Assessing National Airspace System Impact of the Transonic Truss-Braced Wing Aircraft

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Motivation

Why National Airspace System Simulation Assessment?

2023 NASA Aeronautics Strategic Implementation Plan

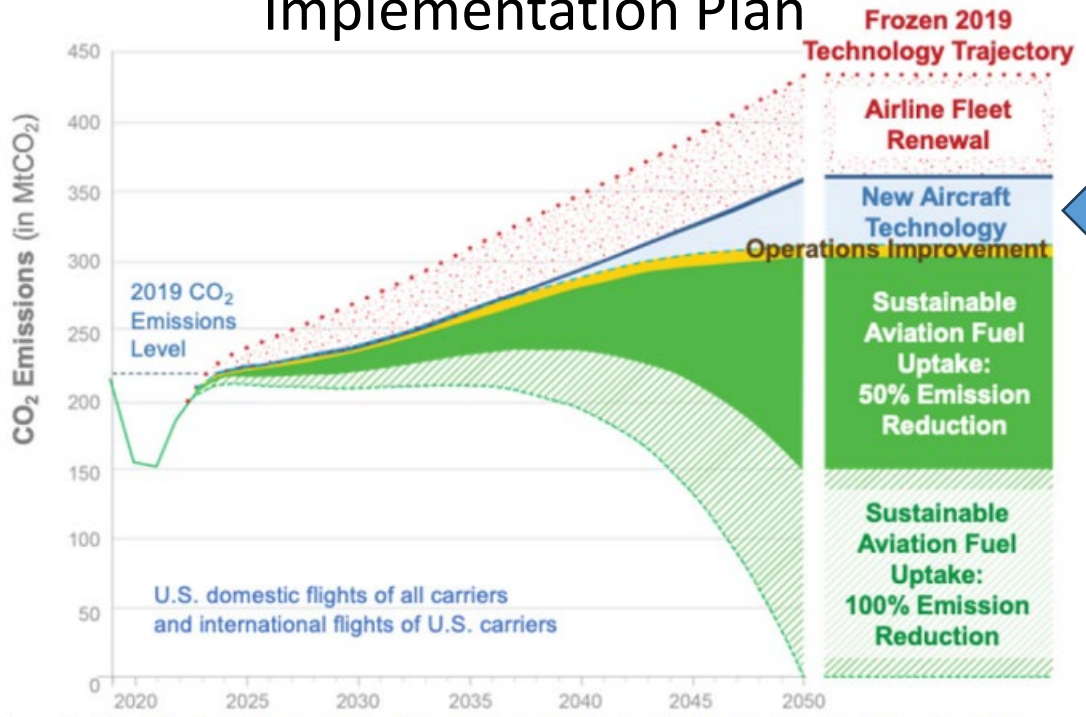
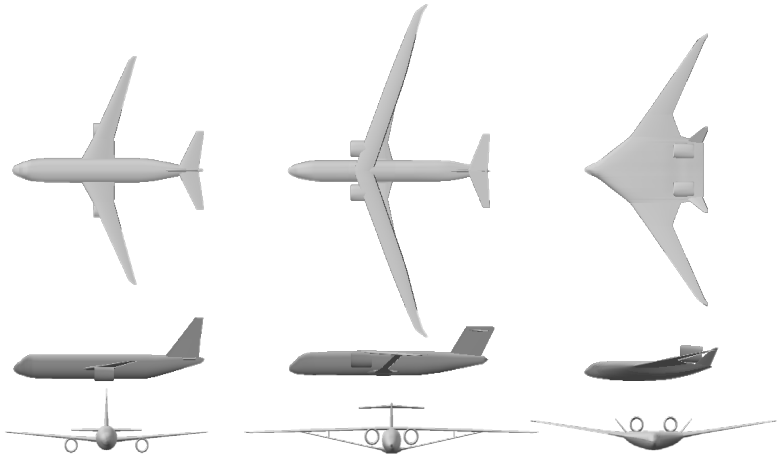


Figure 4. U.S. Aviation Climate Action Plan Path to Net-Zero: Aviation Carbon Emissions by 2050

- Independent verification and validation of industry concepts
- Inform future investments in aeronautics research
- Assess system-wide efficiency and interoperability of New Aircraft Technology

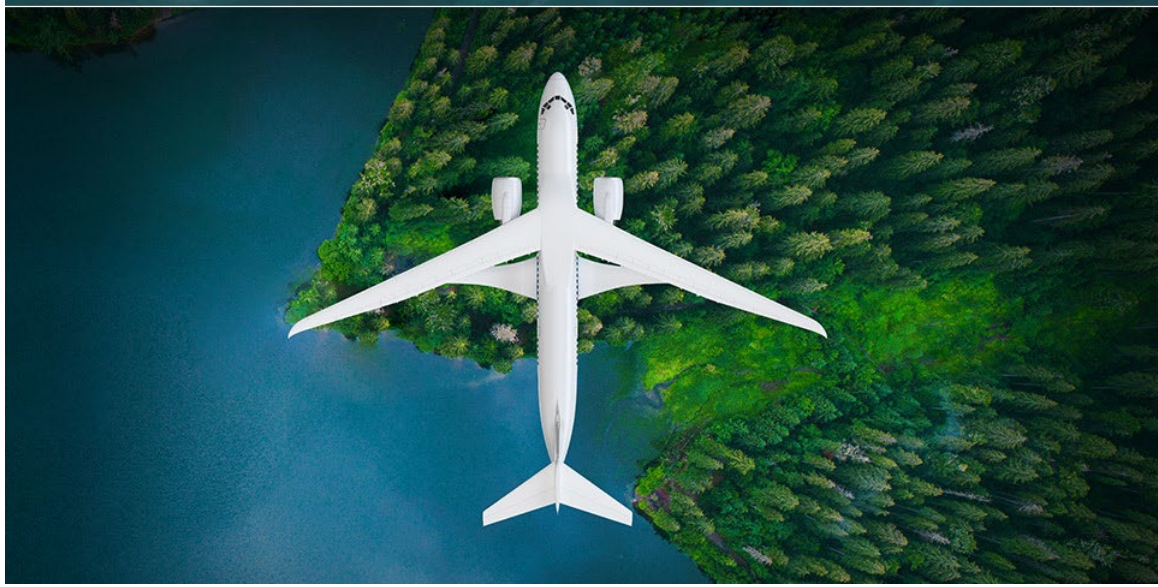


Transonic Truss-Braced Wing (TTBW)

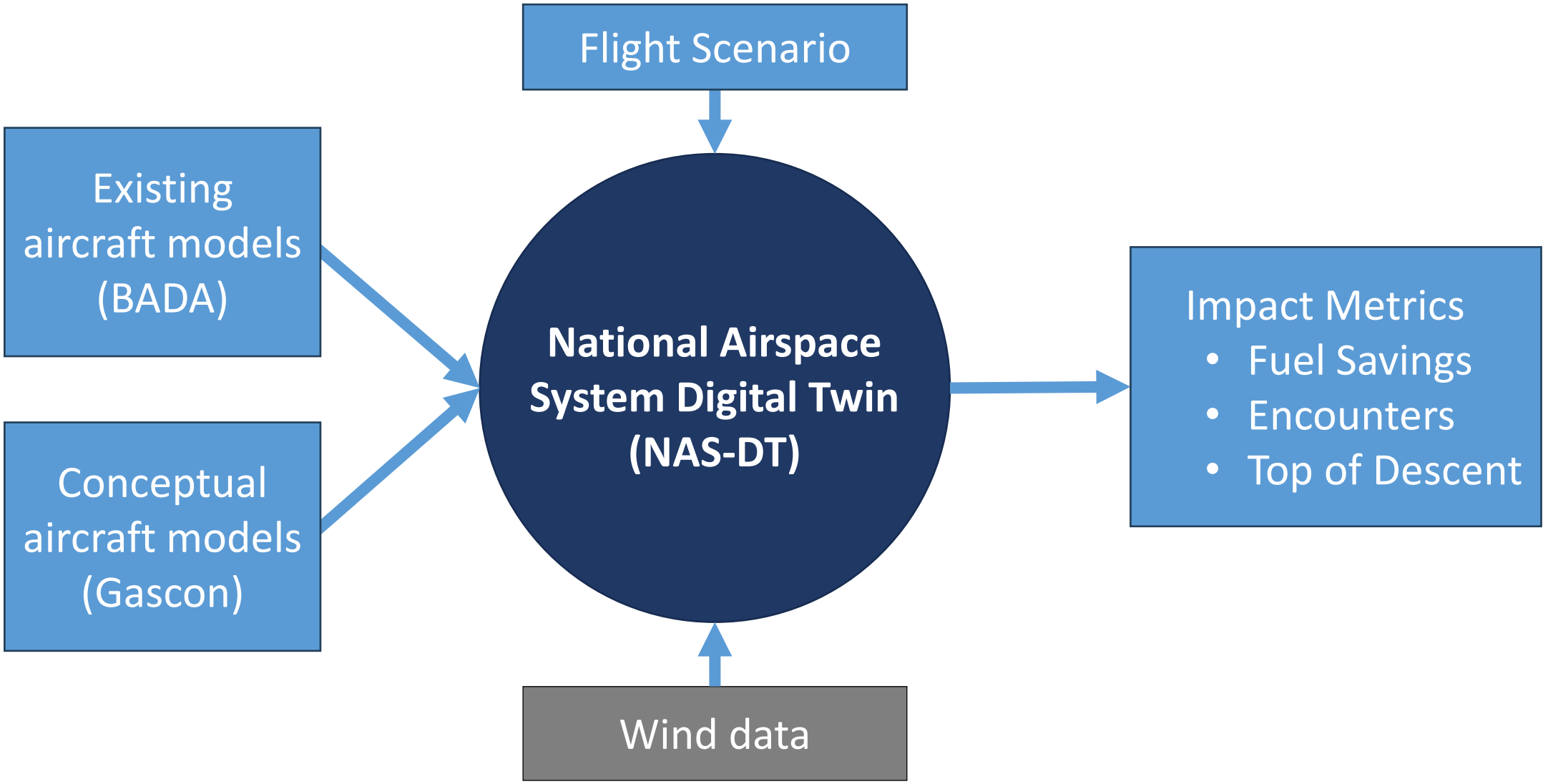
Design Assumptions and Requirements

- 33,750 lbs Payload (150 pax - 225 lbs)
- 3,400 NM Design Mission
- Design Mach 0.8
- 2035 Aerodynamics Technology
- Advanced Direct Drive Turbofan 1.50
- Body tanks allowed

