

# NASA Systems Analysis

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8/20/2025

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# EPFD Systems Analysis Team

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**Andrew J. Meade:** former Systems Analysis Co-Lead

# Near Term Hybrid Regional Turboprop Analysis

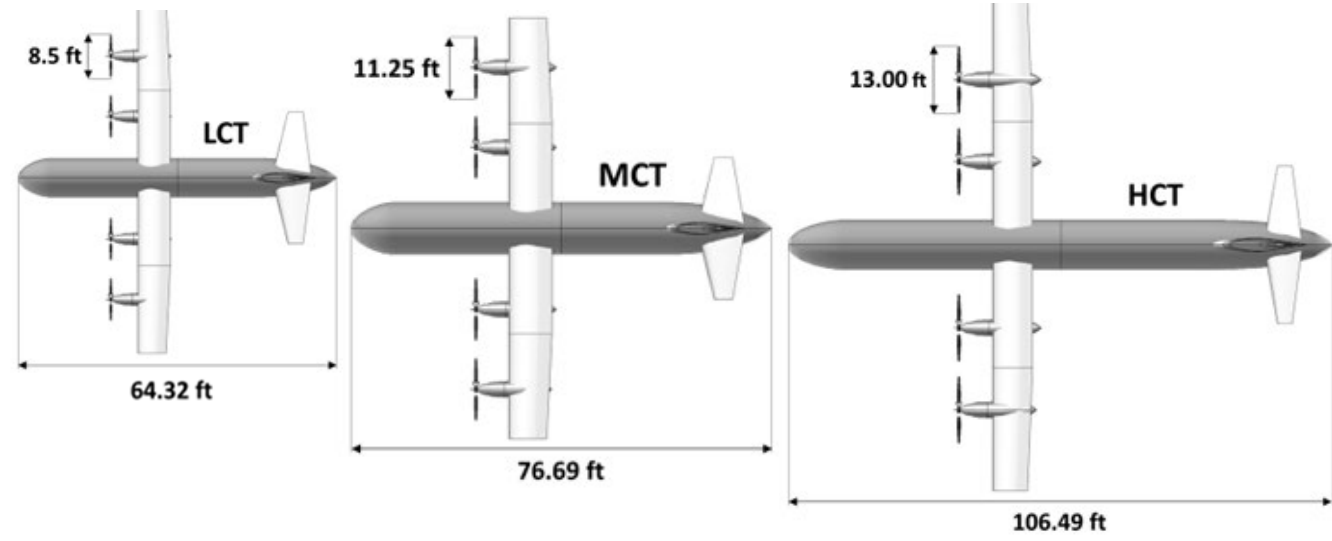
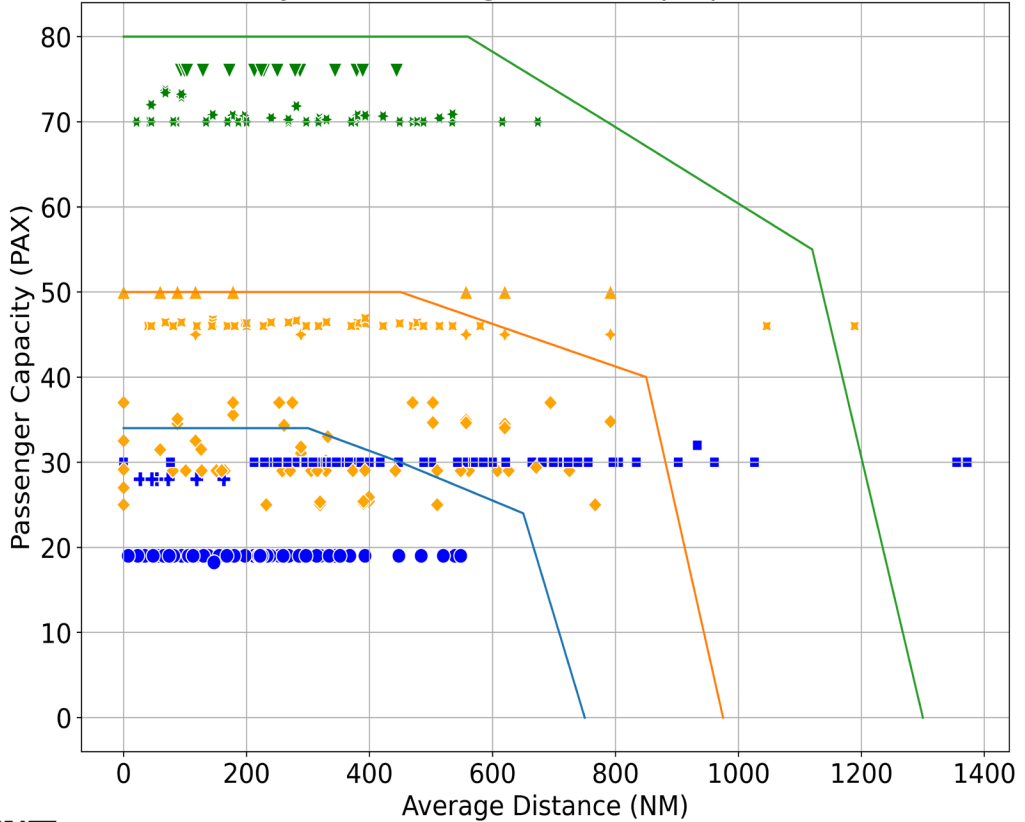
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# Baseline Vehicle Synthesis & Fleet-Wide Payload-Range Analysis

