Modeling Oceanic Traffic in the Era of Satellite-Based ADS-B Surveillance Technology

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Presentation and Acknowledgement

- Motivation and objectives
- Global oceanic modeling
  - Key points about the model
  - Simulation analysis
- Model results

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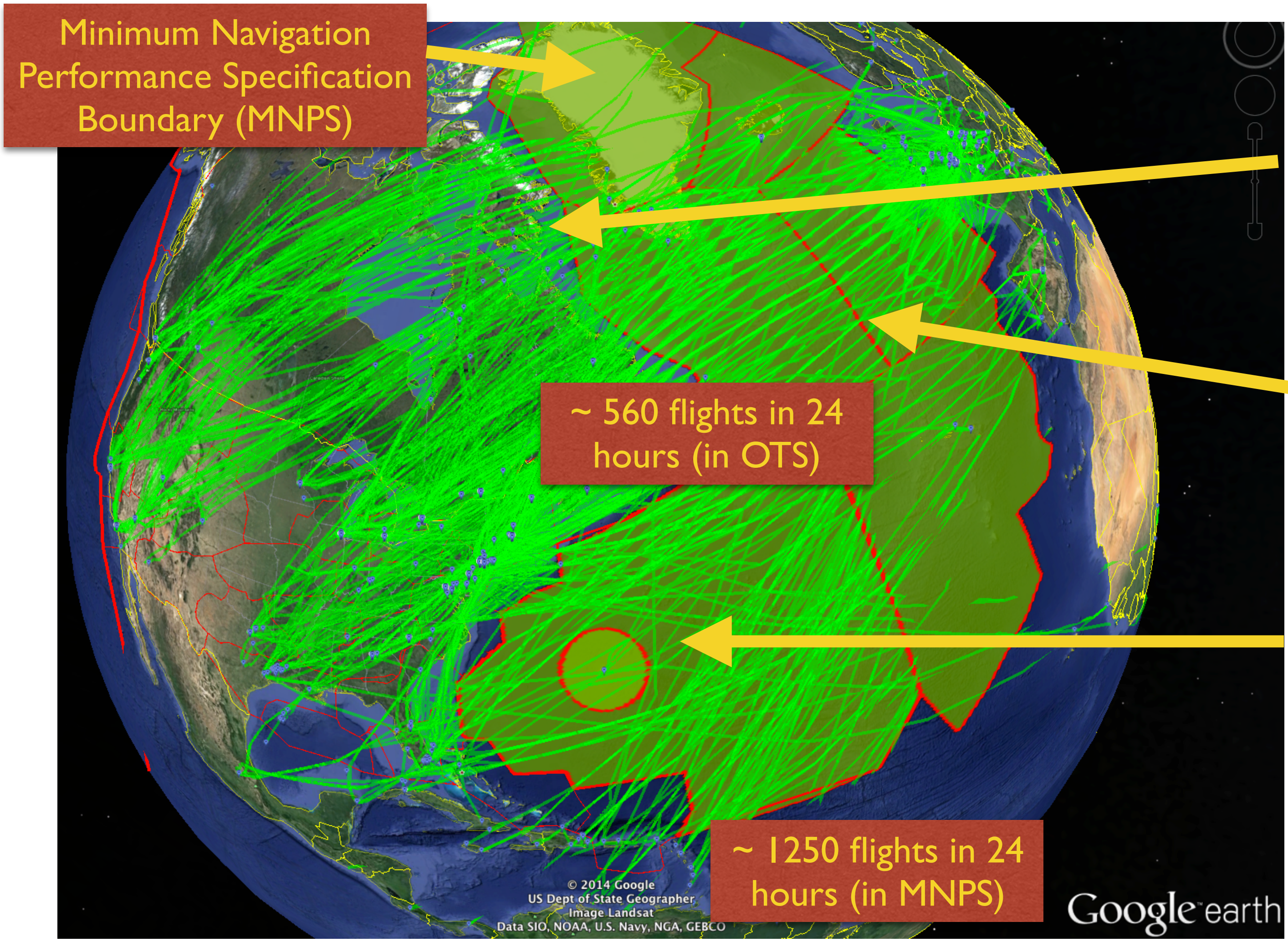
Motivation and Objectives of the Research

- Every year, around half million flights crossed the Atlantic and Pacific Oceans in 2014
- Measuring the benefits of advanced surveillance technologies is important to Air Navigation Service Providers (ANSPs) and to the airlines using oceanic airspace
- Objectives:
  - Estimate future fuel savings and system-level of service metrics if space-based surveillance infrastructure is deployed
  - Provide FAA and ICAO decision makers with a tool for making a business case for new space-based surveillance

Modeling Domains: Atlantic and Pacific Ocean Flights



Northern flights (Non-OTS flights)

Organized Track System (OTS flights)

Southern flights (Non-OTS flights)

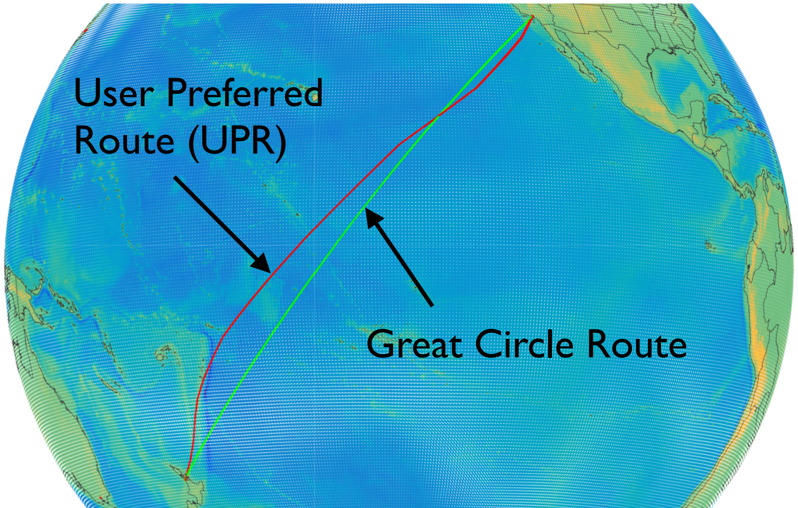
FAA TFMS data
Google Earth

Benefits of Improved Satellite-Based ADS-B Surveillance Technology

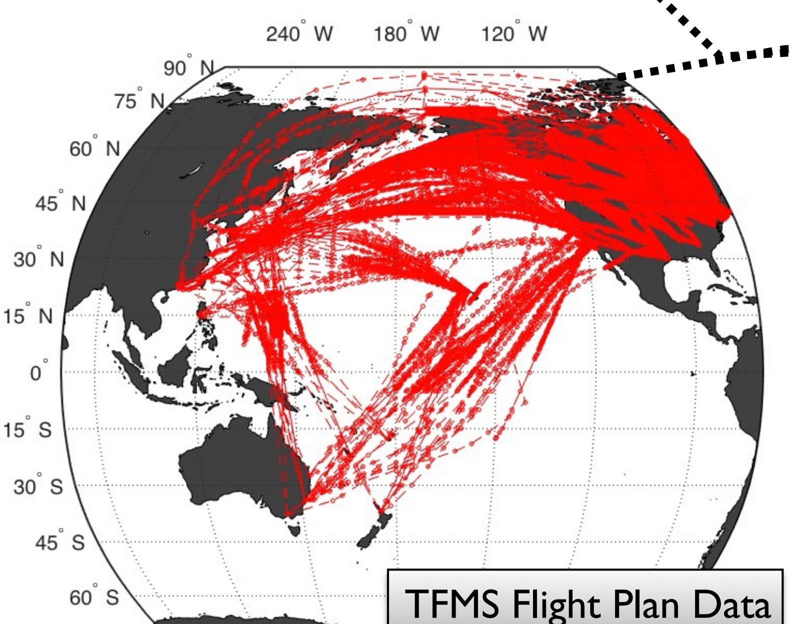
- Reduced Longitudinal Separation Minima (RlongSM)
  - Allows aircraft flying in-trail to be spaced closer (5 minutes instead of 10 minutes as today)
  - In the future in-trail separations to 2 minutes are being studied
- Reduced Lateral separation Minima (RlatSM)
  - Allows OTS tracks to be spaced closer (thus allowing more flights to obtain tracks closer to their optimum flight paths)
- Climbs inside the Organized Track System (OTS)
  - Saves fuel to the destination as most aircraft save fuel at higher cruise altitudes
- Smaller separations for non OTS flights

Global Oceanic Model (NATSAM)