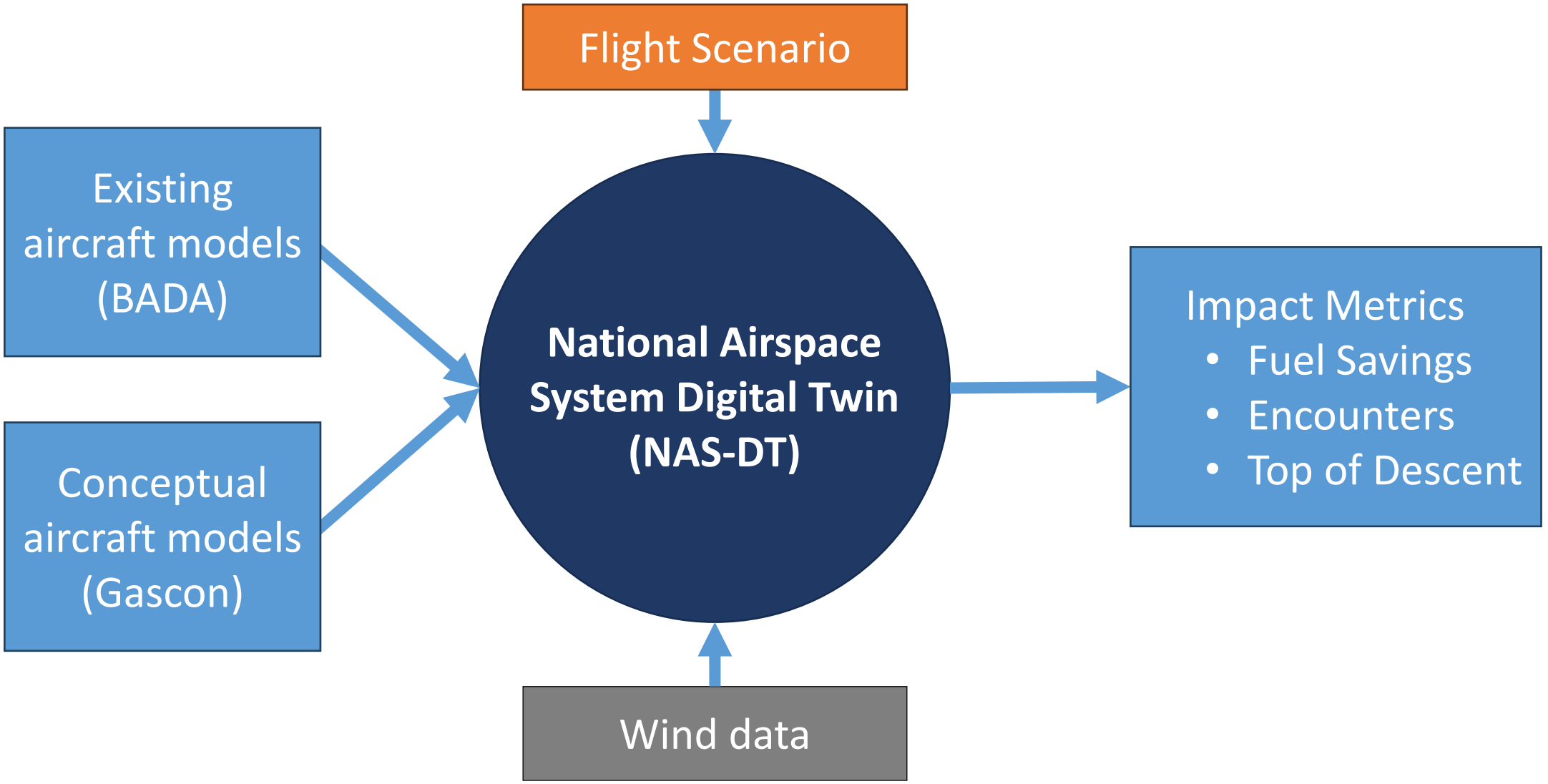
	TTBW
GTOW (lb)	132,843
Empty Weight (lb)	67,586
Wingspan (ft)	155.2
Aspect Ratio	19.6
Start of Cruise L/D	22.8
Engine SLS Thrust (lb)	20,810



Overview


Flight Scenario
Existing aircraft models (BADA)
Conceptual aircraft models (Gascon)
National Airspace System Digital Twin (NAS-DT)
Wind data
Impact Metrics
• Fuel Savings
• Encounters
• Top of Descent

Overview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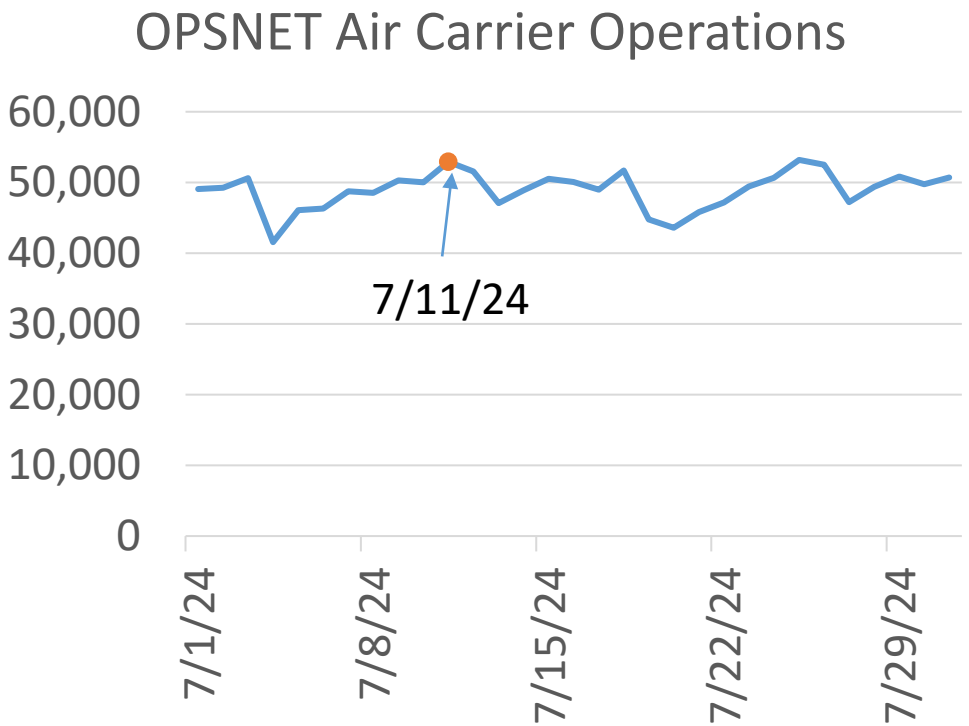
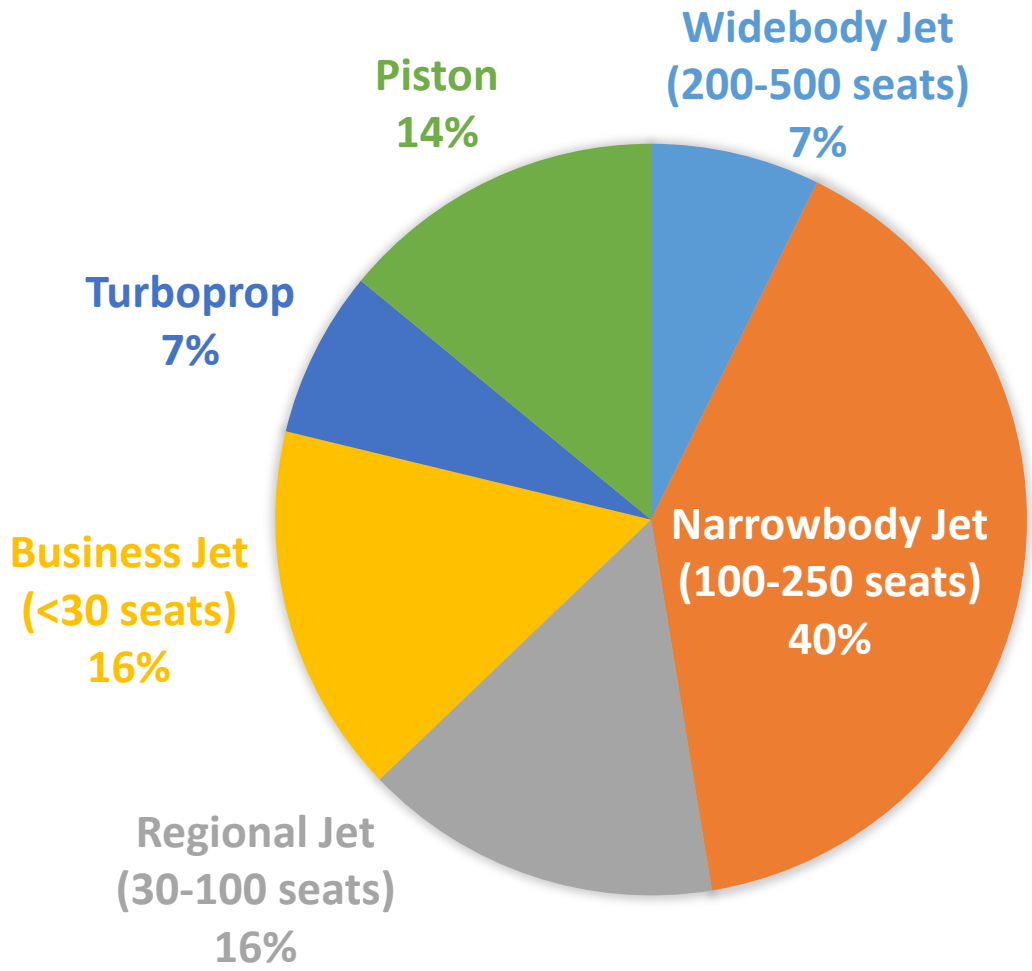
Flight Scenario