- Aircraft Type**
- Beech 1900 A/B/C/D
  - ▲ De Havilland DHC8-300
  - + Saab-Fairchild 340/B
  - ◆ De Havilland DHC8-100
  - Dornier 328
  - NASA 34 PAX (LCT)
  - ◆ Saab 2000
  - ✱ Aerospatiale/Aeritalia ATR-42
  - NASA 50 PAX (MCT)
  - ▼ De Havilland DHC8-400
  - ✱ Aerospatiale/Aeritalia ATR-72
  - NASA 80 PAX (HCT)

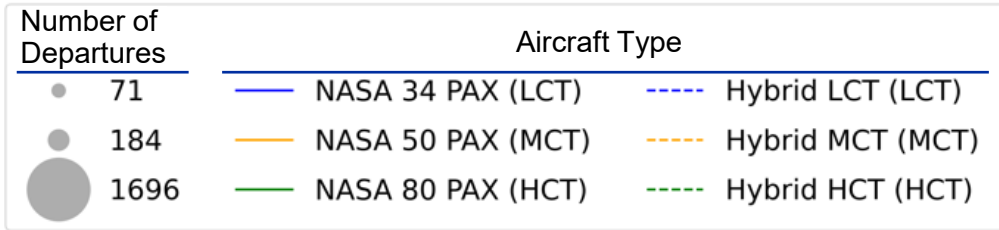
Payload vs. Range for Turboprop Aircraft



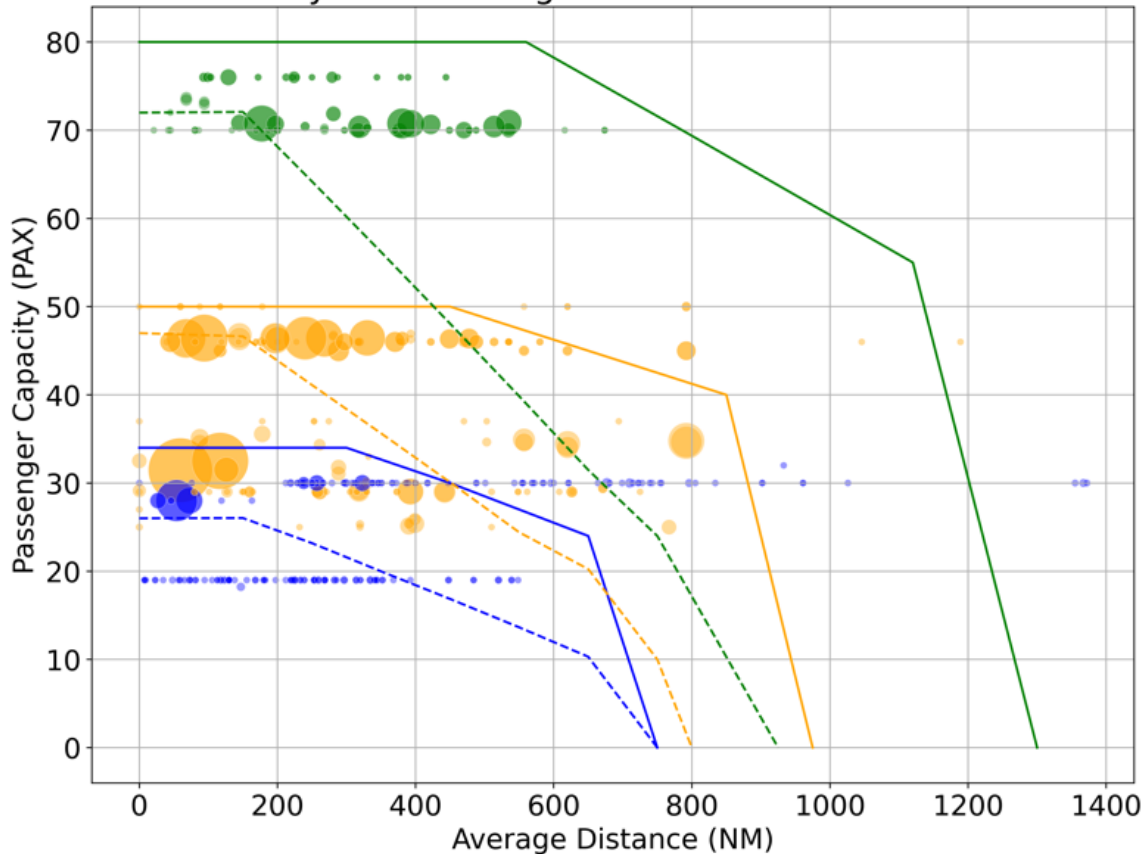
Parameter	LCT	MCT	HCT
Max. Gross Takeoff Weight, lb	29,000	42,000	63,380
PAX Capacity	30-34	45-50	76-80
Wing Loading, psf	64.44	72.04	86.77
Max. Takeoff Power, shp	3,500	4,480	9,184
Percent Total Departures Captured	36%	67%	99%



