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Small Unmanned Aerial Systems Production by the Millions

December 2025

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ABSTRACT

The United States small unmanned aerial systems (sUAS) industrial base faces vulnerabilities due to heavy dependence on Chinese components and limited domestic manufacturing capacity relative to near-peer competitors. Future conflicts demand rapid drone production at scale; the U.S. must identify optimal platform investments and develop mass production capabilities that meet operational tempo requirements. Ukraine's transformation from defensive to offensive drone operations demonstrates the strategic importance of domestic manufacturing—Ukrainian forces have maintained supply continuity by producing drones locally rather than relying on imported completed platforms. This research uses qualitative and analytical methods, including interviews, onsite observations, and analysis of relevant publications. The research examines the composition and supply chain origins of current Blue sUAS platforms to provide leaders with insights to strengthen U.S. drone manufacturing capabilities. Understanding these component dependencies is essential for developing a resilient sUAS industrial base capable of supporting future military operations. Throughout the research, it is apparent that key critical components could prove a detrimental impediment due to geographical dependencies while operating in a contested environment. Ultimately, research recommendations point to the need to incentivize the industry to ensure preventive measures that allow the DoD to begin building a drone stockpile.

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ACKNOWLEDGMENTS

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We would also like to thank the representatives from American Lithium Energy, BoxBlox, Defense Innovation Unit, Neros, Red Cat, and Skydio. These individuals' specialized tacit knowledge of the industry revealed necessary inquiries into pertinent cognitive shortfalls, allowing us to focus research into conceptual gaps.

Instruction from professors in the Defense Department Management curriculum equipped us with the tools to conduct the research necessary for this analysis. Through their lectures, discussions, and application of theory, they provided us with a platform on which to address relevant inquiries we may encounter during our service and follow-on assignments.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAM	advanced air mobility
AI	artificial intelligence
BEC	battery eliminator circuit
BLDC	brushless DC motor
BOM	bill-of-materials
COTS	commercial off-the-shelf
DIB	Defense Innovation Board
DIU	Defense Innovation Unit
DoD	Department of Defense
DRAM	dynamic random access memory
EO	electro-optical
EOIR	electro-optical and infrared
ESC	electronic speed controller
FLIR	Forward Looking Infrared
FPV	first person view
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRS	ground control station
IC	integrated circuit
IMU	inertial measurement unit
IR	infrared
ISP	image signal processor
ISR	intelligence, surveillance, and reconnaissance
LOCUST	Low Cost Unmanned Aerial Vehicle Swarming Technology
NDAA	National Defense Authorization Act
NdFeB	neodymium-iron-boron
PCB	printed circuit board
PCBA	printed circuit board assembly
RoHS	Restriction of Hazardous Substances
RTK	real time kinematic

SWaP	size, weight, and power
sUAS	small unmanned aerial system
TSMC	Taiwan Semiconductor Manufacturing Company
UAS	unmanned aerial system
UAV	unmanned aerial vehicle
UxS	unmanned weapons systems
VARTM	vacuum-assisted resin transfer molding
Vox	vanadium oxide
VRX	video receiver
VTX	video transmitter
VTOL	vertical take-off and landing

I. INTRODUCTION

A. BACKGROUND

Current trends and intelligence emerging from the conflict in Ukraine strongly indicate that drones have been critical to the country's ability to continue launching offensive attacks against Russia, gathering intelligence, and eroding Russian morale (Nixon, 2025). Ukraine is a country initially thought to be outmatched by manpower and equipment. They demonstrated that willingness to back the drone industry and trust the technology could not only stave off invasion but enable mounting offenses against a larger adversary like Russia (Collett-White et al., 2025). The data coming out of Ukraine provides the impetus for this research on attritable drones and underscores an urgent question: can the United States match this pace of innovation and production?

This thesis is part of a larger collaborative body of work examining the future of U.S. drone capabilities across four interconnected areas: attritable drone platforms, United States acquisition policy in relation to drones, gigafactories, and aquatic drones. Each category has a dedicated research team writing about their respective topics, with all research conducted collaboratively to address the overarching question of the United States' strategic future with unmanned systems.

The United States must significantly accelerate its drone production capabilities to remain strategically competitive. Currently, the Defense Innovation Unit (DIU) maintains the Blue unmanned aerial system (UAS) List which is a living document that categorizes DoD-approved small unmanned aerial systems (sUAS). This list includes two categories: Blue UAS, which are approved for government use, and Green UAS, which are DoD-approved platforms whose primary market is commercial and hobbyist applications such as racing and filmmaking (DIU, 2025). While commercial drones may seem tangential to military needs, their designs and manufacturing processes offer valuable insights that should not be discounted.

There are nine companies currently on the Blue List. The largest of these can produce only four thousand drones per month even when operating at maximum legal working conditions. This figure is staggering when compared to China's production capacity. China dominates global drone manufacturing, accounting for approximately 70–80% of worldwide production due to its proximity to raw materials and established production infrastructure (Financial Times, 2024). As of late 2023, over 1.27 million drones were registered domestically in China, with 608,000 new registrations in just the first half of 2024—a 48% increase over the previous period (Civil Aviation Administration of China, 2024). Russia produced around 140,000 drones in 2023, with plans to scale up to 1.4 million annually (McNabb, 2024). The Chinese drone market was valued at $9.7 billion in 2024 and is projected to reach $22.3 billion by 2030 (Grand View Research, 2024). U.S. Department of Defense military assessments confirm that unmanned systems remain a central pillar in China's modernization strategy, further reinforcing its industrial capabilities (U.S. Department of Defense, 2024).

The United States has been anemic toward sUAS investment, and until recently, some branches of service were outright against the employment of unmanned systems (Macdonald & Schneider, 2025). As further explored in Dr. Jacquelyn Schneider and Dr. Julia Macdonald's The Hand Behind the Unmanned, competing ideologies about how warfare should be conducted, supply chain constraints, and a lack of financial incentive for industry have left the U.S. industrial base behind both allies and enemies in drone production and battlefield employment (Financial Times, 2024).

To combat this deficit and push U.S. drone manufacturing forward, this thesis provides a comprehensive supplier guide detailing drone components, materials, production rates, and timelines for manufacturing one million drones annually. The three sUAS platforms researched are selected based on their potential to be attritable, cost-effective to the taxpayer, and producible on American shores. A detailed bill of materials (BOM) serves as the supplement to this thesis, providing actionable data for industry and policymakers alike. These platforms represent what is believed to be the most advantageous for the United States to produce for its arsenal, offering a realistic pathway toward closing the production gap and securing strategic competitiveness in unmanned systems.

B. TERMINOLOGY

A quick note on the terminology used in this study, "Attritable refers to unmanned aerial systems (UASs) that are low cost, emphasize the value of life, and are designed for use in environments where the risk of attrition is higher than acceptable for manned platforms" (Milonas et al., 2024). The term attritable is not to be confused with expendable.

> The intent of attritable equipment is not to be lost, but a higher rate of loss may be deemed acceptable by the commander. This means that these sUASs are intended to be low-cost and reusable but are built with the ability to endure a higher level of damage and still function. However, the commander is accepting the risk that some of those systems might not return due to a higher level of attrition. Expendable is the opposite of that because although it is also low-cost, the difference is that these expendable systems are intended for single-use and meant to be discarded after each mission. (Milonas et al., 2024)

Attritable sUASs continue to surface across major war reporting platforms as the modern warfighter's most essential asset. Being attritable is the future drone's most essential characteristic.

C. PROBLEM STATEMENT

Our focus is on the ability of the U.S. to mobilize to produce millions of drones when needed. To do this, we identified three models of drones that are surrogates for the kinds of drones the U.S. might need in the millions. We used these platforms to set up our analysis of the supply chain issues the U.S. would face if it needed millions of drones like them. This study culminates with the BOM for three different platforms.

The platforms selected for research are those that can be made attritable, with diverse capability sets and designs. The three platforms with the most advantageous capabilities are as follows:

1. Quadcopter drone (X10 by Skydio)

The X10 by Skydio is a quadcopter first person view drone at its foundation. What makes it unique on the market is its camera, flight time, artificial intelligence "thinking" capability, and production within the U.S.

2. Intelligence, Surveillance, and Reconnaissance Drone (Edge 130 by Red Cat)

The Edge 130 is a light-weight tri-copter drone that is capable of deployment regardless of platform launch surface. With effortless payload interchangeability this drone offers a versatile capability for unpredictable environments, through rapid configuration and deployment.

3. Compact First Person View Drone (Stinger Vision by ModalAI)

The Stinger is a compact first-person view drone that incorporates most of its electronics made by ModalAI. Its miniature form, GPS-denied flight, and incorporation of three cameras make it distinct from larger drones that offer the same capabilities.

D. RESEARCH QUESTIONS

The research study will answer the following questions:

1. If the United States needed at least one million drones produced and ready for the frontlines as soon as possible, how would we do it?
2. What sort of platforms might be prioritized for what the U.S would require?
3. Where do the parts for the drones come from and where are the components assembled?
4. What would be required to make these drones more affordable?

The United States currently only can produce a few thousand drones per month at its largest domestic drone production company, Skydio (Skove, 2024). Another drone production company, Teal, recently won the U.S. Army's contract to become a program of record but is only contracted to produce over 5,000 in the next five years (McNabb, 2024). These numbers are insufficient for what the United States will need for future conflict when compared to what is currently being expended in the Russo-Ukraine conflict.

A single Ukrainian drone carrying explosive munitions, one of the most effective tactics that have emerged from the Russo-Ukraine war, only costs $500 or less to produce including the warhead (Zafra et al., 2024). According to data compiled by Novaya Gazeta Europe (2025), Ukrainian forces have conducted approximately 9,700 drone attacks against Russian targets since the commencement of Russia's invasion in February 2022. This figure represents an average operational tempo of 25 drone strikes per day, resulting in estimated production expenditures of $4,850,000 for Ukraine's drone warfare campaign. To contextualize these costs within the broader unmanned systems market, this sum would procure only 122 Skydio X10 units at current U.S. market prices, or alternatively, 108 Black Widow units from Teal Drones. This analysis underscores the asymmetric nature of Ukraine's drone strategy, wherein relatively modest financial investments have yielded substantial operational impact against conventional military assets.

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II. LITERATURE REVIEW

The literature reveals that drone warfare has evolved from a niche capability to a central component of modern military strategy. The Russia-Ukraine conflict has served as a crucial laboratory for testing and refining drone technologies, demonstrating both their tactical effectiveness and strategic implications. The development of attritable systems, advances in autonomous capabilities, and the growing importance of domestic manufacturing capacity all point to a future where unmanned systems play an increasingly dominant role in military operations.

The rapid evolution of UASs has fundamentally transformed modern warfare, with the Russia-Ukraine conflict serving as a pivotal demonstration of drone technology's strategic importance. This literature review examines the current state of drone warfare, technological innovations, manufacturing capabilities, and the broader implications for military strategy and national security. The analysis draws from recent developments in autonomous systems, attritable drone concepts, and the emerging drone industrial base.

A. THE UKRAINE CONFLICT AS A CATALYST FOR DRONE INNOVATION

The Russia-Ukraine war has emerged as a defining conflict for understanding modern drone warfare applications. The New York Times' comprehensive analysis reveals how "suicide drones" have fundamentally "changed the front lines" in Ukraine, demonstrating the tactical versatility and strategic impact of these systems (Chivers, 2024). Ukraine's innovative approach to drone development is particularly noteworthy, with homegrown systems becoming "increasingly lethal, critical tools" that have proven essential to the country's defense strategy (Nixon, 2025.). Ukraine's success in maintaining domestic drone production capabilities contrasts sharply with U.S. industrial base limitations, suggesting that supply chain resilience may prove as tactically important as platform performance in sustained conflicts. This thesis takes particular interest into the "how" behind Ukraine's drone production within their own borders.

Forbes' reporting highlights Ukraine's development of new "rocket drone" systems targeting Russian air forces, showcasing the rapid innovation occurring under wartime pressures (Hambling, 2024). The conflict has also demonstrated the effectiveness of relatively simple systems, with Australian-made cardboard drones reportedly being used in massed attacks against Russian forces, illustrating how cost-effective, attritable platforms can achieve strategic objectives (Hambling, 2024). Ukraine's record-breaking destruction of 122 Russian artillery pieces in a single day further underscores the tactical effectiveness of drone swarms in conventional warfare (Forbes, 2025).

B. TECHNOLOGICAL INNOVATIONS AND AUTONOMOUS SYSTEMS

The advancement of autonomous drone capabilities represents a significant evolution in unmanned warfare. IEEE Spectrum's analysis of Ukraine's autonomous killer drones demonstrates how these systems have successfully defeated electronic warfare countermeasures, marking a crucial technological milestone (Pultarova, 2025). This development suggests a shift toward more sophisticated, AI-enabled systems that can operate independently in contested electromagnetic environments.

The U.S. military's investment in drone swarm technology is evident through the DIU software orders for "massive drone swarms," indicating recognition of autonomous systems' strategic potential (Tucker, 2024). The Marines' tactical resupply demonstrations and deployment of kamikaze warfare systems with 12-mile ranges further illustrate the military's commitment to integrating diverse drone capabilities across operational domains (Kajal, 2025).

C. ATTRITABLE DRONE SYSTEMS AND STRATEGIC CONCEPTS

The concept of attritable unmanned aircraft systems has gained significant traction as military strategists recognize the value of expendable, cost-effective platforms. The Defense Systems Information Analysis Center's comprehensive analysis provides crucial context for understanding how attritable systems challenge traditional military procurement and operational concepts (Milonas et al., 2024). These systems prioritize affordability and rapid production over survivability, enabling new tactical approaches based on overwhelming enemy defenses through numerical superiority.

D. MANUFACTURING AND SUPPLY CHAIN CONSIDERATIONS

The drone manufacturing landscape reveals significant geopolitical and economic implications. Hambling's (2024) analysis suggests that "the U.S. could transform its entire drone industry for the cost of a single F-35 fighter," highlighting both the affordability of drone technology and the potential for rapid industrial scaling. However, supply chain vulnerabilities remain a critical concern, as evidenced by China's restrictions on components supplied to leading U.S. drone manufacturer Skydio, forcing the company to implement battery rationing for customers (Exiger, 2025). Manufacturers are further hamstrung by emerging tariffs, with some drone production companies stockpiling lithium batteries and other components. This research is largely inspired by the war in Ukraine and their ability to crack the code on locally producing drone components to scale, at a lower cost than those made in China. Ukraine has undercut Chinese markets by making their own components, such as "frames, initiation boards, flight controllers, and radio control systems" (Hambling, 2025). Being able to do this and establish sovereign drone capability has allowed Ukraine to stay independent from China and control all aspects of its drone production. Ukraine will be producing over four million drones this year, and this production capacity continues to be Ukraine's most potent weapon in the war against Russia (Hambling, 2025). This research highlights the importance of locally producing drones within continental borders to dominate the battlefield without dependence on the China-centric supply chain.

