
Unmanned Aircraft Systems Demand Forecast Study
NASA

Purpose / Scope / Assumptions

Purpose

- To develop an analytical tool designed to calculate projections for the demand and economic benefit from operating civil and commercial unmanned aircraft systems (UAS) within the National Airspace System (NAS).

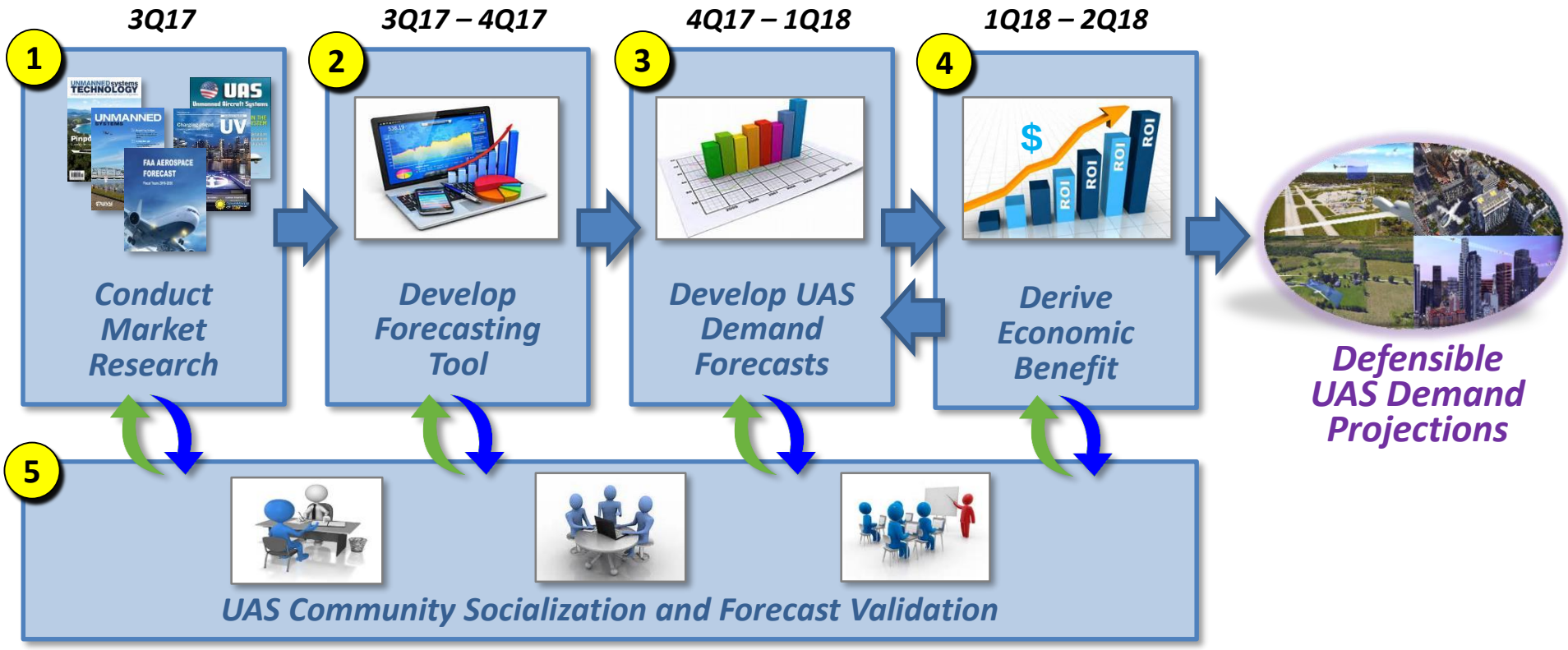
Scope

- ***Region***: US Forecast only
- ***Airspace***: All Airspace Classes
- ***Use Cases***: Commercial and civil (excludes military and hobbyist)
- ***Duration***: Projections should look out far enough to observe forecast stabilization

Assumptions

- Federal, State and local authorities won't establish unfriendly laws preventing the adoption of UAS
- The FAA will continue to move forward with UAS Policy / Regulation development and implementation
- Standards Development Organizations will create the necessary standards needed to certify UAS airspace integration enabling technologies

Technical Approach



UAS demand forecast accuracy is highly dependent on the ability to receive quality inputs from the entire UAS community to include: government, industry and broad commercial-user interest groups.

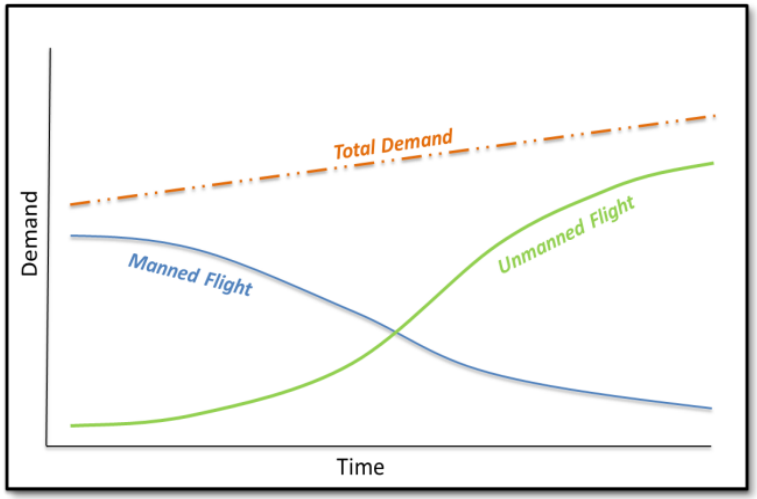
Market Research

1

Objective: To gain an appreciation for the vast array of UAS business cases and key drivers that will impact demand and market adoption.

