economics and Global Markets 2020-2040. [www.nexa-uam.com](http://www.nexa-uam.com)

<sup>2</sup>[https://www.supplychain247.com/article/countries\\_that\\_have\\_the\\_most\\_resilient\\_supply\\_chains](https://www.supplychain247.com/article/countries_that_have_the_most_resilient_supply_chains)

<sup>3</sup> Vertical Flight Society [www.evtol.news/aircraft](http://www.evtol.news/aircraft)

<sup>4</sup> Aviation Week Network Global Supply Network [www.aviationnow.com](http://www.aviationnow.com)

<sup>5</sup> Executive Order 13806, *Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States*. U.S. Department of Defense, October 31, 2018

<sup>6</sup> <https://manufacturersmarketplace.us/product-tour/>

<sup>7</sup> <https://pitchbook.com/news/reports/q3-2020-pitchbook-nvca-venture-monitor>