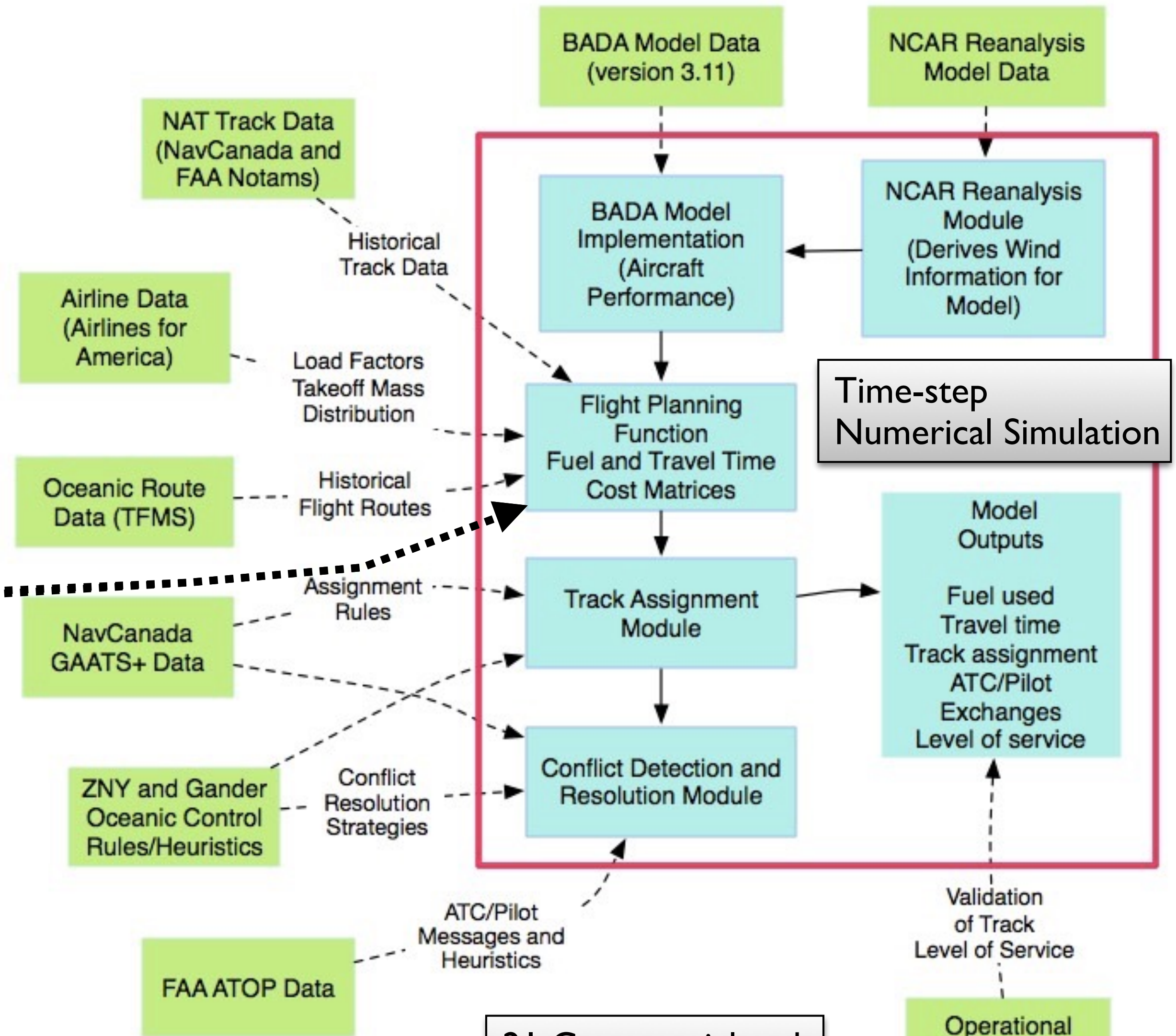
Los Angeles - Auckland



Flight Planning Module



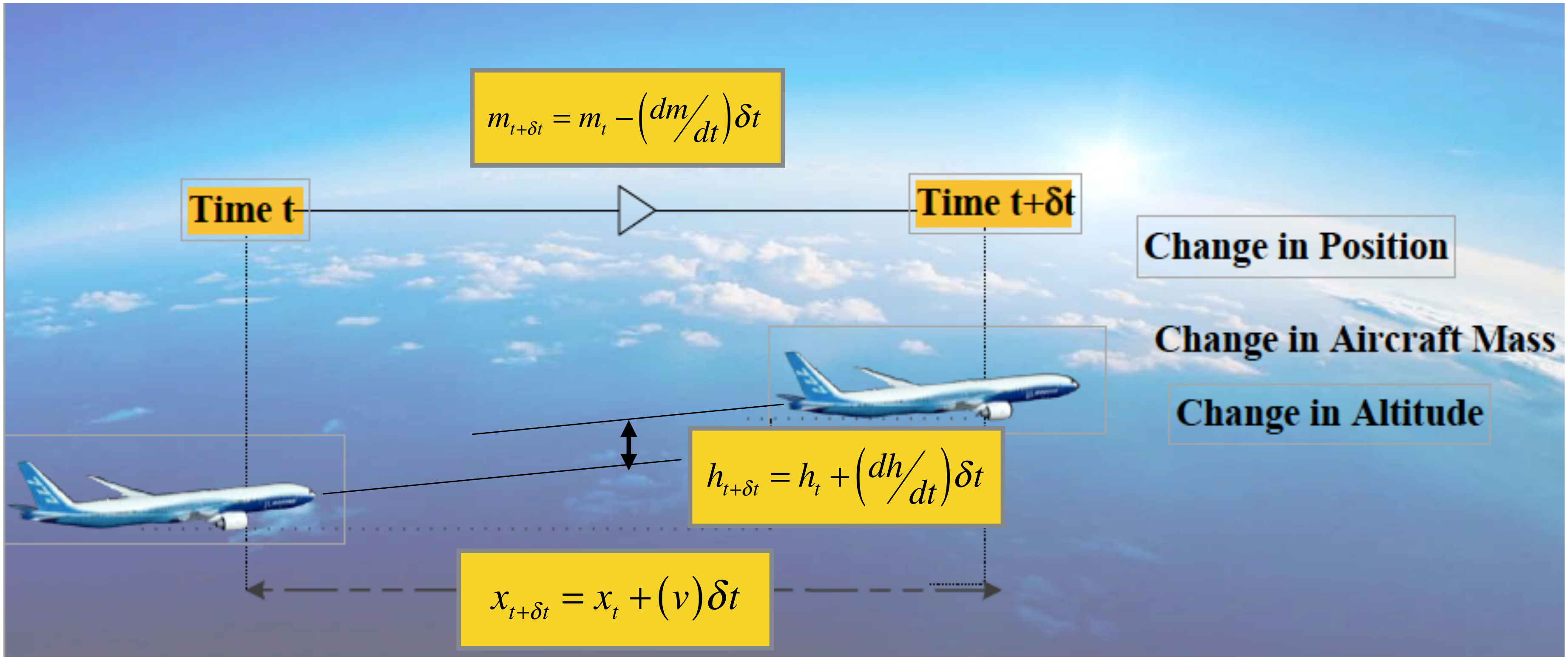
TFMS Flight Plan Data



Time-step Numerical Simulation

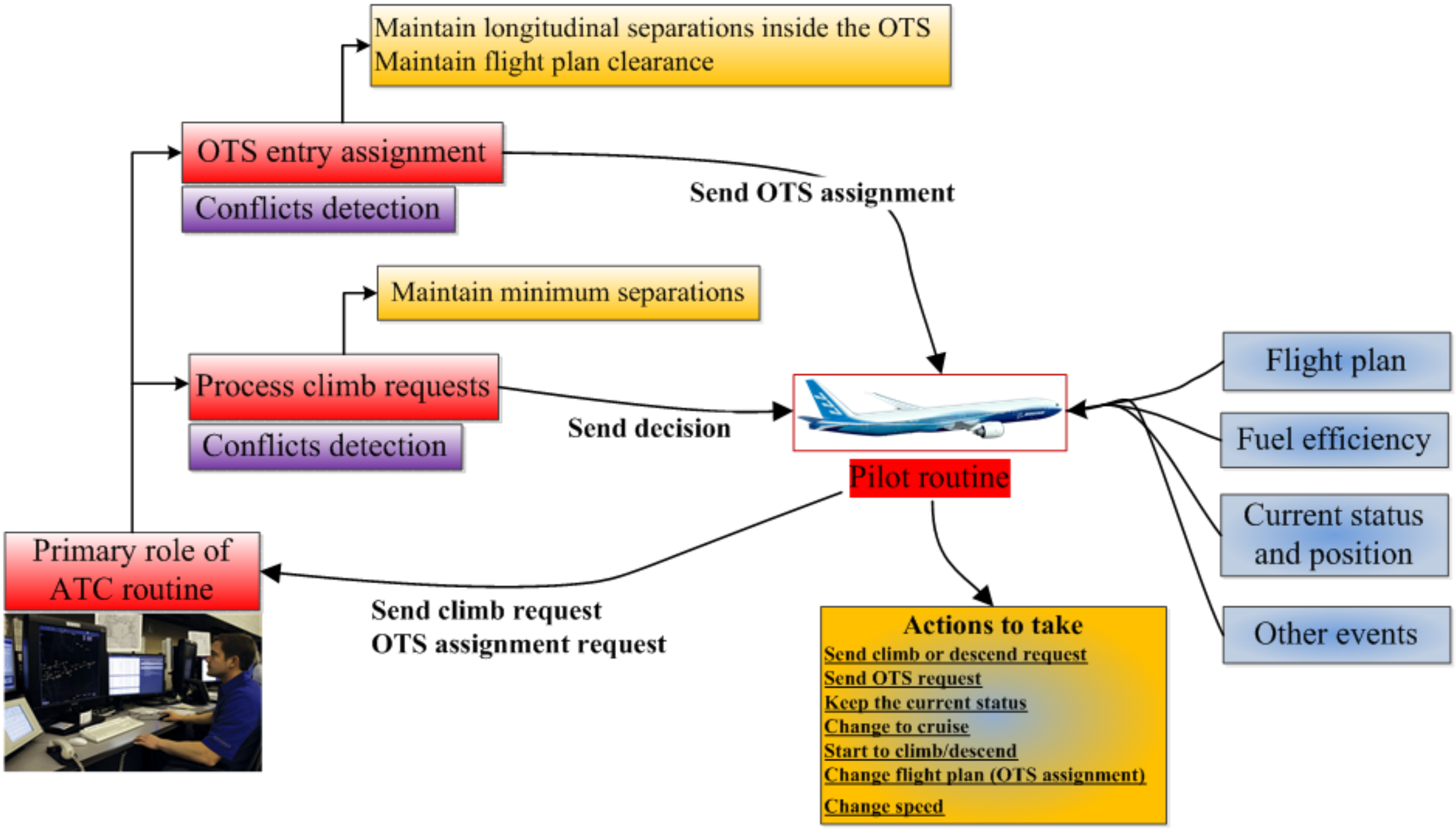
21 Commercial and Corporate Aircraft Modeled