China's sanctions on drone components have affected Ukraine and the United States, as well as one of the biggest drone companies in the United States: Skydio. China sanctioned Skydio in late October 2024 (Post, 2024). Skydio's dependence on China led to bottlenecks of specific components, such as batteries and cameras. This significantly affected their battery supply and forced them to ration their batteries and find another supplier in Taiwan that could meet both their quantity and quality requirements. Skydio's CEO, Adam Bry, emphasized China's ability to create supply chain issues when he told his customers, "This action makes clear that the Chinese government will use supply chains as a weapon to advance their interest over ours" (Post, 2024).

The emergence of American drone manufacturers, including companies like Teal Drones selected for the U.S. Army's Short Range Reconnaissance Program, indicates efforts to develop domestic capabilities and reduce foreign dependencies (McNabb, 2024). The Trump administration's "Unleashing American Drone Dominance" initiative further emphasizes the strategic importance of maintaining technological leadership in unmanned systems (The United States Government, 2025). This executive order has the potential to be the impetus for industry to endeavor into mass production. However, the DoD has made no clear stance on what platforms they want, how many, and how much funding they are willing to devote. This thesis aims to answer what platforms should be sought after and give an estimated cost.

E. MATERIALS AND MANUFACTURING TECHNOLOGIES

Advanced materials and manufacturing processes play crucial roles in modern drone development. The application of composite materials, particularly carbon fiber fabrication for drone frames, bodies, and wings, enables the production of lightweight yet durable platforms (AT Machining, 2024). The integration of 3D printing technologies, including carbon fiber printing capabilities, offers new possibilities for rapid prototyping and distributed manufacturing.

The development of specialized components, from thermal imaging systems provided by companies like Teledyne Forward Looking Infrared (FLIR) to advanced motor systems from Nidec for autonomous platforms like the Skydio X10, demonstrates the sophisticated supply chains required for modern drone production (Nidec, 2024). The complexity of lithium-ion battery manufacturing and the critical materials required for these systems highlight additional supply chain considerations (Kadant DCF, 2025). Identifying bottlenecks in the drone supply chain, regardless of platform, is a critical aspect for the research we share here.

F. STRATEGIC AND SECURITY IMPLICATIONS

The proliferation of drone technology raises significant concerns about the potential for drone terrorism and asymmetric warfare. The Combating Terrorism Center at West Point's analysis warns of the "evolving threat of drone terrorism" emerging from lessons learned in the Ukraine conflict (Rivero, 2025). This concern is amplified by the relative accessibility of drone technology and the potential for non-state actors to adopt military innovations for malicious purposes.

Global warfare is being redefined by sUASs in more ways than just surveillance. The strategic implications extend to resource security, with U.S.-Canada collaboration on critical minerals becoming increasingly important for maintaining technological independence (Hernandez-Roy et al., 2025). Identifying critical mineral deposits on the North American continent would vastly reduce supply chain concerns for tier two and tier three suppliers. A simple explanation of tier suppliers can be described as companies that flow raw materials (tier three) and incomplete components (tier two) to final assembly corporations (tier one) for distribution to consumers. As mentioned, part of Ukraine's success stems from their drone production companies being able to source parts and build drones in Ukraine as opposed to ordering their parts from Taiwan. Shortening the supply chain and reducing shipment distances provides cost advantages and critical technologies to the warfighter faster.

G. FUTURE DIRECTIONS AND EMERGING TRENDS

The literature suggests several emerging trends that will shape the future of drone warfare. War on the Rocks identifies a "coming wave of wartime drone expertise" that will likely influence military doctrine and capabilities development (Mills et al., 2025.). The integration of artificial intelligence (AI) improved autonomous navigation, and enhanced swarm coordination capabilities represent key areas of technological development.

The ongoing tension between China and the West over drone technology access, exemplified by Chinese sanctions affecting companies like Skydio, suggests that the drone industry will become increasingly bifurcated along geopolitical lines. This division may accelerate domestic manufacturing initiatives and reshape global supply chains for unmanned systems.

The challenges of supply chain security, technological competition with peer adversaries, and the dual-use nature of drone technology present ongoing policy challenges that require coordinated responses from government, industry, and academia. As drone technology continues to mature and proliferate, understanding these dynamics becomes essential for maintaining strategic advantage and addressing emerging security threats.

The convergence of AI, advanced materials, and miniaturized sensors suggests that the current transformation in drone warfare represents only the beginning of a broader revolution in how military operations are conducted. Future research should focus on the implications of fully autonomous swarms, the integration of drone capabilities across all military domains, and the development of effective countermeasures to emerging drone threats.

H. ATROPHIED INDUSTRIAL BASE

As the character of war has evolved, so too have the weapons used to fight. "Unmanned Weapons Systems (UxS) have become one of the defining features of modern conflict. Yet, the United States Department of Defense (DoD), once the world's leader in military applications of UxS, has lost ground to other nations in producing and utilizing these systems." (Defense Innovation Board [DIB], 2025). As DIB points out, the theme of the United States' having fallen behind in the production and utilization of UASs crosses most of the research articles used in this report.

The United States' ability to produce sUASs by the millions is incredibly dependent on China, and this problem has been talked about by many. However, there is still no solution for it. Zetter's (2025) article emphasizes the robust requirements for drone manufacturing and supply chain capabilities in the United States. One of the main problems is that China continues to dominate in the technology realm. Most drone components are manufactured in China, but as shown in Figure 1, many have originated outside of China.

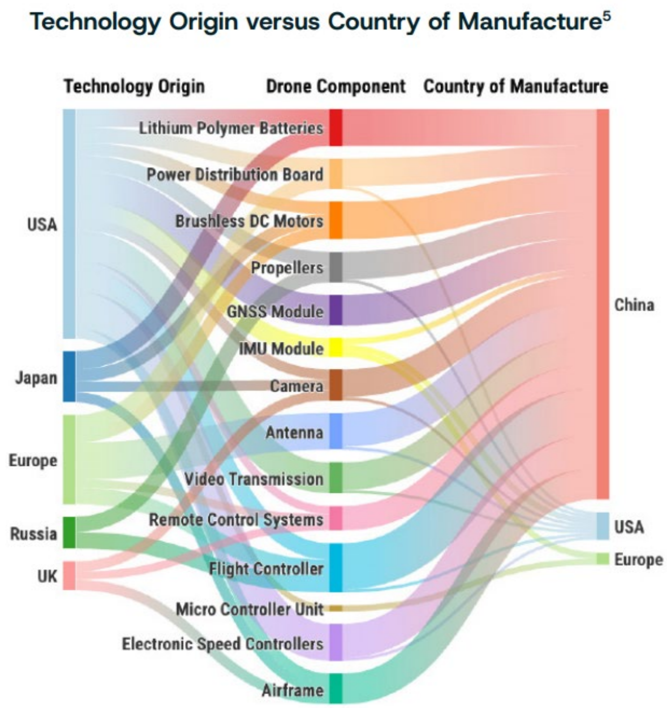

Figure 1. Drone Technology Country of Origin versus Manufacturer. Source: Bloomberg et al. (2025).

As illustrated in Figure 1, the United States makes up for over half of the UAS technology points of origin, yet China dominates in UAS manufacturing. This misalignment plagues UAS manufacturing across the fourteen essential elements of any UAS platform. Most literature reviewed decries China's monopoly on this issue without proposing solutions that are either viable, fast-paced, or achievable with the manpower the United States has available. There are some outliers. "You don't necessarily need automation to reach high volume. What you need is a very easy-to-assemble product that's designed with no silly or dumb requirements. Automation should always be the last step to scaling volume" (Hambling, 2024). Easy to assemble, simple to produce, eventually could lead to ease in mass produced attritable drones.

An NPS thesis analyzed how the United States can tackle supply chain barriers to scale the Low-Cost Unmanned Aerial Vehicle (UAV) Swarming Technology (LOCUST) program (Warre et al., 2019). Their research identified six supply chain barriers affecting the LOCUST program: production and quality challenges, and lead times. Another NPS thesis highlighted the use of additive manufacturing to build military grade weapons (Redden & Conley, 2024). Their research aimed to find a solution allowing the United States to develop its low-cost rockets with additive manufacturing, which can also be applied to building low-cost sUASs.

On top of imposing sanctions, China is also restricting access to key raw materials and rare-earth minerals such as germanium, which is key to producing thermal lenses for a drone (Post, 2024). The DIB (2025) study also pointed out how UxSs heavily rely on critical minerals, such as lithium, cobalt, and nickel, which China dominates the supply chain. China has weaponized the manufacturing process and used the knowledge resources that we have handed them to their advantage. According to McGee (2025), "We've trained a whole country, and now that country is using it against us" (p. 10). This research highlights the obstacles a company can encounter when dependent on the raw materials and manufacturing from another country, especially that of America's largest rival.

III. METHODOLOGY

Based on the Russo-Ukraine conflict, we selected three sUAS platforms that are surrogates for the kinds of drones the U.S military might require in a military conflict with a peer competitor. From there, we conducted a supply chain analysis on each platform from finished product to tier three materials. The unique capabilities each platform possesses necessitate the importance of manufacturing more than one platform style of drone. The importance of diversity of capabilities across weapons on the battlefield cannot be overstated. We identified these trends: drones are operated by one person or small teams, they are composed of inexpensive parts, and they are designed to perform multiple missions (Bondar, 2025). When these criteria were met, we pursued the exact parts makeup of each platform. Once parts were identified we researched the composition of parts down to the types of metals or plastics used for each piece. This ultimately led to the creation of the bill-of-materials (BOM). Due to the high probability of a contested logistical strain on the current supply chain of materials associated with sUAS drone production, an immediate alternative is imperative. Currently, peer adversaries hold a monopoly on scalable parts and platforms associated with mass production. U.S. drone production companies with established supply chains have already been affected by this market dominance. Leading companies have been blacklisted for critical components such as batteries, disrupting order fulfillment, prompting them to scramble for suitable alternative suppliers. Identifying component parts and raw materials of these platforms is necessary. Identifying suppliers in the drone supply chain was just as important to our research.

A. THE BILL OF MATERIALS

The BOM details component specifications, quantities, unit costs, and supplier information, organized by subsystem (flight control, propulsion, sensors, etc.) It includes powertrain, electronics, plastics, metals, and miscellaneous parts that are not to be left out of completed builds. This research aims to produce one thing: a BOM that provides information on which platforms should be made, who supplies the components, and where those components are sourced. Should all parts from one of the platforms be purchased and assembled, the end product is intended to be a fully functional drone.

B. TYPE OF STUDY

The research conducted focuses on qualitative and analytical processes that are performed by interviews, onsite observations, and analysis of pertinent publications. Supply chain investigation for the sUAS platforms identified, ultimately gave quantitative structure to the materials, production rate, and cost modeling associated with mass scalable production. Qualitative information was derived from semi-structured interviews with subject matter experts that included warehouse production managers and system engineers. Through these interviews, tacit knowledge was uncovered with the limitations, risks, and material quality metrics needed that would be critical when implementing mass production.

The research included a semi-structured interview with Skydio, the largest drone manufacturer in the United States, along with a guided tour of their manufacturing facility. The interview was conducted with key personnel, including the factory director, to gain firsthand insight into industrial drone manufacturing processes. A semi-structured interview was used to allow flexibility while respecting the company's proprietary information and privacy concerns. Key questions addressed manufacturing processes ("Can you describe the process for manufacturing drone platforms?"), supply chain challenges ("Are there bottlenecks for materials from suppliers?"), production scalability ("How easily could factory production lines be reconfigured or expanded to accommodate a higher demand of volume or a platform deviation?"), and design adaptability ("Can current drone platforms be economically redesigned for a more disposable purpose?"). The factory tour provided visual context and enabled real-time observation of drone production processes. This combined approach allowed the capture of real-world perspectives from a successful commercial drone manufacturer, facilitating the identification of critical components, sourcing constraints, and manufacturing considerations.

To gain perspective on the broader defense industrial base concerns, an interview was conducted with a representative from DIU. The focus of this interview was to understand the anticipated demand for mass production of drones and what potential factors would be more critical in determining platform designs and procurement priorities. During the discussion, numerous topics were explored, such as technology and the ability of domestic software corporations to produce competitive programs that offer solutions to warfighters' needs that are efficient, adaptable, and user-friendly. The adaptability of software was highlighted as particularly important given the rapid change in tactics seen in current and emerging conflicts, making evolution of production an essential concern in future acquisition strategies. These comments raised the question, "Can American engineers develop platforms malleable to the shifting operational demands of the future battlefields?."

C. SPREADSHEET MODEL DESIGN

The BOM spreadsheet is organized according to the three drone platforms studied. For each platform, the data is broken down by component, subcomponent, material type, and supplier. This structure enables identification of supply chain bottlenecks and determination of which suppliers are American versus foreign-based.

D. LIMITATIONS AND ASSUMPTIONS

Out of five drone production companies that were contacted, only three responded. Of those, we were able to interview all three; however, companies were hesitant to share information with the research team. American-made drone production companies' reluctance to share bill of materials, supplier information, or basic parts list was a significant hindrance to the research. As such, research was limited to publicly available specifications of the sUAS platforms on each respective company's website, coupled with open-source information on component makeup. Skydio allowed us a tour of their final assembly floor at their headquarters and allowed us to photograph anything pertinent to our research. We gathered information not only on main components but also on suppliers due in part to the shipping boxes and exposed labels on the boxes. Skydio was the only factory we were able to tour. When we were unable to identify exact parts, comparison parts were analyzed, and educated assumptions were approximated from there. Additionally, supplier information was surmised based off shipping labels visible on boxes at the facility toured.

One Blue List approved drone manufacturer stated that their biggest supply chain issue was that there were "extreme lead times for key components making manufacturing difficult and not cost-effective... if we could purchase components in bulk, they could be secured at lower rates" (Manufacturer A, 2025). Ordering parts in bulk keeps costs down per individual part and enables manufacturers to stockpile components to mitigate supply chain disruptions.

