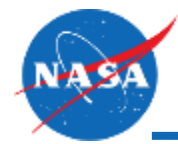


An aerial photograph of a coastal city, likely San Francisco, with a bay on the left and a cityscape on the right. The sky is filled with various aircraft, including commercial jets, private planes, and several drones. A semi-transparent white box is overlaid on the left side of the image, containing the title and date.

Unmanned Aircraft Systems Demand & Economic Benefit Forecast Study

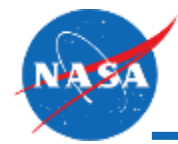
AUVSI XPONENTIAL
30 April 2018



Acknowledgements

- This study is being performed on behalf of the NASA Aeronautics Research Mission Directorate (ARMD). The team assembled to conduct this effort includes various representatives from government and industry; National Aeronautics and Space Administration (NASA), Modern Technology Solutions, Inc. (MTSI), and Aerospace Corporation.





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).

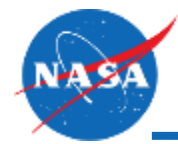
Scope

- **Region:** US-based Markets 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

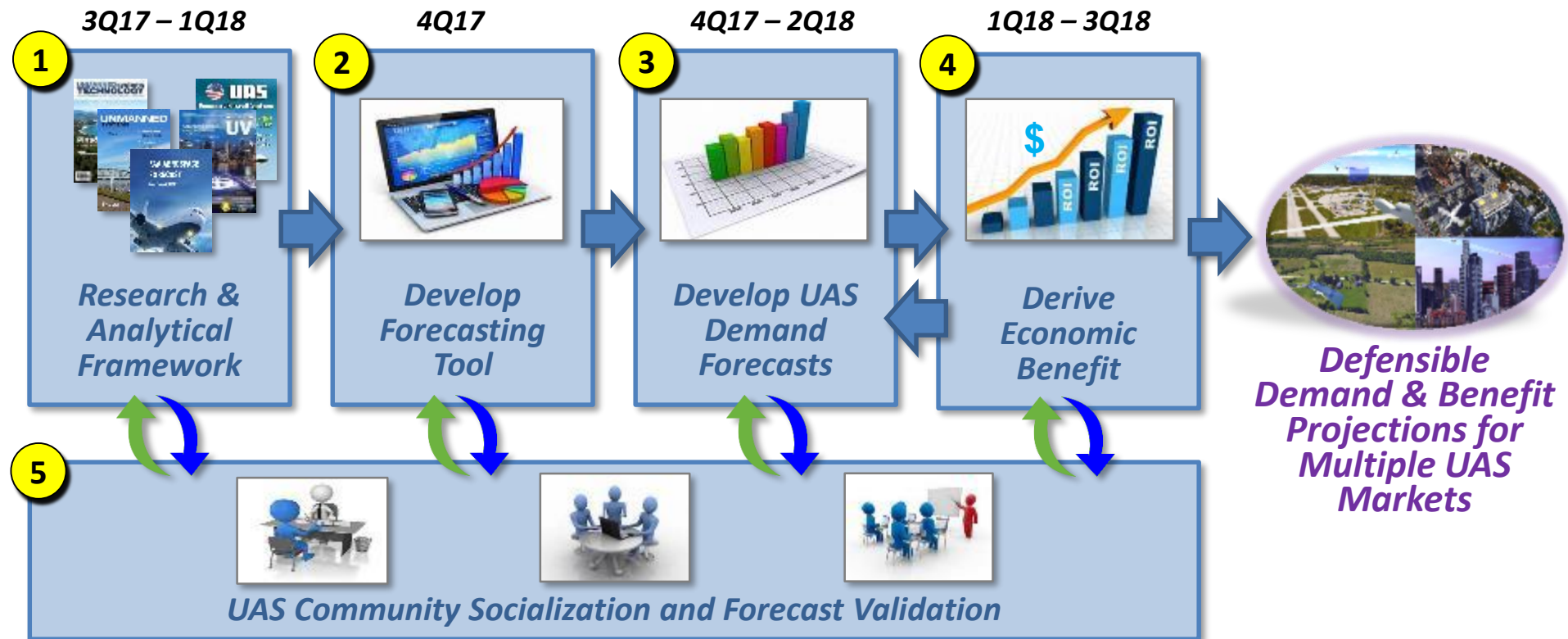
Assumptions

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

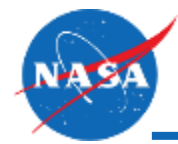




Study Approach & Timeline



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.



