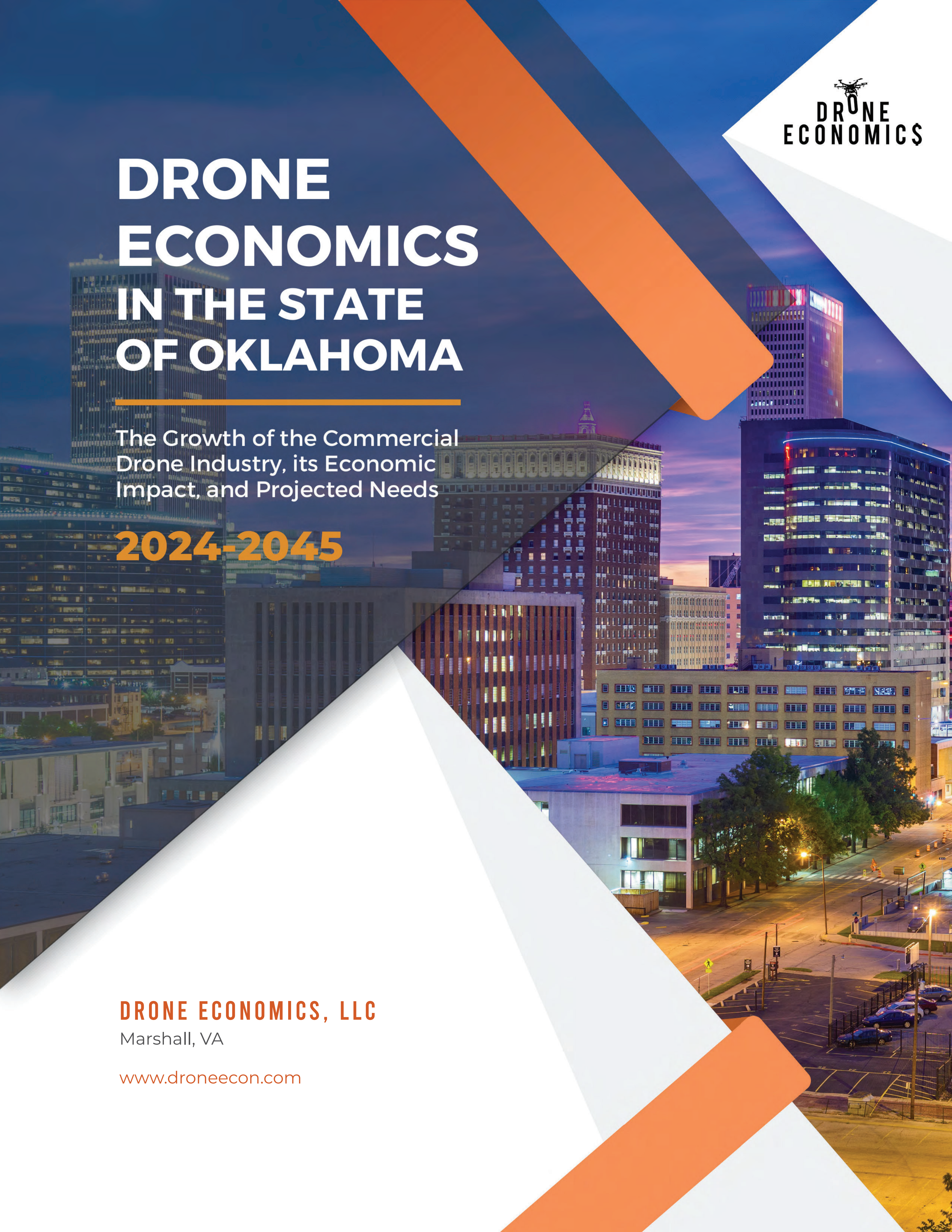

DRONE ECONOMIC$

DRONE ECONOMICS IN THE STATE OF OKLAHOMA

The Growth of the Commercial Drone Industry, its Economic Impact, and Projected Needs

2024-2045

DRONE ECONOMICS, LLC

Marshall, VA

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CONTENTS

Executive Summary

Oklahoma is poised to become a major hub for the rapidly expanding commercial drone industry. The state offers vast uncongested airspace, infrastructure inspection needs, moderate regulation, and key industries like agriculture and energy that can benefit enormously from new technology made available by Unmanned Aerial Systems (abbreviated as UAS and often called drones.)

Currently, except for relatively rare FAA waivers, regulations require drones to be flown within the visual line of sight (VLOS). At some point in the next few years, the FAA will approve Beyond the Visual Line of Sight (BVLOS), which will greatly increase the number of drone operations across Oklahoma and the entire country.

This paper provides a conservative forecast for new jobs and expenditures directly related to drone activity in the state of Oklahoma between 2024 and 2045. Our forecasts should be understood as “the minimum results possible. Actual results will be at least as large as the forecast and most likely larger.”

For instance, we estimate only drone pilot jobs, not software engineers, data processors, and assistants, which would likely double the jobs figure but not much more, as automation will keep their numbers about equal to those of drone pilots.
We estimate direct economic activity, not indirect and induced, which would likely double the jobs figure again.

We use a conservative 25% market absorption rate, though the market could reach as much as a 50% absorption rate by 2045 depending on ease of regulations, popularity, and new efficiencies realized by businesses and residents.

We have concluded the following:

1. At Oklahoma drone market maturity, around 2045, the average annual payroll of commercial drone operators will be close to $69 million.

2. This will generate a total of 1,425 new direct jobs over the forecasted period of 2024-2045.

3. The annual capital expenditure for new and replacement drones will be approximately $100 million over the forecasted period.

4. The market segment with the largest number of daily operations will be package delivery and will dwarf all other market segments in terms of daily operations.

5. There are, most likely, sufficient drone operators to accommodate future growth. Little growth is forecast for the number of drone operators because even as many more businesses will use drones once BVLOS is approved, regulations will move from one pilot flying one drone to one pilot flying many.

   For example, if drone use multiplies by a factor of ten with the onset of BVLOS, and each pilot is permitted to fly ten drones, increased drone use would not increase the number of pilots.

Oklahoma Drone Use 2024-2045

- Average Annual Drone Payroll: **$69 million**
- New Direct Drone Jobs: **1,425**
- Annual Capital Expenditure For New Drones: **$100 million**
- Largest Market Segment: **Package Delivery**

1. INTRODUCTION

Assessing the total drone industry market potential requires analyzing both the supply and demand dynamics at play. On the supply side, factors like the number of registered commercial drone operators and investments by drone makers indicate how much activity drones can support. Demand depends on adoption rates as companies realize gains in productivity, lower costs, and safety improvements from drone usage. Regulatory approvals enabling more complex operations also open greater commercial possibilities.

Quantifying Oklahoma's statewide commercial drone market involves synthesizing data points, including:

- Commercial drone registrations filed in Oklahoma
- FAA expansions of drone operational areas
- Public data on likely adoption rates across potential industries

This data can reveal total market sizing and growth forecasts, segmented by major use cases like infrastructure, agriculture, energy, and more. Ranges may account for varying adoption scenarios.

With its airspace, infrastructure, farms, and oil fields ideally suited for drones, as well as native communities such as the Choctaw Nation actively involved in drone testing, Oklahoma has the ingredients for these high-tech devices to take flight commercially. A thorough forecasting effort can map out this emergence in detail for operators and investors alike.

This report will first present relevant economic facts to determine if growth will be above, below, or parallel to US growth. Having made this determination, we will present the methodology, followed by the markets to be investigated and, finally, the results.

2. OKLAHOMA KEY FACTS

Population

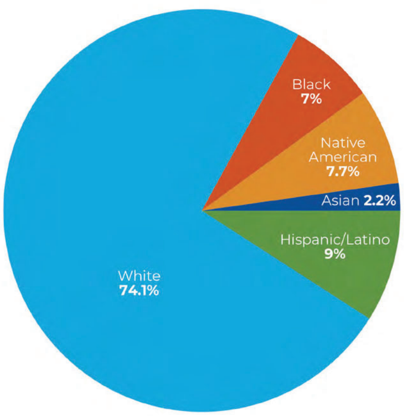
- 3.9 million total (2021 est.)
- 28th largest US state by population
- Grew 3% from 2010-2020
- Median age is 36.3 years

Oklahoma population:
3,959,353

Total US population:
328,239,523

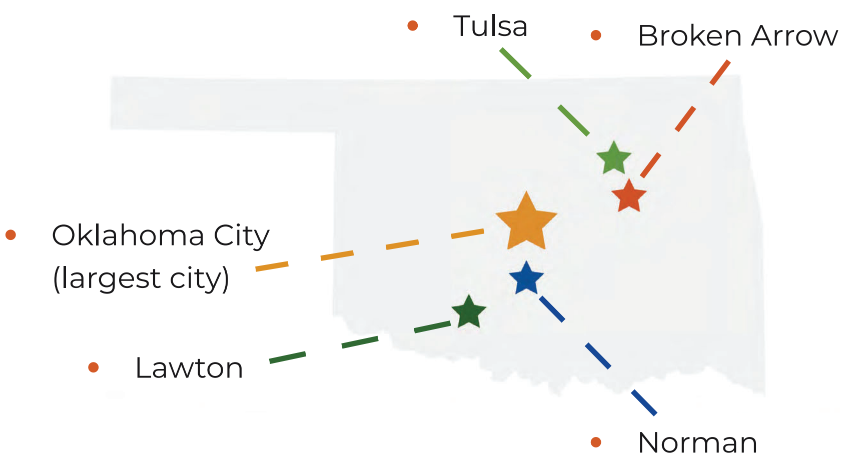
Oklahoma is approximately 1.2% of the total US population.