# Hybridization Impacts on Fleet-Wide Route Capture



Payload vs. Range for All Studied Aircraft



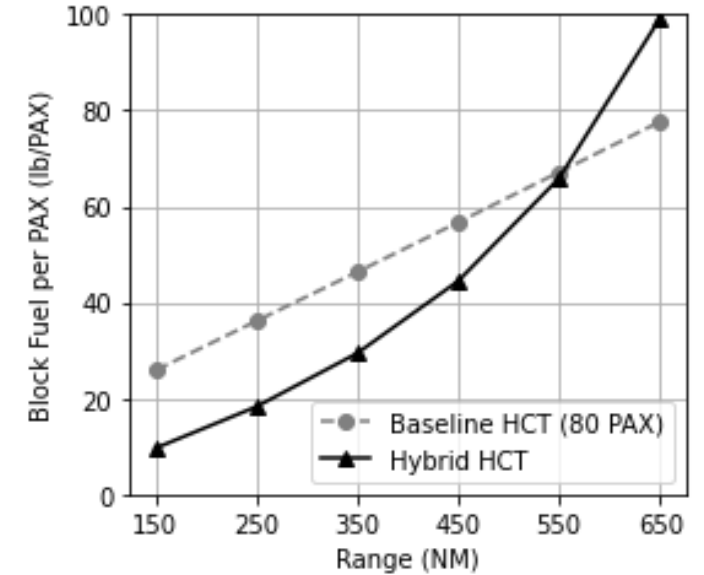
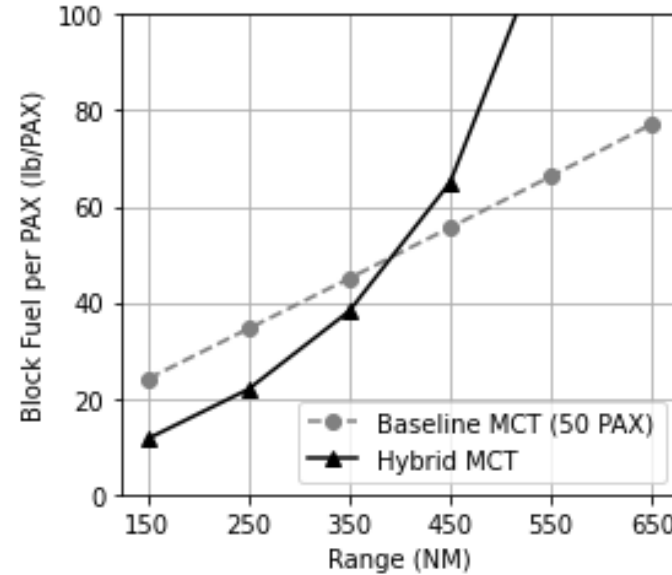
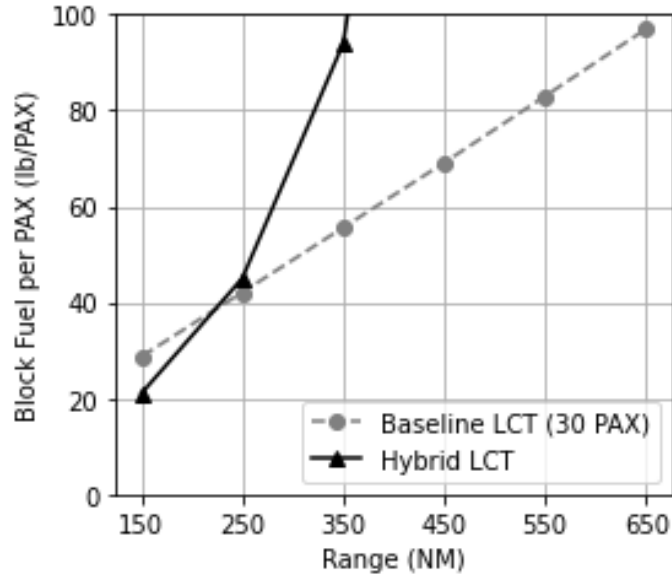
	LCT	MCT	HCT
Baseline Percent of Total Departures Captured	36%	67%	99%
Hybrid-Electric Percent of Total Departures Captured	1%	50%	72%

- Hybrid-electrification yields significant reduction in mission capability particularly in the realm of payload capacity where smaller seat-classes are more heavily penalized
  - Retrofit: battery + fuel + payload = constant
- Route accessibility scales with aircraft size – may require larger aircraft to maintain coverage for majority of flights where hybrid HCT captures 72% of total departures with up to 55% fuel savings