E. SUMMARY

In summary, three platforms were identified, broken down by component parts, and the supplier origins of those parts were listed. The price per component part was listed out. From there, the total price of the drone as a summation of parts was calculated.

IV. ANALYSIS

Component and subsystem identifiers (e.g., PWR-005, ELEC-002) correspond to the BOM (supplemental). These IDs enable traceability between narrative analysis and spreadsheet data. Section headings list the relevant identifiers for ease of cross-reference. Figures 2, 5, and 8 are the three drone platforms that were chosen for their distinct capabilities.

A. QUADCOPTER FIRST PERSON VIEW DRONE (X10 BY SKYDIO)

Figure 2. Skydio X10 Drone. Source: Skydio (2025).

First Person View (FPV) quadcopters have proven the most operationally significant drone platform in the Russo-Ukraine conflict, effectively replacing traditional two-man observation posts while providing continuous surveillance capabilities. Their versatility, reliability, and dual-use capacity for both intelligence gathering and munition delivery have made them indispensable to infantry operations. Current quadcopter production relies heavily on Asian suppliers across multiple critical components. Key dependencies for the X10 include Guangdong Cathay Tat Ming Precision for high-precision metal components (airframes, motor housings, structural inserts, electrical interconnects), Nidec for brushless motors, and Asia Precision for computer numerical control-machined mounting systems essential for operational stability. Electronic components sourced from Digikey, optical systems from Freewell, and thermal imaging capabilities from Teledyne FLIR further demonstrate the distributed nature of the supply chain for some specific quadcopters.

To understand what parts are used in the making of quadcopters, we researched three hundred hours of drone assembly tutorials. This enabled a firm understanding of component parts required as well as labor estimation.

The quadcopter design is simple to source component parts for and some of those parts like the frame and propellers can be 3D printed. However, 3D printed parts were not extensively researched for this report due to the focus on gigafactories and production capabilities of the sort. The attritable feature of a quadcopter is directly related to the price of its parts. The quadcopter assembly is very accessible due to the wide availability of commercial parts, online building tutorials, online blueprints as shown in Figure 3, how-to guides, vast quantities of instructional videos, and a low-cost barrier to entry.

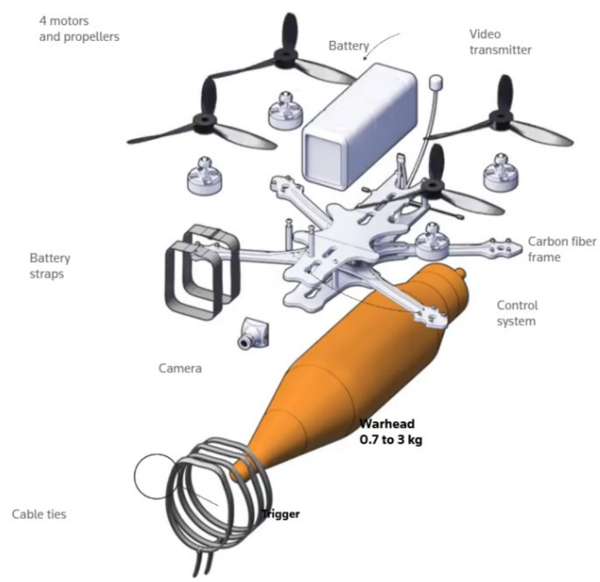

Figure 3. Exploded View of Drone Assembly. Source: Allen et al. (2025).

1. Powertrain

The powertrain of the drone groups together the motor, electronic speed controllers, and propellers among other components as laid out in this section. The powertrain can be conceptualized as the element responsible for propulsion and trust to move the drone through the combat mission area.

a. Motors (PWR-001)

Brushless motors are made from a stator, rotor, and hall sensor as shown in Figure 4. The stator contains stacked steel windings. The motor must be rated at least 1000KV for longer flights and larger payloads. The motor must be above 1000KV if speed is the primary concern.

In the rotor, magnets spin and create the motion for the propellers to spin. The electronic speed controllers (ESC) are what make the propellers either speed up or slow down, which controls the drone flight speed and direction. Motors can be sourced from the supplier Lumenier. Lumenier offers multiple styles and sizes for quadcopters. The motors must be able to support the payload of the drone.

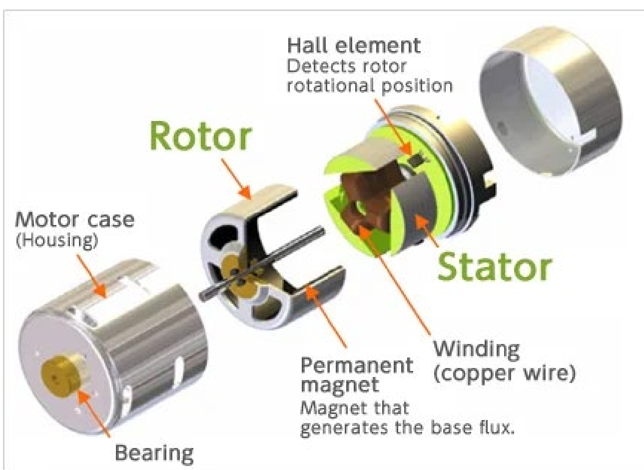

Figure 4. Exploded View of Brushless Motor Assembly. Source: Nidec Corporation (n.d.).

b. Propellers (PWR-002)

Propellers can be procured with minimal complications. Quadcopter drone platforms specifically use propellers that spin both clockwise and counterclockwise. The blades are tapered, which makes them ideal for increased thrust and airflow. The design allows for reduced noise profile which is ideal for intelligence, surveillance, and reconnaissance (ISR) and other stealth operations. The most important feature of the propeller design is that it creates lift. Most propellers are made via injection molding and comprised of plastic, carbon fiber, and fiberglass. The propellers for a quadcopter FPV drone similar to the Skydio X10 can be sourced from HQProp. Propellers can also be 3D printed, constrained by the size requirements. For a drone like the X10, sourcing the propellers from HQProp would likely be more cost-effective.

c. Battery (PWR-003)

Across the board, the battery choice for an FPV quadcopter is the lithium polymer battery. This battery can be sourced from American Lithium Energy in the United States. The battery is one of the most constrained aspects of the drone’s supply chain.

2. Electronics

The electronics of a drone are what separate the platform from being inanimate to being a lethal, kinetic force. Electronics act as the nervous system of the platform and transport the commands from the programming to the propellers, camera, and sensors.

a. Electronic Speed Controllers (ELEC-001)

The ESCs are printed circuit boards (PCBs). A quadcopter needs 4 ESCs; one for each motor to control the speed of propeller rotation. Printed Circuit Board Assemblies (PCBAs) can be sourced from the United Kingdom based company BotBlox. Botblox is transparent about the production and sourcing their products, which makes them ideal vendors. “Our boards are manufactured either in the USA, China and Thailand with our long term manufacturing partners. Our manufacturers are RoHS and ISO 9001 certified and we’re able to quickly scale up production volumes to accommodate our customers’ needs” (BotBlox, 2025). Furthermore, “PCB: China is dominant in PCB manufacture, accounting for around 52% of global PCB manufacture in 2020. Coming second was Taiwan (11.5%), followed by South Korea (10.8%) and Japan (8%). The Americas make up just 4.9%, and Europe, 3.7%. Put simply, pick a country other than China. Aside from China, at Botblox, we manufacture in the USA, Estonia, Thailand and the UK" (BotBlox, 2025). They are transparent with their material sourcing and kept their integrity with the Blue List and National Defense Authorization Act (NDAA) compliance.

PCBAs for drones must be made specific to the drone's intended uses. The relationship between complexity of drone's capabilities and complexity of PCBA construction are interlinked. The more complex the maneuvering, payload, flight plan, etc., of the drone, the more complex the PCBA will be. Simple Arduino boards can be used for mini drones; mini meaning drones with less than 6 inches of diagonal arm span for the purposes of this thesis. However, for scaling up a drone in size and operational uses, the PCBA would need to be manufactured differently.

b. Sensors (ELEC-002, ELEC-003)

Some sUASs integrate the Teledyne FLIR Boson thermal sensor, which is effectively a camera. However, that is not the only sensor that can be fitted in a quadcopter . The type of camera needs to match the type of video receiver (VRX) on the controller. There are two choices: analog or digital. The Teledyne FLIR is a digital camera with a thermal sensor. A sensor and gimbal package comparable to the FLIR were researched for the BOM. The sensors and by default the camera parts of the drone face significant supply chain constraints.

3. Structure

The structure of the drone directly relates to the function of the drone. Various shapes and sizes exist from nano-sized drones to those more similar to Shahed loitering munitions. The structure must support the speed and agility desired for the mission as well house the sensors and cameras needed to be pilotable.

a. Frame and Landing Pegs (STR-001, STR-002)

Quadcopter drone performance is largely dependent on its weight. Lighter drones are more agile. This has trade-offs with performance: lighter platforms are less stable. This must be addressed in the balance and construction of the frame and assembly of components. Smaller, agile drones dominantly comprised of carbon fiber or lightweight metals such as aluminum are able to maneuver with more speed and for longer periods of time. As such, airframes are most commonly comprised of aluminum alloys or carbon fiber. Skydio uses a carbon and glass fiber composite coupled with Additive Molding technology. Additive molding is a hybrid between injection molding and 3D printing, specific to the production company.

The overall structure of the quadcopter is comprised most often of the following materials Carbon/glass fiber composites, polycarbonate, aluminum, magnesium alloys; expanded polypropylene foam, and chopped fiber composites (Ravi, 2023). We researched the frame using the following parameters: larger than 6in distance between arms to facilitate larger payloads, and not 3D printed. This is because investing in 3D printers falls outside this thesis' research parameters. It should be noted that frames can be 3D printed, however that could lead to their initial production costs to be higher than buying already manufactured frames in bulk.

The frame selected for the BOM was comparable in size to one used in the X10, with the integrity of a four-arm frame. There is little to no metal used in the frame itself except for the screws. The landing pegs, cables, battery straps, and anti-slip pads are all made of plastic.

b. Metals (MET-001)

The only metal components of the quadcopter are the screws and fasteners. Most metals are too heavy to be used in an ideal quadcopter structure material but are strong enough to be used for fastening parts. Screws and fasteners can be sourced from a myriad of suppliers from within the U.S as commercial off-the-shelf (COTS) products. Ace Hardware, Home Depot, and Lowe's all carry size M3 and M4 screws which are the most common sizes for fasteners on a drone like the X10.

c. Plastics and Polymers (PLA-001, PLA-002, PLA-003)

Connecting the motors to the camera and the ESCs are the cables. The cables are not made in the U.S but are very inexpensive. The battery straps used to attach the battery to the frame are also not sourced in the U.S. However they can be substituted with zip ties. Battery anti-slip pads are not a necessity, but they do improve the stability of the drone while in flight. These can be sourced cheaply as well.

4. Capabilities

FPV drones can fly above conflicts and relay back live video stream to the user. It can carry various payloads that could be applied to missions for carrying supplies, ammunition, and most critically, it can carry explosives. The FPV quadcopter is well-known for the tactic of kamikaze style attacks. While this may be its best asset, the FPV drone can also be used for surveillance. The live stream relayed back to the user's goggles allow for real time steering. Should the FPV have automated intelligence, it would be able to fly without much input from the user; all based on its programming. The potential for FPV quadcopters on the battlefield is great. Warfighters can see friendly and enemy troops without sending a scout team or sacrificing millions of tax dollars to have a fighter jet fly over. The FPV quadcopter can be built with either analog or digital cameras – each having their own benefits. An FPV quadcopter drone rigged with a digital camera and digital system would help warfighters to locate, approach, and destroy the enemy, all at once.

FPV quadcopters demonstrate significant cost disparities between domestic and foreign production. While these platforms remain highly cost-effective when manufactured overseas, fully assembled systems within the United States range from $14,000 to $56,195 according to the Blue UAS List (2025). This pricing differential highlights a critical vulnerability in U.S. supply chain strategy.

After pricing out each part at market value plus adding estimated labor and labor cost, to make a drone comparable to the Skydio X10 in camera and flight time capability would cost $9,795.69. This number can vary strongly depending on component parts selected and availability of resources.

5. Supply Chain Limitations

As with all platforms researched in this report, the supply chain areas most constrained are sensors and cameras, PCBAs, and batteries. The sensor and camera packages are sourced exclusively from China and Taiwan. PCBAs are largely sourced from Taiwanese companies along with a handful of alternatives from Japan.

Some companies choose to produce as many components as they can. Self reliance on parts solves the problem of looking for suppliers, but it creates the problem of sourcing tier two and three components. Drone companies have expressed difficulties with tariffs and difficulties with bulk ordering; bulk orders would cut down on costs. Skydio's X10 represents a significant attempt to address these supply chain vulnerabilities, demonstrating how U.S. companies are working to reduce foreign component dependencies through vertical integration and advanced manufacturing. Skydio custom engineers their own lenses. Proprietary sensor packages indicate a strategic shift toward domestic high-value component production, moving past simple assembly to core technology development.

B. INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE DRONE (EDGE 130 BY RED CAT)

Figure 5. Red Cat Edge 130 Drone. Source: Red Cat (n.d.).

This research selected the Red Cat Edge 130 as a representative ISR platform due to several critical factors: versatility in operations, durability, and compliance with defense acquisition standards. Manufactured by FlightWave Aerospace Systems, a U.S. based subsidiary of Red Cat Holdings, the Edge 130 has received approval for government use under Blue UAS program (Red Cat Holdings, n.d.). This certification ensures that there are no Chinese components or software while meeting DoD cybersecurity and sourcing requirements. According to FlightWave, the Edge 130 is manufactured domestically with minimal reliance from allied nations, addressing the growing emphasis on supply chain security in defense procurement (FlightWave Aerospace Systems, n.d.)