Racial Diversity



- 74.1% White
- 9% Hispanic/Latino
- 7% Black
- 7.7% Native American
- 2.2% Asian

Major Urban Hubs



Economy

- Median household income of $55,790 (below national median)
- 15.2% poverty rate
- 3.1% unemployment rate (Dec. 2022)
- Top industries: Oil/gas, aerospace, agriculture, government, healthcare, manufacturing
- Major companies include Love's Travel Stops, Hobby Lobby, Devon Energy, Williams Companies, ONEOK
- $209 billion GDP (2021), 1.1% of total US GDP

3. OKLAHOMA BENCHMARKED AGAINST THE U.S.

Economically, Oklahoma lags behind the prosperity of nationwide averages. The state sees lower GDP per capita at $52,919 compared to the U.S. figure of $63,214. Median incomes in Oklahoma also fall short at $55,790 versus $70,784 nationally. Poverty and unemployment levels, however, are mixed, with Oklahoma having slight underperformance on poverty but outperforming on unemployment.

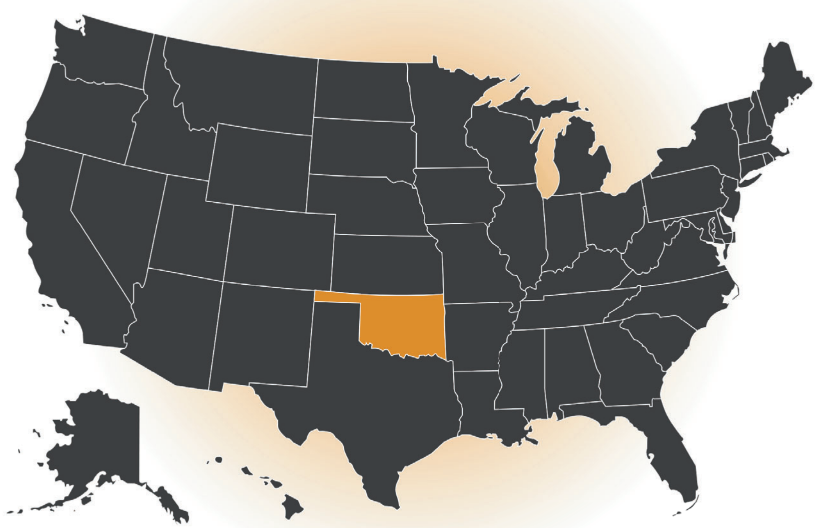
Population growth between 2010-2020 expanded just 3% in Oklahoma, below the national rate of 7.4%. Reflecting its wide-open spaces, 33% of the state population is rural versus just 19% nationwide. However, median age tracks closely to national figures.

Housing in Oklahoma is more affordable but of lower value on average. Home ownership is on par with national rates, but median home values in the state are about half that of the overall U.S. at $170,000 compared to $325,000.

Educational attainment shows little divergence, with Oklahoma residents earning high school diplomas on pace with national averages but bachelor's degrees trailing slightly behind the rest of the country.

In summary, Oklahoma lags national averages across most economic prosperity and demographic growth metrics and also has a lower cost of living. Its economy and population stats remain heavily influenced by agriculture and oil/gas industries.

While there are differences between national averages, we have concluded that they are not large enough to warrant adjusting the forecast in this report.



4. FORECASTING APPROACH

This report utilizes scenario forecasting to estimate total addressable market size and future growth trajectories across the major commercial drone industry segments in Oklahoma. The specific elements forecasted for each sector are:

1. **Total market size:** Estimated using government data on the number of relevant establishments in Oklahoma. This serves as an initial baseline.

2. **Absorption rates:** Sourced from industry surveys published in trade magazines which are assumed directionally accurate, though specifics may differ.

3. **Technology adoption curve:** To remain conservative given uncertainty, a standardized 3% compound annual growth rate has been applied uniformly based on average long-term U.S. economic expansion.

4. **Number of annual drone operations:** Custom forecasts by sector based on key variables driving usage.

4.1 Total Market Size Calculations

The total market size is bounded by the number of relevant establishments per commercial drone industry category, based on Oklahoma-specific data from U.S. government sources including the Census Bureau and Bureau of Labor Statistics. This establishes the maximum potential market. In cases where there is no Oklahoma data, the total market size will be assumed using national figures adjusted by the percentage of Oklahoma population as a ratio to the national population (1.2%).

4.2 Absorption Rates and Adoption

Industry surveys provide initial benchmarks for segment-specific adoption levels among target customers. All market sizes will be held constant to 2023 sizes with no attempts to adjust them for further growth. This also assures the conservative forecast nature. After adjusting the total market to show growth of only 25% of the initial benchmarks, the market will grow at constant rates over the forecast period.

The rate of progress of market growth factors in elements like the pace of regulatory changes, technological enhancements, public acceptance, and realized business benefits.

4.3 Annual Operations Forecast

The Rogers adoption curve[1] is a model that classifies adopters of innovations into five categories based on their openness to change and is useful for understanding how different people react to, adopt, and accept new innovative products and technologies. While the Rogers adoption models demonstrate higher initial growth rates before flattening, exponential curves have not been applied to our analysis given the nascent nature of commercial drone usage.

Updates over time may warrant higher growth rate assumptions. Instead, what will be forecasted is the total market size which will be downsized to assume that only 25% of the total market will ever adopt this new technology. This figure is intentionally low—imagine a few decades ago assuming only 25% of people would use cell phones or computers—but, as stated in the introduction, we want our figures to be on the conservative side.

To quantify demand opportunity, forecasts for annual drone operations are custom-built for each segment based on addressable sub-use cases. The calculations and assumptions involved are elaborated under each market category later in the report.

5. MODELING THE ADOPTION CURVE

Projecting the growth of the commercial drone industry requires analyzing the staged process through which key Oklahoma industries are likely to adopt and integrate these technologies over time. These break down into five stages, each with its own estimated percentage of users.

1. **Innovators:** Companies initially become aware of drones and start researching potential applications and benefits around data collection, surveys, inspections, and more. Pilot tests and trials may occur. Those innovators at the forefront of using new technology are venturesome, interested in new ideas, and willing to take risks. Their size is small: 2.5%.

2. **Early adopters:** Following successful pilot trials, companies begin utilizing drones for specific functions, though usage remains limited as optimal operating procedures and business models develop through experience. Scaled service provider networks also take time to expand. Early adopters are quick to follow the innovators. They are respected opinion leaders and role models who encourage others to adopt the innovation. They make up 13.5% of potential users.

1 https://www.valuebasedmanagement.net/methods_rogers_innovation_adoption_curve.html

3. **Early majority:** Drones become fully incorporated across operational areas where they demonstrate advantages in productivity, safety, costs, and other metrics. Business models have matured to efficiently leverage drone capabilities. The early majority adopts new ideas just before the average individual. They need to see evidence that the innovation works before adopting it. They make up 34% of the total.

4. **Late majority:** The late majority adopters are typically skeptical of change and new technologies. They will only adopt an innovation after it has been implemented and tested by most people around them. Their adoption is generally born out of economic necessity and peer pressure rather than early interest. They are risk-averse and need extensive proof of an innovation's viability before feeling comfortable adopting. They make up 34% of the total.

5. **Laggards:** Laggards are the last group to adopt an innovation. They tend to be advanced in age and very traditional in their ways. Laggards are extremely averse to change and will only shift to a new technology when it has become an established standard or they have no other option left. Financial restrictions often limit their ability to adopt innovations early on. Getting laggards on board typically requires education programs, demonstrations, and incentives to overcome their skepticism. Laggards make up 16%.