# Scaling/Crossover Analysis Results

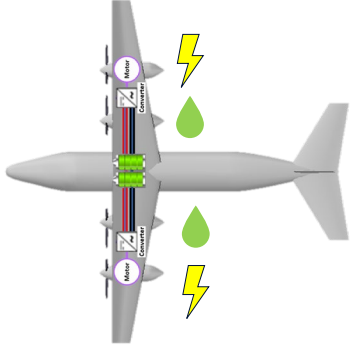
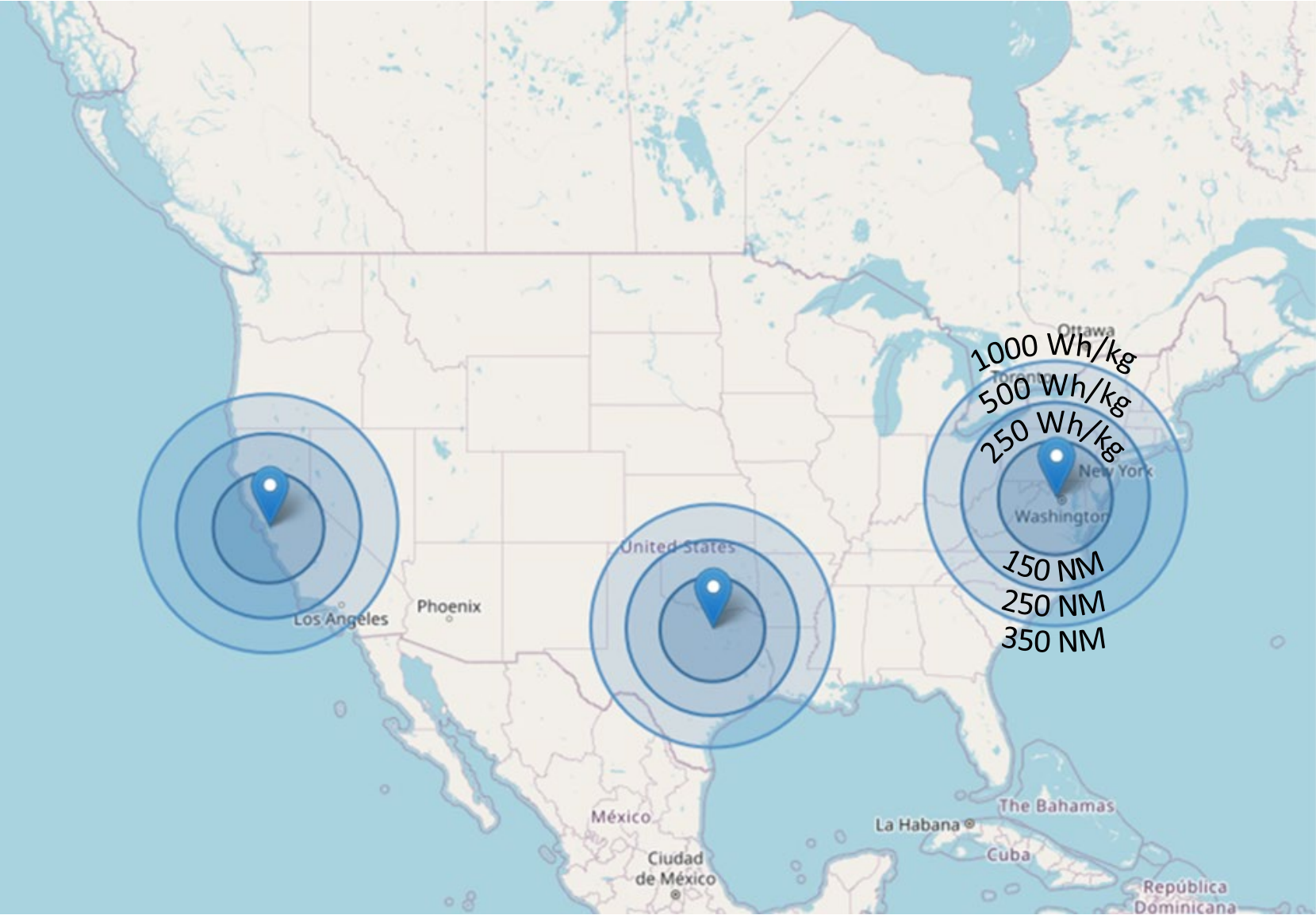
Crossover points mark the range at which each hybrid-electric concept achieves a balance between payload efficiency and fuel savings relative to its baseline counterpart



At the Crossover Point	Hybrid LCT	Hybrid MCT	Hybrid HCT
Range, NM	250	400	550
Hybrid Payload, PAX	16	30	63
BF per PAX, lb/PAX	45.0	50.2	65.8
Block Fuel Savings	42%	40%	38%
Block Energy Savings	35%	31%	30%