The Red Cat EDGE 130 is a tactical ISR platform originally designed for coral reef surveys but subsequently repurposed for military use. Deployable at the squad level, the Edge 130 features encrypted radio transmission, for hardened security between the operator and system (FlightWave Aerospace Systems, n.d.). The platform uses a fixed-wing tricopter, capable of vertical take-off and landing (VTOL). Flight endurance reaches 60 minutes when cruising or 30 minutes loitering (Red Cat Holdings, n.d). An independent tilt-pod transition functionally comparable to the V-22 Osprey nacelle design allows for a transition between cruise and hover mode. Maximum speed reaches 65 miles per hour with a service ceiling rated at 12,000 feet (FlightWave Aerospace Systems, n.d.). This compact size measures 30”x50” when stowed. It allows for backpack portability and rapid deployment with no need for a dedicated launch site. When deployed, the Edge 130 can be seamlessly integrated into squad operations, acting as an additional aerial scout to extend the unit’s situational awareness of the battlefield for two to five kilometers. Drone scouting enables troops to clear routes without exposure to potential threats (Red Cat Holdings, n.d.). Rapid launch capability coupled with multifunction electro-optical and infrared (EO/IR) sensors makes it particularly suited for urban environments, including building clearance, overwatch, and ambush detection (FlightWave Aerospace Systems, n.d.).

ISR drones in modern conflict have been significant to combat effectiveness in units’ abilities. Rivero (2025) documented their impact in the Ukraine theater:

> Drone strikes account for approximately 70 percent of Russian casualties and, in some parts of the front, 90 percent of Russian military equipment losses in engagements with Ukrainian forces. Advanced UAVs have given Ukrainian commanders unparalleled situational awareness, significantly enhancing operational effectiveness during offensive and defensive operations. (Rivero, 2025)

With the ability of persistent surveillance, tactics are fundamentally improved with real-time enemy information at the fingertips of pilots. Commanders will have the luxury of making timely decisions to coordinate troop movements and force integration, while limiting the exposure of casualties.

Beyond its numerous tactical capabilities, the Edge 130 design philosophy emphasizes producibility through COTS integration. Making it uniquely attractive to large scale production. This approach offers several advantages when applied to mass production: reduced unit cost, simple logistical sustainment, and a more resilient supply chain (Personal communication, Red Cat Holdings, September 5, 2025). Red Cat's analytical process applications to manufacturing allow for rapid sourcing, assembly, and field deployment of the Edge 130, consistent with the pace of modern conflict requirements. However, as detailed in subsequent component analysis, even COTS-based platforms are vulnerable to dependencies on foreign suppliers in certain areas including semiconductors, rare earth minerals, battery components, and production processes.

In September 2024, Red Cat Holdings completed its acquisition of FlightWave Aerospace Systems, expanding its portfolio of Blue UAS-certified platforms available for government procurement (Red Cat Holdings, 2024). Company representatives indicated that while current production meets existing orders, manufacturing infrastructure is positioned for rapid scaling should demand signals justify expansion (Personal Communication, Red Cat Holdings, September 5, 2025).

The U.S Army has begun establishing procurement relationships with Red Cat, awarding a $1 million contract for drone platforms with delivery expected early 2025 (Red Cat Holdings, 2024). In anticipation of growing demand, Red Cat has expanded its manufacturing capacity by opening an additional 14,000 square foot facility in Carson, California (The Klabin Company, 2025). This capacity expansion demonstrates the U.S. Industrial base's ability to respond to emerging defense requirements, though actual production scaling remains contingent on firm order commitments rather than speculative capacity building.

The following analysis examines the Edge 130 component-level supply chain, organized by major subsystems: powertrain, electronics, sensors, and airframe structure. Due to proprietary constraints, identifying specific suppliers required triangulating multiple sources: published technical specifications from FlightWave product documentation, information obtained through company interviews, and analysis of comparable NDAA compliant components from established defense suppliers. Where exact components could not be confirmed, this analysis examines representative alternatives that meet the Edge 130's published performance parameters and regulatory requirements.

1. Powertrain

The Edge 130 features a proprietary propulsion system that integrates multi-sized motors and propellers powered by an internal battery that is designed and manufactured in-house by FlightWave.

a. Motors (PWR-001, 002, ELEC-014)

The Edge 130 utilizes three brushless DC (BLDC) motors to achieve its published performance specifications: VTOL capability and cruise speeds ranging from 33 to 65 mph (FlightWave Aerospace Systems, n.d.). BLDC motors were selected for their reliability in demanding operational environments where brushed motor maintenance would be impractical. Unlike brushed motors that rely on mechanical friction for communication, BLDC motors use magnetic field interactions controlled by electronic switching, resulting in smoother operation and extended service life (Ektos, 2024).

BLDC technology offers several advantages over conventional brushed motors for military UAS applications. Efficiency improvements from approximately 75% (brushed) to 85% (brushless) enable enhanced power density and extended flight endurance through superior thermal management (Ektos, 2024). Additional benefits include improved stability during flight, reduced maintenance requirements, extended operational lifespan, and higher torque output at lower rotational speeds, all critical for platforms requiring VTOL capability, precise control, and adaptable payload configurations (Ektos, 2024). Table 1 demonstrates the complete breakdown of a BLDC motor.

Table 1. BLDC Motor Component Functions. Adapted from KDE Direct (2020).

Component	Function
Stator	Laminated steel with cooper coils that are energized from batteries to create rotation in the neodymium magnet.
Rotor	Neodymium magnets that react to the energized stators to produce rotation in the motor.
Bell housing	Aluminum machined to hold the magnets acting as a shell to protect internal components.
Motor shaft	Harden steel acts as a bridge from the rotating magnet to the propeller transmitting energy
Ball bearings	Steel balls that reduce friction and create a smooth rotation in the motor.
End caps	Aluminum molded ends that hold the shaft and bearings in place.
Hall sensor	Semiconductor to monitor the position of the rotor informing the motor controller which stator to power to enable rotation in the magnet.

Among motor components, neodymium magnets and hall sensors present the most significant supply chain vulnerabilities in contested logistics scenarios. Neodymium, a rare earth element critical for high performance permanent magnets, is predominantly sourced from China, which controls approximately 90% of global supply (Gruver, 2025). This market concentration stems from the ability of China to produce at a substantially lower costs, effectively deterring competitor entry despite strategic concerns.

U.S. policy makers are attempting to break down this barrier through guaranteed purchase agreements. The DoD recently announced it will guarantee a minimum price MP Materials, currently one of the few domestic rare earth mining companies, at approximately twice current market rates (Onstad, 2025). This policy intervention aims to incentivize domestic production capacity expansion despite Chinese price advantages. Halls sensors face similar challenges due to their reliance on semiconductor fabrication, which remains concentrated in Asian supply chains despite North American's 40% share of motor assembly and integration (Streetwise Reports, 2025). This disparity between Tier 1 (final assembly) and Tier 2/3 (component) supply chain resilience creates systemic vulnerabilities even for "domestic manufactured" systems.

Red Cat has identified Unusual Machines as its primary supplier of BLDC motors and tilt-rotor mounting hardware (Personal Communication, Red Cat Holdings, September 5, 2025). Unusual Machines, a U.S. based company, has positioned itself to serve the expanding UAS market with specific emphasis on NDAA compliant components for Blue UAS certification requirements. The company has announced plans to scale production capacity to exceed 50,000 motors annually, focusing on three variants optimized for different UAS applications: the 2207, 2807, and 3220 series (Streetwise Reports, 2025).

However, both Red Cat and Unusual Machines face similar scaling constraints: as publicly traded companies, neither will invest in speculative capacity expansion without firm purchase commitments. This creates a circular dependency where government procurement agencies await demonstrated production capacity before placing large orders, while manufacturers require purchase guarantees before expanding facilities. Breaking this impasse will require either advance procurement commitments or government-backed guarantees to derisk manufacturing investment.

Since Unusual Machines does not publicly disclose detailed specifications for motors custom made for vendors, this analysis examines comparable motors with equivalent performance characteristics to estimate pricing and weight. Motor sizing requirements were determined through scaled image analysis: publicly available product photographs showing the Edge 130 with dimensional references enabled tracing and measurement of propeller diameter, yielding estimates of approximately 10 inches for the forward tilt-rotors and 15 inches for the rear pusher propeller (Author analysis based on Red Cat Holdings, n.d.)

For the forward propulsion system, a 2800-series motor provides the optimal balance between power output and weight constraints. The relatively smaller 10-inch forward propellers require motors that prioritize efficiency and lightweight design over maximum torque. For the 15-inch rear pusher propeller, a 3510-series motor is specified to meet the higher power demands imposed by the larger rotor diameter (Liang, 2024). The selection prioritizes torque delivery over maximum rotational speed, as larger propellers operate more efficiently at lower RPM while generating equivalent thrust.

Pricing and weight estimates for these motors are derived from comparable alternatives currently available in the commercial market, as detailed in the BOM (Supplemental).

b. Propellers (PWR-003, 004)

The Edge 130 utilizes three propellers in a tri-rotor configuration: two 10-inch units for the forward tilt-rotors and one 15-inch unit for the rear pusher, as determined through scaled image analysis described in the previous section. FlightWave manufactures these propellers in-house using the same vacuum-assisted resin transfer molding (VARTM) process employed for airframe fabrication (Personal communication, Red Cat Holdings, Sept 5, 2025). The propellers share the airframe's carbon fiber composite construction, utilizing carbon fiber reinforcement with epoxy resin matrix (Personal communication, Red Cat Holdings, September 5, 2025).

From a supply chain perspective, propeller production presents relatively low vulnerability compared to electronic components. Carbon fiber and epoxy resin are readily available from domestic suppliers such as Hexcel Corporation, as discussed in the airframe section. The manufacturing constraint is not material availability but rather molding equipment throughput. Red Cat representatives indicated current tooling capacity adequately serves existing production volumes but would require expansion to support large-scale orders (Personal communication, Red Cat Holdings, Sept 5, 2025). Unlike semiconductor dependent components, propeller production scaling is limited primarily by capital investment in additional machines associated with molding rather than foreign supply dependence. Molding equipment machines depending on the process chosen can range from autoclaves, presses, and resign transfer molding. Companies such as domestically located ASC Process systems are capable of supplying these needs (ASC Process Systems, n.d.).

c. Battery (PWR-005)

The Edge 130's utilizes a 14.8V lithium-ion battery pack designed to meet the substantial energy demands of VTOL operations. FlightWave product specifications indicate the platform requires battery performance of at least 86.4 Wh, 6.0 Ah, and 14.6V under nominal conditions (FlightWave Aerospace Systems, n.d.). While FlightWave manufactures battery packs domestically, individual lithium-ion cells are sourced from Murata Corporation in Japan (Personal communication, Red Cat Holdings, September 5, 2025). This foreign dependency on critical battery cells represents a significant supply chain vulnerability, particularly given the regional concentration of raw materials and the substantial cost advantage that foreign manufacturers maintain over domestic alternatives.

FlightWave battery packs are included in the Edge 130 system price. To estimate unit costs, this analysis examined comparable U.S. manufactured lithium-ion batteries with similar specifications: the MaxAmps Li-ion 6000 at $165 (MaxAmps, n.d.) and MTO Train-43 at $160 (MTO Battery, n.d.) yield a median cost of approximately $1.80 per Wh. Applying this rate to the Edge 130's 86.4 Wh requirement estimate a battery cost of $156 per unit. Battery weight is 425 grams based on Red Cat product testing documentation (Personal communication, Red Cat Holdings, September 5, 2025).

FlightWaves's domestic battery pack assembly provides some supply chain resilience, but the company remains dependent on foreign-sourced materials for cell production. Lithium-ion batteries consist of five critical components, each presenting distinct vulnerabilities: cathode, anode, current collectors, separators, and electrolyte (Belharouak et al., 2020).

Cathode materials (lithium cobalt oxide) face severe supply constraints. The Democratic Republic of Congo supplies approximately 70% of global cobalt, while China controls 60% of rare earth element supplies and refines 60–70% of lithium and cobalt globally (International Energy Agency, 2023). Australia and Chile dominate lithium mining (55% and 25% respectively), but China's control of refining creates critical dependencies regardless of mining location (International Energy Agency, 2023).

Anode production, primarily graphite-based, presents similar constraints. China dominates graphite mining and processing through a combination of rich domestic deposits and production cost structures that deter competitor entry (Park et al., 2025).

Current collectors require battery-grade aluminum foil (cathode side) and copper foil (anode side), while separators utilize polyethylene films. North American commercial-scale manufacturing capacity for these thin electrode foils and separator films remains inadequate for large-scale battery production (Gohlke et al., 2024).

Electrolyte components lithium salt and solvent blends represent perhaps the most severe bottleneck, as all U.S. lithium salt supplies are imported from Asian sources (Mexichem Flour, Inc., 2022).

Scaling production to meet large orders will require either securing alternative cell suppliers or developing contingency plans for supply disruptions. The primary barrier to domestic cell production is cost: domestic manufacturing increases battery costs by approximately 90% compared to Asian imports, eliminating market incentives for U.S. companies to enter production without policy interventions or guaranteed demand (Havlin, 2020, p. 10).

2. Electronics

The electronics package for the Edge 130 platform boasts more sophistication than simple wirings. With the inclusion of state of the art AI, the drone occupies a space of improved navigational abilities and independence that other drones are not equipped with.

a. AI Autonomy Module (ELEC-001, 002)

Onboard autonomy capabilities are powered by the NVIDIA Jetson Xavier NX module (Personal communication, Red Cat Holdings, September 5, 2025). This AI system handles real-time vision processing, object detection, autonomous navigation, and decision-making tasks, leveraging computation capacity of up to 32 trillion operations per second (NVIDIA Corporation, n.d.). The autonomous flight control system enables more resilient operations in contested environments by providing obstacle avoidance and flight stabilization without continuous operator input. This allows operators to temporarily divert attention from active flight control when tactical circumstances demand focus elsewhere, while the system maintains safe flight operations.

The Jetson system's computational capabilities reduce pilot workload but impose thermal management requirements due to high power consumption. Passive heat dissipation through natural convection proves insufficient for sustained operations, necessitating active cooling to prevent thermal damage (Connect Tech Inc., 2023). A Jetson active heatsink fan is integrated with a module to provide supplemental cooling during high-demand processing tasks (NVIDIA Corporation, n.d.).

Both the cooling fan and AI module present notable supply chain constraints related to materials and fabrication processes. The Jetson module's primary vulnerability stems from reliance on advanced semiconductor manufacturing concentration in Taiwan through partnerships with the Taiwan Semiconductor Manufacturing Company (TSMC). The central processing unit and graphics processing unit utilize advanced process nodes fabricated by TSMC (Van Loon, 2025). Additional vulnerabilities include memory storage, printed circuit boards, and power management circuits, all sourced predominantly from Southeast Asian suppliers, as discussed extensively throughout this analysis.