Conduct Research & Define Analytical Framework

1

Research & Analytical Framework

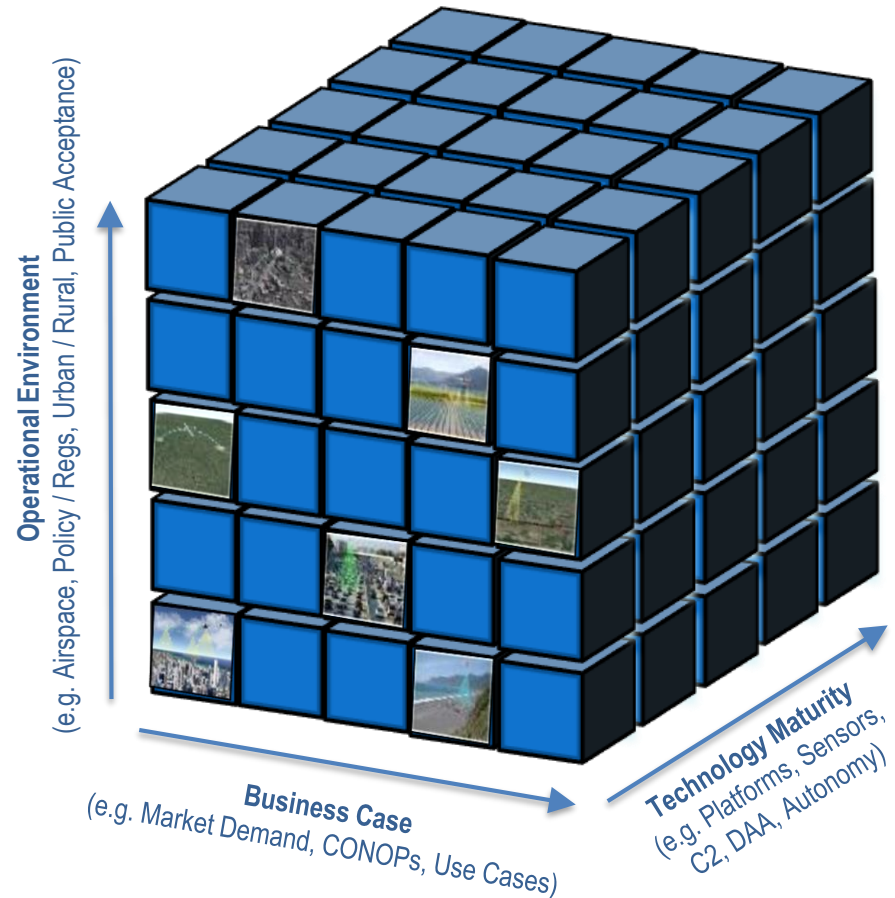
Objective: To gain an appreciation for the vast array of UAS business cases and key drivers that will impact demand and market adoption.

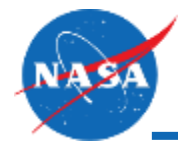
Approach:

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

Results / Benefits:

- Most likely UAS business cases identified
- Key drivers impacting adoption timeframe (e.g. Public Acceptance, Technology Maturity, Levels of Automation, Regulatory Timeframe)
- How to handle different UAS CONOPs (e.g. multi-day missions vs dozens of flights per day)
- Best Analytical Framework for study defined
- Best metrics used to quantify UAS demand & economic benefit





Aviation Market Categories used in Study

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 over both rural and urban settings, well above traditional manned aircraft at high altitudes (>60K ft), for very long endurance (days/weeks/months) missions.
	IFR-Like	Expanding UAS market that increases traditional densities of the NAS, performs long distance and/or long endurance missions at a higher altitudes (18K ft - 60K ft); integrating exclusively with cooperative aircraft.
	VFR-Like	Early UAS market that will operate BVLOS over rural and populated areas at altitudes below critical NAS infrastructure (10K ft – 18K ft); routinely integrating with cooperative and non-cooperative general aviation aircraft.
	Urban Passenger Transport	Newly emerging market that requires high density VTOL operations for on demand, affordable, quiet, fast, transportation of people in a scalable and conveniently accessible verti-port network .
	Low Altitude Urban	Rapidly expanding market that uses fixed wing and VTOL UAS operating below 400 ft and BVLOS to deliver packages and offer a wide range of services to high density urban settings.
	Low Altitude Rural	Emerging market that includes fixed wing and VTOL UAS, ranging in size and capability, that operate beyond visual line of sight (BVLOS) in Class G airspace and above low-risk rural locations.
	VLOS	Growing existing market, partially enabled by Far Part 107, that includes visual line-of-sight (VLOS) fixed wing and VTOL UAS (<55 lb) operating below 400 ft.