# 50 PAX Near-Term Regional Turboprop Operations Tradespace

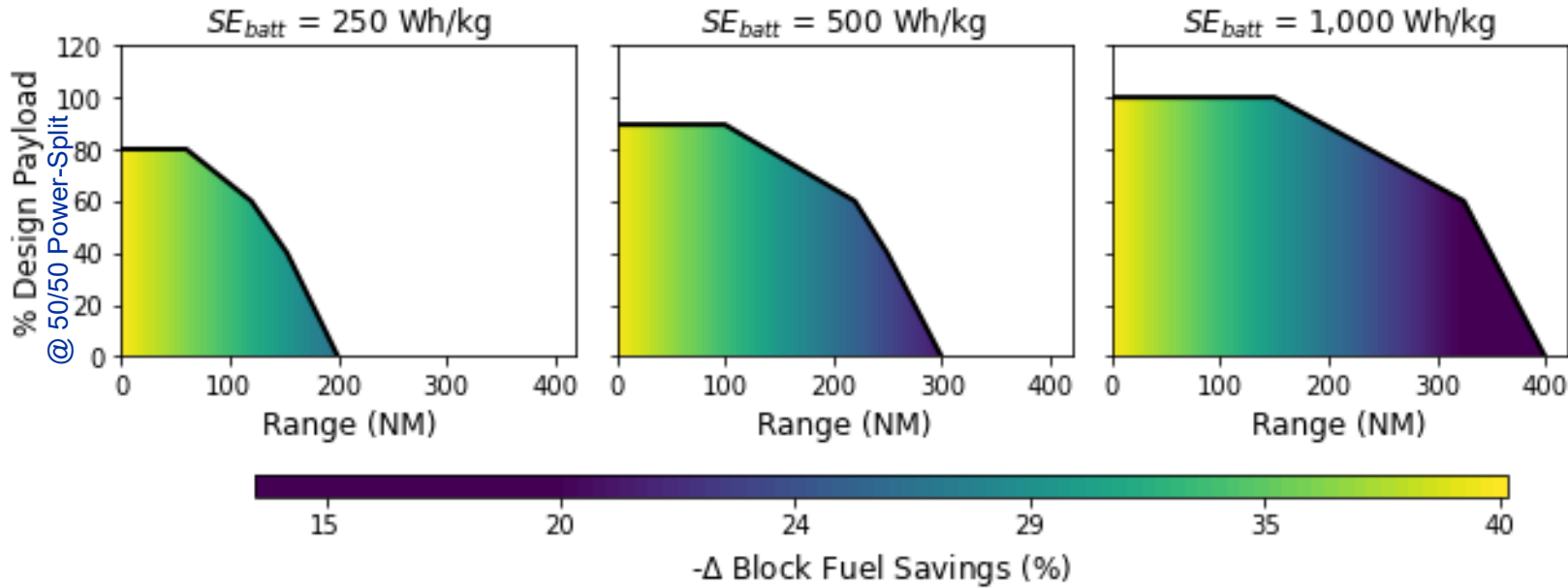


50/50 Cruise Power Split  
At 20% of Design Payload

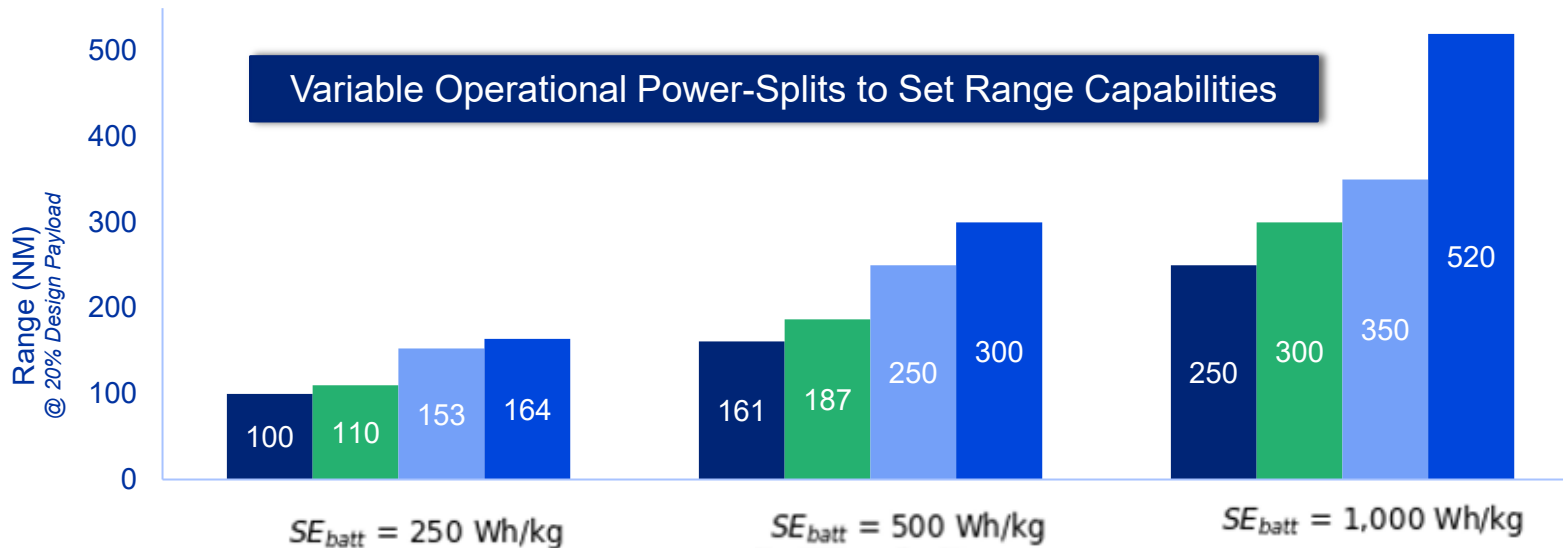
For the same aircraft, improvements in Battery Specific Energy expand maximum range performance, allowing for improved market coverage



# Hybrid-Electric 50 PAX Regional Turboprop Payload-Range



- Payload capacity and range performance expands with improvements to battery technologies
- Parallel-hybrid architecture enables flexibility in efficient power-split throughout flight to achieve target ranges at optimal fuel savings



Potential for purpose-built, “mission-optimized” EAP to meet operational demands of specific routes, markets, and policy goals



# Hybrid Electric Turboprop Commercial Freighter Analysis

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# Hybrid Electric Turboprop Commercial Freighter (HETCOF)