The cooling fan presents supply chain concerns due to Chinese manufacturing. According to NVIDIA forum responses, the original equipment manufacturer fan supplier is DongGuan Dingrui Technology, a Chinese owned company (Trumany,2020). While alternative fan assemblies would remain available in contested environments, subcomponent materials pose constraints, particularly those required for the miniature brushless motor. This cooling motor shares the same architecture and rare earth material dependencies as the propulsion motors discussed previously. Aluminum heatsink material warrants consideration as well: though globally abundant under normal conditions, aluminum has historically become strategically significant during large-scale conflicts. The AI Autonomy module and its cooling system collectively demonstrate multiple supply chain vulnerabilities, spanning regional manufacturing concentration to multi-tier material dependencies.

b. Electronic Speed Control / Battery Eliminator Circuit (ELEC-003, 004, 005)

Three ESCs regulate and convert direct current power into alternating current while independently controlling motor speed. This precise regulation enables stable flight and maneuverability. ESCs form the essential link between the flight controller and motors, serving as a critical determinant of overall platform performance (KDE Direct, 2017). The selected ESCs are KDE's KDE-UAS20LV units, designed to handle the substantial power demands of military UAS applications, including platforms carrying heavier payloads and operating extended flight profiles (KDE Direct, n.d.).

Complementing the ESCs, a battery eliminator circuit (BEC) steps down the main battery pack voltage for subsystems operating at lower power levels. KDE's KDEXF-UBEC22 is specifically designed to pair with higher-grade ESCs and ensures reliable power delivery to the flight controller, servos, and other electronics (KDE Direct, 2017).

Sourcing both ESCs and BECs from KDE provides supplier reliability and integration efficiency with the platform's brushless motors. Single-vendor consolidation reduces delays from component incompatibility and streamlines system integration. KDE's ISO 9001 certified production ensures a repeatable, standardized assembly process aligned with NDAA compliance requirements (International Organizations for Standardization, 2015). This certification demonstrates manufacturing scalability through uniform procedures and continuous process improvement, positioning KDE as a viable partner for rapid production expansion.

KDE's manufacturing capacity and workforce training do not present the primary scaling constraints. Availability of nearshore and allied sourced materials, particularly semiconductors, capacitors, and printed circuit boards, will constitute the bottleneck in contested logistics environments (Peters, 2021). Supply chain disruptions from allied nations will extend component lead times and create assembly delays for KDE-provided systems.

c. Antennas (ELEC-006)

The platform's antenna receives communication from ground control stations (GCS) and relays operator commands to the flight controller. Based on the platform's operational requirements for weight, performance, and NDAA compliant sourcing, the MP Antenna MPSL900 represents a suitable antenna selection for this analysis. The MPSL900 is an omnidirectional and multi-polarized component designed to maintain reliable signal transmission in both line-of-sight and obstacle-dense environments. The MPSL900 provides resilient capability by leveraging superior multi-polarization function to minimize signal interference from reflections and polarization mismatches. According to manufacturer specifications, the signal quality, range, and durability for the MPSL900 match the operational standards of the Edge 130 (MP Antenna, n.d.). The MPSL 900 is fully designed and manufactured within the continental U.S., providing supply chain advantages in logistical planning (MP Antenna, n.d.). The antenna doesn't have any perceived supply chain threats being constructed mostly from high grade plastic, and some metals easily sourced with no specialized materials.

d. Telemetry Radio / Communication Radio (ELEC-007, 008)

Two distinct radio systems support flight communication and operational deployment. For telemetry functions, the RFD900ux from RFD Design provides long-range signal transmission for low-rate data communications, translating operator commands from ground stations (PX4 Development Team, n.d.). The communication radio, Microhard's pMMDL 2450, supports higher data throughput for relaying ISR feeds (Microhard Corporation, n.d.). Radio equipment for the Edge 130 was disclosed during interviews with Red Cat. Both radios share common component architectures, including PCBs, antenna connectors, data connectors, silicon integrated circuits (IC), voltage regulators, and oscillators. The communication radio distinguishes itself through an integrated radio frequency power amplifier that enables more robust data transfer links (Microhard Corporation, n.d.).

RFD Design is an Australian company that provides designs and engineering for the telemetry radio. Conversely, actual manufacturing takes place in Taiwan (NWBlue, n.d.). Manufacturing location alone creates supply chain vulnerability for this component, even before considering additional dependencies on chips and PCBs that rely on Taiwanese fabrication capabilities.

Microhard products represent a more resilient nearshore alternative, sourced from Canada. According to company documentation, Microhard conducts all functions from sales to manufacturing at its Canadian headquarters (Microhard Corporation, n.d.). Though this does not eliminate potential dependencies on imported electronic subcomponents, Canadian manufacturing provides greater supply chain adaptability compared to the Taiwan manufactured telemetry radio, at a higher unit cost, however.

e. GPS Module (ELEC-009)

To provide real-time location data, the Edge 130 is fitted with an RTK-1010 Locosys Global Positioning System (GPS) Module (Personal Communication, Red Cat Holdings, September 5, 2025). The GPS communicates precise coordinates by receiving dual-band real time kinematic (RTK) and Global Navigation Satellite Systems (GNSS) signals. Location accuracy is essential for sUAS operations, supporting autonomous navigation, low-visibility operations, multi-platform deployment, and integration with combined force systems. Locosys is based in Taiwan, where all products are manufactured, creating supply chain risk in contested logistics scenarios (Locosys Technology Inc., n.d.).

The GPS module consists primarily of sensitive electronic components with concentrated manufacturing in Taiwan: the RTK processor, GNSS IC, and PCB. Initial sourcing presents minimal constraints since the end item and its subcomponents are manufactured in the same location. Follow-on shipments during conflict, though, could face significant delays.

The GNSS IC represents a more critical vulnerability. As an essential component, its absence would severely degrade platform functionality. Taiwan produces the majority of GNSS ICs, consistent with its dominance in semiconductor fabrication noted as a trend in this analysis. There are alternative domestic and European suppliers design and integrate GPS modules, the underlying hardware for complete systems remains dependent on Taiwanese ICs (U.S. International Trade Commission, 2024).

f. Companion Computer (ELEC-011)

The companion computer enables the drone to complete functions such as object detection, route planning, communication management, and sensor management (Personal Communication, Red Cat Holdings, September 5, 2025). The Edge 130 utilizes a Raspberry Pi CM3+, a modest computer with 1 GB of random access memory capable of handling reasonable AI workloads (Raspberry Pi Ltd., 2023).

Raspberry Pi is a U.K.-based organization that designs, sources subcomponents, establishes testing standards, markets products, and maintains operating systems for Raspberry products. The company does not operate manufacturing facilities. Raspberry Pi partners with Sony for final assembly, where components are soldered to Raspberry-designed PCBs at Sony's U.K. facility before shipment (Raspberry Pi Ltd., 2023).

Chip sourcing originates from Asia despite U.K. final assembly. Raspberry Pi's production history includes initial manufacturing in China before relocating assembly operations to the U.K. in response to increased demand (Morgan, 2013). The underlying components particularly ICs continue to be sourced from Asian suppliers, following the semiconductor dependency patterns continuously identified.

Raspberry Pi's reliability as a companion computer supplier presents several supply chain risks. The company's software development and system management capabilities are not the constraint; component sourcing has proven to be the primary vulnerability. During pandemic-related disruptions, Raspberry Pi experienced significant difficulties maintaining inventory, leading to production shortages and delays (Raspberry Pi Ltd., 2021). More severe conditions directly affecting Southeast Asia would likely produce similar challenges in meeting order demand. Components limiting CM3+ production include PCB, memory devices, data storage, and most critically, IC chips. These components again follow the Southeast Asian concentrated dependencies persistent bottlenecks in our analysis.

g. Flight Controller (ELEC-012)

Cube Pilot provides the flight controller Cube 2.0, the platform's central processor that interprets pilot commands and relays autonomous signals to the ESCs. This component forms the backbone of command and control within the Edge 130 (Personal Communication, Red Cat Holdings, September 5, 2025).

The flight controller presents numerous supply chain risks due to its complex electronic composition. Cube Pilot's Blue UAS accreditation does not eliminate foreign component reliance. The company conducts assembly in the U.S. and through allied nations such as Tawain; to expound on the core argument of Southeast Asian reliance for subcomponents, Cube Pilot is vulnerable to sourcing in the region (Ready Made RC, n.d.). Specific manufacturing processes are not publicly disclosed, though supply chain constraints can be inferred through known dependencies in semiconductor fabrication and sensor production.

The microcontroller (MCU) and associated power management circuits for the H7 are manufactured by STMicroelectronics, headquartered in Switzerland, but their production depends on raw silicon wafers, capacitors, and packaging services that are primarily located in Asia (STMicroelectronics, n.d.). Similarly, inertial measurement units (IMUs) are supplied by TDK InvenSense based in Japan. TDK follows a fabless business model using partnership companies for silicon wafer production, sensor assembly, and testing (Clarke, 2012). Figure 6 illustrates the fabrication platform used by TDK InvenSense. The barometric sensors needed for the Cube 2.0 can be sourced from MEAS/TE Connectivity another Switzerland based company (TE Connectivity, n.d.). MEAS/TE likely acquires silicon wafers just as the previous companies, manufactures the barometers domestically, and then ships unfinished chips to Taiwan for final packaging. The PCB that integrates these components is a repeated supply chain hazard where Taiwan controls the majority of PCB fabrication outside of China (Taiwan's Industrial Technology Research Institute, 2022).

The flight controller is additionally fitted with a 4GB memory card provided by Delkin (Personal Communication, Red Cat Holdings, September 5, 2025). The storage space is used to log flights, back up data, and serve as the medium for firmware updates. Delkin is a domestical company, but products are manufactured in Taiwan, making the memory card an additional constraint in a contested supply chain (element14, n.d.).

Taiwan-based fabrication facilities remain essential for economically producing key components such as the PCB and silicon ICs at scale.

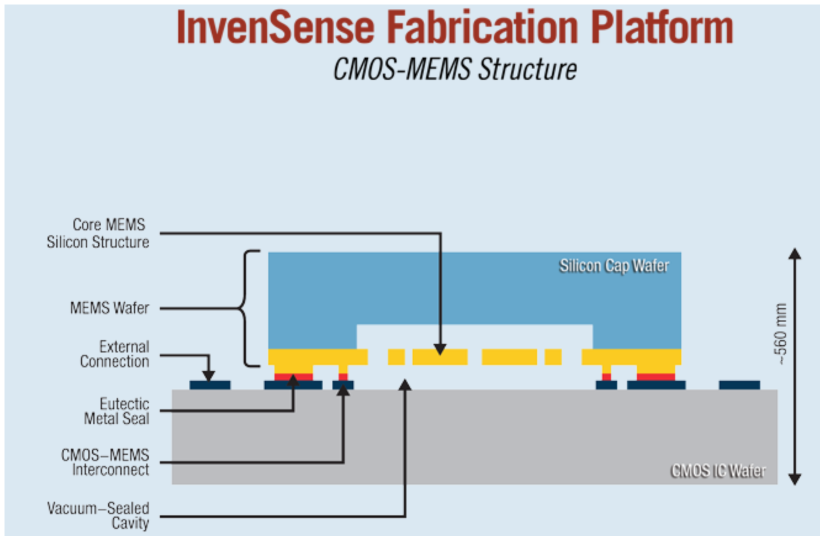

Figure 6. InvenSense CMOS-MEMS Fabrication Structure. Source: TDK InvenSense (n.d.).

h. Tilt Rotor Servo (ELEC-013, 014)

Tilt rotor servos enable the Edge 130’s transition between VTOL and fixed-wing cruise flight modes. Not officially confirmed by Red Cat, but the platform is likely equipped with Hitec MD89MW high-torque servos. Hitec Commercial Solutions is positioned in the industry as a lead supplier of servo actuators for unmanned systems in the compact market, industry observers’ critique Hitec servos as military-grade components (Hitec Commercial Solutions, n.d.).

The servo assemblies primarily consist of readily available mechanical elements, including gears, splines, and housings, but several subcomponents pose potential sourcing risk in a contested logistical environment. The internal brushed motor, which drives the servo actuation, depends on rare-earth magnets similar to those used in the Edge 130’s BLDC motors. Additional vulnerabilities arise from the electronic elements that govern servo control, including the magnetic encoder, PCB, and MCU. These parts are most likely fabricated at Hitec's South Korean or Philippine facilities, reflecting regional manufacturing dependencies previously explained that are shared by other electrical subsystems. While Hitec maintains a U.S. office in California, that site functions primarily as a marketing and distribution hub; the company's main production capacity resides in South Korea (Hitec RCD USA, n.d.).

Despite global operations, Hitec's servo production falls into the same systemic bottlenecks when referring to electronics such as semiconductors and sensor sourcing in relation to PCB components and position sensors. From a defense logistics perspective, availability of domestically produced, small-form-factor servos remains limited, underscoring a broader challenge in securing NDAA-compliant suppliers for attritable sUAS applications.

i. Gimbal (ELEC-015, 016, 017, 018)

The gimbal integrated into the Edge 130 as illustrated in Figure 7, serves as the core of the platform's ISR mission set. Its composite housing is produced as part of the airframe's injected-molded structure, while FlightWave Aerospace Systems integrates the EO/IR sensor and stabilization assemblies during final production (Personal Communication, Red Cat Holdings, September 5, 2025). The unit incorporates a dual-sensor EO/IR payload designed for long-range and low-visibility reconnaissance. According to product documentation, the maximum payload capacity for the Edge 130 is approximately 345g, establishing the upper mass limit for its stabilized sensor package (Red Cat Holdings, n.d.).

Figure 7. Red Cat Edge 130 Gimbal. Source: Red Cat (n.d.).

The EO sensor employed in FlightWave's GS12 gimbal is the Sony IMX530, a global shutter image sensor capable of capturing high-speed imagery without motion distortion, an essential feature for tactical ISR operations (Personal Communication, Red Cat Holdings, September 5, 2025). The IMX530 is among the more expensive components in the system because of its high-performance architecture, limited production volume, and certification requirements associated with Blue UAS compliance (Framos, 2025).