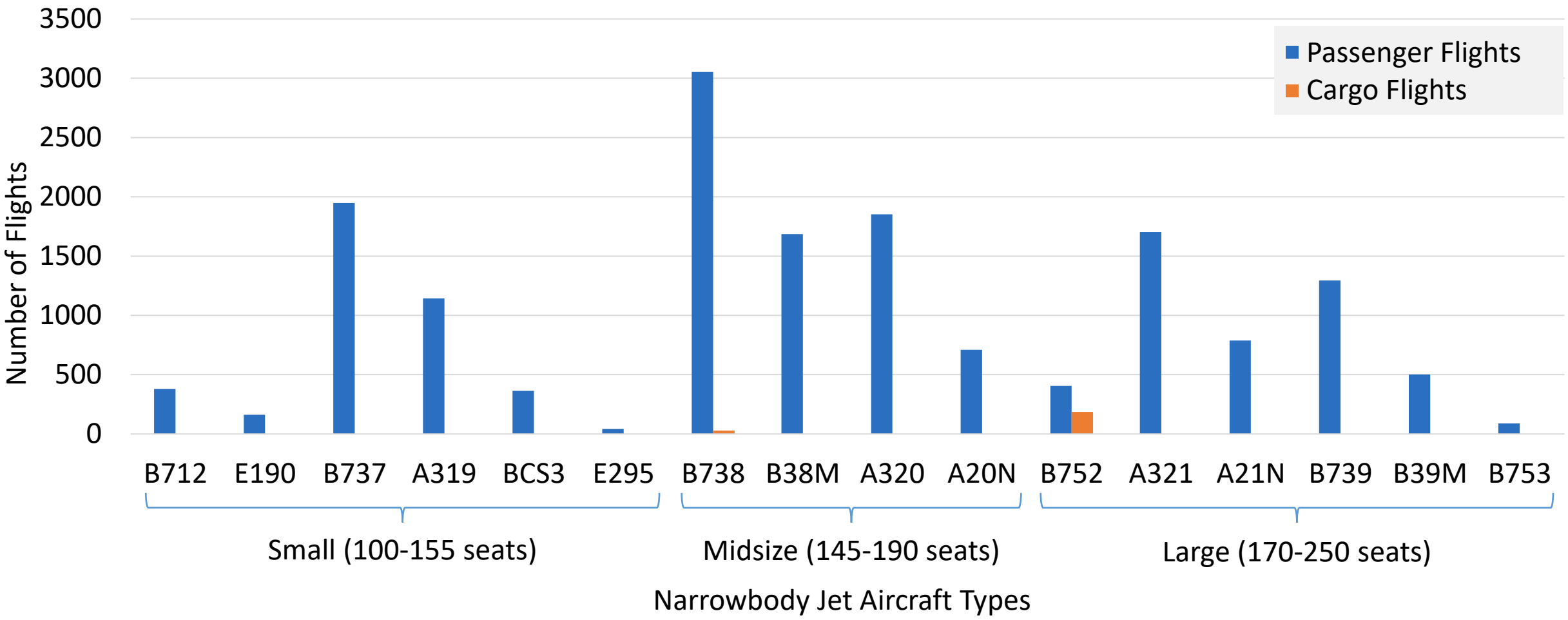
- 7/11/2024 (high volume Thursday)
- Collect all flight plans with departure time within 24hrs starting at 0:00 UTC



- 41,448 flights extracted



Narrowbody Jet Flights



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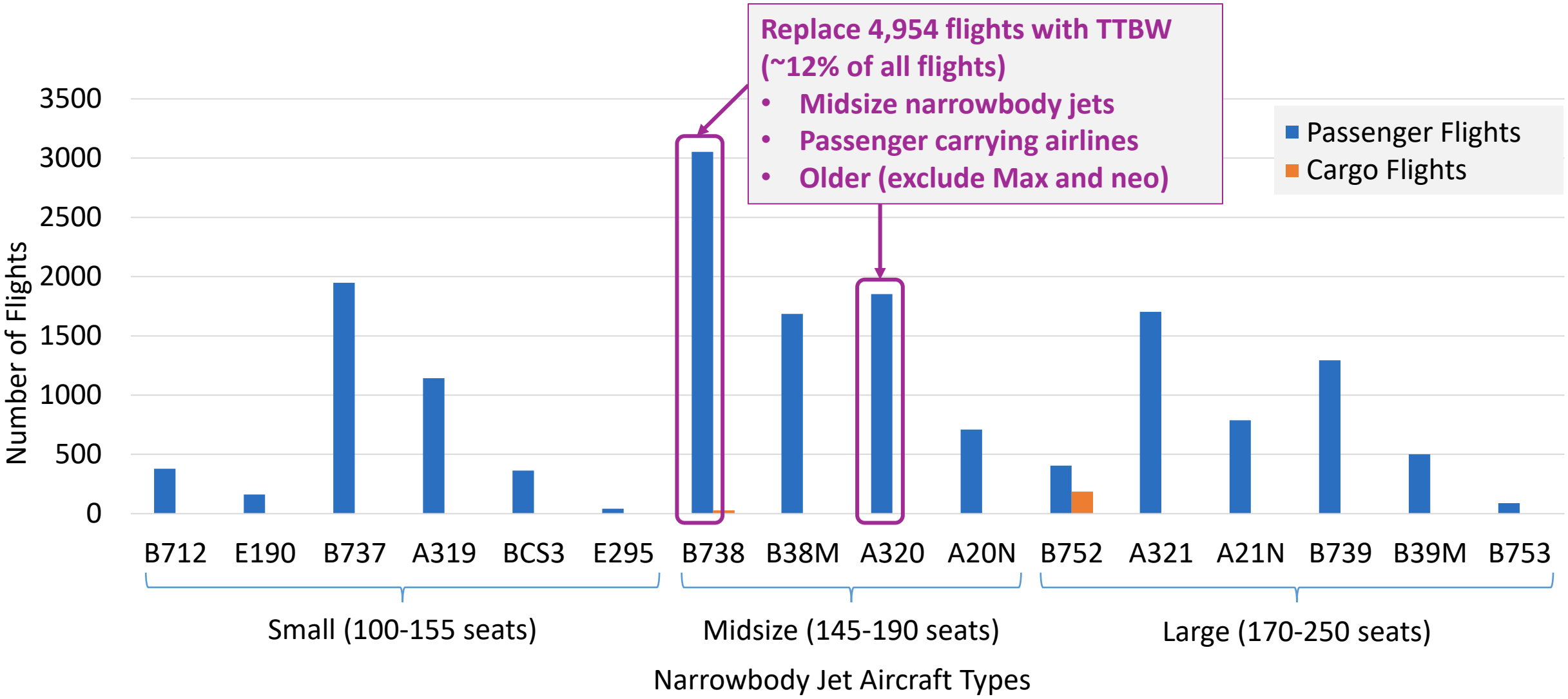
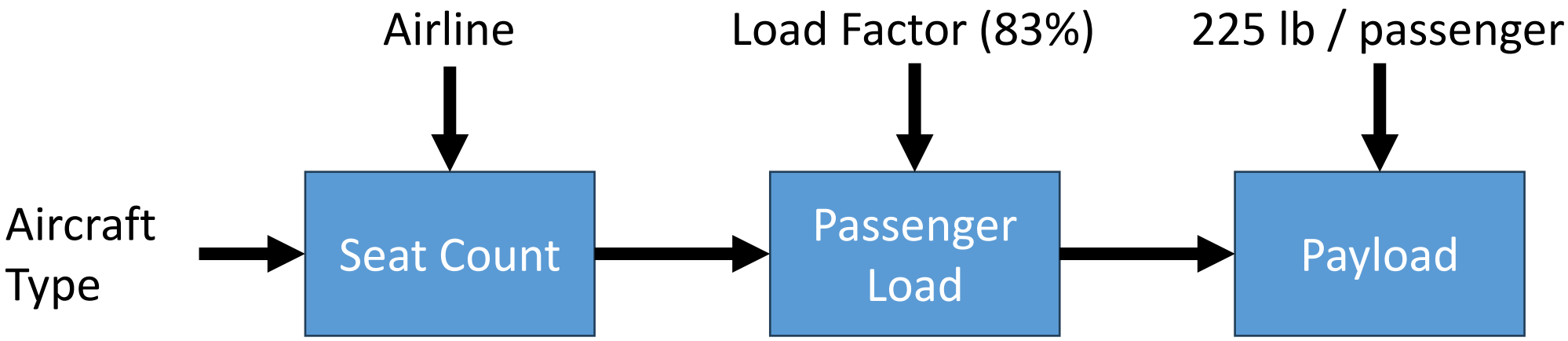