Simulation Model Paradigm



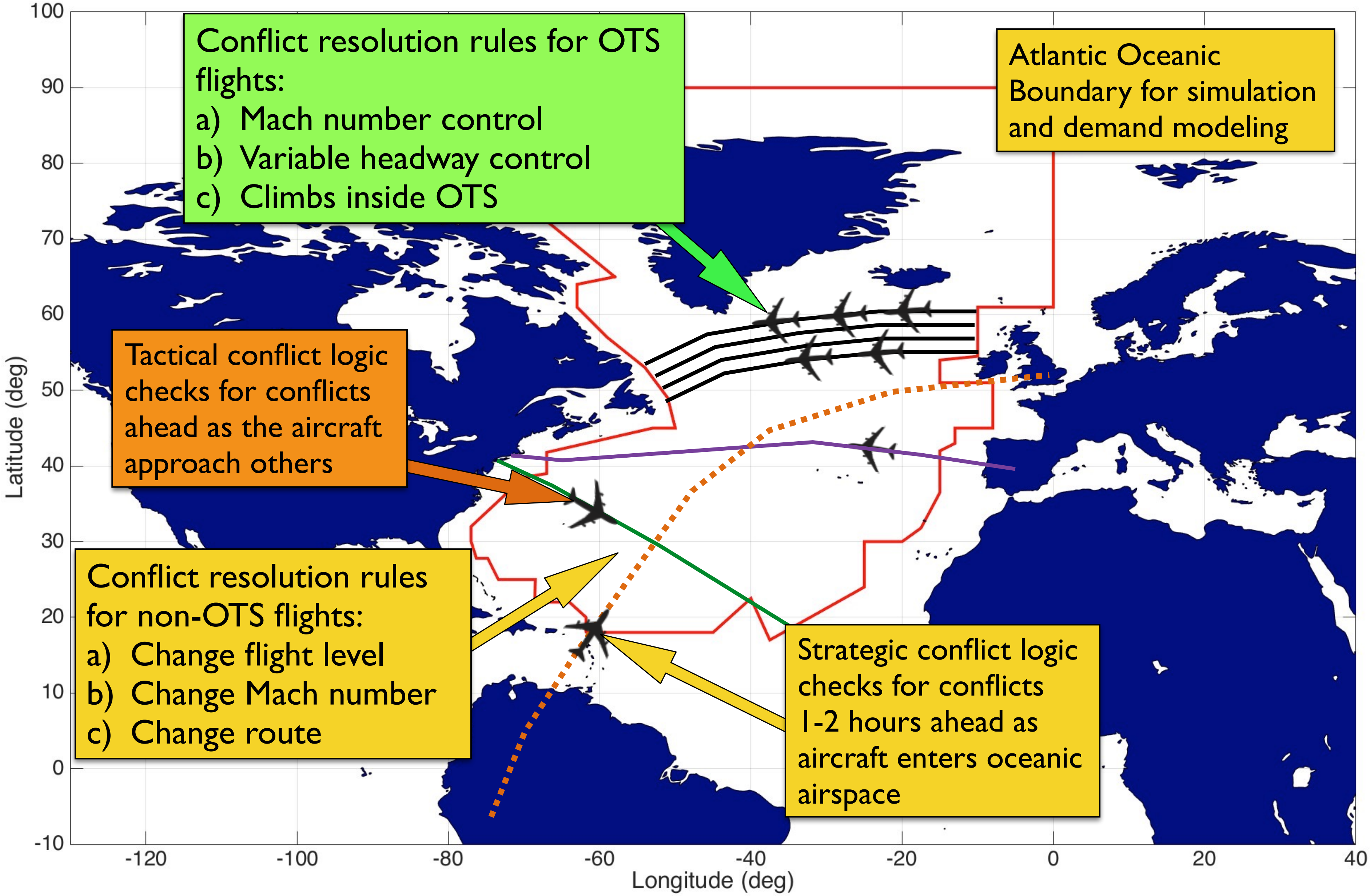
- Aircraft states are evaluated every 5 seconds (sampling rate)
- Model solves the aircraft equations of motion numerically
- BADA aerodynamic model (version 3.11)
- Distance traveled, mass and altitude are aircraft state variables tracked
- NCAR Reanalysis wind model developed by National Oceanic and Atmospheric Administration (NOAA)

Modeling Pilot and ATC Interactions



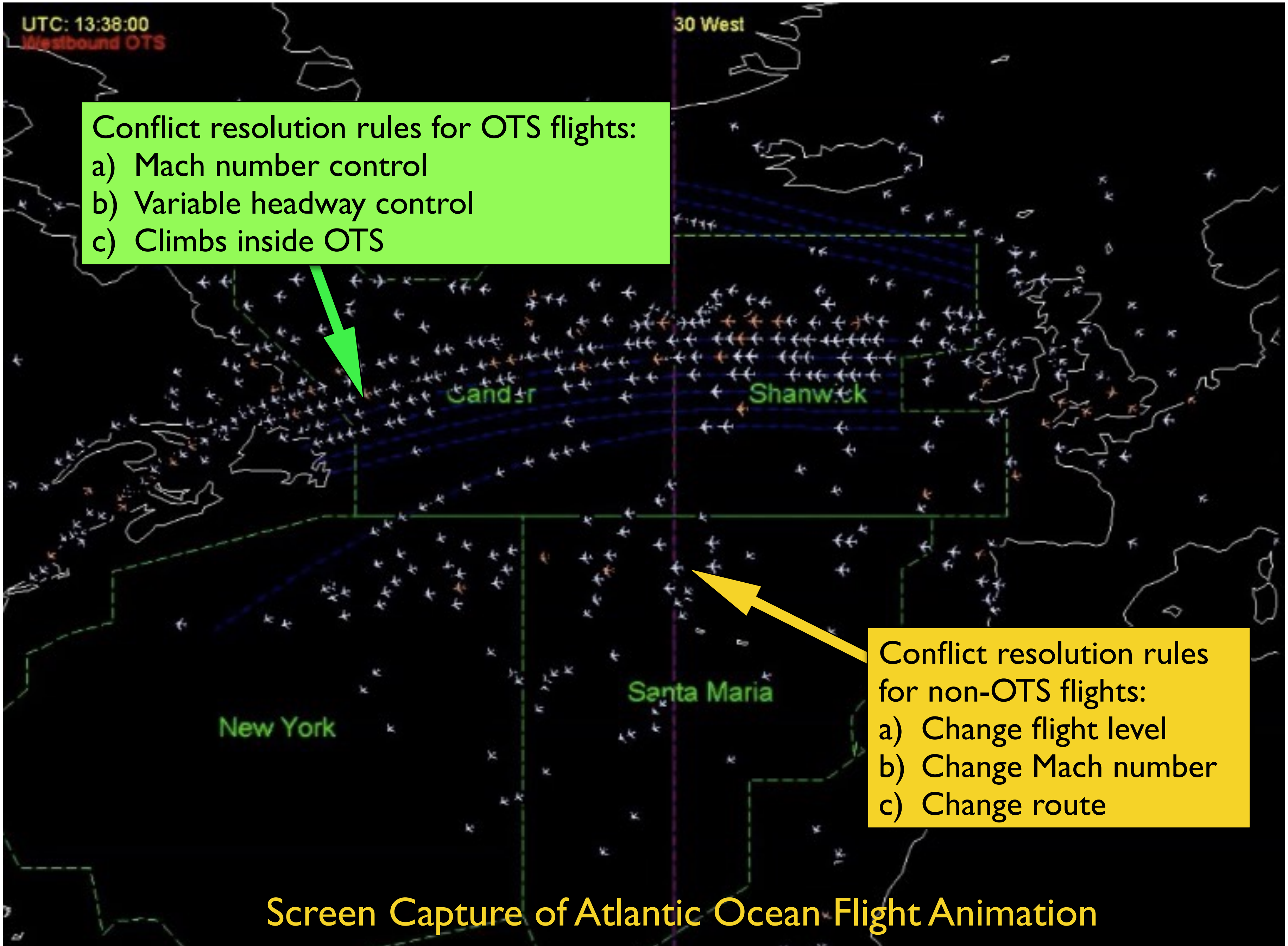
- The pilot routine and ATC routine control aircraft together
- The pilot routine controls an individual aircraft
- The ATC routine controls all the aircraft within a certain airspace