A standard camera assembly, such as the IMX530 module, typically consists of an image sensor, PCB, image signal processor (ISP), optical lens, and data interface (Kumar, 2025). Each element introduces supply-chain risk, largely due to established centralized concentration of advanced electronic manufacturing in Southeast Asia. While Sony does not disclose openly details about its supplier network, the company's subsidiary, Sony Semiconductor Solutions Corporation, lists its global-shutter series among its core imaging products, suggesting that production follows a prevailing regional fabrication trend (Sony Semiconductor Solutions Corporation, n.d.). The image sensor integrates capacitors and transistors components heavily reliant on refined materials and semiconductors foundries concentrated in Taiwan, Japan, and South Korea.

Following fabrication, the sensor is typically mounted and soldered to a PCB, which provides the electrical routing necessary for communication with the ISP. The ISP itself comprises specialized chips, transistors, and capacitors that are likewise produced through Asian semiconductor supply chains (e-con Systems, 2023). Data captured by the sensor is transmitted via an integrated interface composed of a ribbon connector and silicon-based logic, reinforcing the overall dependency of imaging subsystems on Asia-Pacific manufacturing. In contrast, the optical lens represents a relatively stable component of the supply chain: multilayer optical-glass fabrication is globally distributed and less susceptible to the chokepoints that affect semiconductor-based elements (Metoree, n.d.).

The low-light IR sensing capability of the Edge 130 is provided by the Boson 320, manufactured by Teledyne FLIR (Personal Communication, Red Cat Holdings, September 5, 2025). The Boson 320 complements the EO IMX530 module by enabling thermal imaging for night operations, target detection, and reduced-visibility missions. Teledyne FLIR, a U.S. based company, designs and produces the Boson series domestically, with limited reliance on foreign-sourced subcomponents for core assembly (Teledyne FLIR, n.d.).

Unlike EO sensors, which capture visible light, IR sensors detect heat signatures through changes in thermal radiation. The Boson 320 employs a vanadium oxide (VOx) microbolometer (Teledyne FLIR, 2023), a proven uncooled-detector material that converts infrared radiation into measurable electrical signals. Its specialized lens is fabricated from germanium, a semiconductor-class element valued for its transparency to infrared wavelengths (Philipose et al., 2023). Germanium is obtained as a by-product of zinc and coal processing and represents a potential supply-chain constraint (SFA Oxford, n.d.). As noted by Quest Metals (2025), China currently dominates germanium refinement owing to its investment in high-cost recovery methods, though the U.S. has begun investing in domestic recycling and extraction to improve strategic stability in this market.

The Boson 320 also utilized vacuum packaging; a precision encapsulation process required to protect the VOx detector from contamination and moisture (Aydin et al., 2024). This advanced packaging technique provides a measure of independence from Asian specialization in semiconductor assembly yet remains limited by throughput and cost due to its complexity (Mahmoud et al., 2004). Despite these domestic advantages, the Boson 320's supporting electronics including control semiconductors and processing chips still rely on global foundries for fabrication, introducing residual exposure to international supply disruptions (Thadani & Allen, 2023).

The gimbal control motor, responsible for stabilizing and steering the payload, can be sourced from Celera Motion as a frameless direct-drive brushless motor. This motor is not confirmed by Red Cat but inferred due to weight, function, and sourcing. In a comparable Edge 130 configuration, the gimbal housing functions as an interchangeable module that encloses both the sensors and stabilization assembly. Given its precise alignment and finish tolerances, the housing would be produced alongside the main airframe in the same composite-molding tool chain, then integrated during final assembly. The direct drive motor is mounted alongside the gimble axis to ensure smooth, precise motion (Personal Communication, Red Cat Holdings, September 5, 2025).

In contrast to propulsion motors optimized for high rotational speeds, direct-drive gimbal motors deliver high torque at low speeds, critical for stable image capture while conserving battery power. As with other brushless designs, these motors incorporate position-feedback sensors and high-strength magnets, which remain potential points of supply-chain vulnerability due to dependencies on rare-earth and semiconductor materials (Celera Motion, n.d.; Gruver, 2025).

3. Structure (STR-001)

A composite carbon-fiber airframe designed and manufactured by FlightWave is the base of the Edge 130. This design provides a lightweight yet durable structure using materials compatible with modern molding processes (Personal Communication, Red Cat Holdings, September 5, 2025). The airframe's total weight is estimated at approximately 200g (about 7 oz) consistent with comparable COTS sUAS platforms. Carbon fiber has become increasingly favored for drone construction because of its high strength-to-weight ratio, thermal stability, and resistance to corrosion and fatigue, enabling lighter yet more rugged airframes and expanding the scope of UAS customization and mission flexibility (AddComposites, 2024).

Compared to legacy polymer or aluminum designs, carbon-fiber composites offer superior mechanical performance, but this advantage comes with trade-offs. As highlighted in the Role of Carbon Fiber in the Drone Industry, the material's production and molding processes are labor-intensive and costlier, potentially limiting scalability for mass production (Singh, 2024). Red Cat Holdings has confirmed that airframe throughput is presently constrained not by material scarcity but by limited molding capacity and order volume rather than equipment capability (Personal Communication, Red Cat Holdings, September 5, 2025),

Hexcel Corporation and Zoltek Companies are the most likely suppliers for the Edge 130's structural composites. Hexcel is a leading U.S. producer of aerospace-grade carbon fiber and has recently expanded partnerships with the UAS and Advanced Air Mobility (AAM) industries. Hannah Manson (2024) quoted Heatcon Composite Systems a closely associated company of Hexcel, president, Eric Casterline, emphasizing this rapid industry growth: "The UAV and AAM industry is expanding rapidly, and Heatcon is excited to be a part of this growth. Our capabilities allow us to support the industry with readily available inventory in both small and large quantities" (Manson, 2024, para. 3). Hexcel's large-scale domestic production capacity, established aerospace supply relationships, and NDAA compliant sourcing make it a logical and resilient supplier for Red Cat's carbon-fiber needs (Hexcel Corporation, n.d.).

VARTM is the process by which the composite structure is formed for the Edge 130 (Personal Communication, Red Cat Holdings, September 5, 2025). The process layers carbon fiber layers into a mold, that is infused with epoxy resin, and then vacuum-sealed to ensure uniform impregnation and consolidation (AddComposites, 2024). The resulting laminate forms the airframe's structural shell, which is then assembled with electronic and propulsion components. Hexcel also supplies epoxy resins for such aerospace-grade VARTM applications (Hexcel Corporation, n.d.).

C. COMPACT FIRST PERSON VIEW DRONE (STINGER VISION BY MODALAI)

Figure 8. ModalAI Stinger Vision FPV. Source: Business Wire (2025).

The Stinger Vision FPV drone made by ModalAI was chosen due to its unique weight, size, and cost. The Stinger Vision is a compact, caged 3.5" drone that only weighs 575 grams (about 20 oz) (ModalAI, n.d.). Its low noise signature, high-quality camera, and indoor/outdoor versatility enable covert reconnaissance capabilities (ModalAI, n.d.). Stinger is an American-made drone that made the DIU Blue list for its compliance with the U.S. DoD's strict requirements for cybersecurity, supply chain integrity, and operational reliability (Defense Innovation Unit, n.d.). Additionally, ModalAI has 16 components on the Blue UAS framework list, with many of these components being essential electronics such as flight controllers, ESCs, sensors, VRXs, and video transmitters (VTX) systems (Defense Innovation Unit, n.d.). According to Macey (2025), this represents the highest number of components held by any NDAA-compliant drone manufacturer.

Smaller drones are often harder to fly and require more training time for pilots to master the basics. ModalAI considered this learning curve and created a drone for organizations that need to scale operations quickly with minimal training time (Young, 2025). The Stinger Vision FPV can also be created in larger 5-inch, 7-inch, and 10-inch configurations that are also part of the Blue UAS cleared list (Defense Innovation Unit, n.d.). The Stinger was selected due to its compact size and configurable frames, allowing the U.S. to mass-produce these versatile drones, which offer a specific capability that very few companies can provide due to their innovative technology. This capability is best suited for small-unit reconnaissance missions as it provides an excellent capability for short-range tactical operations.

ModalAI was contacted for assistance with this research, but they were unable to answer the research questions provided. Therefore, this research identified components that make up a similar version of the Stinger using open-source documentation including ModalAI technical specification and component documentation (ModalAI, n.d.). The similar Stinger is comprised of 20 components that can be broken down into subcomponents that require multiple suppliers for each component.

1. Powertrain

The powertrain for the Stinger strives to maintain its ultra-lightweight requirement. The motors, propellers, and battery are all uniquely designed for the compact frame. Without compromising on abilities, the Stinger is able to more or less keep the traditional layout of wiring, ESCs, and propellers while integrating the caged structure.

a. Motors (PWR-001)

Typical quadcopter drones require four brushless motors. When creating a compact and lightweight drone, it is essential to save weight by ensuring every single component is lightweight. Motors are an essential part of that equation, as every gram counts. For this type of caged quadcopter drone, Lumenier, a company out of Sarasota, Florida, is a likely motor supplier (Lumenier, n.d.). Lumenier is an American manufacturer and supplier for military and civil entities with the knowledge and capabilities to create custom solutions while ensuring NDAA compliance (Lumenier, n.d.).

A motor contains multiple parts: the stator, bearings, shaft, rotor shell, and magnets. Lumenier uses silicon steel for their stator, which is manufactured by Nippon, a Japanese company with manufacturing plants in Pennsylvania and Indiana (Nippon Steel, n.d.). Additionally, NSK, a Japanese company with manufacturing plants in Indiana, California, and Michigan, manufactures the bearings (NSK Automation, n.d.). This illustrates the intricate supply chains required to manufacture these motors. However, among all the components required to make brushless drone motors, one critical part creates a bottleneck for domestic supply chain development.

Drones utilize neodymium-iron-boron (NdFeB) magnets that are the backbone of motors. However, China is the largest producer of these magnets with roughly 85%-90% of the world's supply (Rare Earth Exchanges, 2025). This creates a critical vulnerability, and the United States has <1% of the global supply with no large-scale capability to make NdFeB magnets (Rare Earth Exchanges, 2025). The only American rare earths mine is being run by MP Materials, which received a $35 million award by the DoD to design and build a facility to process heavy rare earth materials in the United States (U.S. Department of Defense, 2022). The DoD also entered into a public-private partnership with MP Materials that included $300 million equity investment to accelerate the magnet supply chain and reduce foreign dependency (MP Materials, 2025).

b. Propellers (PWR-002)

The similar Stinger requires 3.5 inch 5-blade polycarbonate propellers (ModalAI, n.d.). The size and number of blades on a propeller are important because smaller propellers produce less thrust but are easier on the motor (Liang, 2024). Additionally, having more blades is common in FPV drones like the Stinger, as it makes it easier to control and reduces the required learning time for pilots. Polycarbonate is also less expensive than carbon fiber propellers (Flynt, 2020). However, the propellers used are from Gemfan, a Chinese company (Gemfan Hobby Co., Ltd., n.d.). To ensure the propellers' supply chain stays in the U.S., it would be recommended to acquire propellers from other companies, such as APC Propellers, which has manufacturing facilities in California (APC Propellers, n.d.).

c. Batteries (PWR-003)

The similar Stinger requires a 14.4V lithium-ion (Li-ion) battery pack made from four 18650 cells (ModalAI, n.d.). Most drones use Li-ion batteries due to their longevity and efficiency. Li-ion batteries are a critical component of drones as they have higher energy density, which allows for longer flight times compared to lithium polymer batteries

(Pan, 2025). The weight constraints of compact drones also make Li-ion batteries a better option, as they can be designed in smaller packs to provide sufficient power and endurance while considering weight and size constraints (Pan, 2025). The most likely supplier for the Stinger is Lumenier, as they manufacture the exact battery pack that meets the requirements for the Stinger (Lumenier, n.d.). However, there are only a couple of possible suppliers for Li-ion batteries that meet NDAA specifications. The suppliers are American Lithium Energy, Molicel, and Panasonic. Molicel is a Canadian manufacturer, and Panasonic is from Japan. Nevertheless, Panasonic's plant in Kansas could be leveraged as it is one of the largest cylindrical Li-ion gigafactories in North America (Collins, 2025). Even with these limited NDAA-compliant manufacturers, the fundamental challenge is that the global battery supply chain remains dependent on a single nation.

Li-ion batteries are a critical component that creates a bottleneck for scaling drones in the millions. China manufactures around 77% of the world's Li-ion batteries (Sinha, 2024). Poland ranks second, with slightly above 6%, and the U.S. follows in third, with around 6% of the total Li-ion batteries manufactured worldwide (Sinha, 2024). This dependency and reliance on batteries sourced from Chinese-controlled supply chains pose a significant threat and create a critical vulnerability in the U.S.'s ability to enhance a domestic drone supply chain in mass numbers (World, 2025).

Li-ion batteries are complicated to manufacture in the U.S. due to the lack of raw materials needed to produce these batteries, such as lithium, cobalt, nickel, graphite, and manganese (Hoffs, 2022). The U.S. heavily relies on imports of these materials, with 100% import dependence on graphite and manganese. Cobalt 76%, nickel 48%, and lithium >50% import dependence (Taulli & Busby, 2025). This raw material dependency compounds the supply chain vulnerabilities that China-dominated supply chains have already created. One way to overcome this dependence would be to find alternative batteries that do not rely on Chinese-controlled supply chains, such as lithium-sulfur batteries built from readily available materials in the U.S. (World, 2025).

2. Electronics

The electronics on the Stinger include compact components such as the flight controller that incorporates an advanced companion computer, 4-in-1 ESCs and high quality sensors. The Stinger's ability to navigate in GPS-denied environments is what sets it apart from other compact drones.

a. Flight Controller and Companion Computer (ELEC-001)

The flight controller is the brain of the drone, interpreting data from various sensors and translating pilot commands into motor actions (Grepow, 2024). It manages the drone's movement, stability, balance, and responsiveness. ModalAI produces a Size, Weight, and Power (SWaP) optimized and NDAA-compliant flight controller, known as VOXL 2 Mini, which also incorporates a premium-tier companion computer (ModalAI, n.d.). The companion computer handles advanced processing tasks, such as image analysis and autonomous navigation. By integrating these two components into a single unit, ModalAI provides drone manufacturers with a space-efficient solution that delivers high computational power while minimizing weight and size constraints.