Assign Payload

- Payload is explicitly assigned for all flights with aircraft types replaced by TTBW to ensure fair fuel burn comparison
- All other flights default to aircraft type reference weight (~60% useful load)



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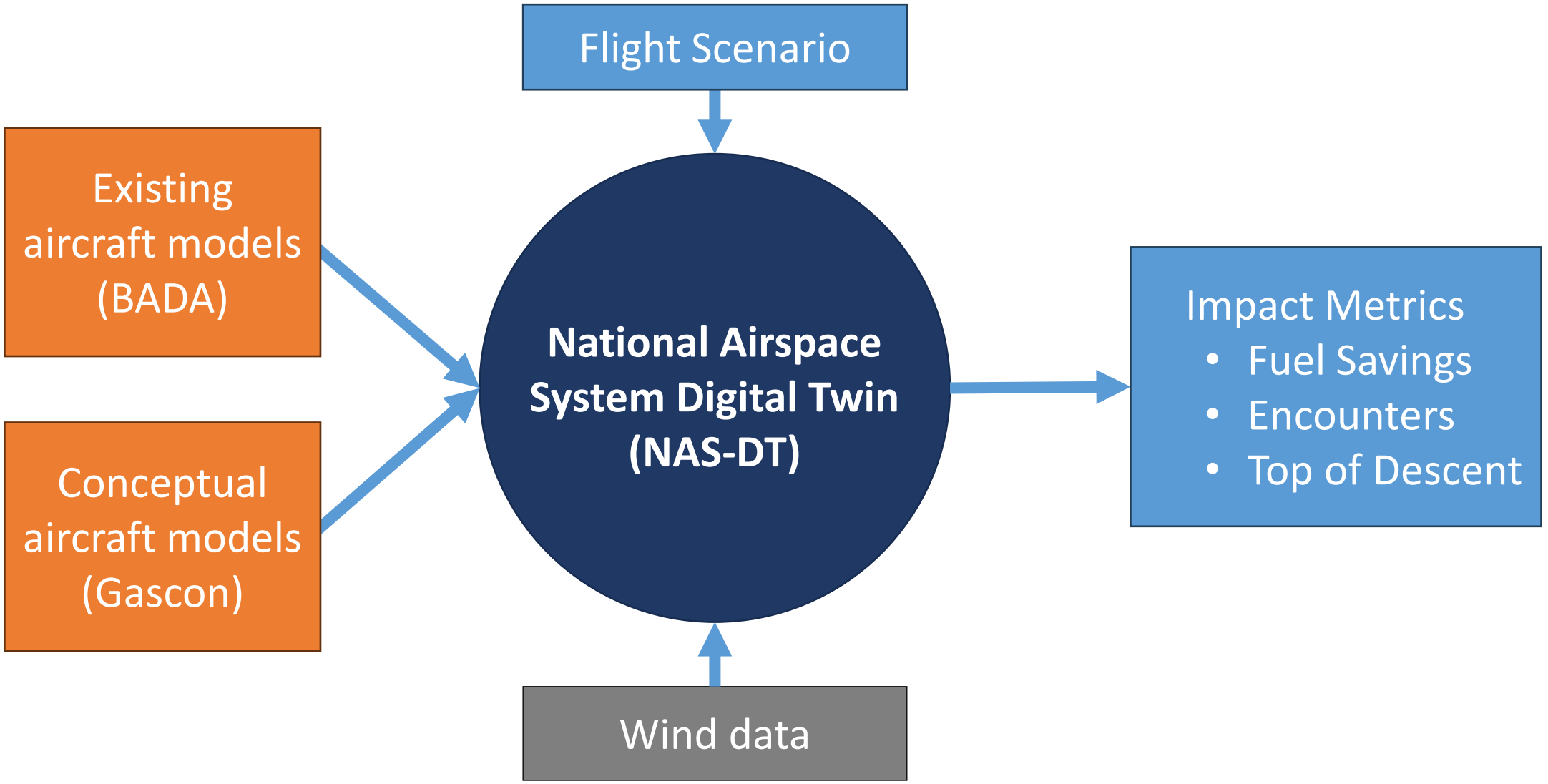
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Aircraft Models

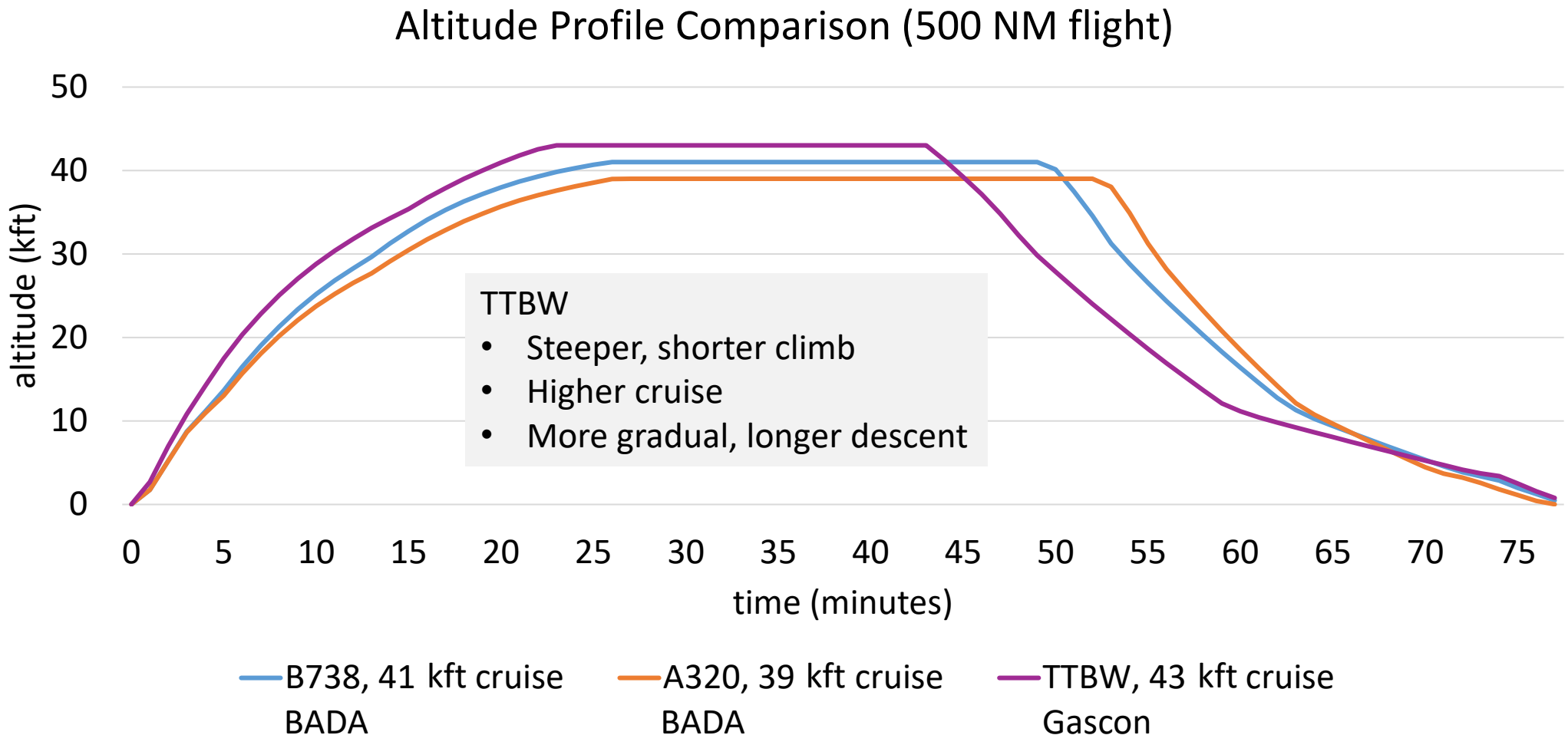
Existing aircraft models (BADA)

- BADA
  - Model exiting aircraft currently in operation
  - Includes over 115 aircraft models that map to over 400 aircraft types
  - Currently used version of BADA does not include more recent aircraft like B737-800 Max and A320 neo (map newer aircraft to closest older counterparts)