Strategic and Tactical Conflict Algorithms in the Model



Global Oceanic Model Outputs

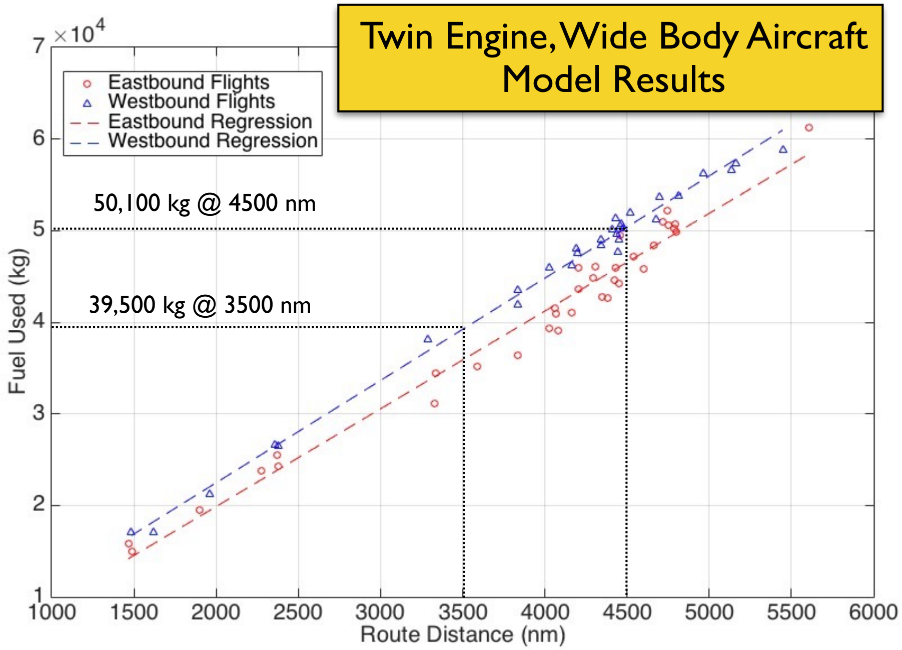
Model Output	Remarks
Fuel consumption	Total fuel used for all flights (random and NAT OTS) from origin to destination
Travel time	Total travel time for all flights (random and NAT OTS) from origin to destination
Percent of non-OTS flights flown with tactical conflict resolution changes	Level of service indicator for OTS flights Reports the number of tactical conflicts detected and resolved
Percent of non-OTS flights flown with strategic conflict resolution changes	Level of service indicator for on-nOTS flights Reports number of strategic conflicts
Percent of OTS flights accommodated in desired NAT track and cruise altitude (both)	Level of service indicator for OTS flights Reports the percent of flights assigned to their requested NAT track and cruise altitude in the NAT region
Pilot and ATC Exchanges	Number of requests for cruise flight level changes
Aircraft trajectory details	5-second interval flight trajectory



Screen Capture of Atlantic Ocean Flight Animation

Model Validation

Twin Engine, Wide Body Aircraft
Model Results

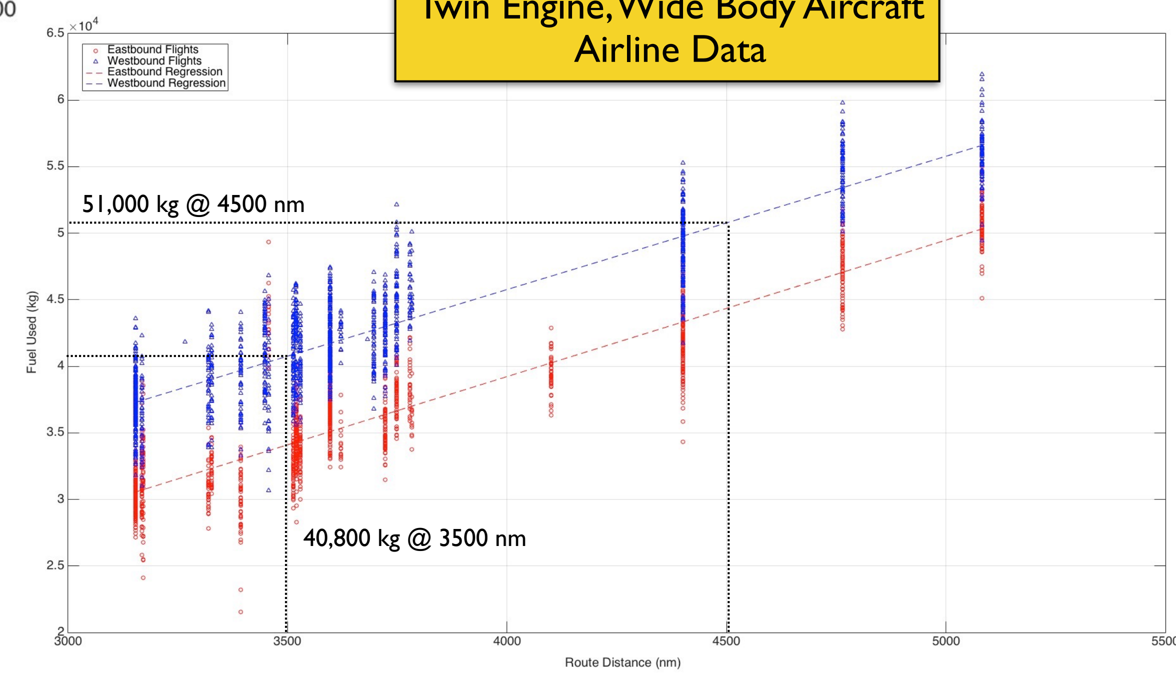


Airline data supplied by Airlines for America

For most aircraft the model replicates within 2-3% accuracy the observed fuel trends derived from airline data (A4A)

Airline data has much wider variability in fuel used because the data is taken from 79 distinct days