The VOXL 2 Mini is a highly compact flight controller that weighs only 11 grams and is powered by the Qualcomm QRB165 (ModalAI, n.d.). The complexity of supply chains is particularly evident when examining the breakdown of the VOXL 2 Mini PCB and analyzing the components that comprise this powerful system. The VOXL 2 Mini requires multiple components from companies such as Qualcomm, Kingston Technology, Micron, TDK, Texas Instruments, Onsemi, Molex, JST Commercial, Hirose Electric, and Amphenol ICC (ModalAI, n.d.). Out of these companies, only five are based in the United States, and the rest are in Japan or Taiwan. This can become a significant problem when it comes to contested logistics, as some of the most critical components that make up the brain of the drone cannot be sourced domestically.

Even though the VOXL 2 Mini is part of the Blue UAS Framework, a closer look at the components that make up the system reveals supply chain considerations (Defense Innovation Unit, n.d.). The VOXL 2 Mini utilizes a System-on-Chip and Power Management by Qualcomm (ModalAI, n.d.). When examining how Qualcomm creates these chips, research has shown that the processors are owned and designed by Qualcomm, but the company does not manufacture them itself. According to Victorino (2025), "Qualcomm follows a fabless business model, so it relies on other entities, particularly specialized semiconductor foundries, to produce its microchips in the absence of its own processor-manufacturing facilities." What can become concerning in a contested environment is that most of their chips are made by TSMC and Samsung (Victorino, 2025).

The VOXL 2 Mini incorporates embedded storage made by Kingston Technology, which has its Headquarters in California but primarily manufactures in Taiwan and China (Global Data, n.d.). Similar to the Red Cat flight controller, the VOXL 2 Mini also uses IMUs and a barometer from TDK InvenSense, based in Japan (TDK InvenSense, n.d.). The VOXL 2 Mini also utilizes Dynamic Random Access Memory (DRAM) manufactured by Micron, which has a significant presence in the U.S., Asia, and Europe (Micron Technology, n.d.). Micron continues to expand its locations in the U.S. and invested approximately $200 billion to create volume fabs in Idaho and four in New York (Micron Technology, 2025). This investment is significant as Micron was banned by China in 2023 due to being perceived as a risk to their national security (Hoskins, 2023). This goes to show how big a role Micron plays in DRAM production, as they are one of the largest manufacturers in the U.S. As mentioned with the Red Cat flight controller, PCB fabrication is a significant supply chain risk because, although Micron manufacturers in the U.S., they still source their silicon wafers from vendors. It is assumed that these vendors are similar to the other platforms mentioned, which are primarily vendors from Asia.

ModalAI utilizes several components from Texas Instruments, including a level shifter, a step-down converter, and a switching regulator, which are incorporated into the VOXL 2 Mini (ModalAI, n.d.). According to Hargreaves (2025), Texas Instruments is making a $60 billion investment to expand its semiconductor manufacturing operations in the U.S., marking one of the largest investments made in the country. Additionally, this is significant not only to ModalAI, which uses a lot of Texas Instruments products, but also for big companies such as Apple, NVIDIA, Ford, and SpaceX, which will also be working closely with Texas Instruments to move the chip industry back to the U.S. (Tarasov, 2025). However, there is still a significant concern because, although there are numerous wafer fabs in the U.S., all of the assembly/test sites are located in Mexico, Taiwan, the Philippines, and Malaysia (Texas Instruments, n.d.). Additionally, it is most likely that Texas Instruments relies on GlobalWafers, a Taiwan-based company, to manufacture the bare silicon wafers used in its products. The positive aspect of this is that GlobalWafers has recently opened a facility in Sherman, Texas, with the intention of bringing the semiconductor industry back to the U.S. (Herzberg, 2025). This is a significant step for the semiconductor industry, as silicon wafers are the foundation for manufacturing chips.

The VOXL 2 Mini utilizes components from Onsemi, one of the few companies that emphasizes a vertically integrated supply chain, which begins with raw materials like silicon carbide powder at their own fabs (Onsemi, 2024). Swanson and Gamio (2024) used Onsemi as an example to demonstrate the difficulties in moving the semiconductor industry from East Asia to the United States. This is illustrated in Figure 9, which demonstrates that, despite Onsemi's vertically integrated supply chain, it still relies on foreign suppliers and factories to deliver the end item to its customers. The crystal bole manufacturing begins in New Hampshire, wafer slicing takes place in the Czech Republic, chip manufacturing occurs in South Korea, and packaging is handled in several facilities across China, Malaysia, and Vietnam (Onsemi, 2024). The finished goods are then shipped to customers in Asia, Europe, Canada, the U.S., and China (Onsemi, 2024). As mentioned earlier, this poses a significant issue in a contested environment, as the semiconductor supply chain remains heavily dependent on foreign entities.

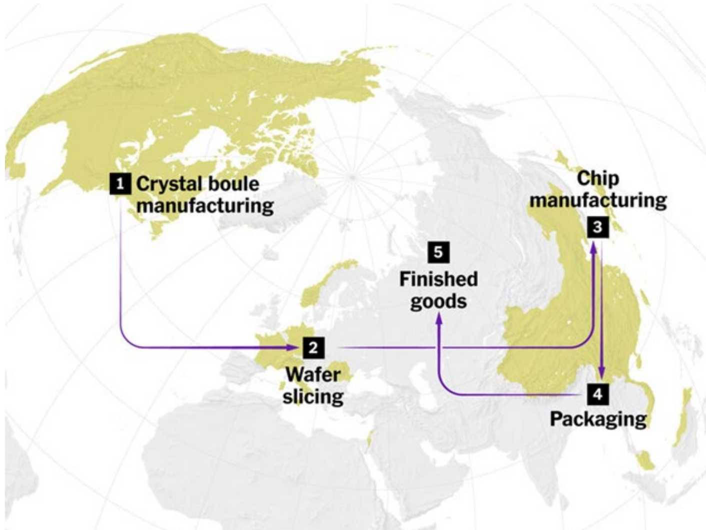

Figure 9. The Global Effort to Make an American Microchip. Source: Swanson & Gamio (2024).

The VOXL 2 Mini requires connectors produced by Molex, JST Commercial, Hirose Electric, and Amphenol ICC (ModalAI, n.d.). Unfortunately, all of these companies, besides Amphenol ICC, do most of their manufacturing in other countries such as India and Japan. Connectors are vital, as they are used to establish electrical connections between components on PCBs (Bao, 2021). Most connectors are manufactured through an injection molding process, which can be performed in the U.S. and is not considered a bottleneck.

b. Electronic Speed Controller (ELEC-002)

The ESC is a component of the drone that serves as the interface between the pilot's commands and the individual drone motors (Flynt, 2019). For compact drones, selecting a 4-in-1 ESC is preferable to enable space-saving and reduce overall weight. This means that the 4-in-1 ESC will control all four motors, eliminating the need for a separate ESC for each motor (Liang, 2024). This allows the drone to have fewer components and fewer points of failure. However, this type of ESC does come with its disadvantages. If one ESC fails in the 4-in-1 system, you must replace the entire part, which can result in additional repairs, higher repair costs, and prolonged downtime. On the other hand, with individual ESCs, you can replace the failed one without affecting the others, reducing repair time. For compact drones, ModalAI makes a 4-in-1 ESC that is NDAA-compliant (ModalAI, n.d.). As mentioned previously, ModalAI manufactures many SWaP components, making it easy to obtain all the necessary electronic components from a single company with expertise in building SWaP parts and drones, such as the Stinger Vision.

The complexity of ESCs lies in their internal components. Figure 10 shows a breakdown of the components that make up an ESC. Among the required components, the metal-oxide-semiconductor field effect transistor, gate drivers, and MCU are particularly challenging to manufacture due to their advanced semiconductor nature. These components are currently produced primarily in Taiwan, creating potential supply chain bottlenecks for drone manufacturers (Jones et al., 2023). As mentioned with the Flight Controller, the ESC PCB is also comprised of multiple components from various companies, including Monolithic Power Systems, STMicroelectronics, Texas Instruments, Bourns, Vishay, Analog Devices, and JST Commercial (ModalAI, n.d.).

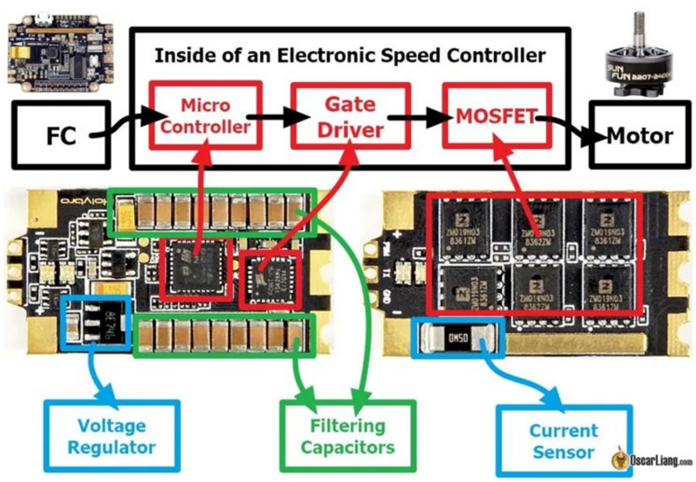

Figure 10. Understanding ESCs for FPV Drones. Source: Liang (2024).

c. *Sensors (ELEC-003, 004, 005, 006, 007)*

ModalAI's Stinger provides multiple FPV views, including EO, downward, and thermal options, for enhanced situational awareness (ModalAI, n.d.). They utilize Multi-Cam Visual Inertial Odometry (VIO), which estimates the drone's position and orientation by combining camera and IMU data (ModalAI, 2025). The advantages of using VIO are that it enables drones to navigate in GPS-denied environments, which can be critical in contested environments. VIO is also a key technology as it helps avoid obstacles, maintains stable flight in windy conditions, and creates 3D maps of the environment (Inertial Labs, 2024). ModalAI combines this technology with its VOXL autopilot to enable drones to fly autonomously in GPS-denied environments (ModalAI, 2025).

The entire imaging system is comprised of a low-light EO FPV Camera, two image tracking sensors, and an IR camera (ModalAI, n.d.). The low-light EO FPV Camera is a high-resolution, NDAA-compliant camera developed by ModalAI, utilizing the Sony Starvis 2 IMX664 sensor. The Sony Starvis 2 imaging technology accurately captures subjects regardless of changes in light and delivers high image quality even in extremely low-light and dark locations (Sony, n.d.). ModalAI also incorporates two NDAA-compliant image tracking sensors, which are placed in the front and downward to allow GPS-denied navigation. These sensors made by ModalAI incorporate an Onsemi AR0144 image sensor (ModalAI, n.d.). The Onsemi sensor is designed for capturing moving scenes accurately and quickly (Onsemi, n.d.). Additionally, a Teledyne FLIR Boson+640 IR camera is an optional NDAA-compliant module that can be paired with the low-light camera (ModalAI, n.d.). The optional IR module can be paired using the required adapters to connect the camera to a camera breakout board, also made by ModalAI. The camera breakout board is required to connect all of the sensors to the VOXL 2 Mini (ModalAI, n.d.).

Upon closer examination of the sensors used in each camera, it becomes apparent that ModalAI designs its cameras in the U.S. but outsources image sensors from companies like Sony, OnSemi, and Teledyne FLIR (ModalAI, n.d.). Although these companies are NDAA-compliant, they predominantly manufacture in Asia. Shih (2023) notes that advanced image sensor manufacturing is concentrated in Asia, creating challenges for U.S. designers and raising concerns about domestic capabilities for technologies critical to national security. This highlights the critical role image sensors play in large-scale manufacturing, as they are found in every drone used today.

d. Radio Receiver and Video Transmitter (ELEC-008, 009, 010)

The radio receiver enables the drone to communicate with the pilot's remote controller. The Stinger uses an express long range system (ELRS) with T-shaped antennas made by ModalAI (ModalAI, n.d.). With compact and lightweight in mind, ModalAI offers a suitable NDAA-compliant solution. The ELRS is comprised of a PCB, MCUs, a transceiver, and a temperature-compensated crystal oscillator (ModalAI, n.d.). The VTX transmits live video from the drone's cameras to the pilot's GCS or goggles. While ModalAI likely produces its own VTX, a Microhard VTX is examined here for comparison with the Stinger. The pMDDL2450 Microhard can be used with the Stinger, along with a Microhard carrier produced by ModalAI (ModalAI, n.d.). As discussed with Red Cat, Microhard has more near-shore components coming from Canada. However, the composition of the Microhard still requires items that can be susceptible to constraints during times of conflict.

e. Antennas (ELEC-011, 012)

The antenna enables wireless communication between the drone and the pilot's remote controller, transmitting both live video feed and command and control signals (Antenna Experts, 2024). For compact drones, antenna selection can be challenging as traditional antennas may be too large or heavy, while smaller antennas often compromise range and signal quality. The antenna must also be durable enough to withstand flight conditions while maintaining optimal signal transmission. TrueRC, a Canadian company, manufactures the antennas chosen for the Stinger. TrueRC also manufactures a range of compatible antennas in various sizes, frequency ranges, and weights, providing custom solutions for different FPV applications (TrueRC, n.d.). This allows compact drone manufacturers to select an antenna that meets their specific requirements.

f. Illumination (ELEC-013, 014)

Illumination in drones provides better visibility for the pilot by illuminating the scene, object, or area (FoxFury, n.d.). The Stinger utilizes IR and visible Light Emitting Diode (LED) compact pills, manufactured by Lumenier. The visible LED features 1400 lux for ultra-bright performance, along with advanced passive cooling and built-in thermal throttling, ensuring reliable and long-lasting operation (Lumenier, n.d.). On the other hand, the IR LED offers maximum visibility in extremely low-light environments, featuring the same 1400 lux output and passive cooling as the visible LED (Lumenier, n.d.). Both components include a temperature sensor, an aluminum casing, and a pigtail for connection. The manufacturing process of LEDs involves creating semiconductor wafers, adding epitaxial layers, incorporating metal conductors, and mounting and packaging (Lindblad, n.d.). LEDs are semiconductor diodes made of thin layers of semiconductor material, which could become a potential bottleneck for manufacturing due to their properties.

g. *Semiconductor Bottleneck*

Among all the electronics mentioned, there is one critical vulnerability that they share, which is the use of semiconductors. Each electronic component requires a different type of semiconductor, making drone production dependent on reliable access to all of them. Unfortunately, most semiconductors are imported (Kurilla, 2024). According to Swanson and Gamino (2024), "the first computer chips were invented in the United States, but by the late 1960s, part of the supply chain began to move overseas as companies looked to save costs." This offshore shift now poses a significant threat to U.S. supply chains and the U.S. ability to manufacture semiconductors. Semiconductor sourcing is centralized in or around Taiwan, the leading global producer and exporter of advanced chip systems. Taiwan is also prone to natural disasters, such as typhoons, floods, and earthquakes, which have historically interrupted the country's ability to meet international demands (Moh, 2005). This vulnerability in semiconductor manufacturing represents one of the biggest bottlenecks in the ability to produce drones at scale.