*Traditional Markets are the categories the FAA has historically tracked for manned aviation.

** UAS Enabled Market Categories are based largely on projected topics for periodic policy / regulatory releases



UAS-Enabled Market Categories used in Study

HALE Low risk BVLOS ops above IFR-controlled airspace. (E.g. Internet Service Provider)



IFR-LIKE Moderate risk BVLOS ops within IFR-controlled airspace, integrated with traditional air traffic and ATM services. (E.g. Long-distance Cargo Transport)



VFR-LIKE High risk BVLOS ops below NAS infrastructure, integrated with both cooperative and non-cooperative aircraft. (E.g. Border Surveillance, Regional Cargo Delivery)



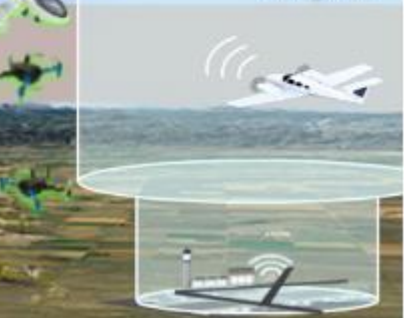
URBAN PASSENGER High risk BVLOS operations within dense controlled ATM and UTM environments and uncontrolled airspace.



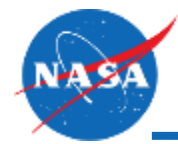
LOW ALT. RURAL Low risk BVLOS rural operations integrated with General Aviation aircraft (E.g. Linear Inspection)



LOW ALTITUDE URBAN Moderate risk BVLOS small UAS operations over populated areas using UTM services



VLOS Very low risk VLOS rural/urban operations. (E.g. Infrastructure Inspection, Agriculture)



Forecasting Tool Development

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

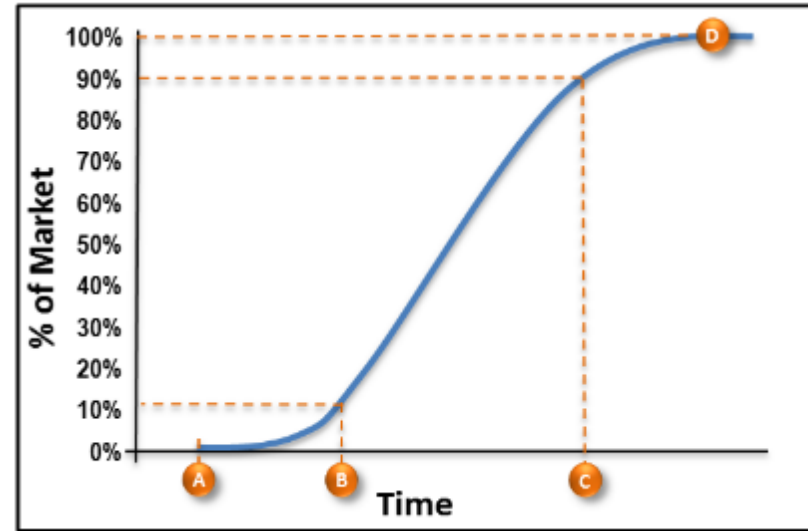
Approach:

- **UAS Demand:** 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)
- **Economic Benefit:** Modify the existing Aerospace Corporation-developed Cumulative UAS Benefit to the Economy (CUBE) Tool

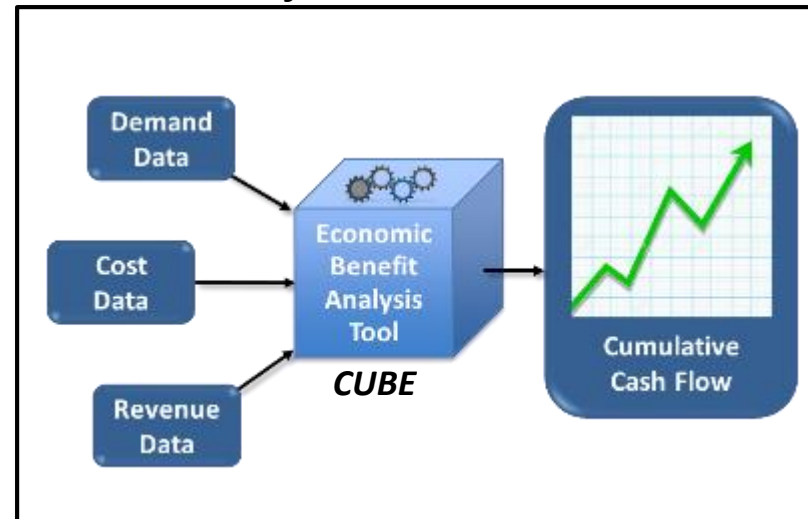
Results / Benefits:

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

UAS Demand



Economic Benefit



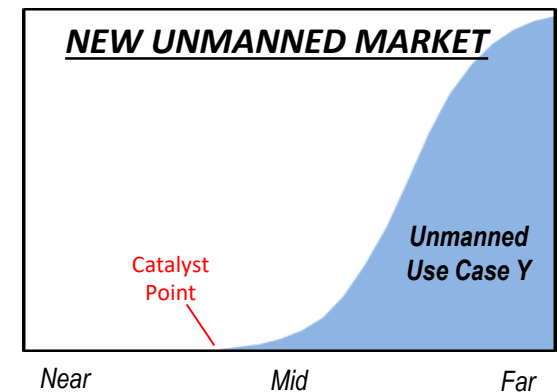
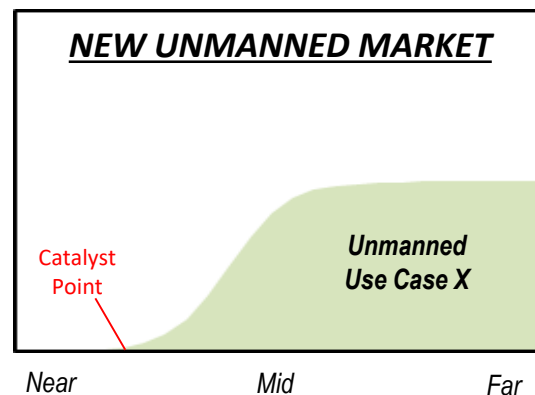
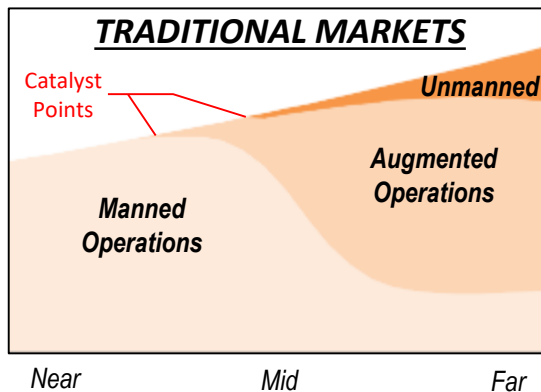
Objective: To generate defensible UAS demand forecasts for each aviation market category based on community supplied inputs and rationale. Periodically update UAS Demand forecasts as new data becomes available.

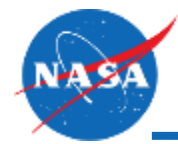
Approach:

- **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





Economic Benefit Determination

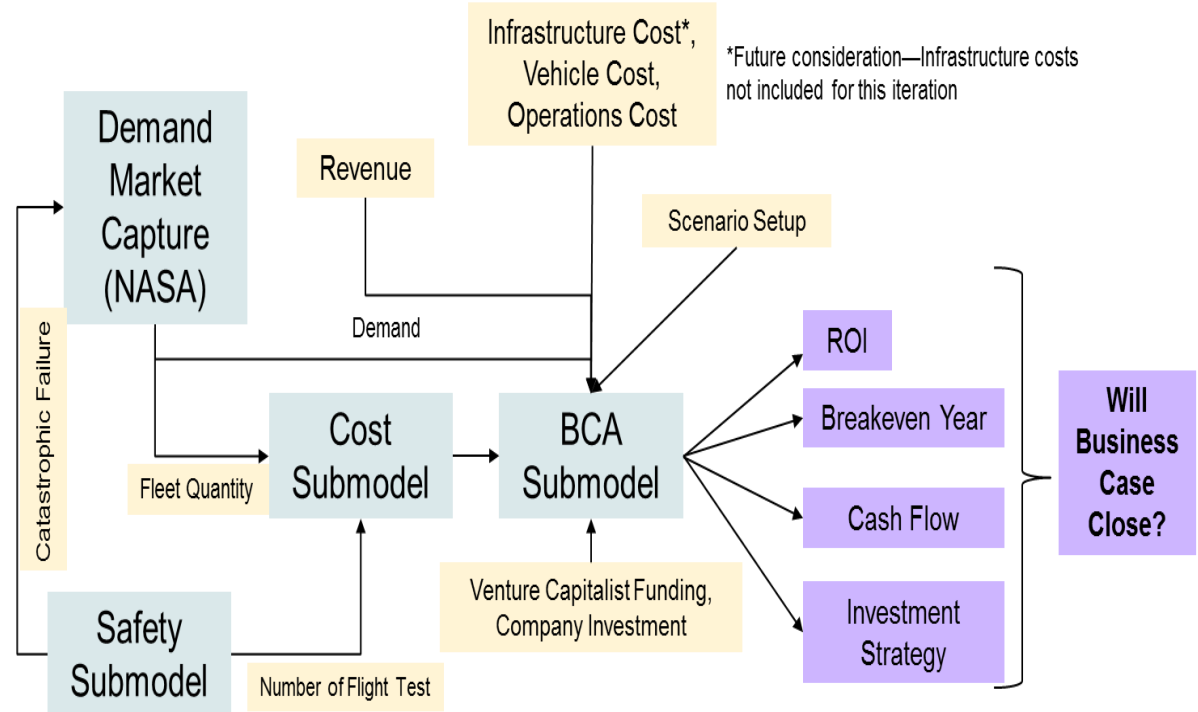
Objective: To determine the forecasted economic benefit and return on investment (ROI) for each aviation market. Compare results of the economic analysis across markets to identify the markets that provide the largest overall benefit to the nation.

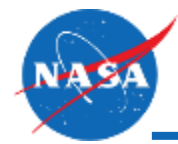
Approach:

- **Ph. 1:** Conduct financial analysis to determine ROI multipliers for each UAS business case
- **Ph. 2:** Develop initial 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:

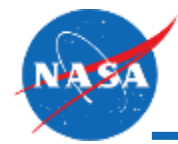
- Ability to convert use-case demand values into economic revenue
- Provides insight into which aviation markets provide the largest return on investment potential
- Tool allows different economic multipliers to be used for each unique business case





Sample Results for 2 Representative Use Cases

Use Case	Market Category	
	<p>Package Delivery</p>	<p>Low Altitude Urban</p>
	<p>Internet Service Provider</p>	<p>HALE</p>



UAS Demand: Package Delivery

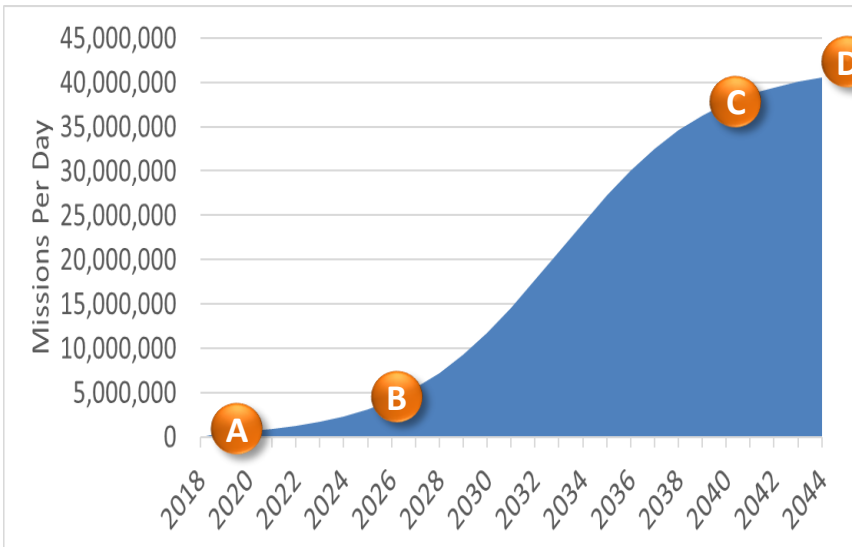
Use Case: Package Delivery



Supporting Research:

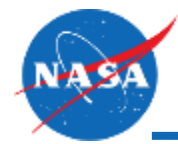
Sub Use Cases	Calculated Estimates
Parcels	38.5 million per day
Prepared Food	3 million per day
Groceries	166 thousand per day
Flowers	82 thousand per day
TOTAL	41.8 million per day

UAS Demand:



Date Projections:

Start year	A	2019 (Initial ops, trial cases)
10% Growth	B	2026 (Regs/Infrastructure finalized)
90% Growth	C	2040 (Country-wide ops)
Total Saturation	D	2044+ (Market saturation)