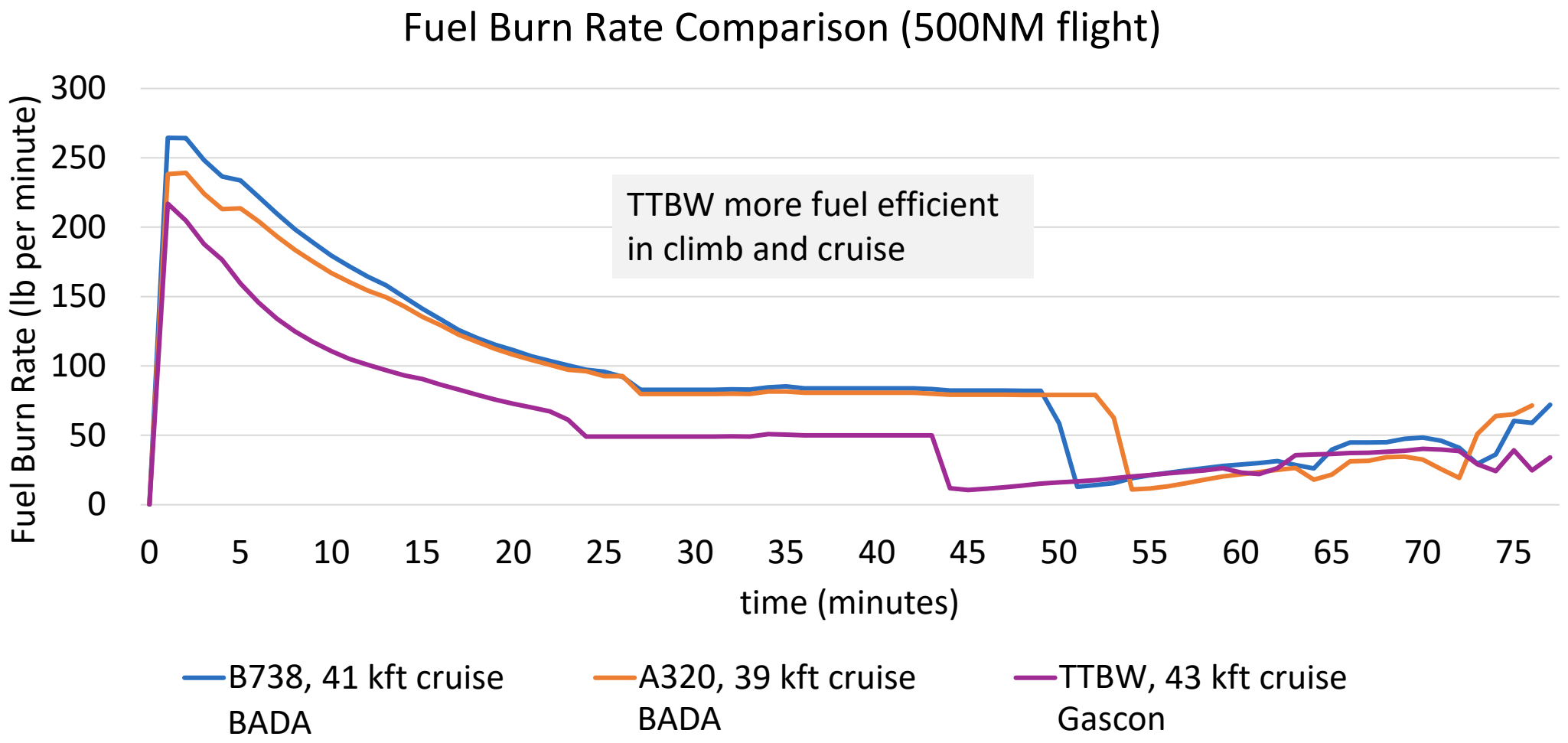
Conceptual aircraft models (Gascon)

- Gascon
  - Model existing or conceptual aircraft not yet built or operational
  - Models specific aero and engine type performance
  - Models developed by Ames Vehicle Analysis Group and adapted to NAS-DT

Aircraft Performance



Aircraft Performance



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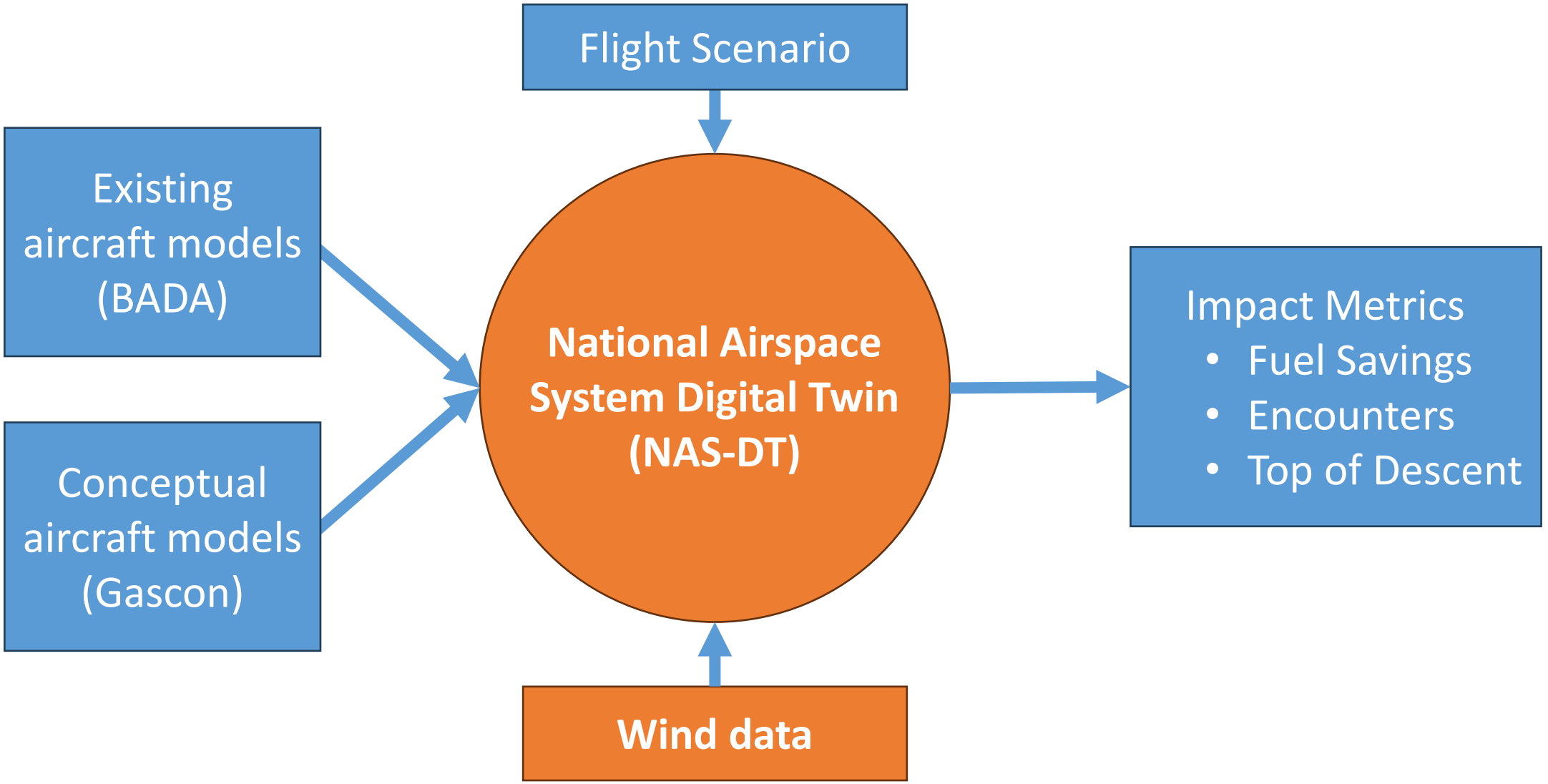
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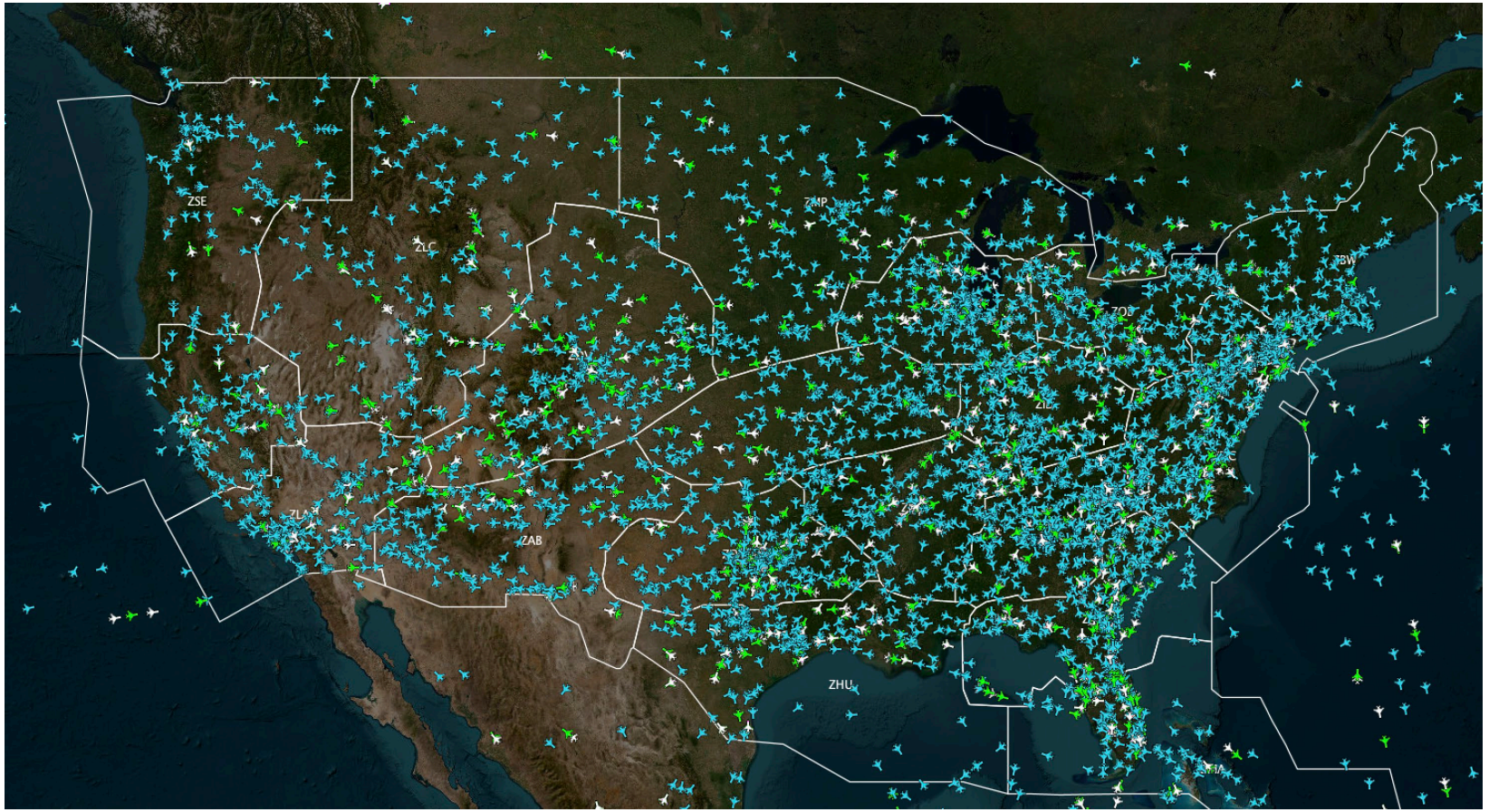
NAS Digital Twin Simulations

- Baseline – all 41,448 flights with current day aircraft types
- Replaced – replace B738 and A320 (4,954 flights, ~12%) with TTBW



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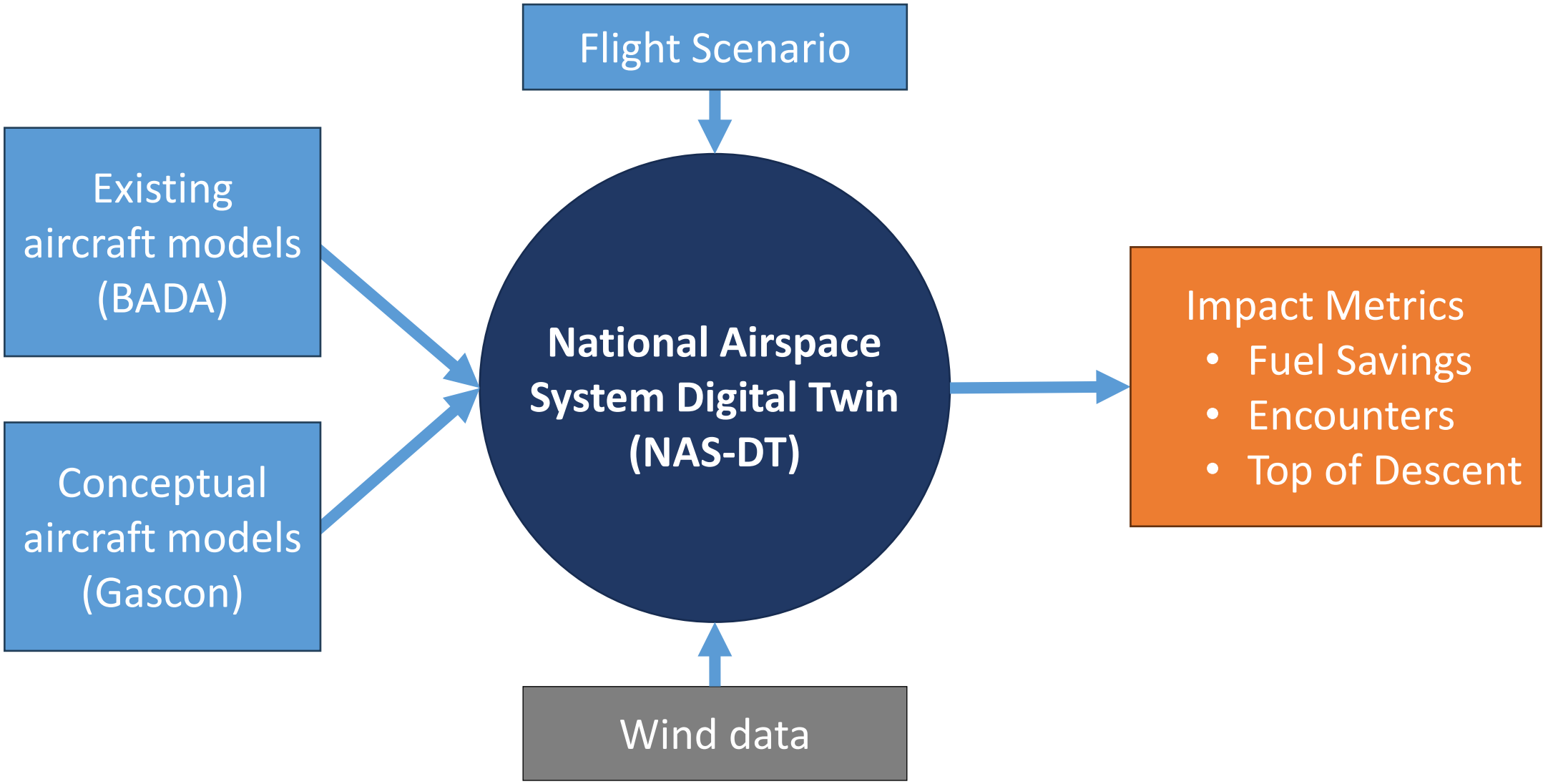
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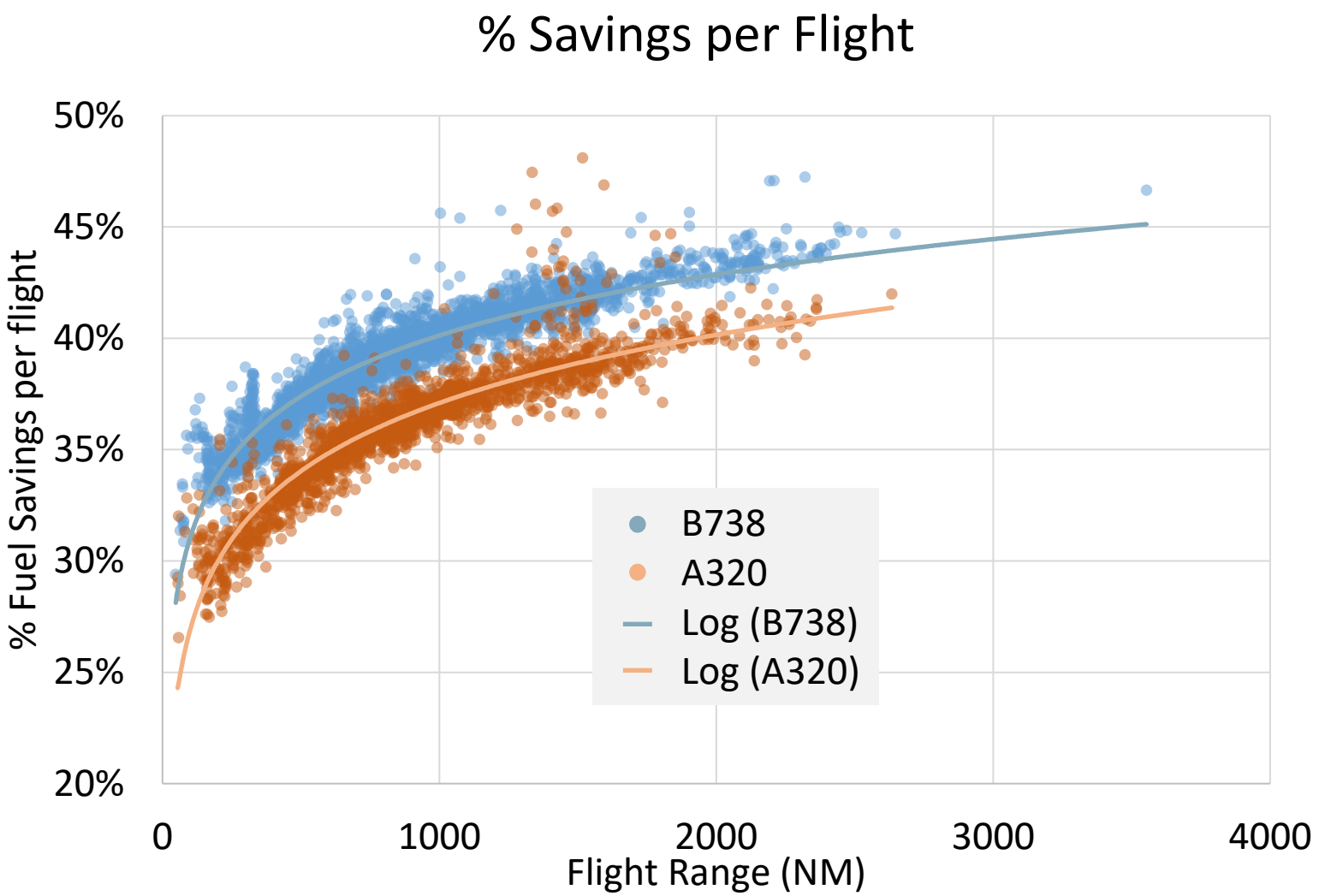
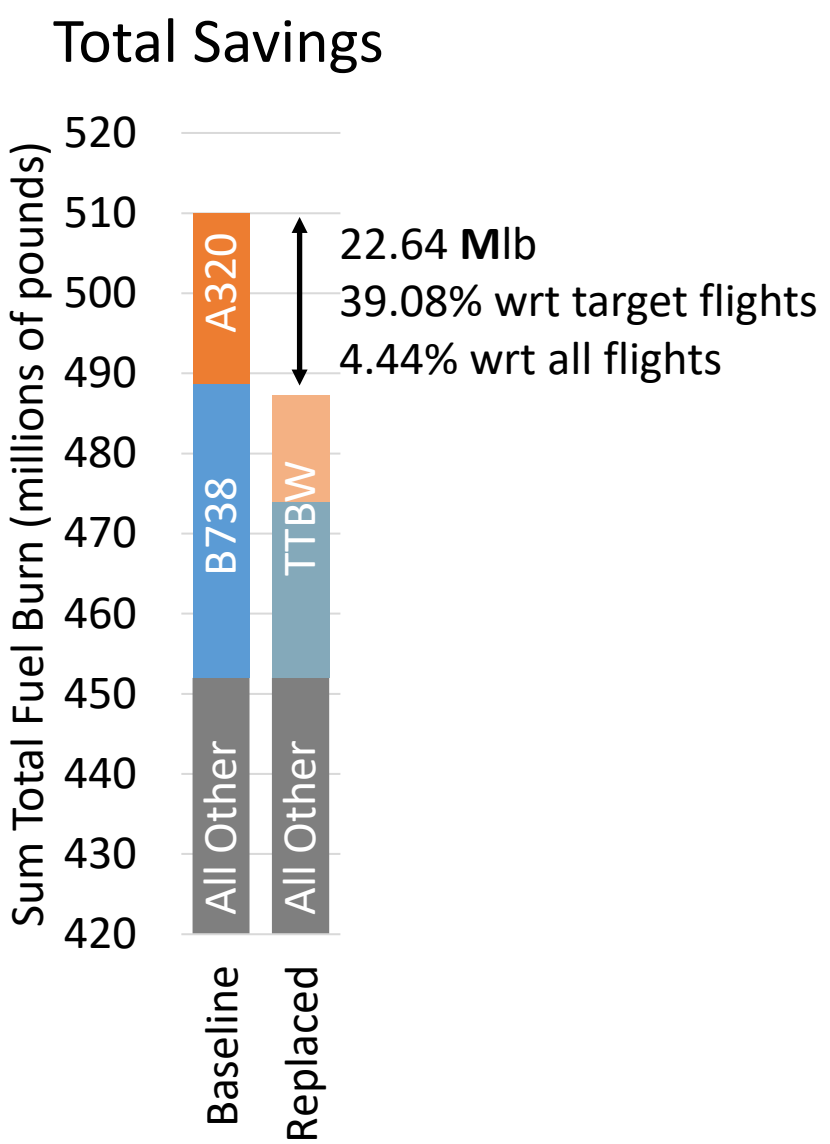
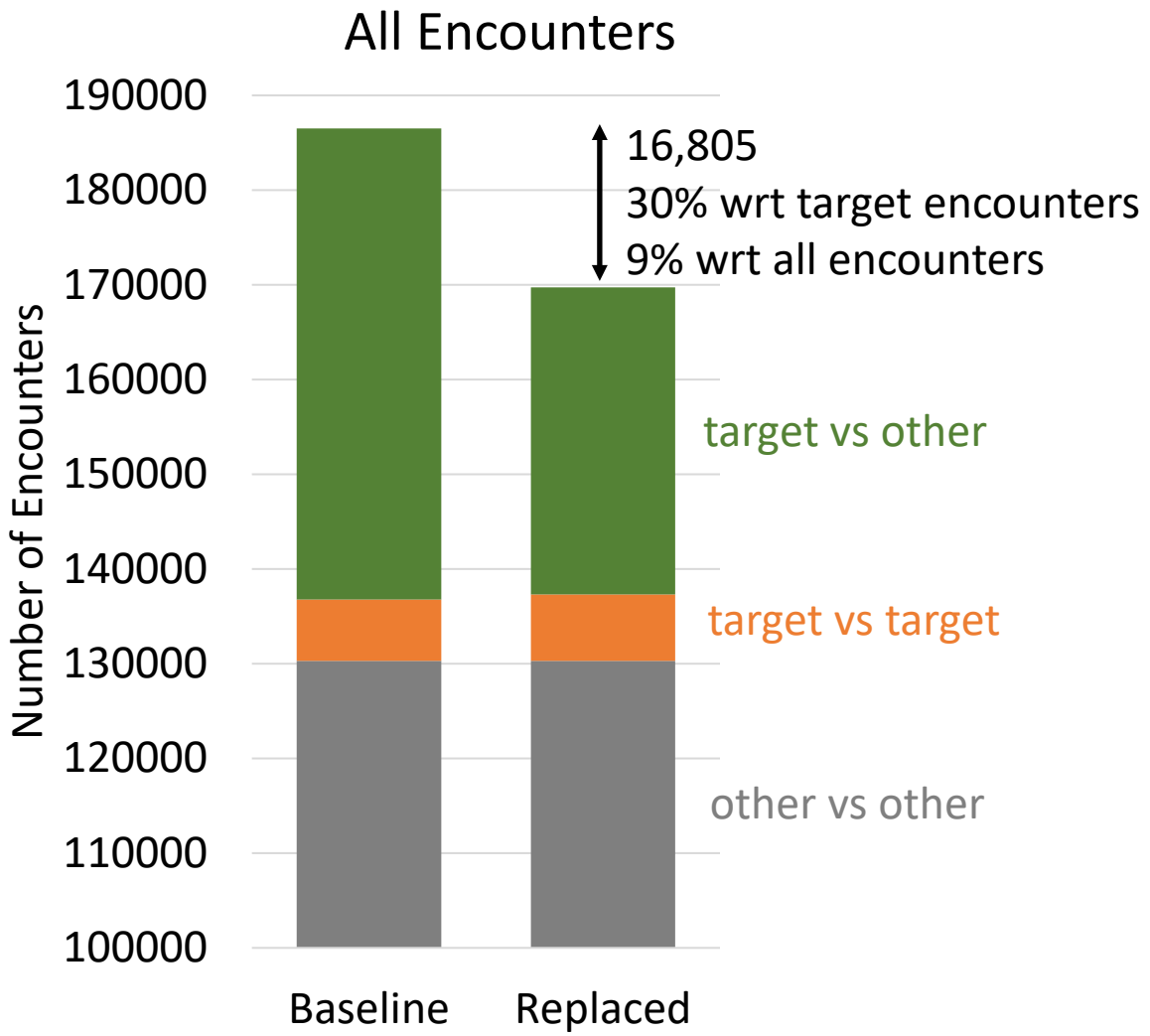
Impact Metrics - Fuel Savings