Twin Engine, Wide Body Aircraft
Airline Data

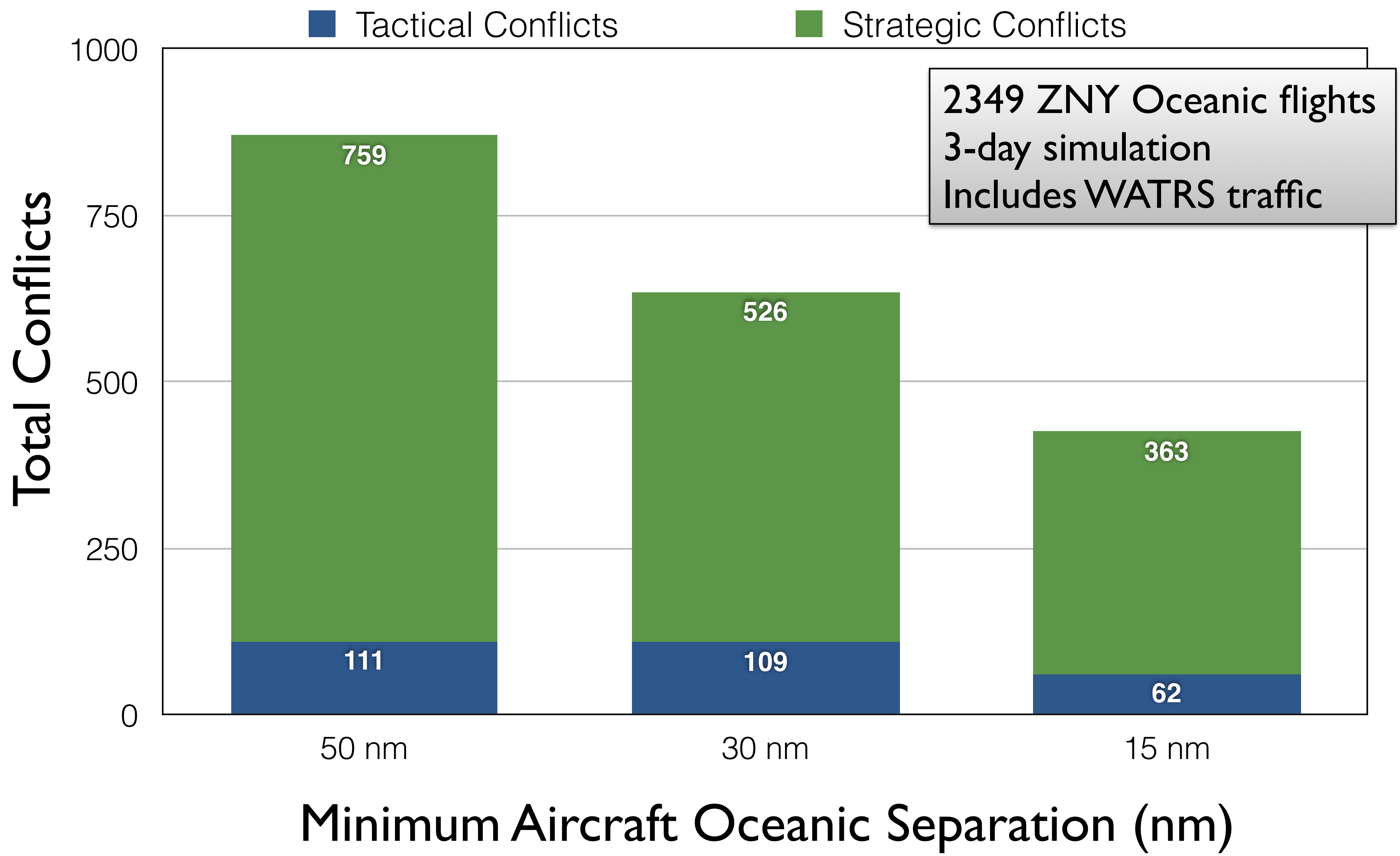


Preliminary Results of the Modeling Effort

Modeling Assumptions

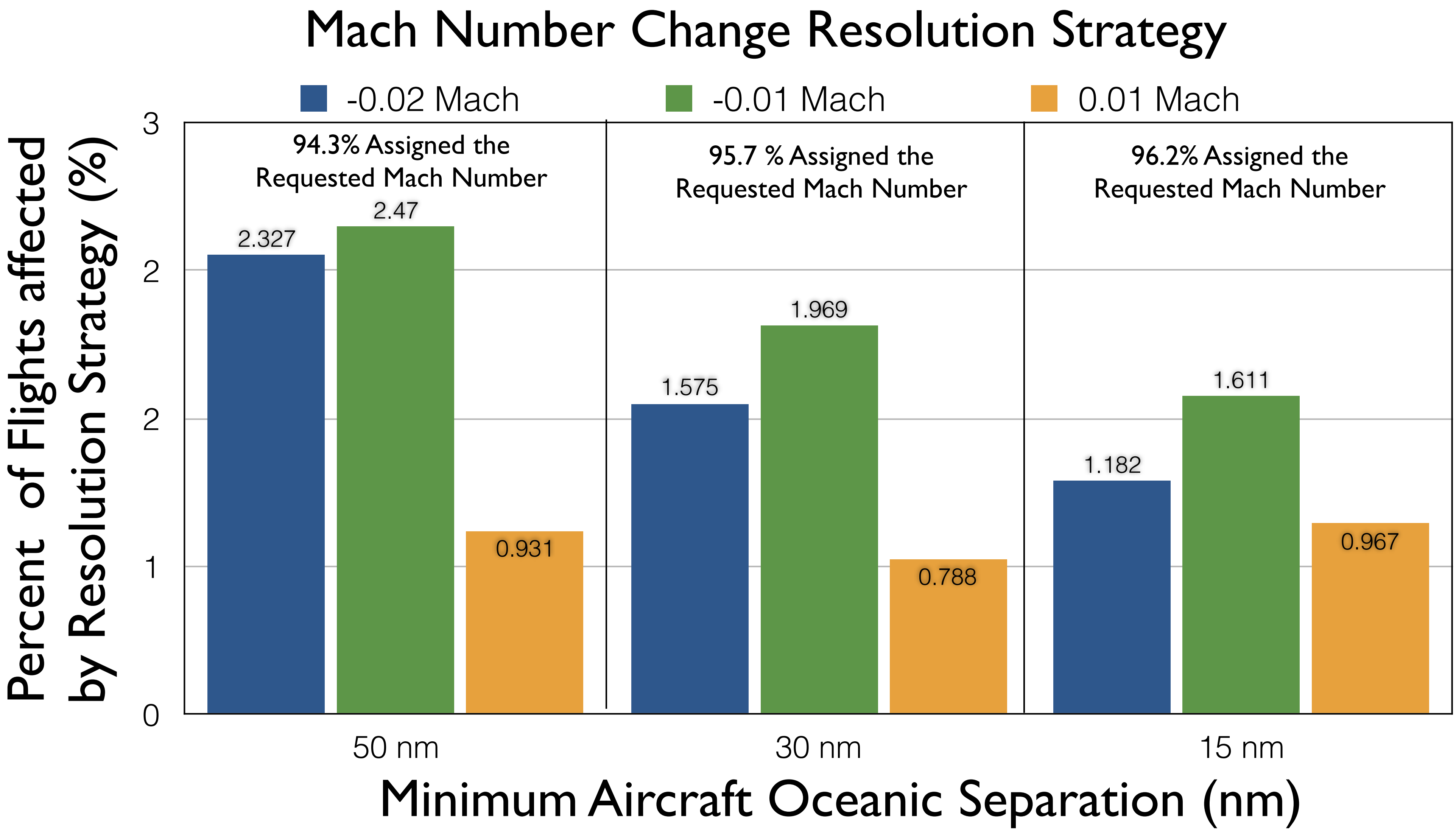
- Modeled both OTS and non-OTS flights in the Atlantic
- Modeled Pacific Ocean flights as non-OTS flights (for now)
- NCAR Re-analysis wind data
- 21 aircraft groups included in the simulation runs (B787-8 and B747-8)
- Pilots/controllers check every 10 minutes for possible climbs
- 3-Day demand set simulation (using TFMS demand data sets provided by FAA)
- Assumed 2,000 foot hemispherical rules
- Equipage levels per FAA/CSSI equipage level survey
- $0.7 US dollars per gallon of fuel