Approach:

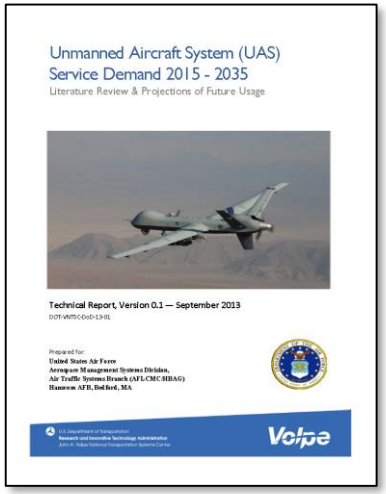
- Conduct Literature Search
- Review previous UAS Forecasts
- Interview Gov't and Industry Stakeholders



Outcome/Results:

- Understand rationale behind increased adoption
  - Cost savings (e.g. fewer pilots, eliminate cockpit)
  - Safety (remove potential for pilot error)
  - Gained efficiency (e.g. long -duration flights)
  - New missions not feasible today
  - Excitement surrounding new-technology
- Identify key drivers impacting adoption timeframe (e.g. public acceptance, regulatory, technology maturity, existing platform's replacement lifecycle)
- Predict likely transition path (e.g. Manned →Augmented →Semi-Autonomous → Fully Autonomous)
- Determine what metrics should be used to quantify UAS demand (e.g. Flights/Day, Flight hours/Day, Missions, Revenue Passenger Miles, Revenue Ton Miles)
- Propose how to handle differences in UAS CONOPs
  - Internet Service Provider (e.g. multi-day missions): Count each day aloft as 1 flight
  - Package Delivery (e.g dozens of flights/day): Count 1 take-off/landing combination as 1 flight

Previous Unmanned Aircraft Forecast Examples



Source: Volpe UAS Service Demand 2015 - 2035
https://fas.org/irp/program/collect/service.pdf

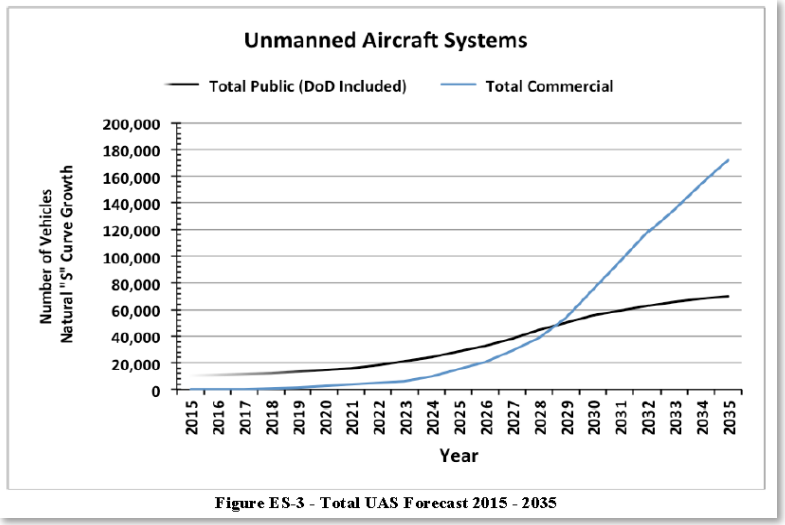
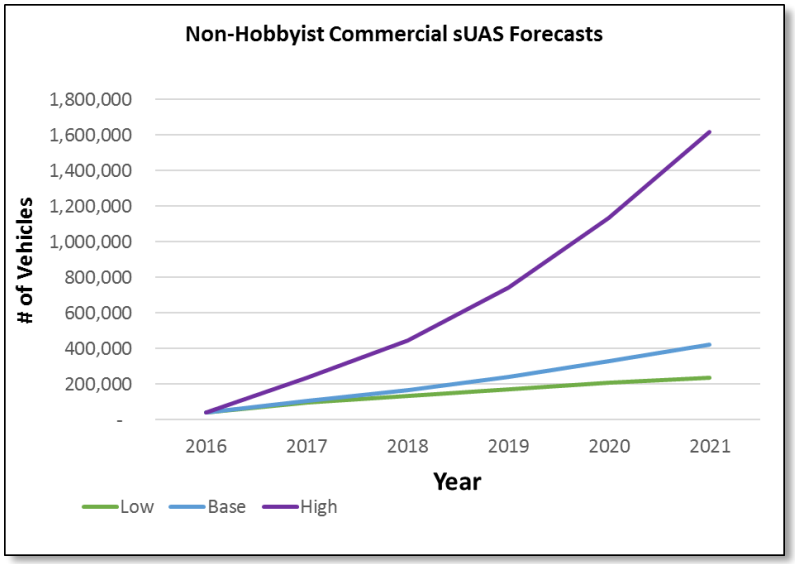


Figure ES-3 - Total UAS Forecast 2015 - 2035

Year	Total Non-Hobbyist (Commercial) Fleet Million sUAS Units Low	Base	High
2016	0.042	0.042	0.042
2017	0.095	0.108	0.235
2018	0.133	0.167	0.445
2019	0.173	0.242	0.742
2020	0.207	0.327	1.133
2021	0.238	0.422	1.616



Source: FAA Aerospace Forecast 2017 – 2037
https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2017-37_FAA_Aerospace_Forecast.pdf

Recent FAA Manned Aircraft Forecast Example

1

2016 Baseline Data

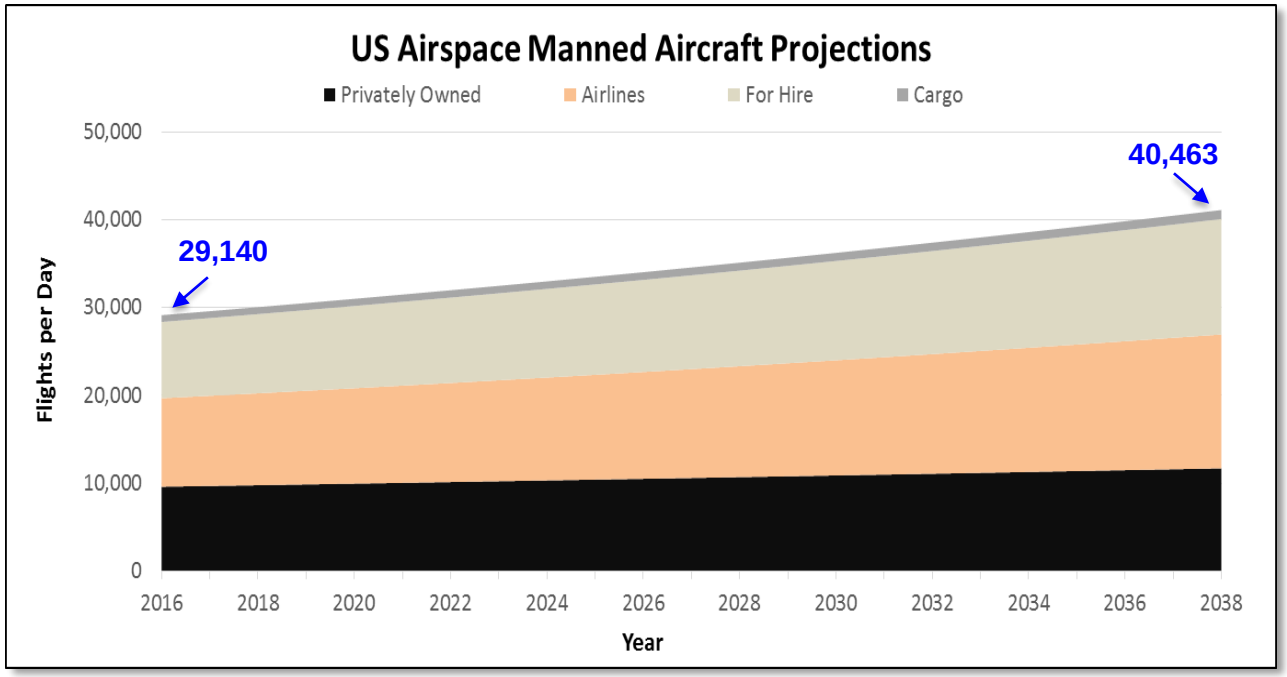
Category	Flights / Day	% of Total Aviation
Privately Owned	9,610	31%
Airlines	10,075	32.5%
For Hire	8,680	28%
Cargo	775	2.5%
	29,140	