UAS Economic Benefit: Package Delivery

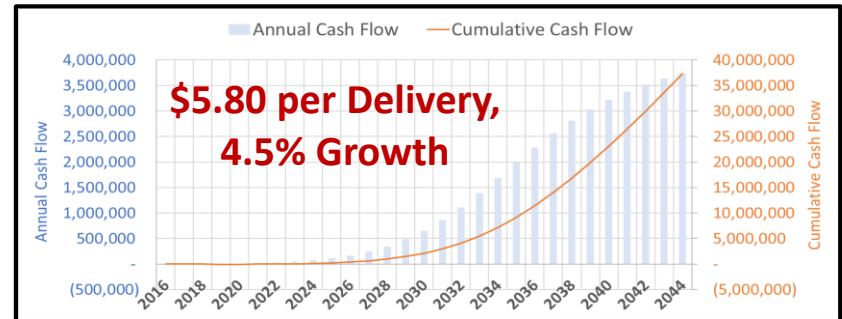
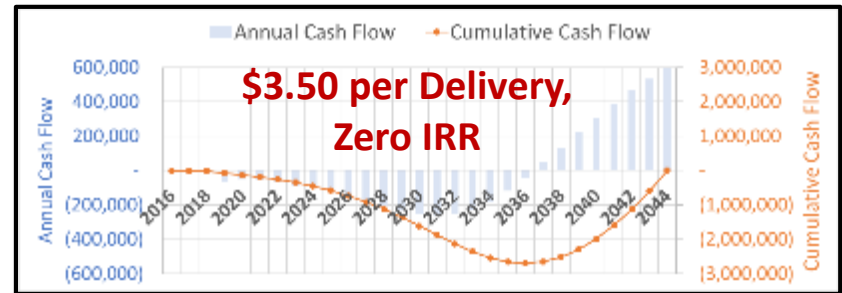
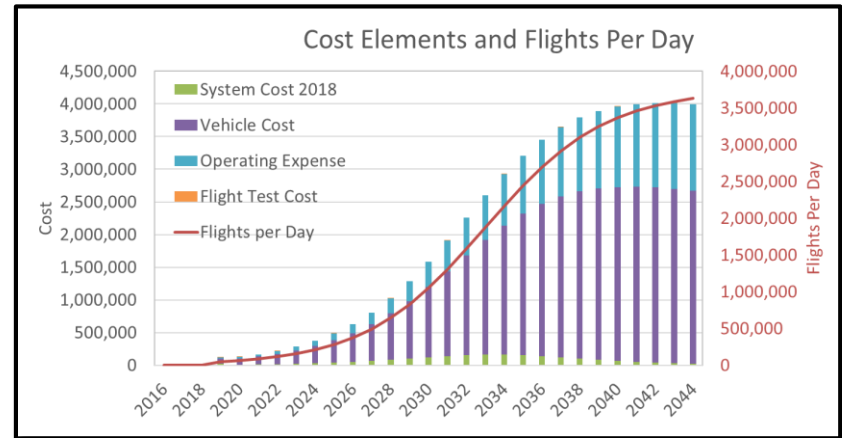
Assumptions:

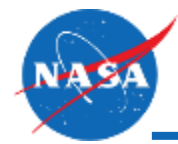
- Vehicle design life = 1 yr
- Av. delivery time = 0.5 hrs
- Return/Recharge time = 1.5 hrs
- Utilization = 60%
- Operational days/yr = 365
- Vehicle specifications
 - VTOL
 - Distribution hub to receiving vessels or custom location
 - Distance: 10 mile radius
 - Speed: Up to 50 mph
 - Altitude: 200-500 feet
 - Payload capacity: 5 lbs
- Not Included:
 - Development Costs
 - Infrastructure Costs
 - Sunk costs

Key Findings:

- Feasible for Business case to close
- Closure timing dependent on customer willingness to pay delivery surcharge
- Other...