Atlantic Ocean Results
Tactical and Strategic Conflicts



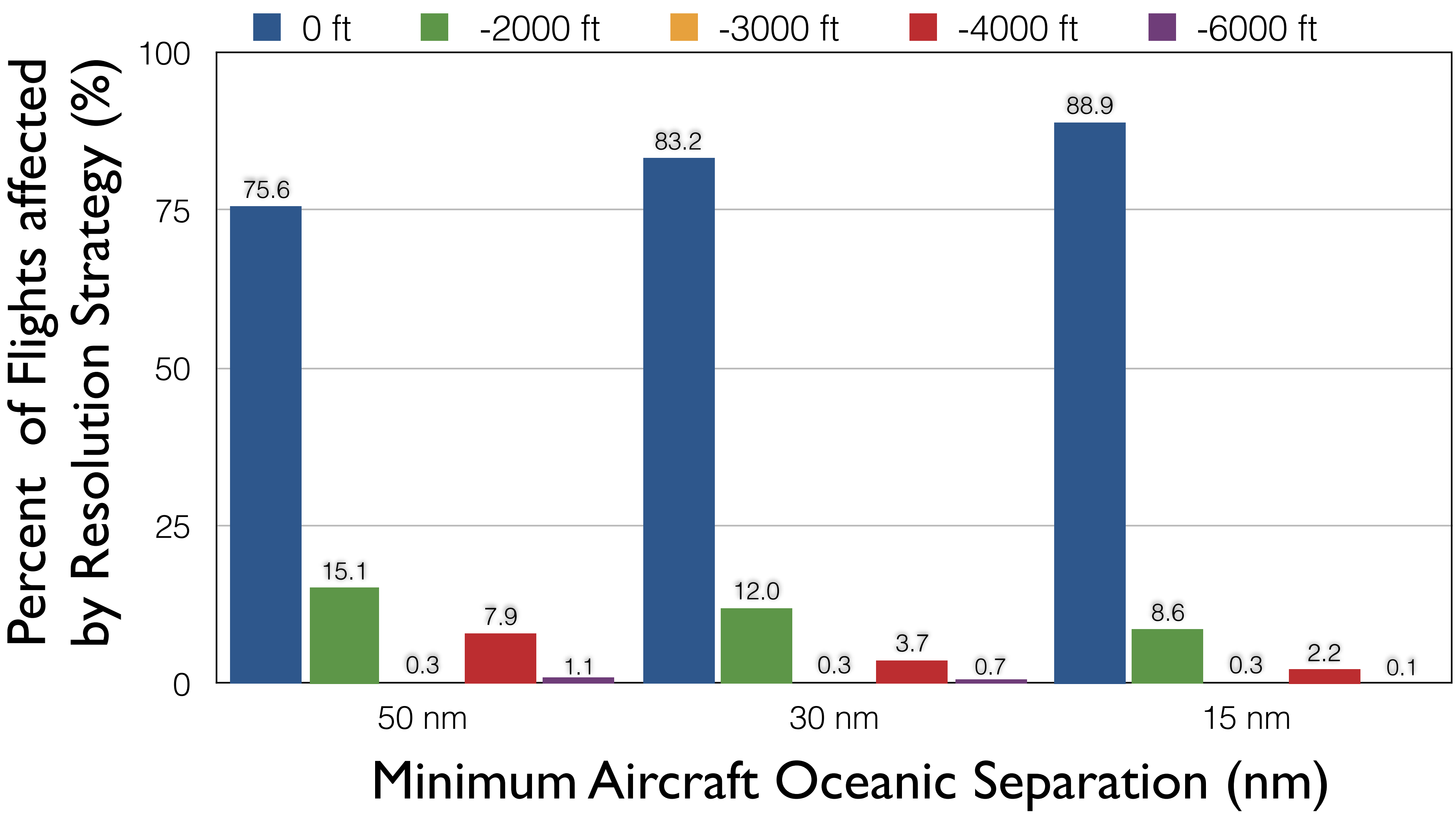
Results for Pacific Ocean Flights

3-day simulation - includes flights to and from Hawaii

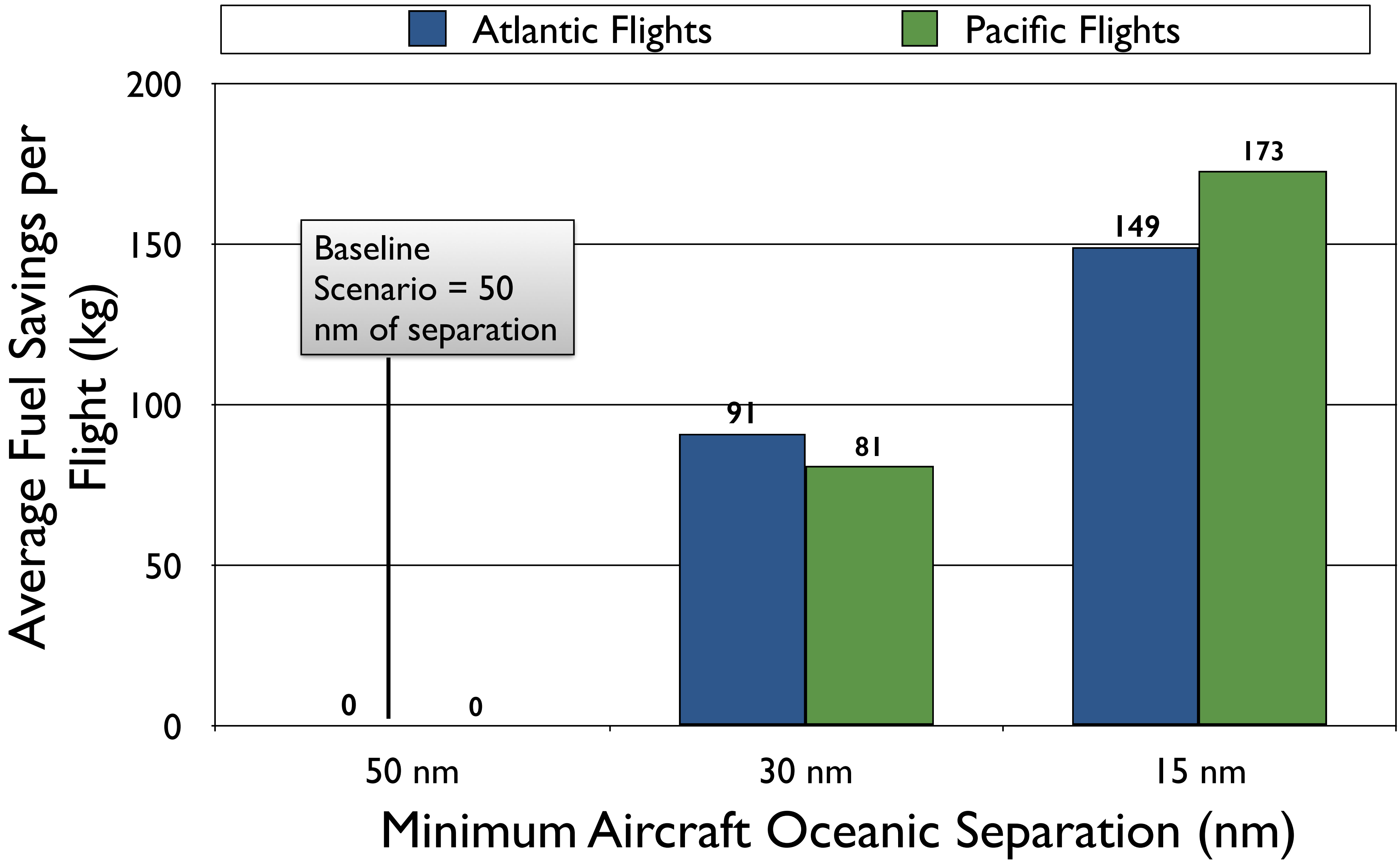


Cruise Altitude Resolution Strategy Results

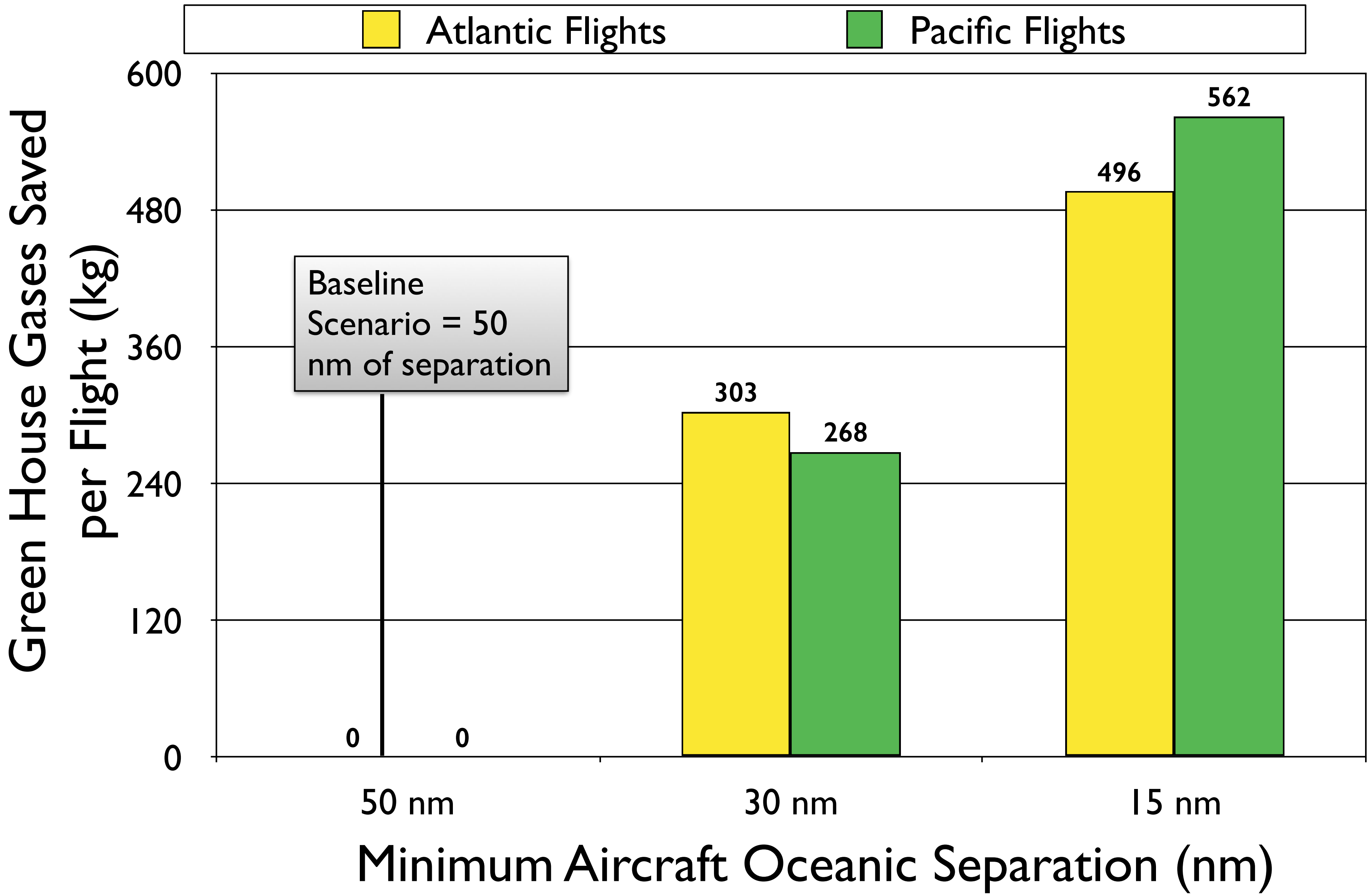
3-day simulation, non-OTS ZNY flights, Includes WATRS traffic



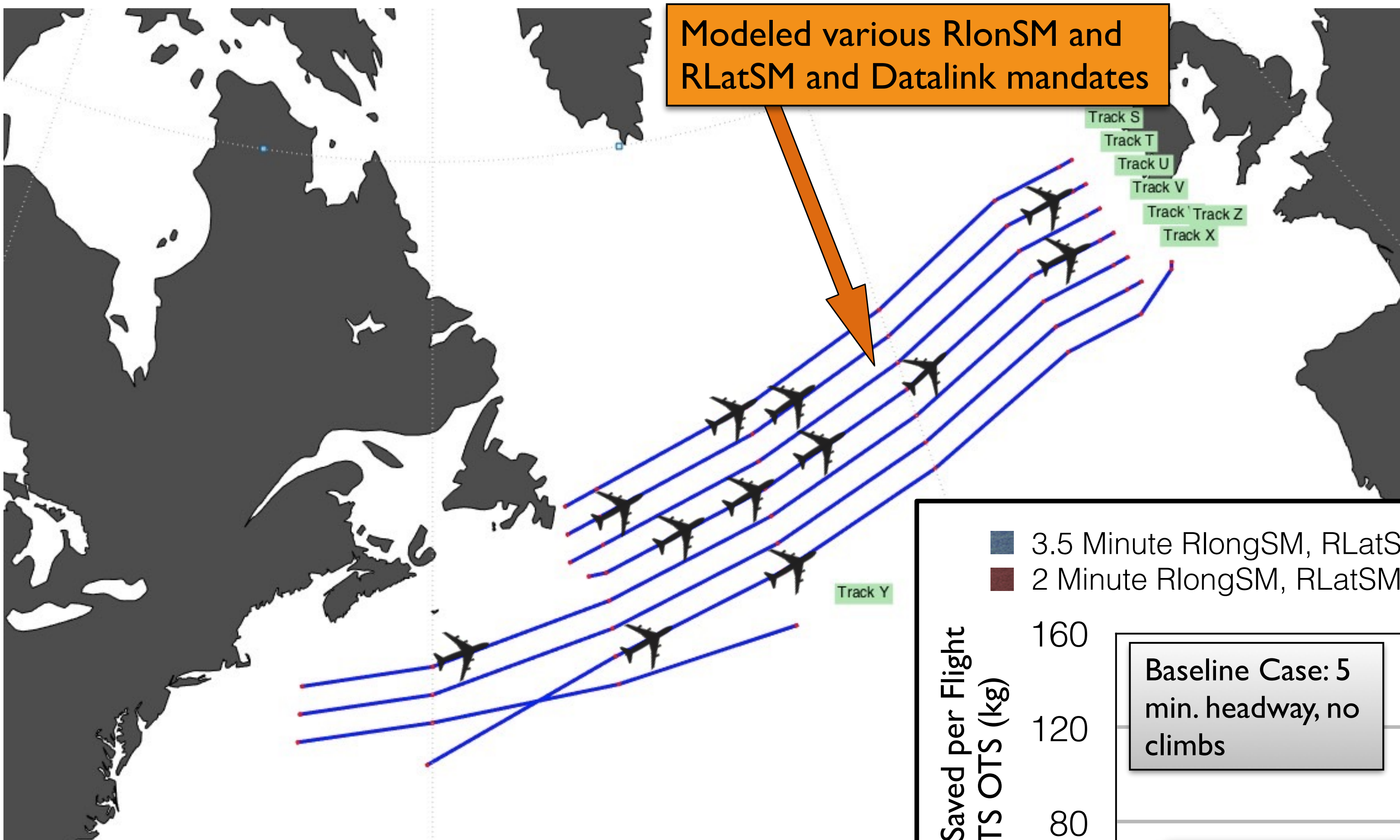
Fuel Savings for Oceanic Non-OTS Flights