Source: FAA Aviation Data Website (https://www.faa.gov/data_research/aviation_data_statistics/)

Growth Projections (2017 – 2037)

Category	Growth Rates
Privately Owned	0.9%
Airlines	1.9%
For Hire	1.9%
Cargo	1.3%

Source: FAA Aerospace Forecast 2017 – 2037 https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2017-37_FAA_Aerospace_Forecast.pdf



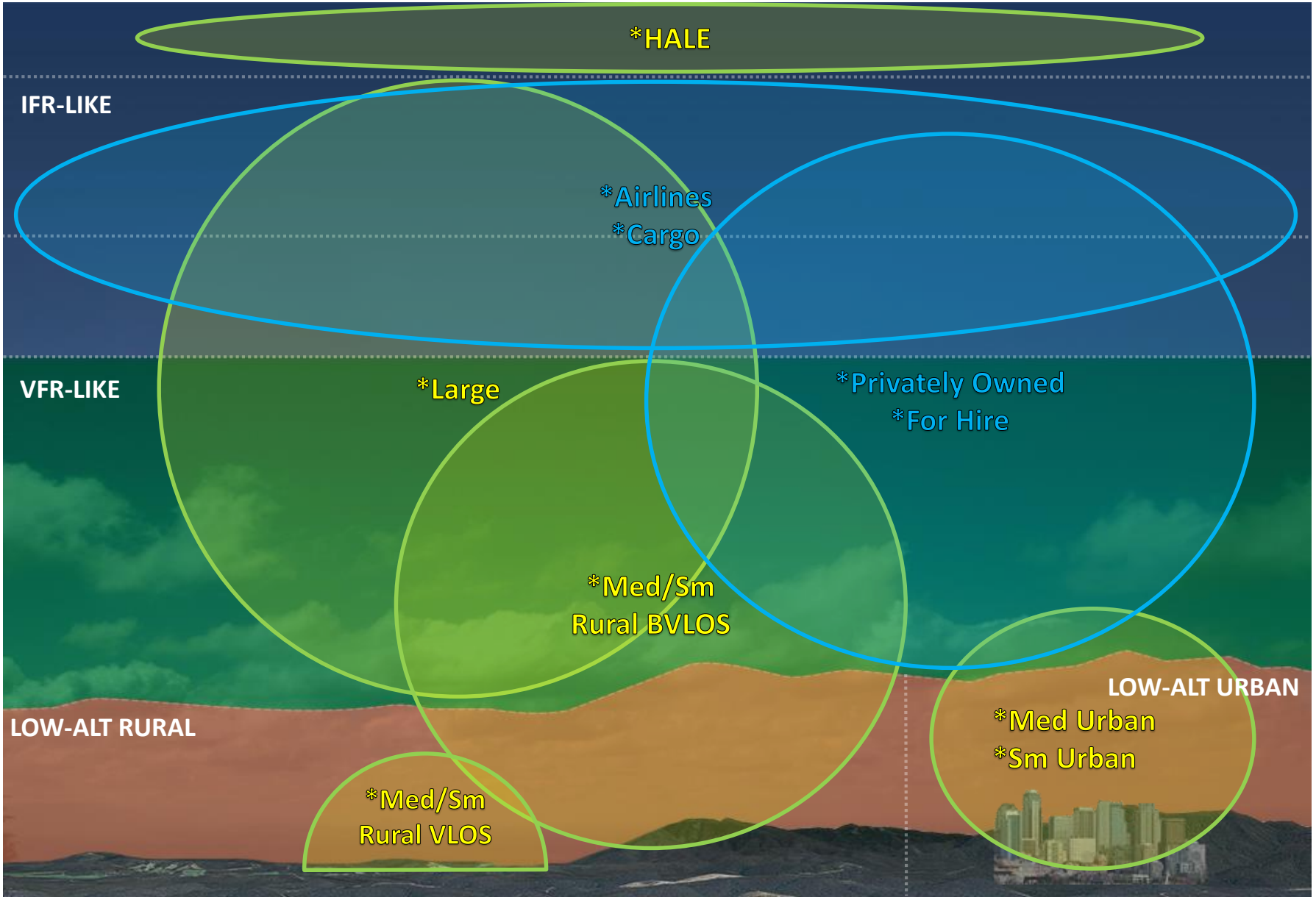
Note: Military #s excluded from chart due to scope of study (~6% of total aviation)