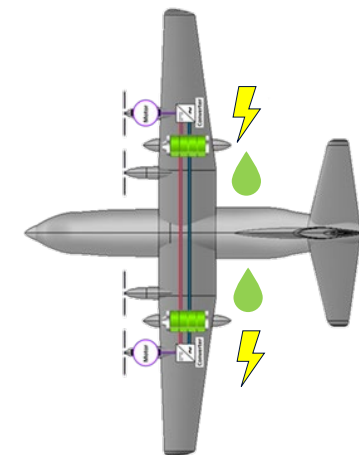
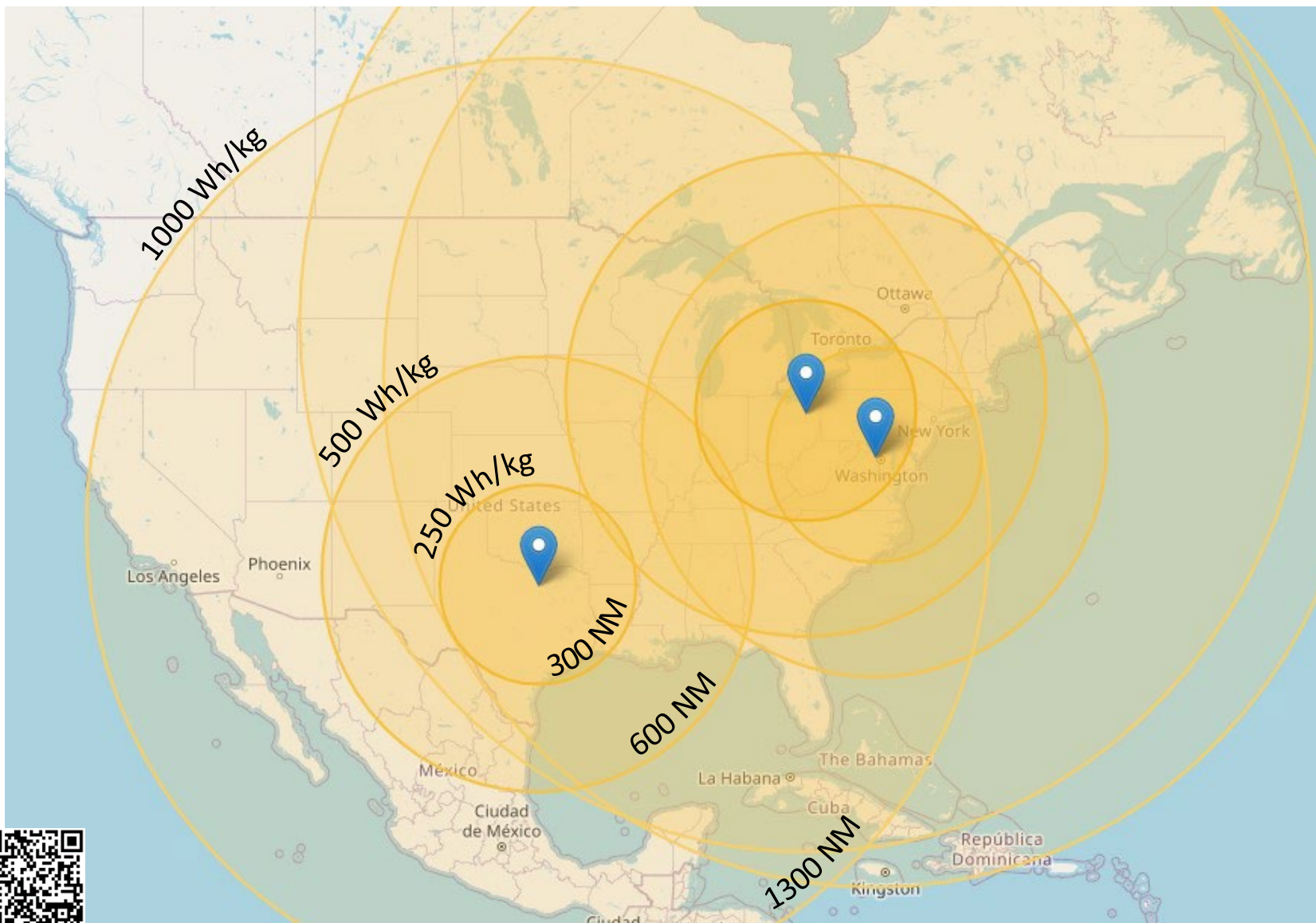
- Hybrid turboprop intended for regional cargo operations.
- Significant portion of total mission energy for economic mission stored in batteries
- Study done at a range of technology assumptions to determine key performance parameters for components and subsystems like power, energy storage, thermal, etc.
- Market – domestic freight operations



- Range:
  - Economic – 750 NM
  - Design – 2400 NM
- Electric Power level – up to  $\approx 8$  MW total (2x  $\approx 4$  MW electric engines)



# Mid-Term (2035) EAP Turboprop Freighter Operations Tradespace



50/50 Cruise Power Split  
25,000 lb Design Payload

- Fuel savings of 24% to 52% across 250-1,500 NM missions translate directly to reductions in CO<sub>2</sub> emissions compared to conventional cargo aircraft

Ranges up to 1,300 NM capture 95% of total annual U.S. narrowbody cargo operations