However, the CHIPS and Science Act of 2022 allocated $52.7 billion in federal subsidies to support chip manufacturing in the U.S. (Kurilla, 2024). This has incentivized companies to bring semiconductor manufacturing back to the U.S., as our capacity has dropped significantly from producing 40 percent of the world's semiconductor supply in 1990 to 12 percent in 2024 (Kurilla, 2024). Figure 11 shows the entire semiconductor ecosystem, including the locations where semiconductors are designed, facilities that supply raw materials, sites where manufacturing equipment is produced, and research universities. This figure highlights a significant critical vulnerability in the semiconductor industry, specifically in the raw materials, due to the disparity between the limited number of material locations and the facilities capable of manufacturing semiconductors.

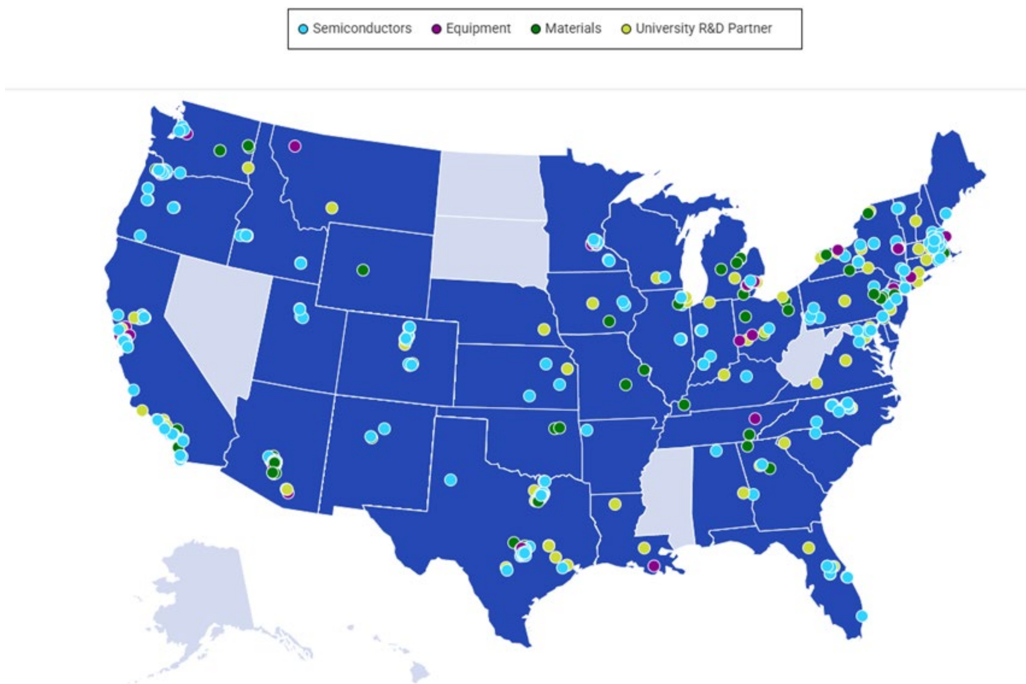

Figure 11. U.S. Semiconductor Ecosystem Map. Source: Semiconductor Industry Association (2025).

NVIDIA, based in Santa Clara, California, is one of the largest semiconductor companies in the United States (Ross, 2025). As a fabless company, it focuses on chip design and partners with other companies to manufacture them. NVIDIA manufactures the majority of its chips at TSMC's Taiwan-based factories (Ross, 2025). TSMC will invest an additional $100 billion on top of its existing $65 billion investment, for a total of $165 billion in Arizona, including three new fabrication facilities, two advanced packaging facilities, and a major R&D center — a significant move given TSMC's status as one of the world's largest semiconductor manufacturers (TSMC, 2025). Bringing this capability back to the U.S. will help enable drone production at scale, as semiconductors are integral to various components of drones.

In Thandani and Allen’s (2023) supply chain analysis of semiconductors, they highlight significant issues in multicountry dependency for manufacturing. Stating that, though countries are now instituting policy changes to incentivize industrial growth, no single country can conduct the entire manufacturing process of semiconductors. Assembly, test, and packaging facilities were expressed as centralized in the Info-Pacific region, which covers 95% of the market. Thadani and Allen’s (2023) research, as shown in Figure 12, reinforces the findings of this research, explaining the heavy dependency of outsourced semiconductor assembly and test that companies subcontract to countries in Southeast Asia, primarily Taiwan, China, Singapore, Malaysia, Vietnam, and the Philippines.

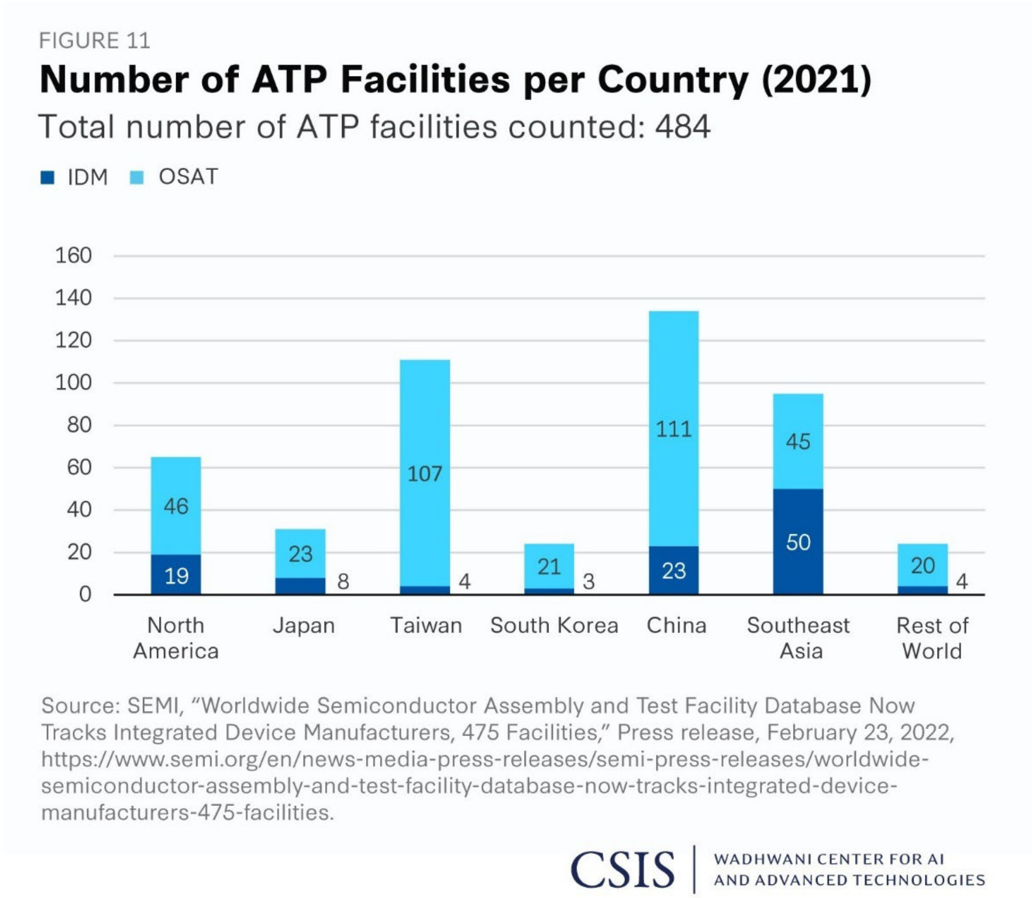

Figure 12. Assembly, Test, and Packaging Facilities per Country. Source: Thandani & Allen (2023).

Other cautionaries mentioned in Thandani and Allen's (2023) research include the complexities of the semiconductor supply chain, mentioning a lengthy process spanning months with hundreds of individual steps conducted in numerous countries. Materials and equipment required for manufacturing have their own barriers to the process from centralized suppliers, further complicating a country's ability to be self-sufficient. A country's ability to produce chips cannot be expressed by the number of fabrication facilities due to the variance in quality and throughput. Quality chips are produced by mature corporations, though there may be a large number of facilities, they may not be able to yield high-grade products. In short, even if there is a sudden surge in demand prompting companies to enter the market, it will take time to become as specialized as the outsourced assembly, test, and packaging firms.

3. Structure (STR-001, 002)

The Stinger requires a 3.5” frame to ensure it remains compact and lightweight (ModalAI, n.d.). The frame used for comparison is a frame made by Lumenier. The frame is made out of premium quasi-isotropic carbon fiber (Lumenier, n.d.). Quasi-Isotropic means that the strength and stiffness are the same when measured in any direction of the material (DragonPlate, n.d.). As mentioned with the Red Cat Edge 130, Hexcel is the largest U.S. supplier of carbon fiber. Lumenier and other drone companies most likely use carbon fiber because it offers high strength-to-weight ratios, which makes drones lightweight yet robust (Thornefield, 2025). This is crucial for manufacturing compact drones, as it maximizes flight performance while meeting design requirements. As discussed in detail in the Red Cat Edge 130 analysis, carbon fiber supply chains do not currently pose significant constraints to mass production. The Stinger also utilizes straps to hold the battery in place, made by a U.S. Company, Pure-Tech (ModalAI, n.d.). Pure-Tech manufactures its straps from nylon webbing, as nylon is the strongest fiber compared to polyester and polypropylene (Pure-Tech, n.d.). Nylon is not a supply constraint, as it continues to be manufactured domestically (Sewport Support Team, 2025).

V. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

This research was made possible by the assistance of companies associated with drone manufacturing and vendors responsible for providing essential subassemblies. Skydio and Red Cat were the prominent companies for contributions that furthered the research of this analysis, providing critical information essential to the development of the BOM. Additionally, American Lithium Energy and BotBlox were extremely helpful in providing information regarding batteries and PCBs. These companies' willingness to work with research students from the DoD should be looked at as a willingness to work with us in the future when it comes to procurement. We spoke with other companies in the industry, but unfortunately, we were not successful in collaborating with them. The majority of the information was gathered through email interviews when companies were willing, open-source information available on company websites, and reverse engineering efforts on drone repair part online websites, as well as YouTube video tutorials.

This research does not encapsulate what would go into producing the drone controller or the drone headset with as much detail as what comprises the platforms. These researchers specifically focused on the drone platforms themselves. In order for a drone to be attritable, what follows the most logic is for the cheapest component parts to be used. Aside from that, cost is attributed to the software used. Software and programming will be the primary cost driver when it comes to these drones.

1. Economic

Domestic publicly traded companies are bound by shareholder interest and will not invest in uncertain endeavors without solidified demand signals to motivate expansion of production for procurement. In an uncontested environment, competing global imported components at fractional pricing is more attractive to maintain conservative material expenditures. Cost advantage for semiconductors packaging and assembly of has driven the centralization of these processes to a small region due to thin price margins. Corporations are developing contingency plans to mitigate interruptions in manufacturing with numerous variables to consider with minimal resources to manipulate. Companies' contingencies may prove unreliable to yield planned results because of a lack of real-world constraints realized. Factors such as dual sourcing liked components to multiple agencies from single vendors will lead to extended lead times and lags in production lines. Pre-implemented manufacturing expansion and failure to procure sensitive materials until after the demand is needed will place operational forces immediately behind the power curve waiting for critical systems. Systems will be impeded by the need for vendors to reposition themselves through administrative hurdles, leasing, expanding, hiring, training, and developing to meet known needs.

2. Batteries

Battery production presents a critical supply challenge for drone manufacturing. The most significant factors for drone applications are batteries that contain sufficient energy, meet strict weight specifications, and maintain thermal stability due to intensive onboard computing requirements. Unfortunately, as discussed in Chapter IV, many current companies in the U.S. cannot produce batteries of the same quality as those used by most manufacturers. The primary recommendation is to increase R&D for alternative battery technologies, such as lithium-sulfur batteries currently being produced by Lyten in California. Lyten sources and manufactures these advanced batteries domestically, directly addressing the dependency on foreign and adversarial supply chains.

3. Semiconductors

Semiconductors pose a significant challenge when being able to produce drones in the millions. As mentioned in Chapter IV, all three platforms are constrained by the type of semiconductor they use and the fact that most of them come from companies located in Asia. Ensuring that the U.S. brings back semiconductor manufacturing capabilities to the U.S. is critical, and this can only be done by continuing to invest and incentivize domestic manufacturing and R&D. Ensuring the U.S. continues to design semiconductors is vital, but ensuring every aspect of the manufacturing moves back to the U.S. is also essential, such as assembly and packaging.

B. RECOMMENDATIONS

Future research must focus on the following questions. What issues are related to the scalability of component manufacturing in the U.S.? What actions would incentivize corporations to build the facilities that would be large enough to make one million drones a year? Additionally, it would be useful to know timelines associated with a full export ban on America and American Allies in relation to how long it would take to manufacture enough parts on U.S. soil.

C. PROPOSED ACTIONS

- Component parts that cannot be 3D printed should be sourced from suppliers that already have established histories of mass production in small parts machining and electronics; especially in countries that have a skilled labor workforce that can work to the standard required.
- The DoD should offer a stipend and purchase order guarantee for whatever Blue List approved company can produce five thousand NDAA compliant drones the fastest. That way industry is incentivized and the DoD can begin to build the stockpile of drones.
- Research the feasibility of uniformity across drone components with different platforms. To include software and accessories such as controllers, headsets, and chargers.
- For acquisition purposes, future contracts should be prioritized for companies that can demonstrate inshore Tier 3 manufacturing capabilities.
- Communication across vendors and suppliers will play a significant role when mass-producing drones, as the primary concern in the event of a conflict will be who can produce the most drones and work together effectively.
- Develop a plan that focuses on harnessing comparative advantages between corporations to streamline mass production contingency plans in the event of a contested environment. This would include the company's

operational capacity during the interim, with estimations of the lead time required to regain full operational capacity, taking into consideration the new suppliers.

SUPPLEMENTAL: BILL-OF-MATERIALS FOR SUAS

The bill-of-materials includes a breakdown of components for three different drone platforms. It is broken down to the subcomponent level, including supplier, domestic or foreign origin, weight, component count, and cost.

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