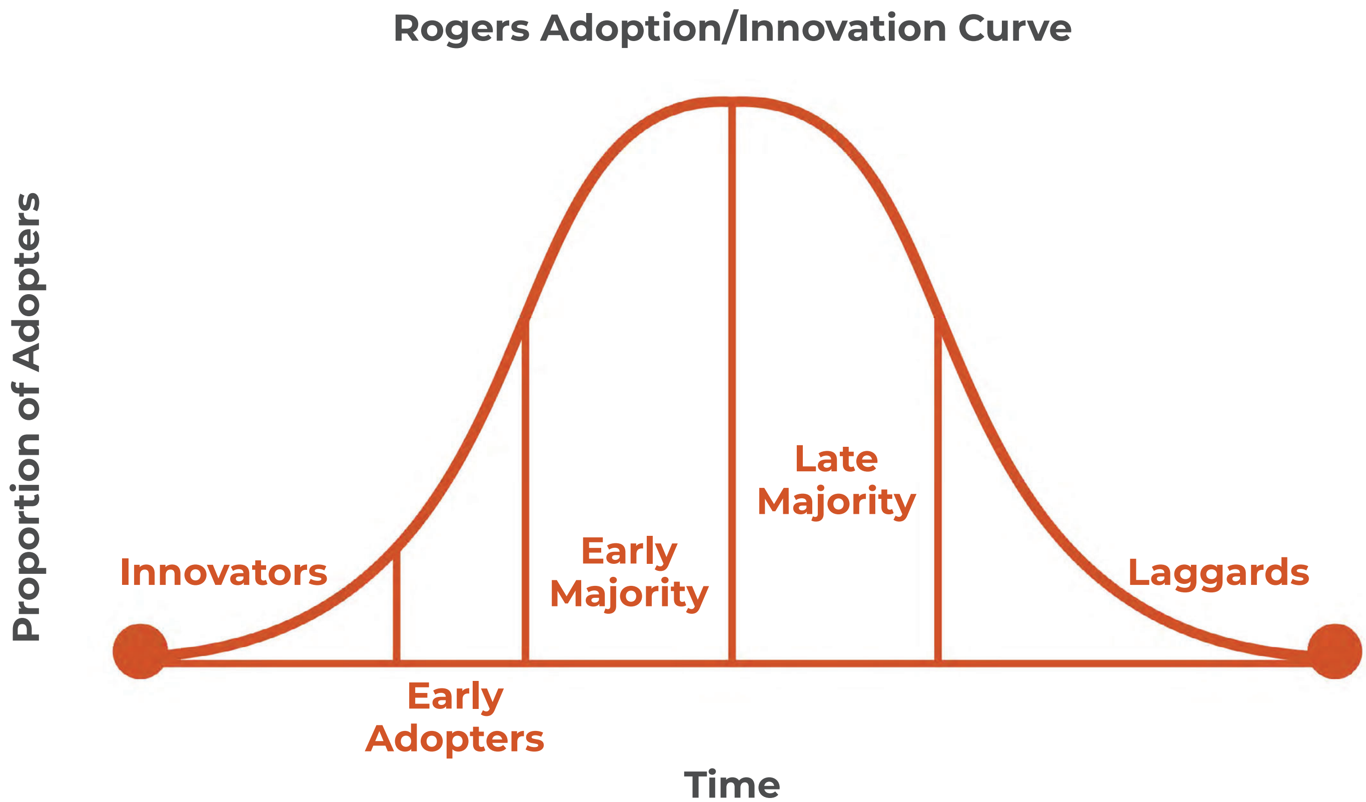


Figure 1: The Rogers adoption curve.

Quantifying reasonable timeframes for Oklahoma's major sectors to move through these phases allows modeling of the S-curve adoption pattern. The rate of progress factors in elements like the pace of regulatory changes, technological enhancements, public acceptance, and realized business benefits.

Since the forecasted period in this report is less than 30 years, it will be assumed that none of the markets investigated will comprise more than early majority. This puts a 50% market share cap on all markets. This means no market can gain more than one half of the anticipated total market. To be conservative, all the forecasts in this report will not be more than 25% of total market share. This amounts to halving most forecasts.

These percentages represent the typical market share captured by each adopter category. The curves are modeled as bell-shaped distributions, with innovators and laggards in the tails and the early and late majorities making up the bulk of adopters. Understanding where different customer segments fit within these adoption rate ranges is key for appropriately targeting innovation diffusion strategies.

Commercial drones have been available for over a decade now, indicating the market has likely moved beyond the innovator category and into the early adopter stage. Another factor in broader adoption is the high promise and public visibility around drone technology, especially with the FAA selection of the Choctaw Nation UAS Test Site in Durant, as well as regulatory openings.

The aim is to strike a balance between recognizing the maturity of core drone technologies while still seeing meaningful room for adoption expansion as regulations, integration models, and public trust evolve further over the next several years at a minimum. This methodology aims to capture a reasonable range for this fast-developing market.

6. OKLAHOMA COMMERCIAL DRONE REGISTRATIONS

As per Federal Aviation Administration (FAA) data, over 835,000 commercial small drones were registered nationally across the U.S. as of January 2021. This figure has expanded rapidly in recent years with rising adoptions. However, easily accessible state-level registration data remains sparse.

Independent analysis estimates Oklahoma represents 1-2% of total US drone registrations based on the state's proportional population and economic footprint. Applying this estimated range to the FAA's aggregate count suggests between 8,350 to 16,700 commercially registered drones currently active across Oklahoma as of early 2021.

While imprecise, overlaying national drone ownership penetration rates provides an initial indicator of existing commercial drone activity within the state. Updates from FAA state-by-state registration databases can refine this baseline figure as localized data becomes available. For now, estimated totals rely on broader normalization approaches across geographic and economic variables.

These current registration approximations, even with acknowledged underlying data limitations, help size the existing commercial drone owner base in Oklahoma. As regulations and use cases continue expanding, additional registrations flowing into the state will allow tracking adoption momentum. Updated owner data will clarify the degree to which Oklahoma's booming drone opportunity materializes amid nationwide proliferation.

6.1 Drone Regulations

The FAA has broad authority over airspace regulation in the United States, which limits the ability of state and local governments to regulate drones and low-altitude airspace. Here are some key points on the FAA's rules and county authority.[2] The FAA Act of 1958 asserts federal control over navigable airspace, while allowing state and local governments some authority below that airspace. In general, state and city governments cannot regulate aviation safety, set rules for pilot licensing, or limit flight paths altitudes, etc. These are under FAA's authority. The FAA does allow airport owners (typically local authorities) to apply limited airspace restrictions around airports, but the FAA has final approval.

In 2018 Congressional legislation, the FAA was explicitly given exclusive authority over low-altitude aviation below 400 feet.[3] This aimed to prevent inconsistent state/local drone laws. The FAA can file federal lawsuits against state and local authorities that attempt to restrict drones or other aircraft by imposing aviation rules in the national airspace or setting opera-

2 State-Local-Regulation-of-Unmanned-Aircraft-Systems-Fact-Sheet.pdf (faa.gov)

3 Unmanned Aircraft System Traffic Management (UTM) | Federal Aviation Administration (faa.gov)

tional mandates.[4] Rules from local counties seeking to govern flight patterns, forbid drone delivery services, or other flight restrictions within airspace are likely to be struck down if challenged legally.[4]

The FAA has broad power over all airspace regulation, while local counties have very limited authority, typically only related to airport ownership. County governments cannot impose broader restrictions on drones or other aircraft that conflict with FAA statutes without facing legal override.[4] FAA's updated 2023 fact sheet states:

> "States and local governments may not regulate in the fields of aviation safety or airspace efficiency but generally may regulate outside these fields. A state or local law will be preempted if it conflicts with FAA regulations. State or local laws affecting commercial UAS operators are more likely to be preempted."[4]

There are some restrictions on commercial drone use in the state of Oklahoma, but overall the regulatory environment is fairly accommodating. Here are some key aspects of the laws governing commercial drones in Oklahoma:

- The Oklahoma legislature passed the Unmanned Aerial Surveillance Act in 2013 to prohibit the use of drones for surveillance purposes without a warrant, with some exceptions. This protects against privacy violations using drone technology.[5]
- The Oklahoma Department of Aerospace and Aeronautics does not impose extensive state-level drone regulations beyond the FAA rules. However, drone operators must coordinate any flights within 5 miles of an airport with the appropriate entities.[6]
- Drone use for purposes like agriculture, insurance inspection, and oil/gas industry surveying are permitted and becoming more popular.

Despite some regulations, Oklahoma has been ranked #1 or #2 in recent years as the most drone friendly state in the country, according to the George Mason University Mercatus Center.[7] And the Choctaw UAS Test Site has received FAA waivers to conduct BVLOS tests in a six by nine-mile corridor. The state seems poised for increasing commercial drone operations.