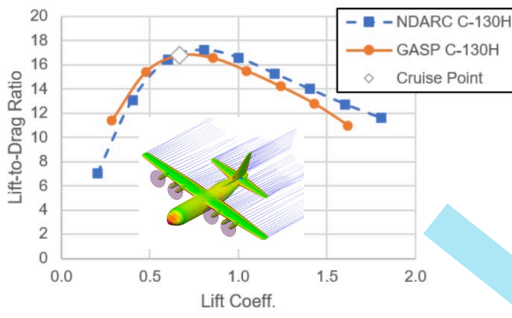


# Airspace Integration Analysis

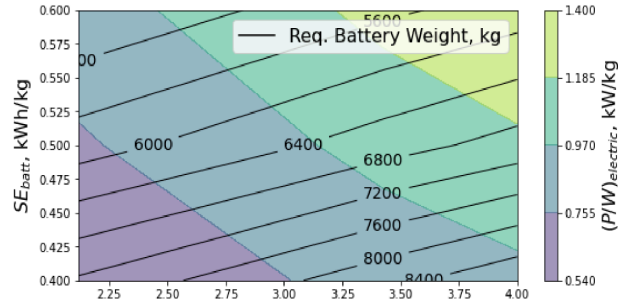


# NAS Level Assessment of EAP Operations

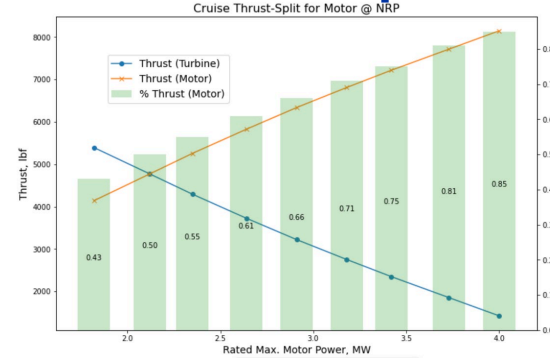
## Aerodynamics



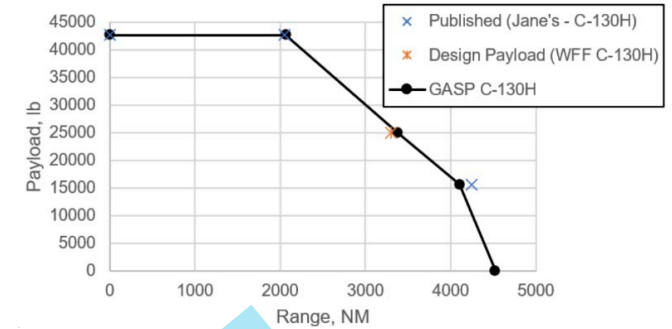
## Required Battery Weight



## Thrust Split



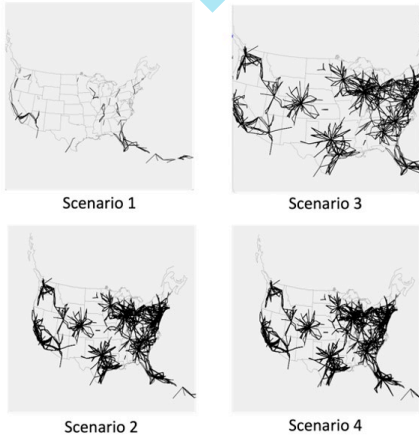
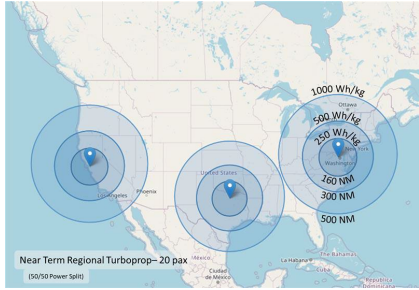
## Payload vs Range



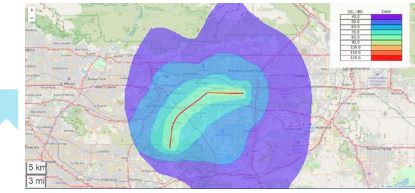
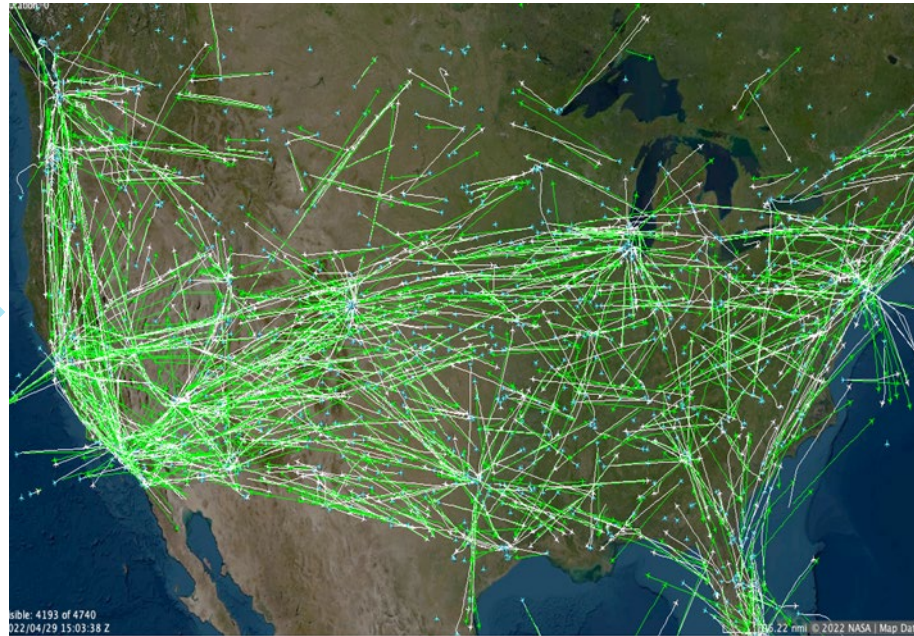
## Modeled EAP Hybrid PAX Aircraft