Aviation Market Categories Definitions

1

Category		Definition
Traditional Markets	**Privately Owned**	General Aviation Aircraft owned and operated by individuals or corporations (e.g. Cessna, Piper Cub, Learjet)
	Airlines	Commercial air carriers that offer a service to transport people to and from airports across the country and internationally (e.g. United, American, Delta, SouthWest)
	For Hire	Aircraft that is rented by the hour, day, week to provide a service to anyone willing to pay the negotiated fee (e.g. sightseeing helicopter, NetJets)
	Cargo	Aircraft used to transport freight to and from airports across the country and internationally (e.g. FedEx, DHL, UPS)
New UAS Enabled Markets	**HALE**	Expanding unmanned aircraft market that operates at high altitudes (>60K ft) for very long endurance (days/weeks/months) missions.
	Large	Expanding UAS market that increases traditional densities of the NAS, performs long distance and/or long endurance missions at a broad range of altitudes (10K ft - 60K ft).
	Medium/Small Rural BVLOS	Emerging market that includes a diverse continuum of fixed wing and VTOL UAS, ranging in size and capability, that operate beyond visual line of sight (BVLOS) in mixed manned/unmanned environments (500 ft – 10K ft)
	Medium/Small Rural VLOS	Growing existing market partially enabled by Far Part 107 that includes line-of-sight fixed wing and VTOL UAS (<55 lb) operating in rural locations and below 400 ft.
	Medium Urban	Rapidly emerging market that includes requiring high density VTOL operations for on demand, affordable, quiet, fast, transportation in a scalable and conveniently accessible verti-port network.
	Small Urban	Rapidly expanding market that includes a diverse continuum of fixed wing and VTOL UAS (<55 lb) operating below 400 ft that will require technologies and CONOPs that allow high density operations in urban settings.

Operational Environments: Category Overlays



Forecasting Tool Development

2

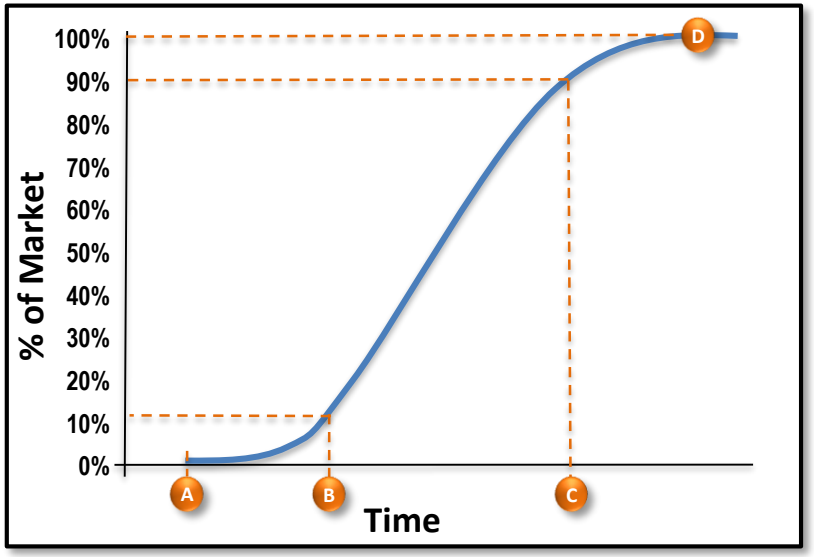
Objective: To develop an analytical tool that facilitates the forecasting of UAS demand and economic benefit across various UAS market categories.

Approach:

- Utilize a standard S-curve technology adoption calculation reliant on 4 variables
  - A Estimated start year of new technology
  - B Estimated fast-growth year (10% of market)
  - C Estimated takeover year (90% of market)
  - D Estimated total market saturation level (Either as a percentage of the existing market or estimated total of a new market)

Results / Benefits:

- Tool allows for quick prediction adjustments by simply adjusting any of the four variables
- Input values can be based upon subject matter expert (SME) input or from rigorous business-case-based demand projections



UAS Demand Forecasts

3

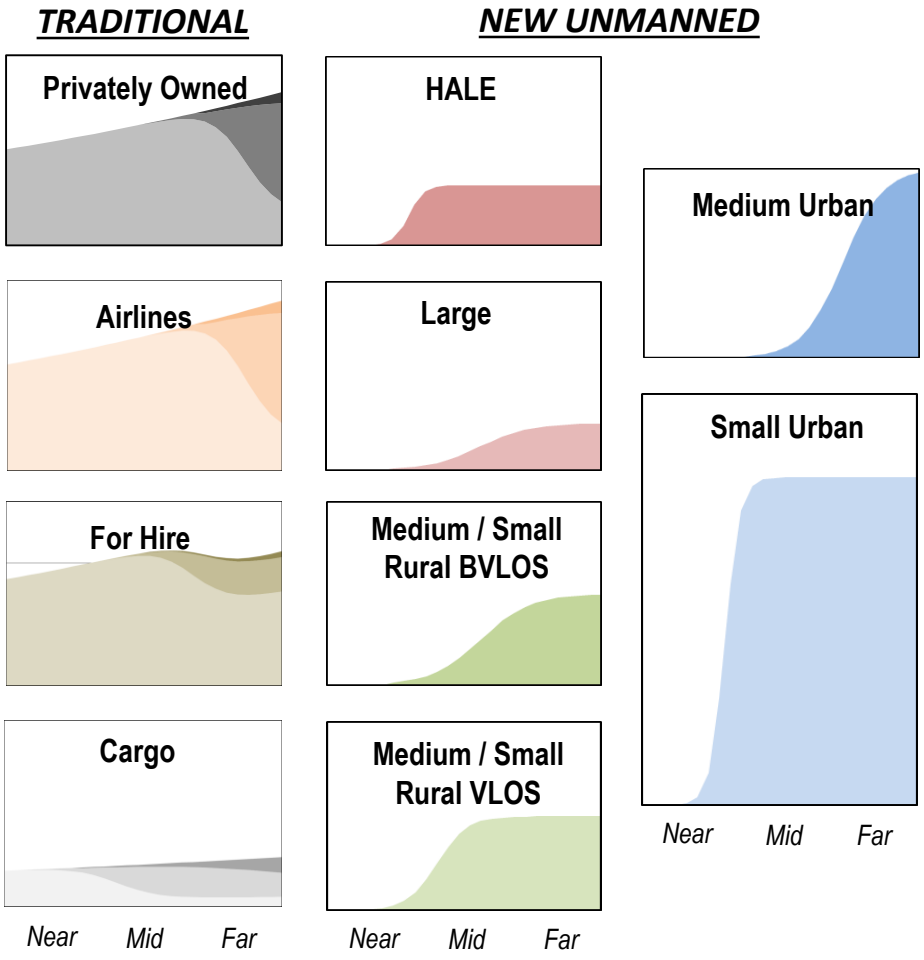
Objective: To generate defensible UAS demand forecasts for each aviation market category based on community supplied inputs and rationale. Periodically update UAS Demand forecasts as new data becomes available.