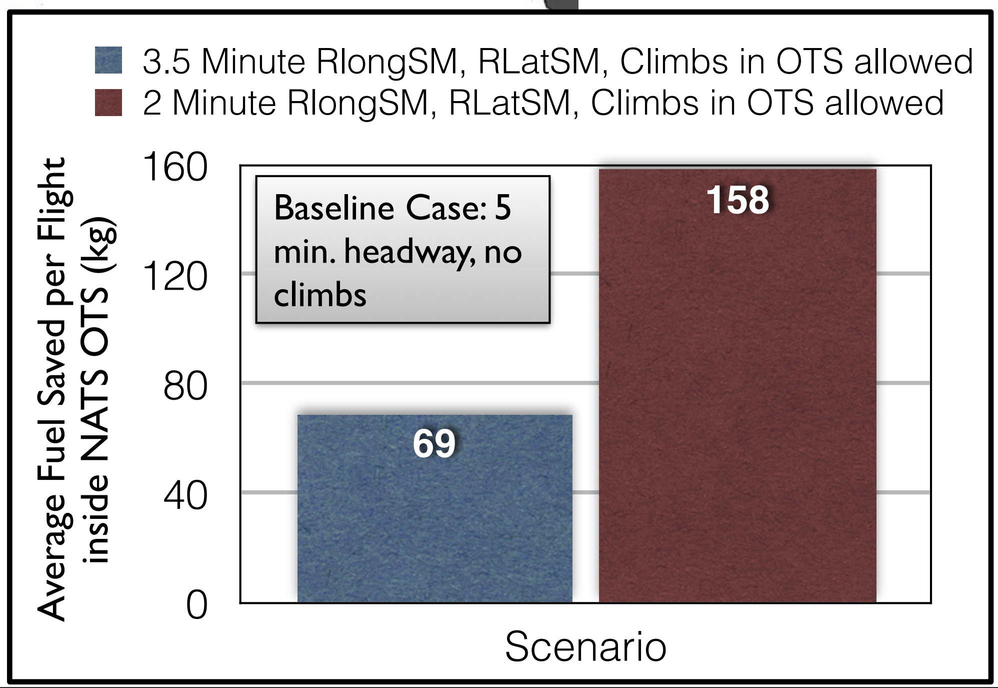


GHG Savings for Non-OTS Flights



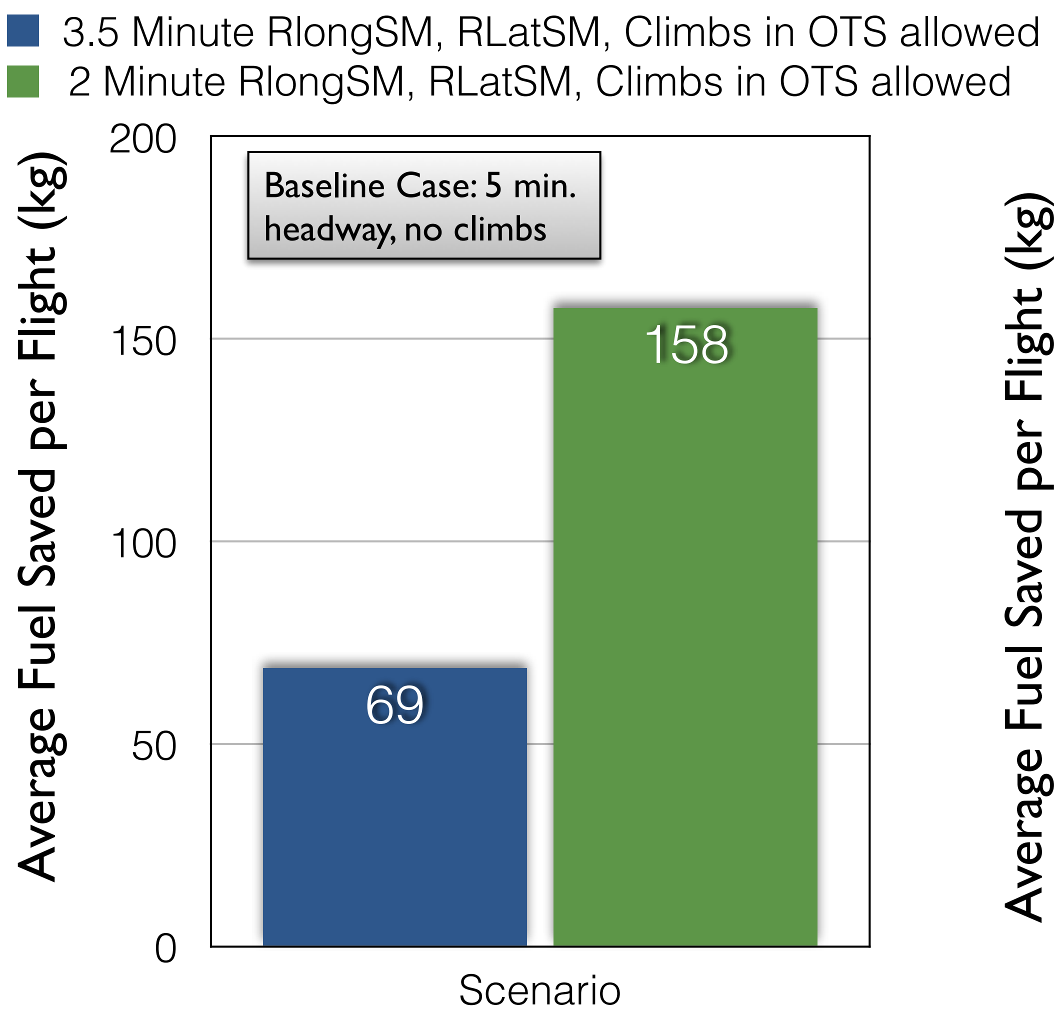
Fuel Savings for North Atlantic OTS Flights