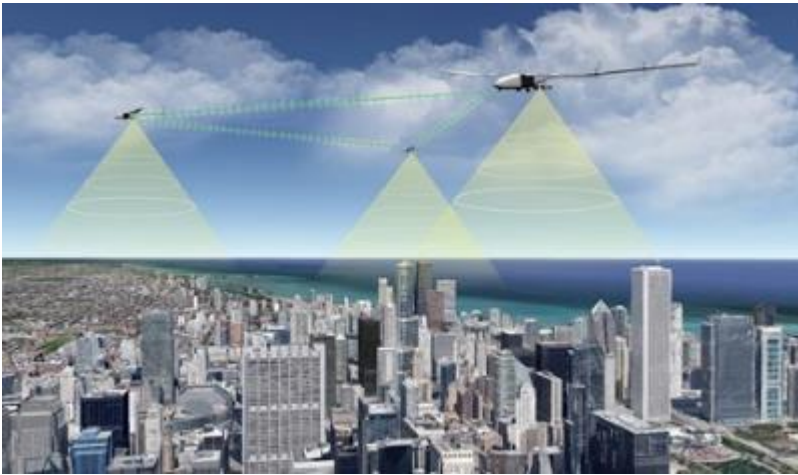
Economic Benefit Plots:



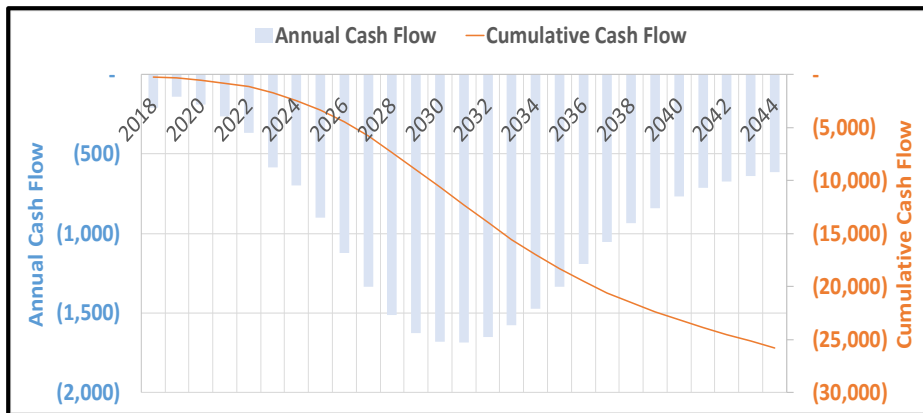


UAS Demand: HALE Internet Service Provider

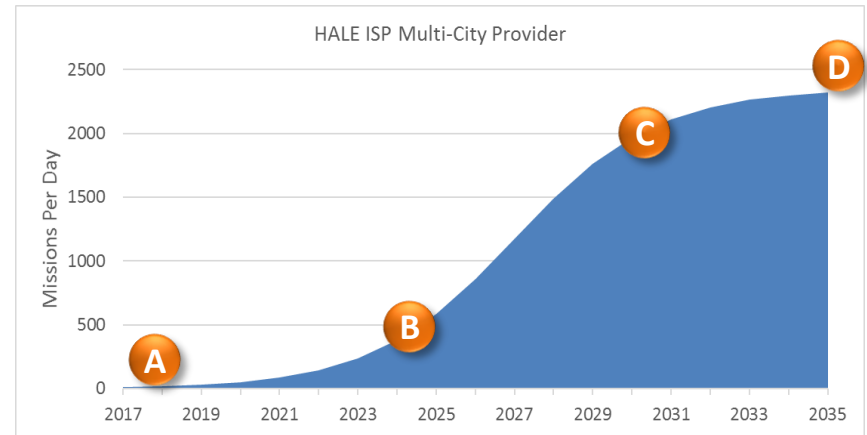
Use Case: HALE Internet Service Provider



Economic Benefit:

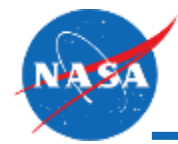


UAS Demand:



Key Findings:

- The Internet Service Provider (ISP) Use Case does not close for a single payload HALE system
- For this Use Case to be viable, consider the following:
 - Add additional payloads to have multiple funding streams
 - Charge higher service charge (may not be feasible if there are cheaper alternatives)
 - Business case may be limited to areas of world without existing infrastructure.