4 State-Local-Regulation-of-Unmanned-Aircraft-Systems-Fact-Sheet.pdf (faa.gov)
5 Oklahoma Statutes §21-1743 (2022) - Unlawful use of drones. 2022 Oklahoma Statutes US Codes and Statutes US Law Justia
6 Section 81 - Citation, Okla. Stat. tit. 3 § 81 | Casetext Search + Citator
7 Oklahoma | 2023 State Drone Scorecard | Mercatus Center

7. BVLOS AND VLOS

VLOS usually limits the maximum distance a drone can fly to several hundred meters horizontally and 120 meters vertically, as these are the typical visual limitations of the pilot.

With BVLOS, the pilot loses sight of the drone and instead must rely on other means, such as GPS tracking and telemetry data, to monitor and control the drone flight. BVLOS enables drones to fly much further distances, often multiple kilometers or even longer on some commercial drones.

There are several key differences between BVLOS and VLOS:

Distance: The maximum distance, as outlined above, is the most obvious difference. BVLOS allows drones to fly well beyond what any pilot could possibly see. VLOS restricts distance to direct eyesight.

Operational complexity: BVLOS is a much more complex type of drone operation that involves managing issues the pilot does not directly see like air traffic obstacles, signal transmission over long distances, contingency management if signal is lost, etc. VLOS is simpler as the pilot visually handles obstacles and drone issues.

Regulations: Due to the higher risks involved, regulations are typically more stringent regarding who can fly BVLOS and under what conditions, whereas VLOS flights may have minimal or no flight regulations in some jurisdictions. Pilot certifications also often differ between BVLOS and VLOS.

Equipment requirements: BVLOS requires additional specialized equipment to manage longer flight distances. This can include satellite transmission capabilities, stronger batteries, and sensors like detect-and-avoid systems to automatically handle potential collisions without pilot visual contact. VLOS flights usually rely only on standard direct RC transmission and the pilot's eyesight.

Overall, the core defining difference is the vastly expanded distance enabled with BVLOS flight compared to VLOS. But allowing BVLOS operations introduces several secondary technical and regulatory considerations for safe drone flight management as well.

The forecast section will divide the market segments into VLOS and BVLOS.

8. MARKET SEGMENTS

Below are listed the major markets to be examined:

- **Agriculture:** Drones in agriculture conduct crop spraying, create prescription maps for fertilizer and pesticide use, monitor crop health, and survey fields. Advanced drones can detect plant diseases and irrigation issues.
- **Construction:** Construction drones perform aerial mapping of construction sites, survey topography, monitor projects, and inspect buildings, real estate, equipment, and job sites. Drones improve worksite safety.
- **Delivery:** Delivery drones transport lightweight packages, food items, medical supplies, documents, and other goods with speed and at low cost. Companies like Amazon and UPS are exploring drone delivery.

- **Entertainment:** Media and entertainment drones are used for filming videos, movies, commercials, and TV shows. Sports broadcasts use drones for overhead shots. Drones are used in journalism, weddings, and events.
- **Energy:** Energy drones conduct inspections on power lines, pipelines, platforms, and facilities. They survey sites, inspect equipment, and monitor environmental compliance. Drones enhance safety and cut costs.
- **Insurance:** Insurance drones inspect properties and sites to settle claims faster, assess damage, investigate fraud, and mitigate risks. Roof inspections are a major use case. Drones improve productivity.
- **Mapping:** Mapping drones survey and photograph land and buildings to create precise 2D and 3D maps. They're used in urban planning, construction, conservation, and mining. Drones update maps cost-effectively.
- **Public safety:** Public safety drones support law enforcement, fire departments, emergency response, and search/rescue teams. They find missing persons, monitor disasters, and assess emergencies. Drones boost situational awareness.

9. METHODOLOGY

This report will forecast the following for each market sector:

- Total Market Size
- Absorption rates
- How much of the market will adapt the new technology
- Number of annual operations
- Number of personnel needed to crew the operations
- Expected annual salaries of personnel

9.1 Forecasting Assumptions

- No market will reach maturity
- All markets will only go to one half of maturity (25% of the total market potential).
- All markets will grow at a constant rate.

9.1.1 Total Market Size

Total market size will be estimated using governmental data on the number of establishments. This data is available at the national level, and in some cases at the state level as well.

9.1.2 Absorption rates

The best source for absorption rates is from surveys taken by trade magazines. While these may not be individually correct, the assumption is they are correct on average.

9.1.3 How much of the market will adapt to the new technology

The best way of calculating this is by using comparable examples from within the same industrial sectors.

9.1.4 Number of annual operations

The number of annual operations will be calculated differently for each drone submarket and will be explained in those sections.

9.1.5 Number of personnel needed to crew the operations

This will be greatly influenced by regulations, and various scenarios will be examined.

9.1.6 Expected annual salaries of personnel

This will be calculated using trade surveys.

9.1.7 Adjustment for inflation

For these forecasts, constant 2023 dollars are used.

9.2 Drone Operator Salaries

- The average annual salary for drone pilots in Oklahoma is between $44,868 and $67,451.[8]
- Drone pilot pay can vary significantly based on factors like industry, drone types operated, piloting workload, and experience level.
- Top earning industries for drone pilots include construction, agriculture, utilities, and state government work. Pilots in these sectors can earn $60,000 - $80,000 on average.
- Freelance drone pilots can earn hourly rates ranging from $15 per hour for basic recreational drone flights up to $250 per hour or more for specialized commercial piloting services requiring substantial expertise.
- Highly experienced drone pilots working full time in complex fields like infrastructure inspection, public safety, mining, and cinema production can make over $100,000 annually.
- Drone pilot salaries are expected to increase as more companies adopt drone technology requiring their services. The growth of commercial drone use should drive pay higher.

Drone Operator Salaries by Percentile	Salary
10th percentile operator salary	$39,379
25th percentile operator salary	$48,327
50th percentile operator salary	$58,154
75th percentile operator salary	$72,651
90th percentile operator salary	$85,849

Figure 2: Drone operator salaries.

8 https://www.salary.com/research/salary/posting/drone-operator-salary

10.ECONOMIC PRINCIPLES

To understand the economics behind small (<55 pounds) commercial drones, it is necessary to comprehend certain fundamentals. This section begins by defining a disruptive product and discusses under what conditions small drones will unsettle markets. Several other key economic principles are important. These include opportunity cost, supply and demand, and economies of scale and scope.

10.1 Product Disruption and the Opportunity Cost

A product disruptor is an **innovation that represents a change in a product's direction, business model, or value proposition.** The term is borrowed from "industry disruptor," which describes an innovation (Uber, for example) that creates a new industry by displacing an existing one (taxicabs). Disruptive products usually have three characteristics:

The concept of opportunity cost is important to understanding disruptive products. An opportunity cost is the loss of potential gain from other alternatives when one alternative is chosen. Any time a decision is made, it involves choices between alternatives. Consider going to the airport for a one-week business trip. The alternatives are listed below:

1. Drive your car and pay $30/day parking fee ($210)
2. Take a cab and pay round trip fee of $50 each way ($100), or
3. Take an uber $40 each way ($80).

The final decision is up to the flyer, but all decisions are made between alternatives, and for a new product to replace an existing one, the opportunity cost is an important decision. This is especially important for UAS. Just because it is an exciting new concept and has the possibility of disrupting does not mean it will.

10.2 Economies of Scale

Economies of scale refer to production economics. Economies of scale are cost advantages reaped by companies when production becomes efficient. Companies can achieve economies of scale by increasing production and lowering costs. This happens because fixed costs are spread over a larger number of goods. Economies of scale are characterized by volume and refers to a reduction in marginal cost by producing additional units. Economies of scale helped drive corporate growth in the 20th century through assembly line production.

10.3 Economies of Scope

An economy of scope means that the production of one good reduces the cost of producing another related good. Economies of scope occur when producing a wider variety of goods or services in tandem is more cost effective for a firm than producing less of a variety or producing each good independently. In such a case, the long-run average and marginal cost of a company, organization, or economy decreases due to the production of complementary goods and services. For example, the Virginia- based company DroneUp may use their package delivery hubs for their other services as well. This is an economy of scope, characterized by efficiencies created by variety,

10.4 Product Demand and Pricing

The relationship between demand and price is intuitive. When prices are high, there is less demand, and when they are low demand increases. The economic principle that drives costs and therefore pricing is economies of scale.

10.5 The Economics of BVLOS

The economies for many companies taking advantage of BVLOS are large. The reason for this is simply enlarged geography. Calculating the area of a circular market is not difficult. The formula is:

$$A = \pi r^2$$

A = market area in square miles

π = 3.14

If we measure the radius in miles, we get Figure 3. The increase in market size from one mile to multiples of 1 shows the mathematics of BVLOS. Increase in market size is only one facet of BVLOS.

Market Radius	Square Miles	Percent Improvement
1 mile	3.14	
2 miles	12.56	300%
3 miles	28.26	125%
4 miles	50.08	77%
5 miles	78.5	57%
6 miles	113.04	44%
7 miles	153.86	36%
8 miles	200.96	31%
9 miles	254.34	27%
10 miles	314	23%
11 miles	379.94	21%
12 miles	452.16	19%
13 miles	530.66	17%
14 miles	615.44	16%
15 miles	706.5	15%

Figure 3: Market size Increase by radius.

10.6 When One Pilot Flies Multiple Drones

Another facet of BVLOS is how many drones a single pilot can fly, an important economic consideration as pilot salaries are one of the single largest operating costs. Figures 4 and 5 show the capital and operating costs of a fixed-wing drone, obtained by interviewing various fixed-wing manufacturers. Fixed-wing drones are commonly used for aerial mapping and inspection of pipelines/power lines. If fixed-wing drones aren't used, these values and calculations will be similar to other types of drones.

Capital Costs	
Drone	$250,000
Command center	$ 50,000
Total cost	$300,000
Depreciation years	5
Capital costs/year	$60,000
Hours/year	1,800
Costs/hour	$33

Figure 4: Capital operating costs of a fixed wing drone.

The operating costs are based on using a fixed-wing drone that can fly for long time periods (six to eight flight hours).

Operating Costs	
Depreciation/hour	$56
Maintenance /hour	$70
Insurance/hour	$1
Overhead/hour	$40
Pilot costs/hour	$70
Total Hourly operating costs	$237

Figure 5: Operating costs of a fixed-wing drone.

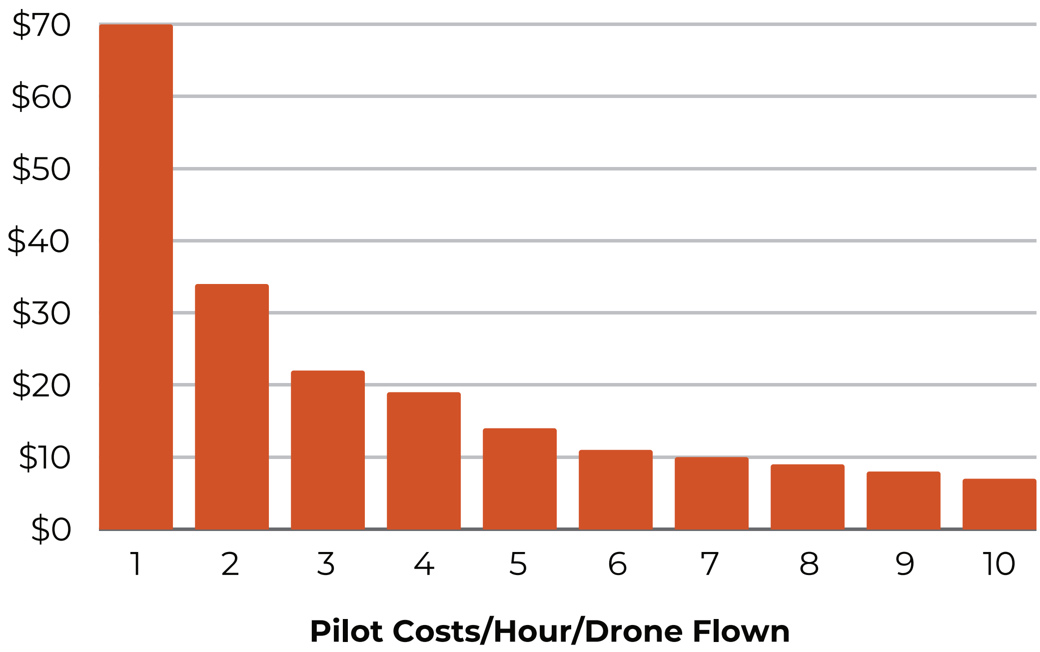


Figure 6: Pilot costs.

Figure 6 shows how hourly pilot costs go down as the number of drones they can fly at the same time increases. Over time, the role of the drone pilot will change significantly as they become more hardware and software dependent. Drone pilots, in the future, will evolve to becoming more flight followers, as command and control and other highly automated systems take over significant flight aspects.

10.7 Flying Higher than 400 Feet

Figure 7 shows the significant increases in number of acres flown and the amount of imagery with higher altitudes.

At 400 feet, a drone pilot can only cover approximately 500 acres per hour, whereas at 5,000 feet almost 9,000 acres per hour can be imaged. The increase in productivity is substantial. Productivity increases of this nature disrupt market structures and lower costs to the end user.

As the instantaneous field of view is larger at higher altitudes, the number of images needed and the overlap are reduced greatly. In important markets such as natural resources, the ability to capture large amounts of data in shorter time periods reduces the costs to end users and makes this technology more disruptive.

Altitude (ft)	GSD (inches)[9]	Number of images	Acres per hour
400	5.26	17,980	489
500	6.57	11,532	610
600	7.89	8,112	723
700	9.2	5,963	844
800	10.52	4,524	974
900	11.83	3,588	1,091
1000	13.14	2,914	1,209
1500	19.72	1,302	1,806
2000	26.29	744	2,370
2500	32.86	475	2,973
3000	39.43	192	4,608
3500	46.01	140	5,426
4000	52.58	70	7,618
4500	59.15	63	7,528
5000	65.72	50	8,898

Figure 7: As altitude increases, the amount of data captured increases.

The examples in this section are instances of economies of scale and point out the future of small drones. As small drones are increasingly able to fly higher and longer, the correct economic direction is for a pilot to command a fleet.

Knowing these economic concepts, attention can be turned to future job scenarios.

9 Ground Sample Distance (GSD) refers to the dimensions of a single pixel in an image, as measured on the ground.

11. CALCULATIONS

11.1 VLOS Markets

While all current markets are generally considered VLOS due to regulations, some of these, such as construction, certain parts of energy, insurance, mapping, public safety, and security are long-term VLOS markets. These will be examined first.

- **Construction:** Construction drones perform aerial mapping of construction sites, survey topography, monitor projects, and inspect buildings, real estate, equipment, and job sites. Drones improve worksite safety.
- **Entertainment:** Media and entertainment drones are used for filming videos, movies, commercials, and TV shows. Sports broadcasts use drones for overhead shots. Drones are used in journalism, weddings, and events.

11.2 Construction

The rapid advancement of commercial drone technology presents new opportunities for enhanced monitoring, data collection, and analysis capabilities on construction sites. Drones equipped with cameras, sensors, and scanning systems can provide project managers and contractors precise aerial insights to supplement ground-based perspectives.

Specifically, some key applications where drones show immense promise in the construction industry include:

- **3D Site Mapping:** Drones can quickly develop detailed 3D maps of site terrain to help plan earthwork and drainage needs. Photogrammetry software leverages drone photos to create detailed site models.
- **Project Progress Monitoring:** Frequent drone flights allow closer tracking of the ongoing status across vast and multiple sites in terms of percent complete metrics. Aerial views make it easier to spot any delays.
- **Safety and Security Surveillance:** On larger sites, continuously patrolling camera drones can augment current monitoring capabilities to inspect safety practices or unauthorized access issues across broader footprints.

The goal of this section is to assess key drone-powered use cases that can transform how construction projects leverage drone capabilities for operational gains in planning, monitoring, security, and maintenance.

According to Bureau of Labor Statistics data, in the U.S. there are 188,808 residential building companies and 41,110 commercial building companies. Adjusting these figures for Oklahoma (1.2%) gives us 2,265 residential firms and 493 commercial building companies. According to 2018 survey data from the Office of Industries, 18% of construction firms use drones. Using assumptions previously stated, the market is capped at 25%. Therefore, the beginning adoption rate is 9%, which will grow to 25% over the forecast figure. Therefore, the beginning and ending adoption numbers for Oklahoma are:

1. **Residential** 203 firms, 566 firms
2. **Commercial** 44 firms, 123 firms

Construction Market

- **2,265 Oklahoma residential building companies.**
- **493 Oklahoma commercial building companies**
- **At least 9% will use drones growing to 25%**
- **Drone depreciation rate: 5 years**

There is no available data to show whether the companies use in-house expertise or hire outside contractors. Therefore, in compliance with our conservative forecast, it is assumed no additional employment is generated. Drones used for this work are mostly small quadcopters using photography cameras with no specialized software. These drones cost in the $2,500 price range and have a useful lifetime of at least five years. Over the forecasted period, adding the purchase of new drones for companies entering the drone market (13 per year) and calculating the replacement of older drones gives us an average annual capital expenditure of $1,743,536 per year through 2045.

For commercial construction firms, the forecast starts at 44 firms using small drones and growing to 123 over the period. This translates to an average annual capital expenditure of $380,916.

In addition to construction firms, realtors make up a significant part of this market. According to the

Drone Capital Expenditure

Residential construction firms adopting at a rate of 13 new firms a year for 25 years result in average annual capital expenditure of $1,743,536 for both new and replacement drones.

National Association of Realtors, 56% of realtors use drones to market listings. Of agents who use them, 36% hire a professional to operate them.[10] In Oklahoma there are approximately 12,000 agents.[11] In 2022, there were 56,448 homes sold in Oklahoma, 4.7 homes per agent. The average real estate firm in the US has 14 agents, which gives us 857 drone operators as a starting point for calculating drone operations. We estimate that approximately 2,400 agents use their own drones, and the remainder use one operator per remaining agency, or approximately 857 operators.

Given the competitive nature of this market, it is assumed the drone operator earns a median salary doing real estate and other work. This gives us annual payrolls of $49,837, 978. The average annual capital expenditure of new and replacement drones is $8,143,500.

11.3 Entertainment

This market segment is comprised of TV stations and video filming. According to Data USA, the average salary of a photographer is $42,250. According to published photographer demographics, there are 29,586 photographers in the US. If the same statistics are used to allocate photographers to Oklahoma (1.2%), this gives us 355 photographers in Oklahoma. Assuming our market share of 25%, this translates to a total annual salary of $3,749,687 for drone photographers. There is no data to believe many motion pictures are made in Oklahoma, and the assumption for the drones being used are small VLOS drones in the $2,500 price range with five years of economic value after which a replacement drone is bought. Even though the Bureau of Labor Statistics is assuming minimal growth for this sector, we are holding it constant over the forecasted period as the numbers are not large enough to be significant. However, we do believe at least one half of all photographers use drones.[12] While we are unable to break down how much of their income is due to using drones, we can, however, estimate the annual capital expenditure, which amounts to $445,000 annually.

11.4 Insurance

While there are no reliable statistics for claims adjusters in Oklahoma, we do know there are 127,600 in the U.S. Using our 1.2 % adjustment, this gives us 1,531 claims adjusters in Oklahoma. Reports by the accounting firm Deloitte claim as many as 50% of all adjusters use drones. However, this figure will be reduced to be in line with our assumption of 25% market share. The assumption of a five-year life span and an inexpensive VLOS drone remain constant in this section. This gives us an average annual drone capital expenditure of $857,354. We have no way of portioning what part of a claims adjuster's income derives from drones, and all usage is done by in-house personnel.

10 Quick Real Estate Statistics (nar.realtor)

11 Top Real Estate Agents in Oklahoma (November 2022 Rankings) (listwithclever.com)

12 DRONEII Drone Industry Barometer 2022 - DRONELIFE

11.5 Mapping

This section assumes mapping is the purview of civil engineers, of which, according to the Bureau of Labor Statistics, there are 307,000 in the U.S. We assume there are 3,684 in Oklahoma (1.2%). Mapping drones are much more sophisticated than drones used in photography. The drones must be heavier to carry the larger sensors, and the sensors use more software, increasing the cost per drone to about $100,000. We have no information on the size of the various firms and assume ten people per firm. We also assume one drone per firm. As with all our forecasts, the market share will be capped at 25%. Engineers are trained at a high enough level to do their own sensing. Therefore, no additional employment is expected from this sector. However, capital costs can be calculated. A five-year depreciation schedule is used. An average annual expenditure of $8,039,400 is expected from this sector.

11.6 Public Safety

According to the Bureau of Justice Statistics, there are 483 law enforcement agencies in Oklahoma with 8,639 police officers.[13] The Fire Department Directory of Oklahoma lists 1,015 fire departments.[14] Surveys indicate that 1,172 police departments in the US use drones.[15] In the US, there are 18,000 police departments[16], and 27,164 fire departments.[17] Police and fire departments that use them are generally in larger communities.

In order to be conservative, as a starting point, we will begin with 21 police and 21 fire departments utilizing drones, only 2% of the police stations, and less than 2% of the fire departments. As this report has capped total market share at 25%, the allowed growth rate is adding 3 new police and fire stations annually. Anecdotal evidence collected by this researcher shows most police departments have at least four drones, with many departments having ten or more. For the purposes of this forecast, four drones per department will be used. The costs for these drones will be set at $5,000 due to the additional software and the depreciation period of five years. For the police this amounts to 110 departments using drones with average annual capital expenditures of $1,917,500. It is also assumed all work is done in-house.

Fire departments using drones will grow to approximately 253 in 2045 from the initial figure of 21 in 2024 at a rate of 8 per annum. The same costs and depreciation rates for the police will be used, and it is assumed each department will have two drones. This amounts to an average annual expenditure of $1,944,166.

13 Patrol Divisions | City of OKC
14 Fire Department Directory: State of Oklahoma
15 How Police Departments Are Using Drones - Pilot Institute
16 Police Departments, Funding, Stats & Data (usafacts.org)
17 National Fire Department Registry Quick Facts (fema.gov)

11.7 Energy Inspection

This section can be split into both VLOS and BVLOS. Mines, refineries, wind turbines, bridges, etc., are VLOS markets, whereas transmission lines and pipelines are well suited to BVLOS which may not start until the late 2020s or 2030.

Drone use for energy operations includes all mining operations as well as inspections of power lines, smokestacks, and windmills. Oklahoma has 50,381 miles of pipelines,[18] 3,736 wind turbines,[19] 6,800 bridges,[20] 12,266 miles of roads,[21] and 5,200 circuit miles of transmission lines.[22] Oklahoma has 5 operable refineries, 21 coal producing plants, and 15 power plants. Oklahoma is the nation's fifth largest producer of marketed natural gas and the sixth largest producer of crude oil.[23] In addition, Oklahoma has 328 identified mines. Figure 8 shows the breakdown between these sectors and BVLOS and VLOS. Each of these sectors will add employment due to the specialized nature of the services and the fact that there are already established firms providing these services.

Pipelines	Adds Employment	BVLOS
Wind Turbines	Adds Employment	VLOS
Bridges	Adds Employment	BVLOS
Roads	Adds Employment	BVLOS
Transmission Lines	Adds Employment	BVLOS
Refineries and Power Plants	Adds Employment	VLOS
Mines	Adds Employment	VLOS

Figure 8: BVLOS and employment for inspection

Wind turbines require frequent inspections ranging from weekly to monthly to semi-annual to three years. These will most commonly be inspected at six months, annual, and three-years. Active mining operations use drones on a weekly basis to measure the amount of material mined using volumetric measures.

18 Pipeline Safety (oklahoma.gov)
19 Oklahoma Wind Farms Mapped | KOSU
20 Bridge Progress to Top Ten Nationally (oklahoma.gov)
21 Oklahoma Transportation Facts (odot.org)
22 OG&E - Transmission & Distribution (oge.com)
23 U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

Power lines are inspected regularly for safety and reliability reasons. The frequency of inspections can vary somewhat, but typically:

- Transmission lines (high voltage power lines) are inspected 1-2 times per year via helicopter or drones looking for damage, vegetation issues, etc. Critical towers may be examined more frequently.
- Distribution lines (neighborhood lines) are often inspected every 1-3 years on the ground for risks like corrosion, equipment failures, and tree branches too close to lines. Areas with more trees/vegetation may be inspected more often.
- Wooden utility poles specifically are inspected every 3-10 years to check for rotting, cracks, or fire ants which can compromise integrity.
- Infrared inspections are done occasionally to check for any hot spots that could indicate problems.
- Targeted inspections may happen more frequently in high fire risk areas to prevent power line-related fires.
- After major storms, utilities deploy crews to inspect equipment damage and begin repairs.
- The goal is to find issues proactively before power failures occur. Reliable power delivery and public safety are the top priorities behind routine inspections.

Roads are inspected on a regular basis to identify any maintenance issues and ensure public safety. Here are some typical frequencies for road inspections:

- **Highways:** Inspected at least once a year, with higher traffic roads inspected more often. Some states inspect their entire highway system semi-annually or even quarterly.
- **City/county roads:** Typically inspected every 1-2 years on average. Certain hazard areas like bridges or tunnels may be inspected more frequently.
- **Pavement condition:** Pavement evaluations are conducted every 2-4 years using equipment to identify cracks, rutting, and surface wear to help prioritize repair and paving projects.
- **After severe weather:** Roads are checked following major storms, floods, etc., to identify any damage that needs immediate repair.
- **Traffic signals/signing**: Traffic lights, signs, and road markings are surveyed annually to catch any maintenance needs as well as identify new locations that require signals or signage.
- **Focus areas:** Higher risk areas like curves, intersections with frequent accidents, mountain passes, etc., tend to be inspected more regularly than straight rural backroads.

Overall, most government transportation departments have annual or biannual inspection goals to cover their entire road network on a routine basis. More frequent safety inspections occur on critical infrastructure like bridges. Keeping roads well-maintained through regular inspections is key for public safety.

Pipelines are inspected regularly to ensure they continue operating safely and to identify any potential issues before leaks or failures occur. Here are some typical frequencies:

- **Aerial patrols:** Transmission pipelines (large interstate lines) are flown about 26 times per year (every 2-3 weeks) to visually inspect the right-of-way for leaks, construction activity, suspicious equipment, etc.
- **Quarterly/annual inspections:** Comprehensive ground inspections of valves, corrosion protection systems, pressure readings, leak detection systems, etc., are undertaken throughout the pipeline network.
- **Inline inspections:** Smart inspection tools called "pigs" are run through the pipelines about once every 5 years. These devices provide great detail on pipe wall thickness and detect tiny pitting/corrosion.
- **Cathodic protection:** Pipe corrosion protection systems are checked annually to twice a year. This ensures proper voltage for corrosion prevention.
- **Stream/river crossings:** Inspected more frequently whenever water flow rates are high to check for exposures or scouring.
- **After extreme weather:** Floods, storms, fires, etc., may prompt additional patrols and inspections to check for any damage.

While aerial patrols happen more routinely, comprehensive ground and inline inspections occur on most transmission pipelines at least once a year. Frequent inspections help prevent major pipeline failures.

Smokestacks and industrial chimneys are subject to frequent inspections to ensure they are structurally sound and operating properly. Some general guidelines on inspection frequency:

- **Annual inspections:** A comprehensive evaluation of the entire stack system including visual checks for cracks/deterioration, measurement of remaining wall thickness using ultrasonics, corrosion monitoring, integrity of ladders/ platforms, emissions testing, etc.
- **Quarterly inspections:** Flue gas analyzers check air emissions to verify compliance with environmental regulations for pollutants like SO2, NOx, and particulate matter.
- **Monthly:** Heat scans use infrared cameras to check for hot spots that could indicate decomposition in the chimney lining. Emissions control equipment is also checked.
- **Ongoing:** Continuous opacity monitoring systems ensure smoke density stays within permitted levels during operation. Alerts trigger shutdowns if exceeded.

In addition, inspection frequency tends to increase with chimney age and height. Older, taller stacks may require even more frequent thickness and corrosion testing. Also, any repairs or damage will prompt immediate follow-up inspections to verify integrity. Proper maintenance based on routine inspections prevents catastrophic failures in aging smokestacks. Modern monitoring also helps minimize polluting emissions.

Bridges are typically inspected on a regular schedule to check their structural integrity and safety. Some key points about bridge inspections:

- In the United States, most highway bridges are inspected at least every two years according to Federal regulations. Certain bridges, such as newer ones or those in good condition, may be inspected less frequently.
- More critical or deteriorated bridges may be inspected more often, yearly, or even every 6 months in some cases. Bridges will also get special inspections after major events like earthquakes, floods, collisions, etc.
- Inspections involve trained engineers visually checking the bridge, looking for cracks, deterioration, damage, and other issues. They may use advanced methods like drone cameras, sonar, etc. Load testing is also sometimes performed.
- The specific inspection frequency and procedures are usually set by Departments of Transportation at the state level in the U.S., along with Federal Highway Administration guidelines.

- With older bridges in particular, regular inspection and maintenance are vital for identifying issues early on and preventing major safety problems or failures. But even new, well-built bridges require periodic inspection over time. Ensuring the safety and longevity of infrastructure involves an ongoing investment and vigilance.

11.8 Calculating Direct Employment

As mentioned in the Introduction, for each market segment described below, we calculated direct employment of drone operators in Oklahoma, not indirect (those jobs created by the drone supply chain of parts and technology) or induced employment (shops and restaurants hiring new employees because drone operators are spending money.) Nor did we calculate increased jobs for software developers and data processors, though automation will likely keep their numbers about equal to drone pilots.

11.8.1 Wind Turbines

The employment numbers are calculated using a man-hour calculation combined with a 3.5-day work week (given weather conditions) and a six-hour work day given battery life and recharging and maintenance. Conversations with those in this field indicate a one-hour inspection for each turbine. This gives us 1,092-man hours per worker. In other words, three workers working full time can do the wind turbines once each year. We assume an average drone pilot salary of approximately $58,000. The drones are specialized and need extra heft due to the windy conditions; we assume $20,000 drones with a five-year lifetime. This gives an annual average capital expenditure of $25,000 with an average annual income of $174,000.

11.8.2 Refineries and Power Plants

There are 41 coal power plants, coal producing plants, and refineries in Oklahoma. Conversations with those who supply drone operations to these companies indicate it takes an entire day to do one plant. Assuming a 3.5-day work week and a six-hour day operating year-round gives us the figure again of 1,092 man-hours. Dividing this number by 41 gives us a figure of 26.63. This is the employment number of what is needed for the weekly and other inspections required. The drones are still small but have sophisticated software. The figure of $10,000 per drone with a five-year life span will be used as well as the median salary. This gives us an average annual capital expenditure of $455,000 and average annual salaries of $1,508,000.

11.8.3 Mines

There are 381 mines in Oklahoma used for a variety of purposes. According to conversations with mine inspection experts, it takes one person an entire day to inspect and perform the mine calculations each week. Thus, one person can inspect 3.5 mines per week, given weather conditions, or 174 mine inspections per year. Some 1,905 inspections are needed, requiring a total of 11 operators. Usual assumptions about absorption are eased for this example. Therefore, we have an average annual capital expenditure of $192,500 with average annual salaries of $638,000.

12. BVLOS MARKETS SEGMENTS

This section will continue the inspection section with bridges, roads, transmission lines, and pipelines.

12.1 Bridges

Conversations with drone operators tell us it takes one half-day to inspect a typical bridge. We will use one bridge per day given travel times with a 3.5-day week over the entire year and the 1,092 man-hours available. This gives us 4 full-time operators performing only bridge inspections. This amounts to an average annual capital expenditure of $30,000 with an average annual payroll of $232,000.

12.2 Roads

With 12,266 miles of roads, we use a man-day of 300 miles. Thus, one operator can inspect 1,050 miles per week over one year. Doing one fly-over per year, this translates into a requirement for 12 operators. This gives us an annual average payroll of $696,000 with an average capital expenditure of $120,000.

12.3 Transmission Lines

All the various inspections needed for transmission lines including the inspection of towers, etc., will be covered here. There are 5,200 miles of transmission line in Oklahoma. Using the 300-mile day, this gives us the need for 5 operators. The average annual payroll is $290,000 with an average annual capital expenditure of $50,000.

12.3 Pipelines

Pipelines are king in Oklahoma which boasts some 50,381 miles. These require frequent inspection for a multitude of reasons. However, the same assumptions will be used here as for the above. This gives us 47 operators with an average annual payroll of $2,726,000 and average annual capital expenditures of $352,500.

12.4 Package Delivery

Package delivery has the potential to be the largest single segment of the commercial drone industry. Walmart has already begun services in this field. The potential for this cannot be understated as Walmart's stores are within ten miles of over 90% of the total population of the United States.[24]

There are a growing number of well-financed private companies pursuing small package delivery such as DroneUp, Matternet, Wings, Flytrex, Wingcopter, and Zipline. Also available for entry into this submarket are public companies such as DHL Parcelcopter, UPS Freight Forward, and Amazon Prime air.

The necessary condition for drone package delivery to increase on a massive level is the widespread introduction of BVLOS. While the timeline for this is uncertain, many of our discussions with those most heavily involved in this business believe BVLOS will become a reality by 2027. To be more conservative, we are forecasting its commencement by 2030.

BVLOS is the beginning of economies of scale for this market as the market size increases by the square of the market radius. Moving out from one mile to two miles increases the market size by a factor of three. As the market size and distance increase, the number of drones needed to service these markets also increases, driving unit costs down as production ramps up. The second factor attributing to scale economies is increasing the number of drones a single pilot can fly simultaneously. Currently under Part 107, one pilot per drone is required. This is cost-prohibitive for large-scale small package delivery and must be eliminated for commercial success to occur.

Discussions with those seeking waivers inform us of applying for one pilot to five drones and moving up thereafter. In addition, software for command and control, dynamic flight planning, and weather monitoring will be needed. One of the biggest external constraints is weather. An examination of the AUVSI Uncrewed and Robotics Database (USRD) showed that less than 5% of commercial drones can tolerate winds greater than 25 miles per hour. Given the lack of weather expertise from the ground up to 10,000 feet, this is an area of concern. With BVLOS, weather may be one of the biggest constraints.

Since there is no publicly available data on companies such as DroneUp and others, the forecast will be centered on FedEx, UPS, and USPS.

24 https://fortunly.com/statistics/walmart-statistics/

The emerging drone delivery industry aims to leverage drones to transport packages, food, medicines, and other goods safely, rapidly, and efficiently to customers' homes and businesses. While consumer home delivery has received much attention, there exists various specialized sub-markets across industries that could greatly benefit from the flexibility of drone delivery models. Delivery of critical medications, vaccines, blood products, or medical samples between hospitals, clinics, or laboratories located within the same city represents a major opportunity for lifesaving drone transport. Drones could also move supplies into disaster response areas more swiftly.

Major retailers aiming to achieve faster fulfillment and respond to customers' dynamic ordering patterns can employ drones to deliver online orders or move inventory quickly between locations. The fast-growing food service industry represents a major opportunity for drone delivery. Major pizza and fast-food chains have already begun testing drones for short-distance meal delivery from restaurants to customer homes. Benefits include:

- Faster delivery times, ensuring food arrives hot and fresh. Drones can traverse a 2–3 mile radius in under 10 minutes.
- Lower delivery costs compared to automobiles, boosting profit margins.
- Improved order capacity: drones operate continuously without needing breaks.

While initially focusing on homes near dining establishments, food service drones may eventually service larger residential areas from centralized meal preparation hubs as the model matures. Aside from traditional fast food, drones also prove promising for grocery chains offering meal kit subscriptions and delivering perishable pre-portion ingredients for home cooking.

Below are the relevant points being used to forecast package delivery:

- Unit Operational costs to be economic: approximately 3 dollars per operation
- BVLOS mileage frame: 10 miles plus
- Factors driving scale:
  - BVLOS, which enlarges market size exponentially
  - The number of drones each pilot can handle safely
- Amount of market to be disrupted: 25%

- Total U.S. Market Size:[25]
  » 36,986,301 packages per day (FedEx, UPS, USPS)
  » 21 packages per person per year in the US.
- The greatest years of growth for package delivery were during the pandemic.[26]
- Only package delivery using small packages will be forecasted to be conservative. However, given the potential size of pizza (2 billion deliveries in the US annually) and other food deliveries, it is easy to envision just how large this segment will become.

Using Oklahoma's population of 3.9 million people and the average number of deliveries per person at 21 per year gives us a total package delivery market of 81,900,000. As 85% of these are under five pounds, this gives us a probable total market size of 69,615, 000. If this is constrained to 25%, we arrive at the final total market size of 17,403,750 packages, which will grow at a constant rate over the period.

Thus, drone package delivery begins with 1,700 deliveries per day during the first year (2030) and grows to almost 50,000 deliveries per day at maturity in 2045. The important number is the average annual capital expenditure of $25 million for drones and other equipment. This assumes one drone can make ten deliveries per day over a 360-day year. This translates to a ten-hour workday with a trip out and back and time to charge batteries and load packages. It is a tad more difficult to estimate employment. It is assumed the employee will earn the median income of approximately $58,000 per year. Assuming one pilot can commandeer thirty drones, with one assistant, this translates to a beginning figure of 18 employees per year at the commencement and 465 in 2045. This amounts to beginning payrolls of $1 million and in the year 2045 payrolls of $27 million or an average annual payroll of $13 million throughout the forecasted period.

12.5 Agriculture

While agriculture has current drone usage with VLOS, the significant economies of scale are such that under VLOS the prices per acre are relatively high. The assumption of this section is that widespread agricultural drone use will only begin with BVLOS using fixed-wing drones with superior aerodynamics, allowing operators to cover larger amounts of farmland with one battery charge, reducing the cost per acre significantly and allowing demand to increase significantly. Several surveys were examined from usage rates ranging from 4% of all farmers to 35% of all farmers. It will be assumed the current adoption rate of 4% will grow to 25% over the forecasted time.

25 Infographic - How Many Packages Are Shipped in the United States (packola.com)
26 Annual reports and 10-K reports for UPA and FedEx

According to the Oklahoma Foundation for Agriculture, there are 86,000 farms in Oklahoma on 35,100,000 acres, ranking fourth in the nation. The period for this forecast starts at 2030 and continues until 2044. 4% of the farms amounts to 295 farms, growing to 21,500. The drone needed for this type of work uses sophisticated sensors, and fixed-wing drones are more expensive. While the usual price for such a drone is in the $250,000 range, a more conservative figure of $100,000 will be used. The depreciation period for this drone is 7 years. The average annual expenditure over the period is approximately $500,000,000.

If the farmer is using drones monthly, over a five-month growth cycle, and a drone operator can service at least 20 farms, employment begins at 12 operators in 2030 and grows to 1,007 in 2045 with payrolls beginning at $684,000 growing to $58,419,050, or an average annual payroll of $29,304,928.

13. CONCLUSION

The drone revolution is almost certainly going to transform the Oklahoma skies over the next ten to twenty years in ways that the conservative forecasts in this report may dramatically underestimate. That is because the assumptions underlying many current models and predictions are based on comparatively incremental evolutions of existing technology, regulations, and economic factors. Yet multiple signs point to drone adoption in Oklahoma on the cusp of reaching an exponential growth phase rather than following the conservative modeling used herein. In fact, we believe the State will experience what is known in economics as "hockey stick growth," a period of slower growth followed by a sudden sharp increase. Hockey stick growth is often used to describe the success of startups or innovative products such as drones.

On the technology front, drone capabilities are expanding at a breakneck pace in terms of duration, range, obstacle avoidance, intelligence integration, uniquely specialized sensor payloads, and more. The coming few years will likely witness the emergence of regional drone delivery networks spanning across entire metro areas and enabling everything from life-saving medical transport to convenient consumer item orders from retailers. Data capture functionality will also progress enormously with enhanced sensors able to scan vast swathes of land, infrastructure, or emergency scenes in high resolutions previously unimaginable. Swarm drone technologies allowing dozens or even hundreds of tightly coordinated drones to collaborate on complex missions could revolutionize the way the oil and gas industry surveys sites. Advanced AI integration will enable increasingly autonomous functionalities like dynamic navigation, object recognition and decision making. All signs point to a technology environment in which dramatically more ambitious and mission-critical drone deployments become feasible across Oklahoma soon.

On the regulatory front, the FAA and other agencies are demonstrating clear support for opening national airspace access to accelerated drone adoption. New rules like remote ID tracking for expanded visibility combined with special waivers and exceptions for promising use cases will likely enable an increasingly permissive flight environment. Enthusiasm is particularly high for enabling more sophisticated drone commerce models. Regulators perceive immense economic growth and productivity benefits from unfettered drone delivery networks, infrastructure and remote site management programs, and innovative emergency response capabilities. More expansive drone operations spanning wider geography and leveraging breakthrough functionalities will almost certainly gain legal approval at an accelerating pace.

Finally, on the economic front, the business case for enterprise and public agency drone adoption is becoming far more compelling and diverse. The high costs which once restricted drone investments to only the best funded operations are rapidly falling. And the range of quantifiable benefits only continues to grow – from agricultural crop and equipment monitoring to utility and pipeline inspection efficiency gains to public works planning enhancements and traffic management upgrades leveraging airborne data. Entirely new use cases enabling transformations not possible before drones will inevitably emerge as the technology proliferates. Cost-benefit analysis will drive surging growth as organizations perceive game-changing advantages at manageable expense.

Market Segment	Average Annual CAPEX	Added Operators by 2045	Payroll in 2045
Construction	$8,143,500	857	$49,837,978
Entertainment	$445,000	89	$3,749,687
Insurance	$856,354	0	$0
Mapping	$8,039,400	0	$0
Public Safety	$1,944,166	0	$0
Energy Inspection			
Refineries and Power Plants	$455,000	26	$1,508,000
Mines	$192,000	11	$638,000
Wind Turbines	$25,000	3	$174,000
Infrastructure			
Bridges	$30,000	4	$232,000
Transmission Lines	$50,000	5	$191,000
Roads	$120,000	12	$696,000
Pipelines	$352,500	47	$2,726,000
Package Delivery	$25,000,000	465	$27,000,000
Agriculture	$500,000,000	1007	$58,419,050

While sober modeling calls for conservative growth, the emerging reality points to drones in Oklahoma on the precipice of explosive hockey stick expansion. The coming five to ten years may witness adoption that reaches ten times what current forecasts suggest across commercial, governmental, and consumer domains. Rather than reactively catching up to the "disruptive" nature of drone services throughout industries and across the state, both public and private institutions should embrace and proactively plan for the drone inundation heading their way, reaping greater advantages for residents, businesses, and government agencies.

www.droneecon.com