Impact Metrics - Encounters

- Proxy for airspace complexity
- Occurs when a pair of flights are within 10NM and 2000ft at the same 1-minute time step
- Record only the first encounter in a string of subsequent (less than 5 minutes apart) encounters between the same flight pair
- A flight pair may have multiple encounters if there is more than 5 minutes between encounters



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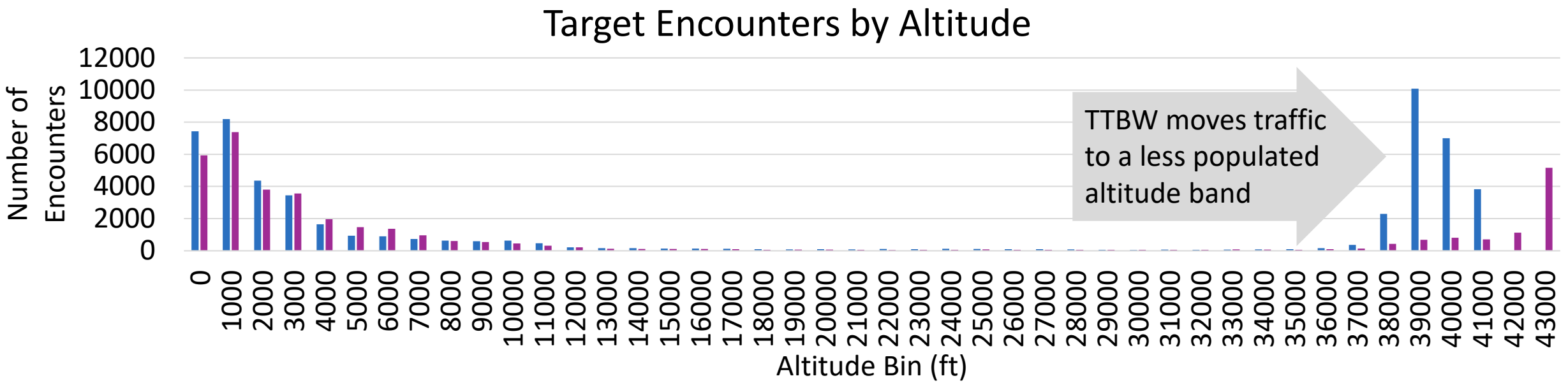
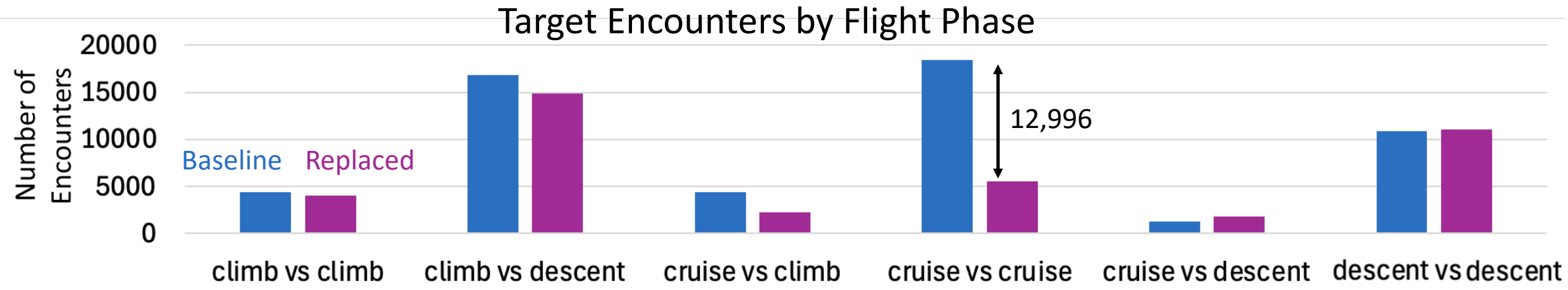
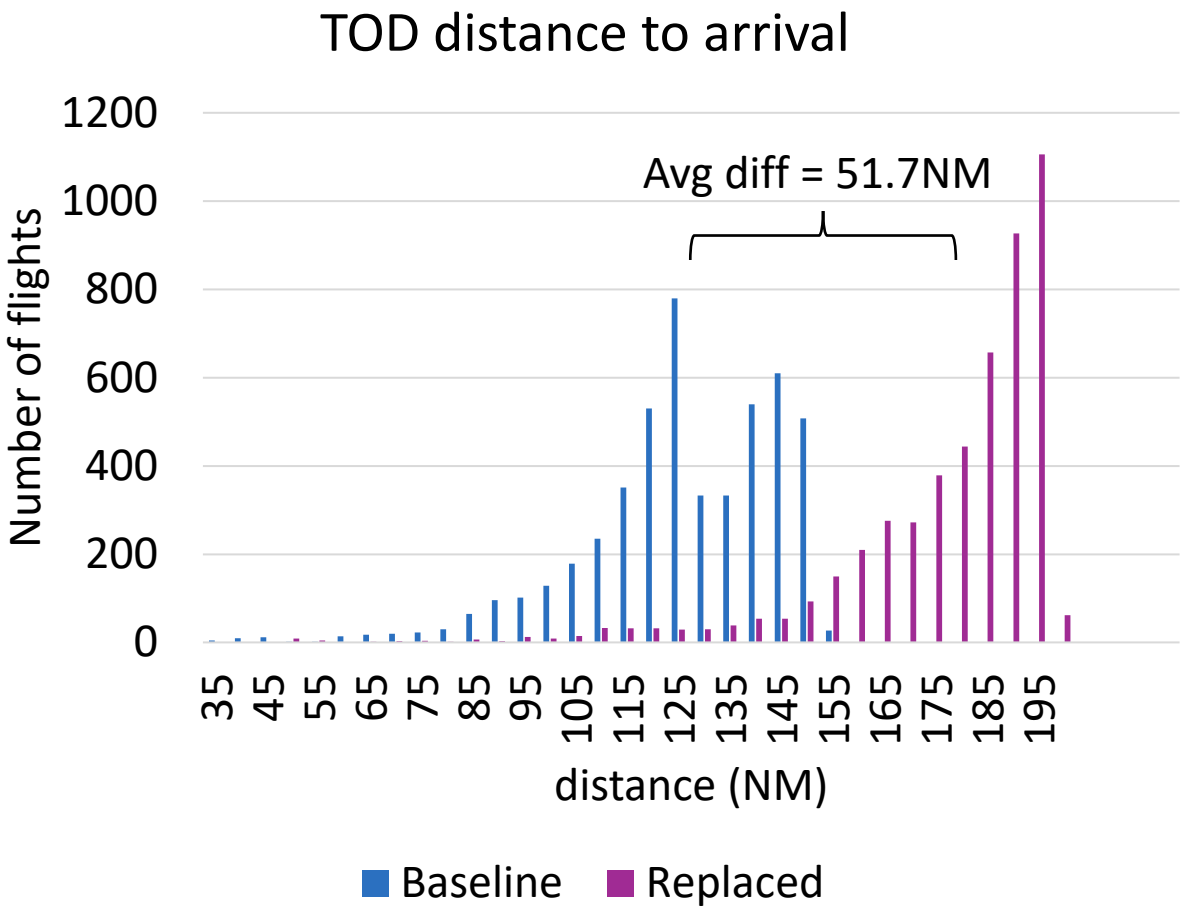
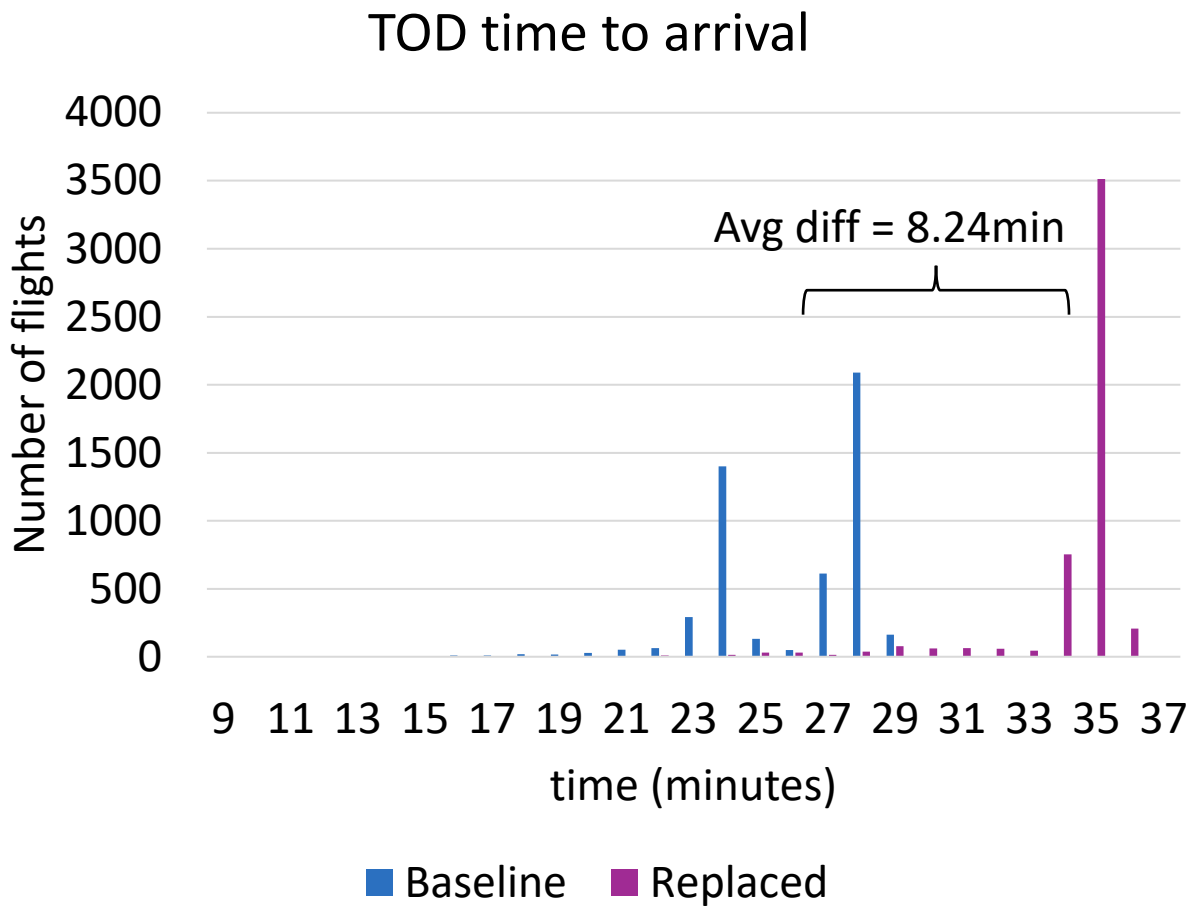




Impact Metrics – Top of Descent (TOD)





Summary

- Replaced 4,954 B738 and A320 flights with TTBW
- Fuel Burn
  - Total 39% savings for replaced flights
  - Savings increases logarithmically with flight range
- Encounters
  - Total 30% savings for replaced flights
  - Savings is concentrated in cruise phase
- Top of Descent (TOD)
  - TTBW flight TOD occurs ~52 NM or ~8 min farther from arrival airport
  - Consideration for controller training

Future Work

- Include state-of-the-art aircraft models from a more recent BADA version
- Explore replacement with other advanced aircraft concepts (e.g. advanced tube and wing, blended wing body)
- Explore cascading replacement strategies repurposing displaced aircraft