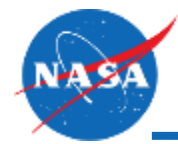


UAS Enabled Market Representative Use Cases

Progress to Date

TRADITIONAL MARKETS		
Existing Routes	<input type="checkbox"/> Airlines- % of Existing Routes	<input type="checkbox"/> For Hire- % of Existing Routes
	<input type="checkbox"/> Cargo- % of Existing Routes	<input type="checkbox"/> Gen Aviation- % of Existing Routes
NEW MARKETS		
HALE	<input type="checkbox"/> High Alt. ISP/Comm	<input type="checkbox"/> High Alt. Science Monitoring
	<input type="checkbox"/> New Regional Cargo	<input type="checkbox"/> sUAS Monitoring
IFR-Like	<input type="checkbox"/> ISP/Comm	<input type="checkbox"/> Thin/Short Haul Passenger
	<input type="checkbox"/> New Intermediate Cargo	<input type="checkbox"/> Area Science Monitoring
VFR-Like	<input type="checkbox"/> Area First Responder	<input type="checkbox"/> Area Infrastructure Surveillance
	<input type="checkbox"/> Border Patrol	<input type="checkbox"/> Area Science Monitoring
	<input type="checkbox"/> Area Surveillance	
	<input type="checkbox"/> Rural Package Delivery	<input type="checkbox"/> Precision First Responder
Low Alt Rural	<input type="checkbox"/> Linear Infrastructure Inspection	<input type="checkbox"/> Precision Science Monitoring
	<input type="checkbox"/> Photogrammetry	<input type="checkbox"/> Advertising
	<input type="checkbox"/> Agriculture	
	<input type="checkbox"/> Urban Air Taxi (Point to Point)	<input type="checkbox"/> Urban Vehicle (Owner Operated)
Urban Passenger	<input type="checkbox"/> Urban Commuter (Set Routes)	<input type="checkbox"/> Urban Ambulance
	<input type="checkbox"/> Urban Package Delivery	<input type="checkbox"/> Urban Surveillance/Traffic/News
Low Alt Urban	<input type="checkbox"/> Urban Infrastructure Inspection	<input type="checkbox"/> Urban First Responders
	<input type="checkbox"/> Aerial Photography	<input type="checkbox"/> Security/Emergency Mgmt
VLOS	<input type="checkbox"/> Aerial Filming/News	<input type="checkbox"/> Advertising/Entertainment
	<input type="checkbox"/> Structural/Inspection/Survey	

<input type="checkbox"/> Initial Research	<input type="checkbox"/> Demand Results	<input type="checkbox"/> Economic Benefit	<input type="checkbox"/> Data Validation
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Questions



Points of Contact:

Jak Linkel

jak.linkel@mtsi-va.com

703-564-3842

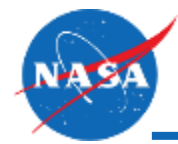


Jennifer Noble

jennifer.j.noble@aero.org

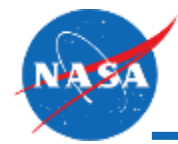
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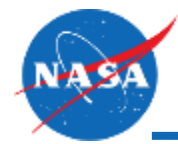
BACKUPS

- Only use the 2 slides that follow if we receive the final Cargo economic benefit data in time for the conference.



Sample Results for 3 Representative Use Cases

Use Case	Market Category
	<p>Package Delivery</p> <p>Low Altitude Urban</p>
	<p>Internet Service Provider</p> <p>HALE</p>
	<p>Regional Cargo Transport</p> <p>IFR-Like</p>



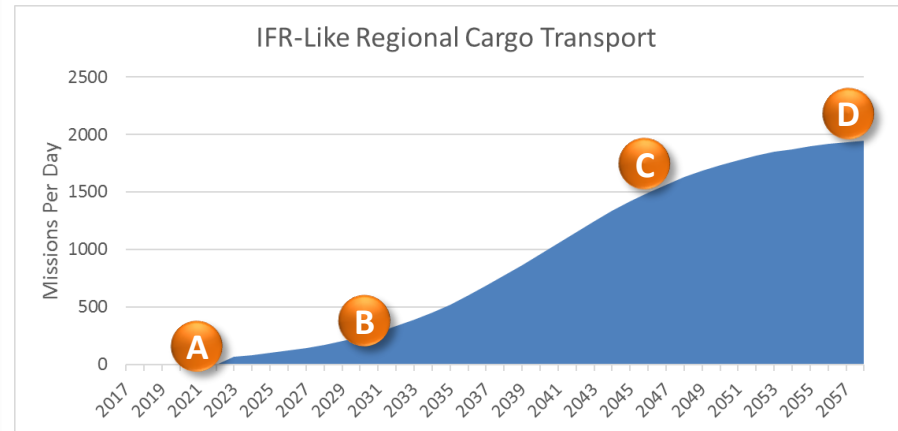
UAS Demand: Regional Cargo Transport

Use Case: Regional Cargo Transport



Economic Benefit:

UAS Demand:



Key Findings:

- Tbd
- Tbd