Approach:

- **Ph. 1**: Develop notional demand curves for each category to validate tool works properly
- **Ph. 2**: Work with Gov't & Industry to elicit inputs related to specific markets and business cases
- **Ph. 3**: Adjust UAS demand forecasts based on Ph. 2 inputs & validate results

Results / Benefits:

- Ability to visualize projected growth rates across categories
- Assess impacts to traditional aviation markets
- Identify opportunities to enable faster growth and adoption



UAS Demand Forecasts

New UAS Enabled Market Representative Use Cases

3

Categories	Representative Use Cases	
HALE	Internet Service Provider	sUAS Monitoring
	Communications Relay	HALE Science Monitoring
Large	Large Cargo Distribution	Large Disaster Support
	Thin/Short Haul Passenger	Large Search and Rescue
	Large Border Patrol	Large Science Monitoring
Med/Small Rural BVLOS	Med/Small Cargo Distribution	Photogrammetry
	Pipeline Monitoring	Agriculture
	Road Monitoring	Med/Small Border Patrol
	Rail Monitoring	Med/Small Disaster Support
	Power Line Monitoring	Med/Small Search and Rescue
	Waterway/Shipping	Med/Small Science Monitoring
Med/Small Rural VLOS	FAR Part 107 Operations	Aerial Photography/Filming
	Infrastructure Inspection	Agriculture / Wildlife
Med Urban	Urban Air Taxi	Emergency Response
	Med Package Delivery	Med Urban Police Operations
Small Urban	Small Package Delivery	Surveillance/News/Traffic
	Infrastructure Inspection	Small Urban Police Operations

Economic Benefit Determination

4

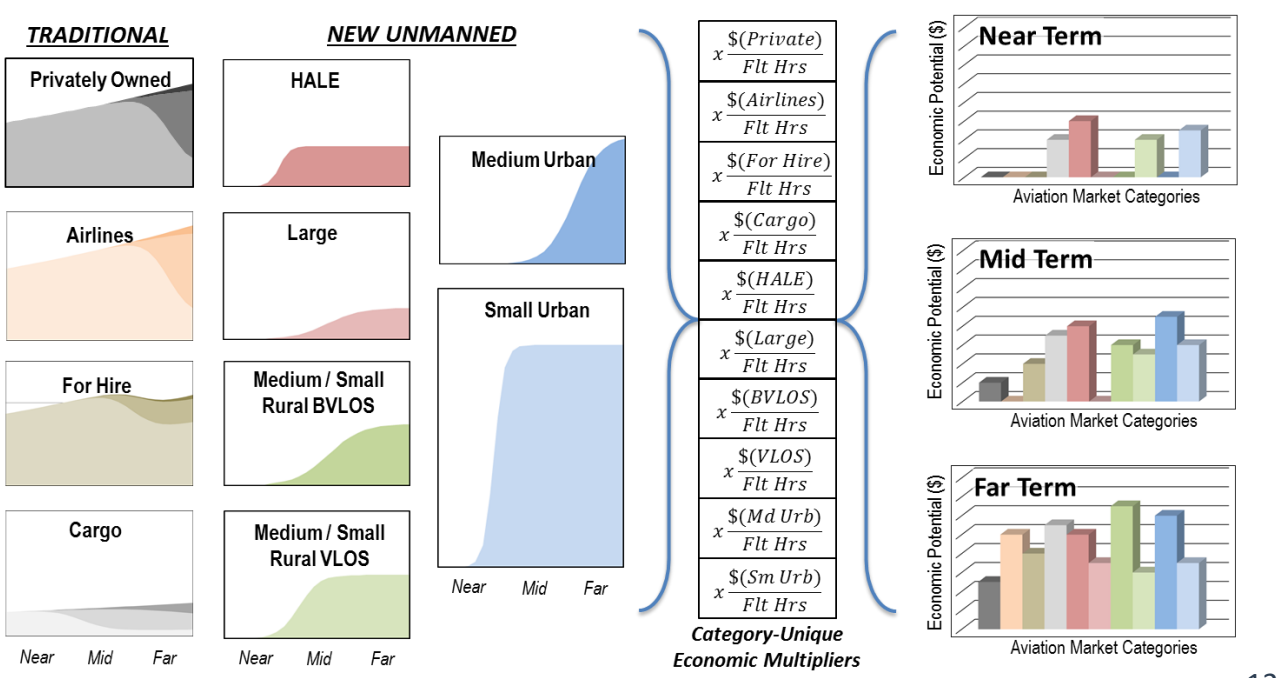
Objective: To determine the forecasted economic benefit and return on investment (ROI) for each aviation market. Compare results of the economic analysis across markets to identify the markets that provide the largest overall benefit to the nation.

Approach:

- **Ph. 1**: Conduct financial analysis to determine ROI multipliers for each UAS business case
- **Ph. 2**: Develop notional ROI curves for each category to validate the tool works properly
- **Ph. 3**: Work with Gov't & Industry to elicit inputs; use to refine tool & validate results

Results / Benefits:

- Ability to convert category-specific demand values into economic revenue
- Provides insight into which aviation markets provide the largest return on investment potential
- Tool allows different economic multipliers to be used for each unique business case



Requests for Assistance and Recommendations

Requests for Assistance:

- Provide feedback on overall approach, assumptions and proposed timeline
- Assist with identifying reference sources and subject matter experts
- Evaluate results of study for consistency and reasonableness

Recommendations:

- Socialize effort with other Gov't/Industry members to make them aware of the benefits this decision support tool can provide
- Periodically re-run analysis every few years to take into account real-world data, trends and new markets

Questions

BACKUP

Aviation Market Categories & Assumptions

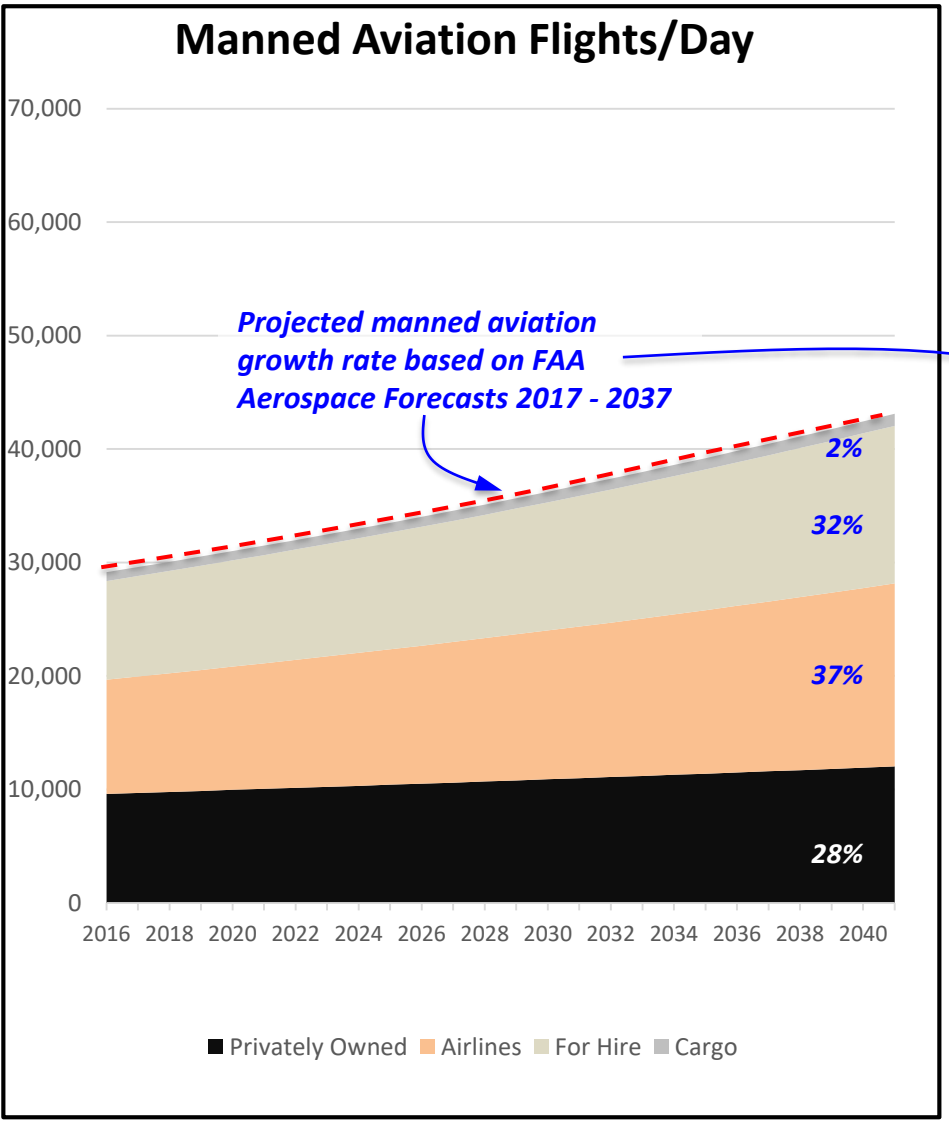
- Recommended aviation market categories:
  - **Privately Owned** (General Aviation; individual, corporate)
  - **Airlines** (Passenger Transport)
  - **For Hire** (Sight-seeing, Movies, Crop-dusting)
  - **Cargo Transport** (FedEx, DHL)
  - **New UAS Enabled Markets** (e.g. urban air mobility, package delivery, agriculture, photogrammetry, inspection, traffic monitoring, communication relay)

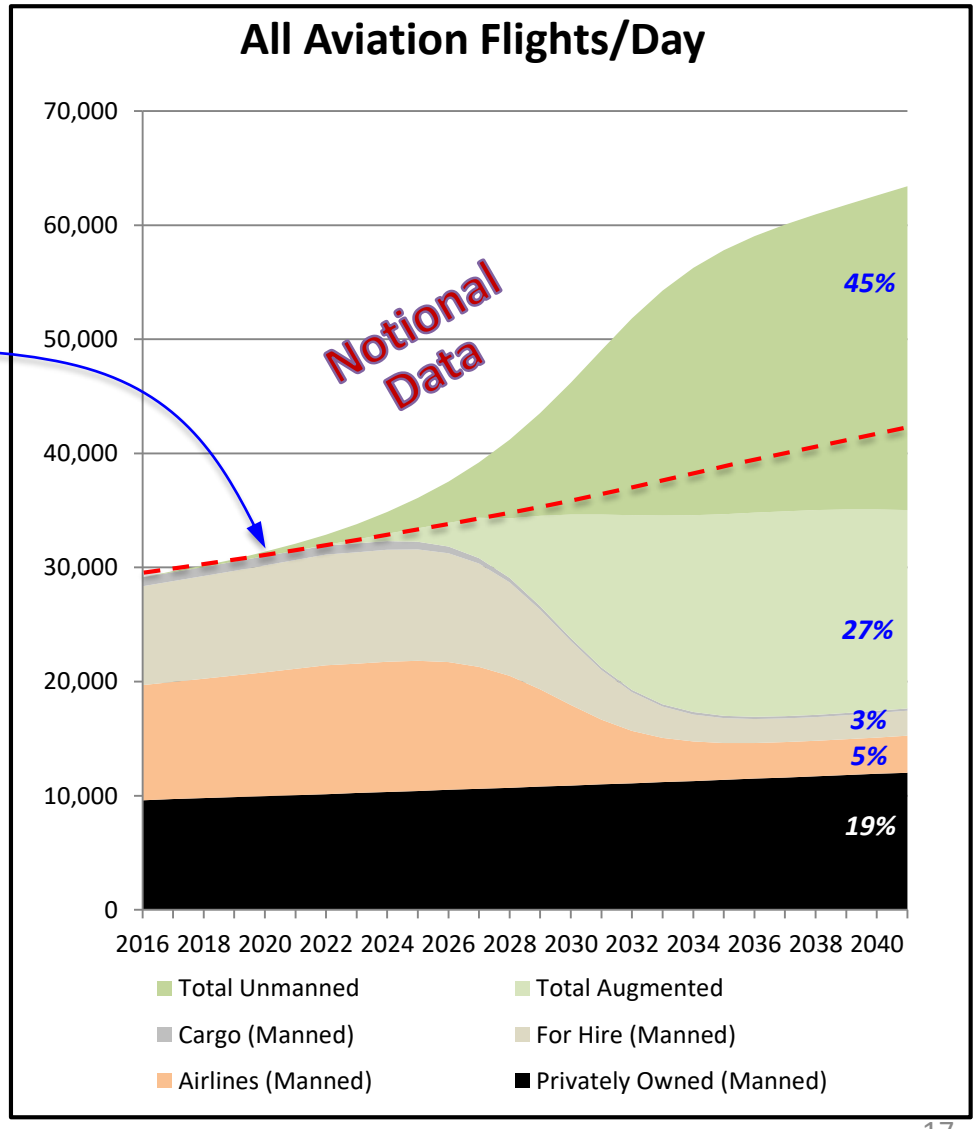
Traditional Aviation Categories

Market Name	General Assumptions
Privately Owned	• No change to FAA forecast. People who enjoy flying their own aircraft will continue doing so in the future.
Airlines	• Near term transition to "simplified vehicle operations", to include reduction to single pilot (automated or remote co-pilot). • Long term transition to unmanned cockpit aligned to fleet turnover & public acceptance
For Hire	• Same as Airlines, with a noted reduction as Urban Air Mobility (UAM) will likely overtake a portion of the market
Cargo Transport	• Same as Airlines • Does not include sUAS FAR Part 107 package delivery (see New Unmanned below)
New UAS Enabled	• Divided into 6 categories: 1) HALE 2) Large, 3) Medium/Small Rural BVLOS, 4) Medium/Small Rural VLOS, 5) Medium Urban, 6) Small/Urban

Military Aviation & Hobbyist categories are excluded due to them being out of scope

Example Plots from the UAS Demand Tool





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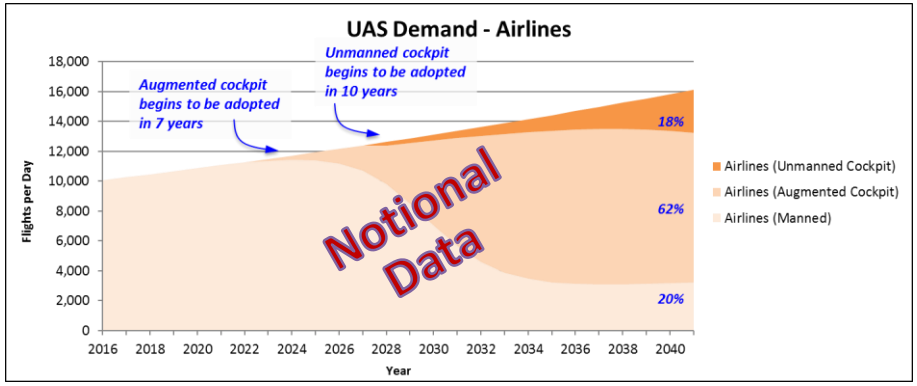
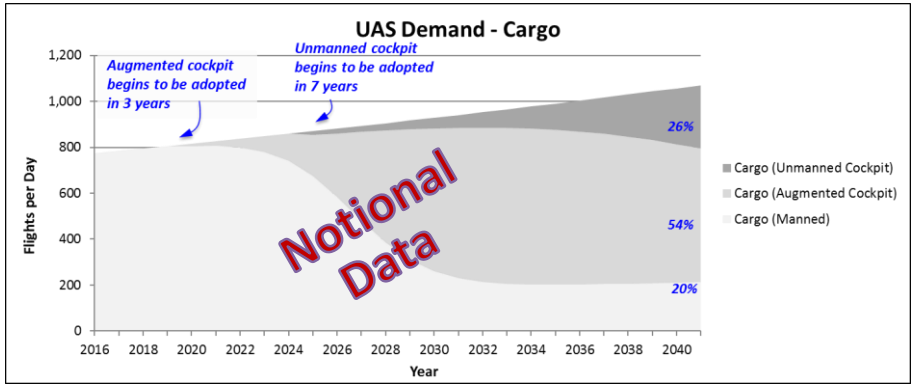
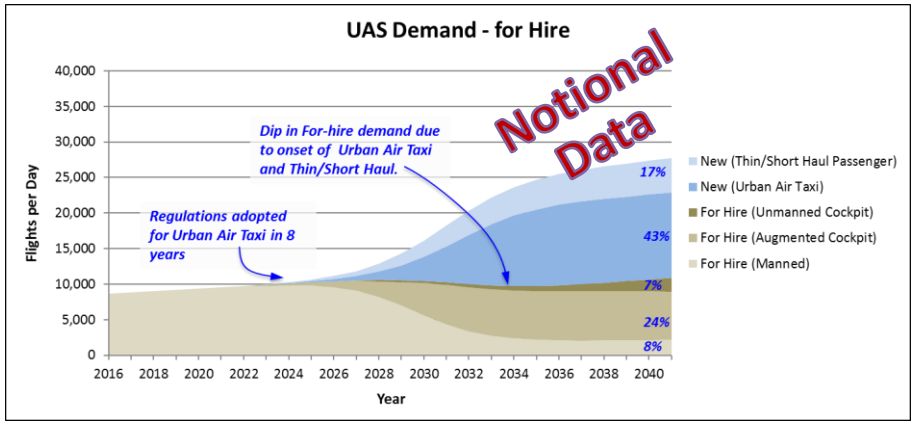
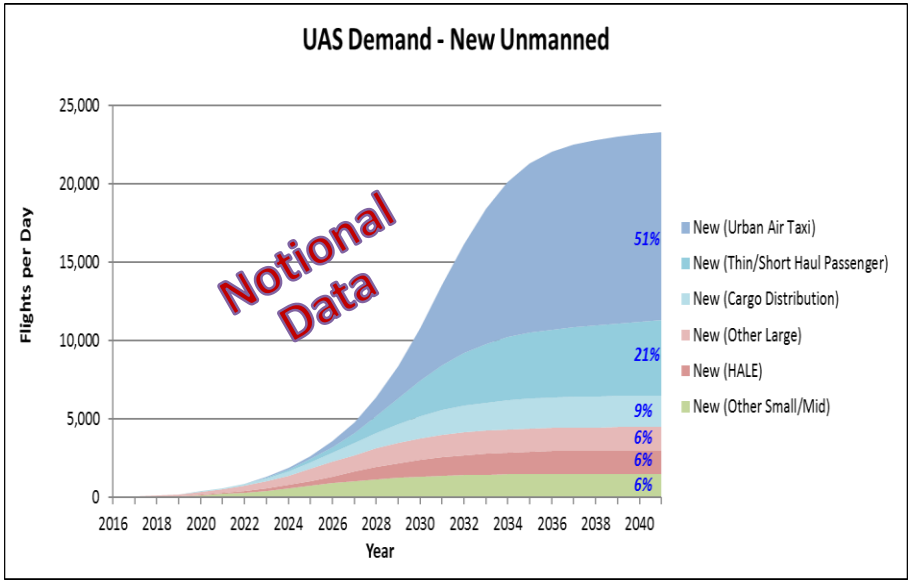
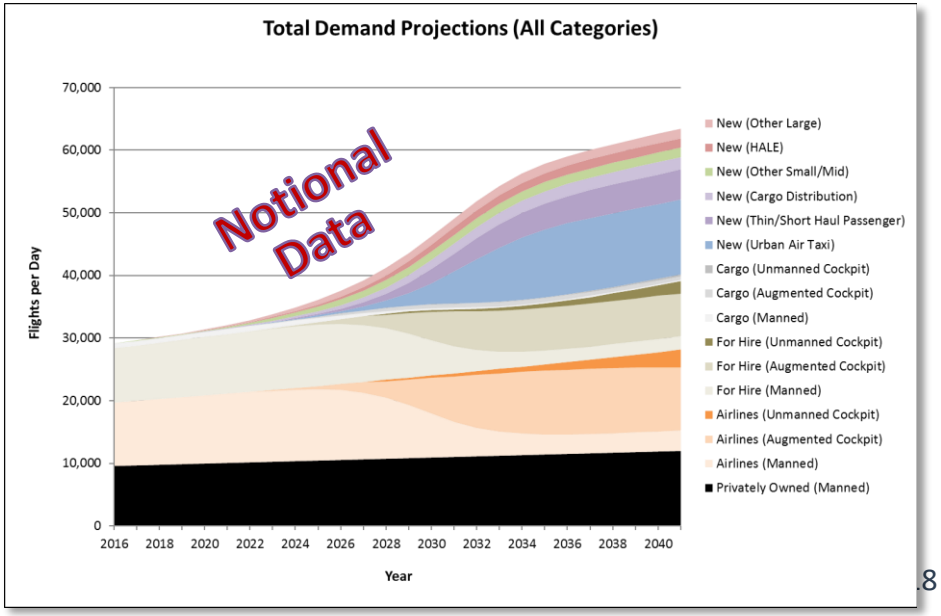




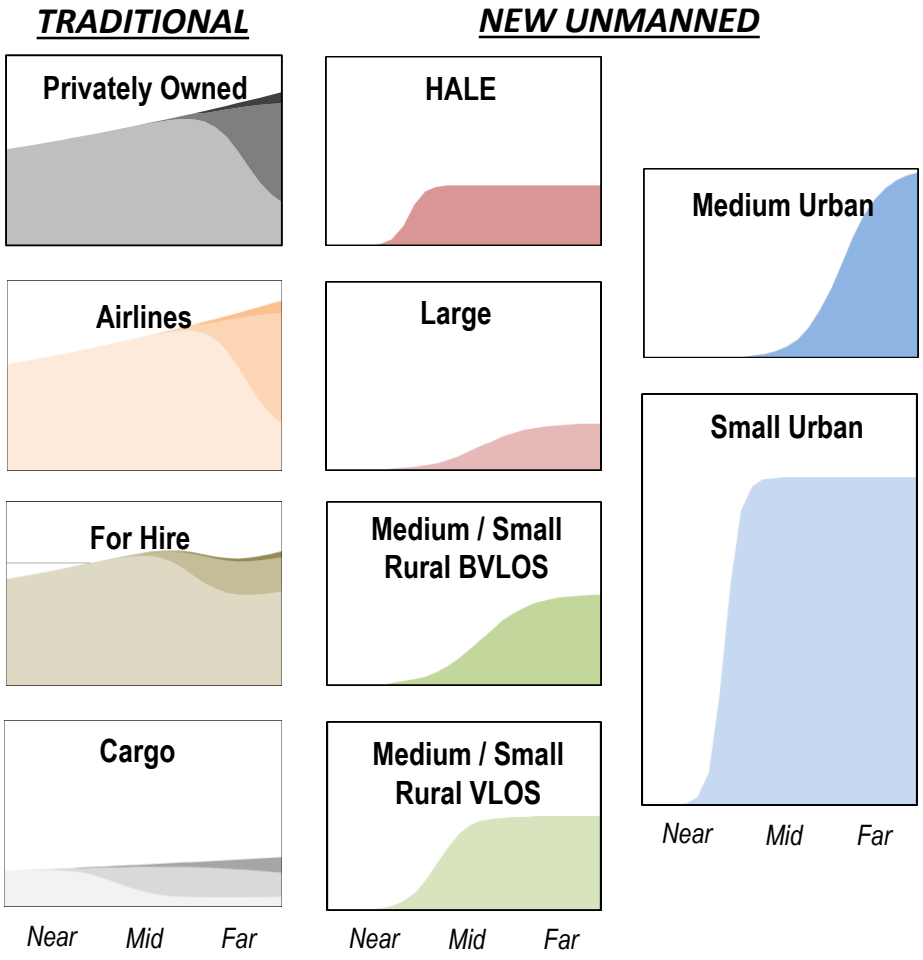






Proposed Approach for Quantifying UAS Demand

UAS Demand Forecasts by Market Category



$x \frac{\$(Private)}{Flt\ Hrs}$

$x \frac{\$(Airlines)}{Flt\ Hrs}$

$x \frac{\$(For\ Hire)}{Flt\ Hrs}$

$x \frac{\$(Cargo)}{Flt\ Hrs}$

$x \frac{\$(HALE)}{Flt\ Hrs}$

$x \frac{\$(Large)}{Flt\ Hrs}$

$x \frac{\$(BVLOS)}{Flt\ Hrs}$

$x \frac{\$(VLOS)}{Flt\ Hrs}$

$x \frac{\$(Md\ Urb)}{Flt\ Hrs}$

$x \frac{\$(Sm\ Urb)}{Flt\ Hrs}$

Category-Unique Economic Multipliers

Economic Market Potential