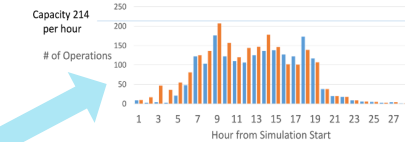
# NAS Level Assessment of EAP Operations



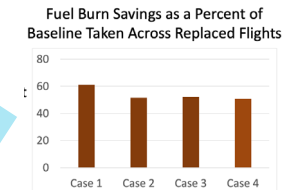
National Airspace System Simulator



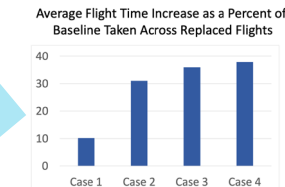
Community Noise Impact



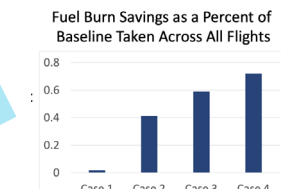
Airport Capacity



Fuel Savings Compared to Replaced Flights



Flight Time Increase



Fuel Savings Compared to All Flights

Obtain relevant metrics to assess Cost and Benefit of proposed operational changes



Replacement opportunities for flights within 300 miles.

- 1 vehicle for 1 EAP Hybrid
- 1 vehicle for up to 2 EAP Hybrid
- Etc

Simulate proposed operational changes that can provide a pathway to introduce electrified vehicles to the NAS

# Conclusions

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# Concluding Remarks

1

## **Flexible Payload and Range**

For the same aircraft, improvements in Battery Specific Energy expand maximum range performance, allowing for improved market coverage

Electrified aircraft propulsion unlocks the potential for purpose-built aircraft with flexible payload and range performance for energy-efficient regional air cargo and passenger operations

2

## **Efficient Power Splits**

Parallel-hybrid architecture enables flexibility in efficient power-split throughout flight to achieve target ranges at optimal fuel savings

3

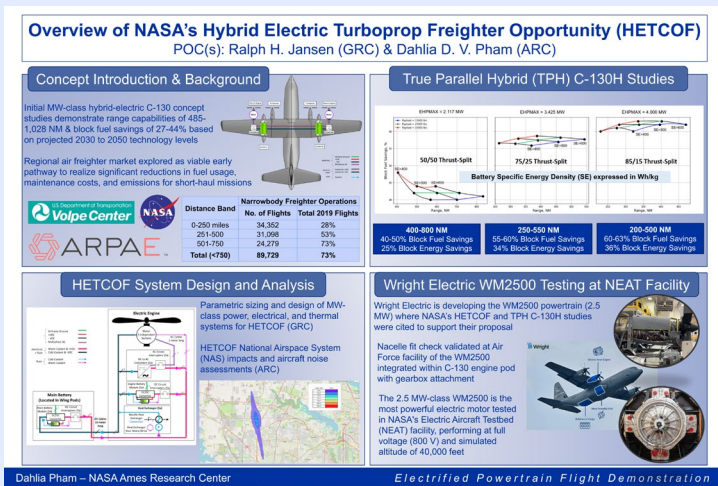
## **Battery Technology Performance**

Payload capacity and range performance expands with improvements to battery technologies

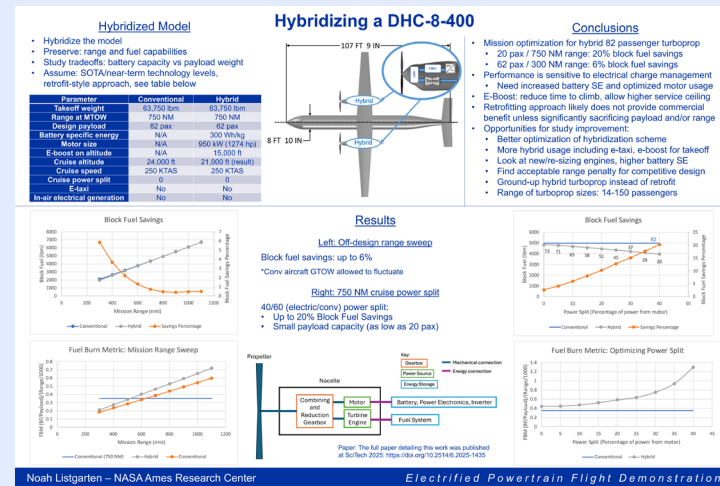


# NASA Systems Analysis Posters

## 1) HETCOF (TPH):



## 2) Dash-8 (MPH):



## 3) Airspace Assessment:

