Drone Hub Location Strategy for Prime Air

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Online Business Landscape & Drone-Hub Relevance

Global e-commerce sales ≈ US$6.9 trillion in 2025.

Online retail ~21% of global sales (rising)

2.77 billion global online shoppers as of 2025.

Drone delivery market: $1.5B → $18B by 2032

Implication of Drone – Hub Strategy

High online volume → strong need for fast delivery

Continued growth supports long-term drone investment

Many e-commerce parcels are lightweight (<2 kg)

Candidate Items for Drone – Hub Storage

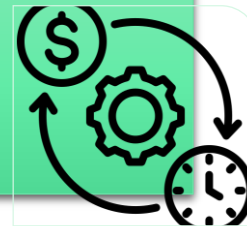| Item Category	Why Suitable for Drone Delivery
Apparel & Footwear	Typically light, small packages — ideal for drone payload limits
Small Electronics & Accessories	Compact, often < 2 kg, good demand
Cosmetics & Personal Care	Lightweight, small volume, high frequency of purchase
Subscription Boxes & Essentials (e.g. supplements, small household goods)	Regular demand, small-to-medium parcel sizes
Books / Media / Small-Goods	Easy to package, low weight, predictable demand

Drone Technology Overview

o Payload: **1–5 kg**

o Range: **10–25 km**

o Speed: **40–70 km/h**

o Ideal for small, lightweight orders

Drone Delivery Capability

o **Low** operating cost (electric)

o **70–80% cheaper** than vans for short routes

o Higher upfront cost per drone

Cost & Efficiency

o Zero tailpipe emissions

o Up to **50–90% lower CO_2** than trucks

Environmental Impact

Innovation, Regulations and Constraints

Innovation & Patents
- Leaders: Amazon, Wing, UPS, DJI
- Patents in autonomy, landing accuracy, obstacle avoidance

Regulatory Landscape
- FAA limits on BVLOS (beyond visual line of sight)
- Remote ID + geofencing required
- Progress through expanding pilot waivers

Practical Constraints
- Battery life limits range
- Weather sensitivity (wind, rain)
- Noise & privacy concerns

Massachusetts Population & Online Demand

State population: ~7.0 million

High median income: ~$101k

Younger counties: Suffolk (34), Hampshire (37)

Older counties: Barnstable (56), Berkshire (47)

Broadband access: ~98% statewide

High online shopping potential in Boston metro + suburban belts

Massachusetts County Profiles (For Drone Delivery)

County	Population	Drone Delivery Insight
Middlesex County	**1,623,411**	State's primary demand center; anchors Eastern hub (Boston).
Suffolk County	**792,647**	Dense urban core; very high demand; airspace constraints present.
Essex County	**804,598**	Strong coastal cities; high e-commerce activity.
Norfolk County	**720,403**	Affluent suburbs; highly drone-friendly geography.
Worcester County	**856,858**	Central location; ideal for intermediate hub coverage.
Bristol County	**576,070**	Dense suburban corridor; strong drone adoption potential.
Plymouth County	**527,602**	Coastal + suburban mix; broad coverage potential.
Barnstable County	**227,942**	Seasonal peaks; tourism shipments; wide rural areas.
Hampden County	**466,265**	Springfield anchor; key Western MA hub candidate.
Hampshire County	**161,810**	College towns; predictable stable demand.
Berkshire County	**129,089**	Rural; drones significantly reduce long-distance road miles.
Franklin County	**71,085**	Very rural; long delivery times - drones highly beneficial.
Dukes County	**20,277**	Island deliveries; drones reduce reliance on ferry logistics.
Nantucket County	**13,795**	Ideal drone environment; isolated delivery routes.

Urban, Suburban & Rural Suitability

Urban (Boston, Worcester)

High demand

Airspace + building constraints

Best served by *nearby* hubs
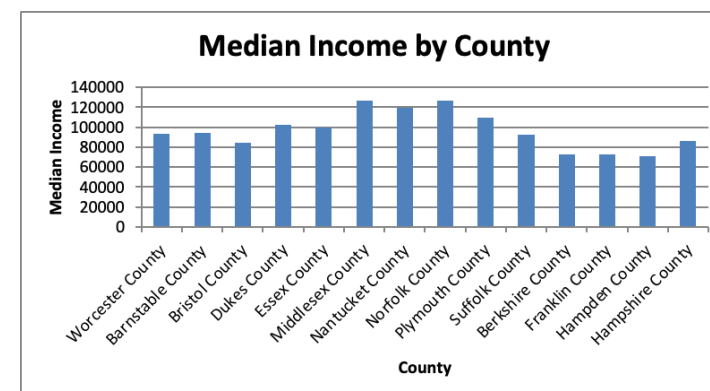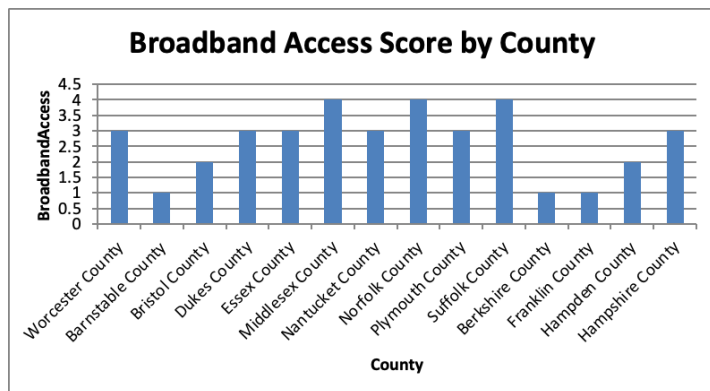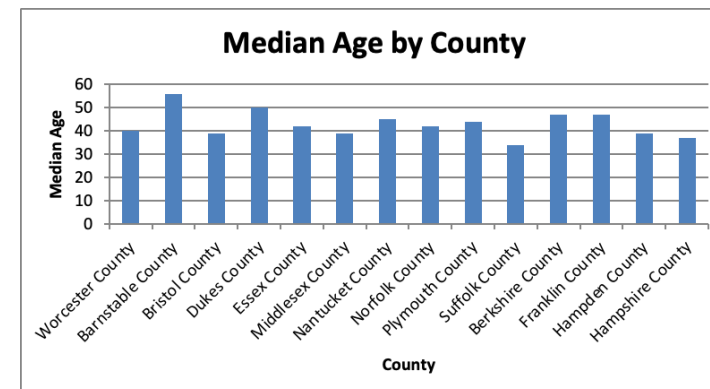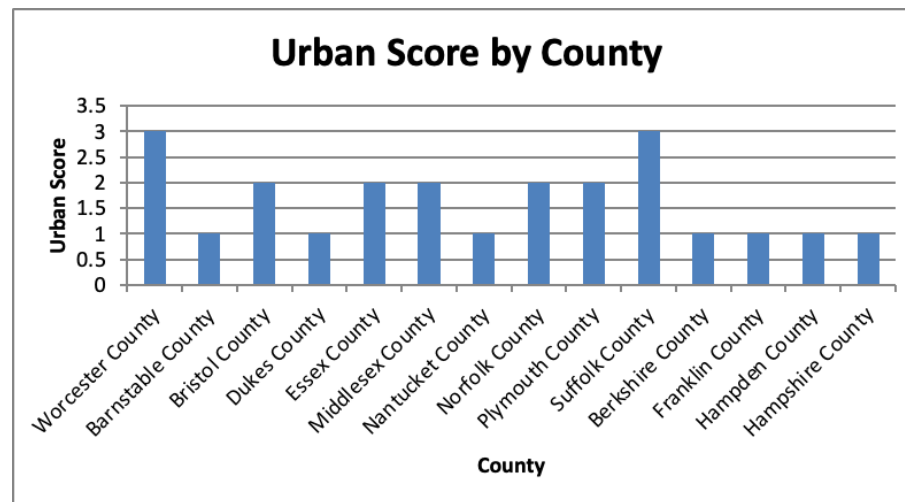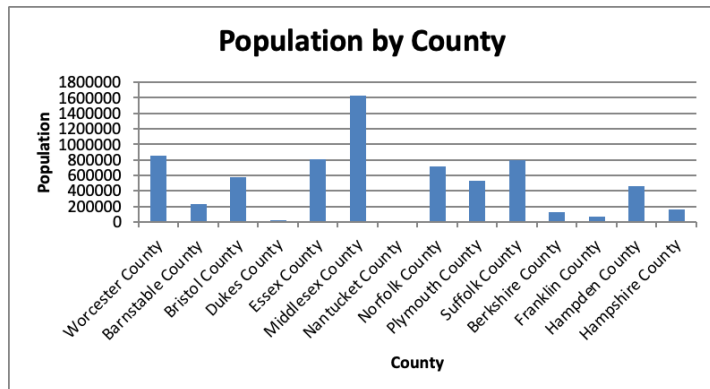
Suburban (Middlesex, Norfolk, Essex, Plymouth)

High income, strong broadband

Good drop-off points

Best initial drone-hub locations

Rural (Franklin, Berkshire, western MA)

Lower density but long delivery times

Strong opportunity for drone coverage

LOCATION ANALYSIS

Input data

County	Latitude	Longitutde	Population	Region	Median Income	Urban Sc	Median Ag	BrodbandAcces	Weight
Worcester County	42.31805833	-71.84049333	856858	Central	93,561	3	40	3	856858
Barnstable County	41.78373333	-70.17709333	227942	Eastern	94452	1	56	1	31163.94
Bristol County	41.87969	-71.209005	576070	Eastern	84198	2	39	2	195582.7
Dukes County	41.40828571	-70.70435714	20277	Eastern	102348	1	50	3	8046.429
Essex County	42.65145588	-70.96847353	804598	Eastern	99431	2	42	3	521110.9
Middlesex County	42.46072778	-71.32539815	1623411	Eastern	126779	2	39	4	1659813
Nantucket County	41.2835	-70.0995	13795	Eastern	119750	1	45	3	5764.476
Norfolk County	42.18244286	-71.19643214	720403	Eastern	126497	2	42	4	791450.7
Plymouth County	41.99928148	-70.85091852	527602	Eastern	109698	2	44	3	394946.2
Suffolk County	42.38315	-71.0286	792647	Eastern	92859	3	34	4	776234.3
Berkshire County	42.4022875	-73.27090938	129089	Western	72565	1	47	1	141078.8
Franklin County	42.57037692	-72.64664231	71085	Western	72584	1	47	1	77707.73
Hampden County	42.11776522	-72.6109913	466265	Western	70535	1	39	2	822014.7
Hampshire County	42.34249	-72.68504	161810	Western	86391	1	37	3	497215.1

County-level demographics (population, income, age, urbanization, broadband access) and converted them into a single regional **weight** that reflects overall drone-demand attractiveness.

Region	Total Population	Median Icome	Median Age	BrodbandAccess	Urban Score	Weight
Eastern	5306745	102348	42	3	3	4384113
Western	828249	72574.5	43	1	1	1538016
Central	856858	93,561	40	3	3	856858

These weights show that Eastern MA is by far the most attractive region for a high-capacity hub, with Western and Central MA playing smaller but still important supporting roles

Applying the weighted COG method (using county population and socio-economic weights), the Eastern region's center of gravity – and thus our ideal drone hub – is located in **Newton, MA**

Eastern Region Calculation: COG method

County	Latitude	Longitutde	Weight	Weight * Latitude	weight * Longitutde
Barnstable County	41.78373333	-70.17709333	31163.94145	1302145.819	-2186994.827
Bristol County	41.87969	-71.209005	195582.716	8190943.515	-13927250.6
Dukes County	41.40828571	-70.70435714	8046.428571	333188.8133	-568917.5594
Essex County	42.65145588	-70.96847353	521110.8749	22226137.49	-36982443.33
Middlesex County	42.46072778	-71.32539815	1659813.299	70476880.64	-118386844.4
Nantucket County	41.2835	-70.0995	5764.475996	237977.7448	-404086.8851
Norfolk County	42.18244286	-71.19643214	791450.6784	33385323.02	-56348464.52
Plymouth County	41.99928148	-70.85091852	394946.1725	16587455.47	-27982299.09
Suffolk County	42.38315	-71.0286	776234.2932	32899254.48	-55134835.12
				185639307	-311922136.3

COG_Latitute	42.34364217
COG_Longitude	-71.1482904

NEWTON

Coverage Area

- Newton hub provides coverage to ~1.7 million residents, making it by far the highest-impact location and confirming Eastern MA as the core demand center.

- Springfield and Worcester hubs each cover ~360–370k people, ensuring Central and Western MA still receive strong regional coverage even though they are less dense.

Area	Total Population covered by the area
Newton	1724123
Springfield	373892
Worcester	357118

Coverage at 5, 10, 15 Minutes

If drone speed = **60 km/hr**, then:

- 5 minutes → $\frac{5}{60} \times 60 = 5$ km
- 10 minutes → $\frac{10}{60} \times 60 = 10$ km
- 15 minutes → $\frac{15}{60} \times 60 = 15$ km

Region	15KM	10KM	5KM
Eastern (Newton)	1724123	1299920	220,381
Western(Springfield)	373892	183916	25369
Central (Worcester)	357118	268046	265454

Volume Estimates

Assumptions:

- 20% of residents in coverage zone place at least one Amazon order per week

- 10% of those could convert to drone–eligible deliveries (lightweight items)

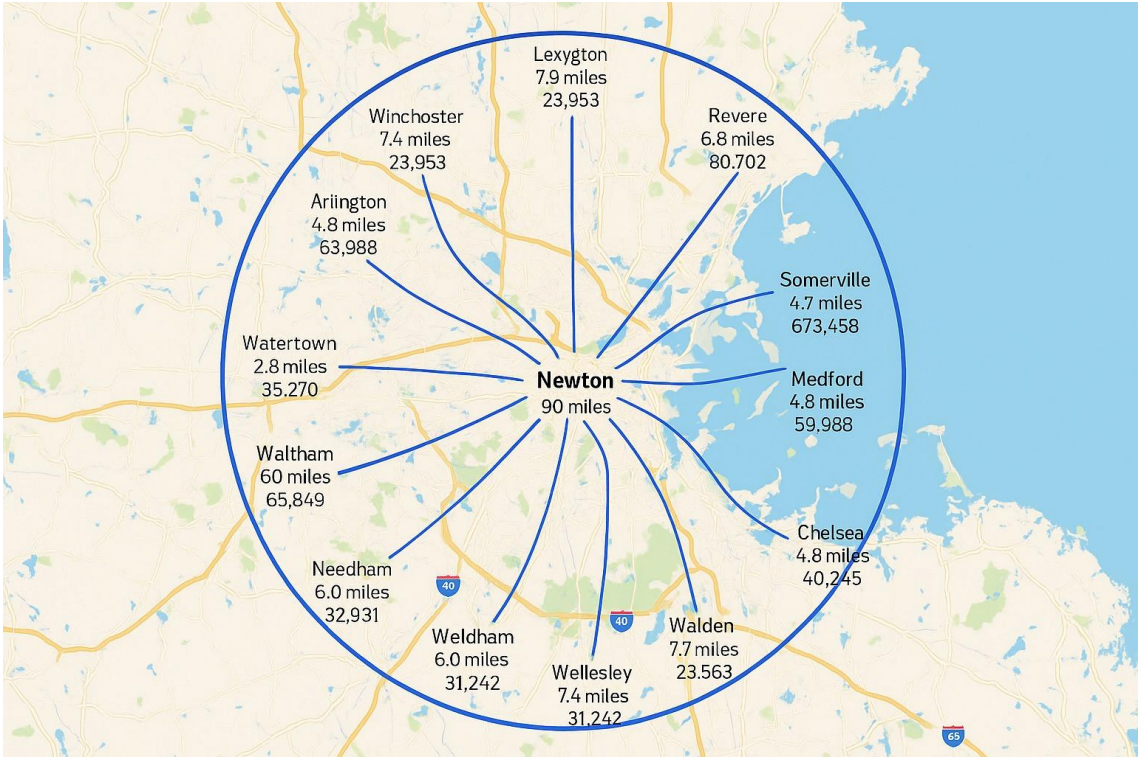| Region	Total Population covered by the area	Weekly orders (20%)	Drone – Eligible (10%)	Daily Drone Volume
Eastern (Newton)	1724123	344,825	34,48	4926
Western (Springfield)	373892	74,778	7478	1020
Central (Worcester)	357118	71,424	7,142	1068

Current Amazon Drone Delivery

- Amazon's Prime Air drone program is currently operating only in a limited number of U.S. cities, such as parts of California, Arizona, Texas, and Michigan.

- These deployments follow strict FAA regulations, limited delivery radii (~5–10 miles), and only lightweight items (<5 lb).

- Adoption remains small because weather, packaging constraints, and safety requirements restrict which orders can be delivered by drone.

- This context supports our assumption that only **10% of weekly orders** are drone-eligible and justifies our phased rollout strategy for Massachusetts

The Huff's Method

$$E_{ij} = P_{ij}C_i = \frac{S_j/T_{ij}^a}{\sum_j S_j/T_{ij}^a} \, C_i$$

- Ci – population (demand) in county i
- S_j – size/attractiveness of hub j (regional weight)
- T_{ij} – distance/time from county i to hub j
- a – distance-decay factor (how strongly distance hurts attractiveness)
- P_{ij} – probability that county i uses hub j
- E_{ij} – expected number of people from county i served by hub j

Hub	Total Expected Demand (people)	Market Share
Newton	5058495.713	72.35%
Worcester	1094538.694	15.65%
Springfield	838817.5932	12.00%

Comparing Huff's Model and Center of Gravity (COG)

COG (CENTER OF GRAVITY)

- Placed Eastern hub in Newton, which minimized total flight distance to 1.72M residents within 15 km. (9 miles)

- Identified Worcester as the true geographic + demographic center for Central MA.

- Showed Northampton area as the Western center of demand, but taken into consideration other factors we choose Springfield

- COG gave us the physically optimal hub points where drones travel shortest average distance to service cities.

- Strength: Best method for *where* the hub should be located to minimize distance.

- Limitation: COG does not tell us how much of the population will prefer or depend on each hub.

HUFF'S MODEL

- Newton captures 72.3% of statewide demand, confirming it as the primary mega-hub.

- Springfield captures ~88% of Western MA demand in the Huff model, validating its attractiveness even though the COG was slightly north (Northampton).

- Worcester captures 100% of Central MA demand, showing perfect alignment between COG and attractiveness.

- Huff proved that distance + attractiveness (income, broadband, urbanization) make these 3 hubs naturally dominant.

- Strength: Shows the *probabilistic demand share* each hub will serve.

- Limitation: Huff does not generate a location — it only evaluates attractiveness of hubs we propose.

Recommended Method

- Use Weighted COG to choose *optimal locations* (Newton, Worcester, Springfield).
  Use Huff's Model to confirm *how much demand* each hub will capture,

- Why this specific combination works:
  COG told us WHERE hubs minimize drone travel distance
  → Newton, Worcester, Springfield.
  Huff told us HOW MUCH demand each hub attracts
  → Newton dominates statewide demand (72.3%)
  → Springfield dominates Western MA (88%)
  → Worcester perfectly serves Central (100%)

- This gives Amazon both operational efficiency (COG) and market-share certainty (Huff), which no single method can provide alone.

Recommended Hub Network

Newton (Eastern Hub)

- Aligns perfectly with Eastern *Center of Gravity*
- Serves *72.3%* of statewide demand
- Highest-income and highest-broadband-access corridor
- Ideal for large-scale drone deployment
- Makes Newton the *primary mega-hub*

Worcester (Central Hub)

- Regional COG matches Worcester exactly
- Captures *100% of Central MA demand* in Huff model
- Balanced midpoint between East and West
- Best central routing point for network stability

Springfield (Western Hub)

- Attracts *~88% of Western demand*
- Offers *~12% greater coverage* than Northampton
- Strong urban density + regional economic hub
- Best candidate for Western MA operation

Deployment Roadmap

Phase 1 — Newton (Year 1)

Launch the primary mega-hub in Newton to capture the majority of statewide demand. Use this phase to refine flight operations, routing logic, and rapid-delivery workflows.

Phase 2 — Worcester (Year 2)

Activate the Central hub to expand statewide reach and stabilize network flow. Worcester enables efficient East–West balancing and reduces repositioning costs.

Phase 3 — Springfield (Year 3)

Establish the Western hub to complete full Massachusetts coverage. Springfield anchors Western demand and allows optional micro-hub expansion later.
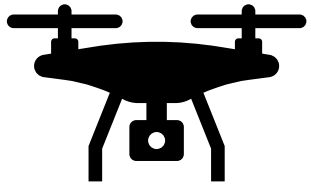
Further Scope & Future Enhancements

Operational Viability Assessment

Cost & Infrastructure Modeling

Demand Forecasting & Order-Level Insights

Sensitivity & Risk Analysis

Network Expansion Pathways

Thank You