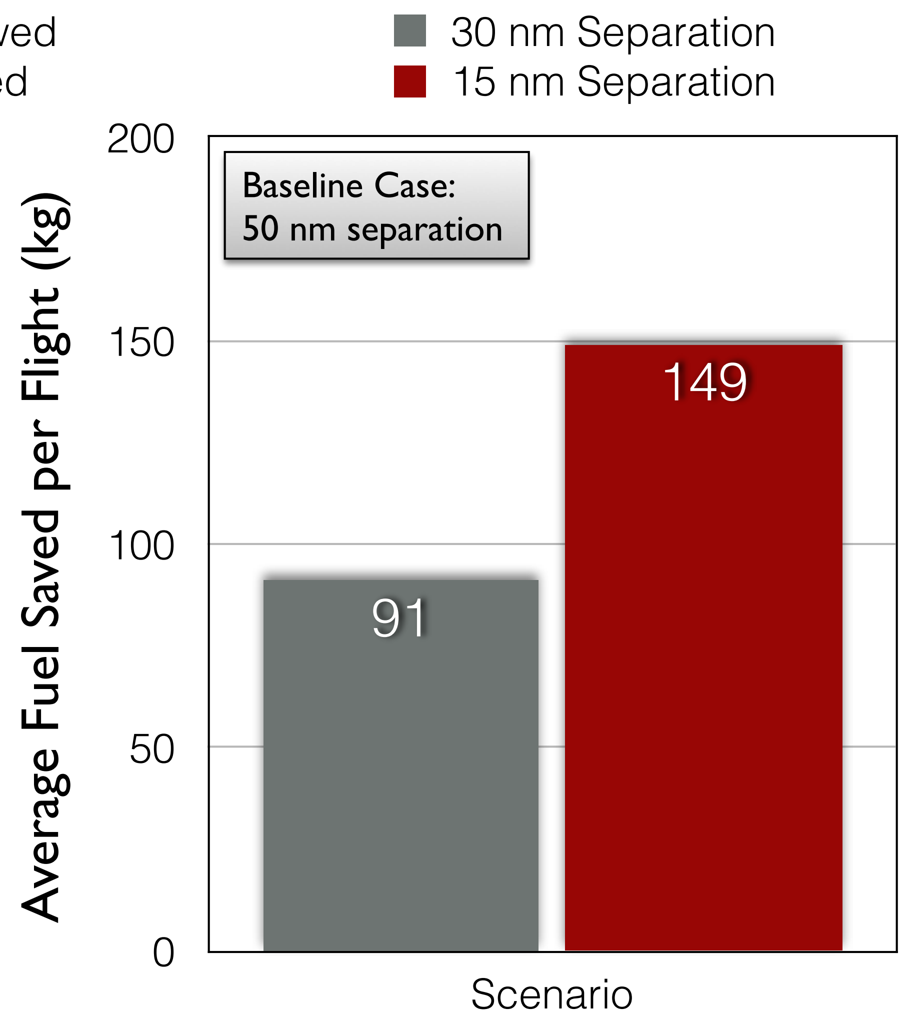


Atlantic Ocean Fuel Benefits per Flight using Satellite-Based ADS-B Surveillance Technology

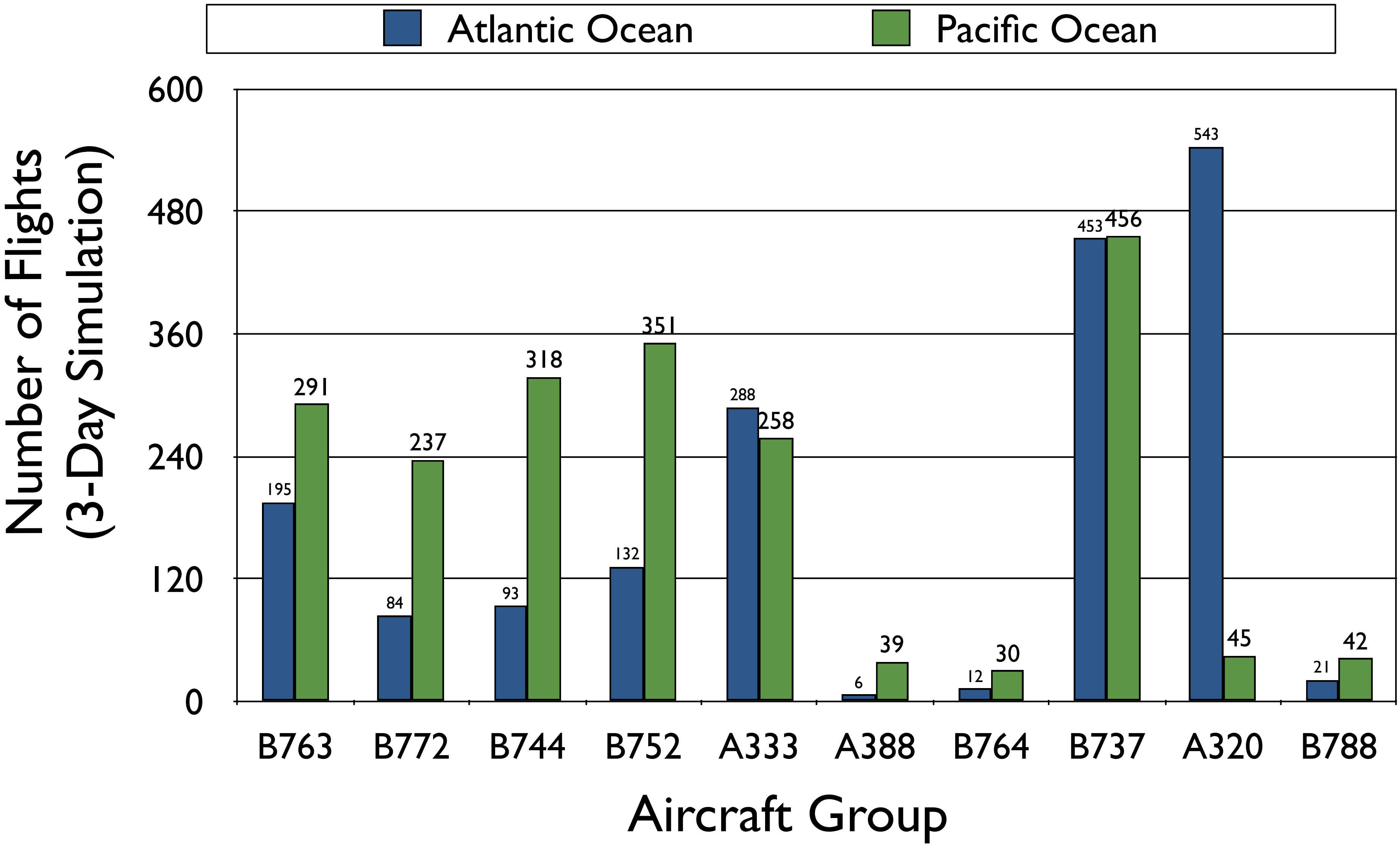
North Atlantic OTS Flights



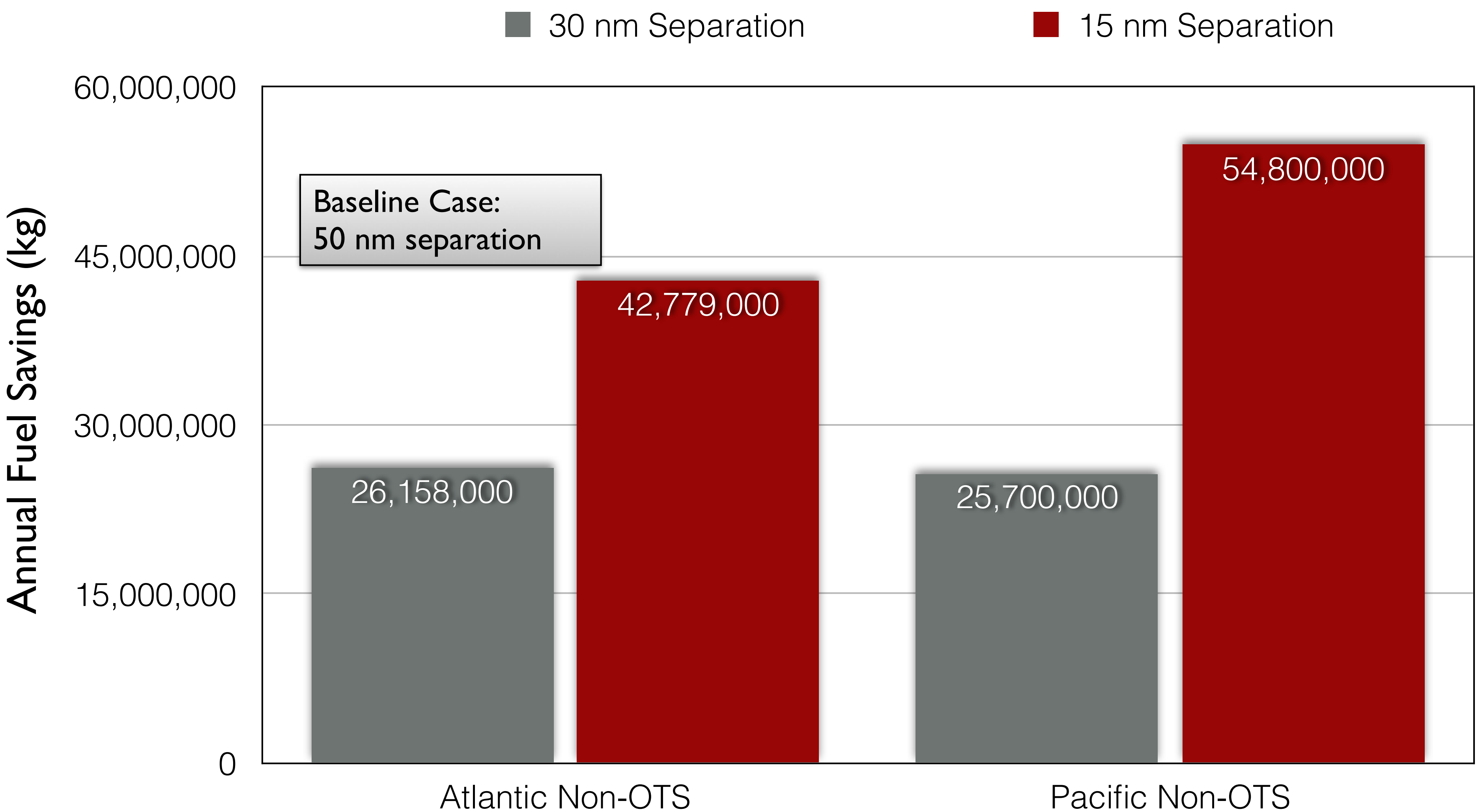
Non-OTS Flights Includes ZNY Oceanic Flights



Aircraft Fleet Mix Composition (Non-OTS Flights)



Preliminary Annual Fuel Benefits for Various Advanced ATM Initiatives (for Non-OTS Flights)



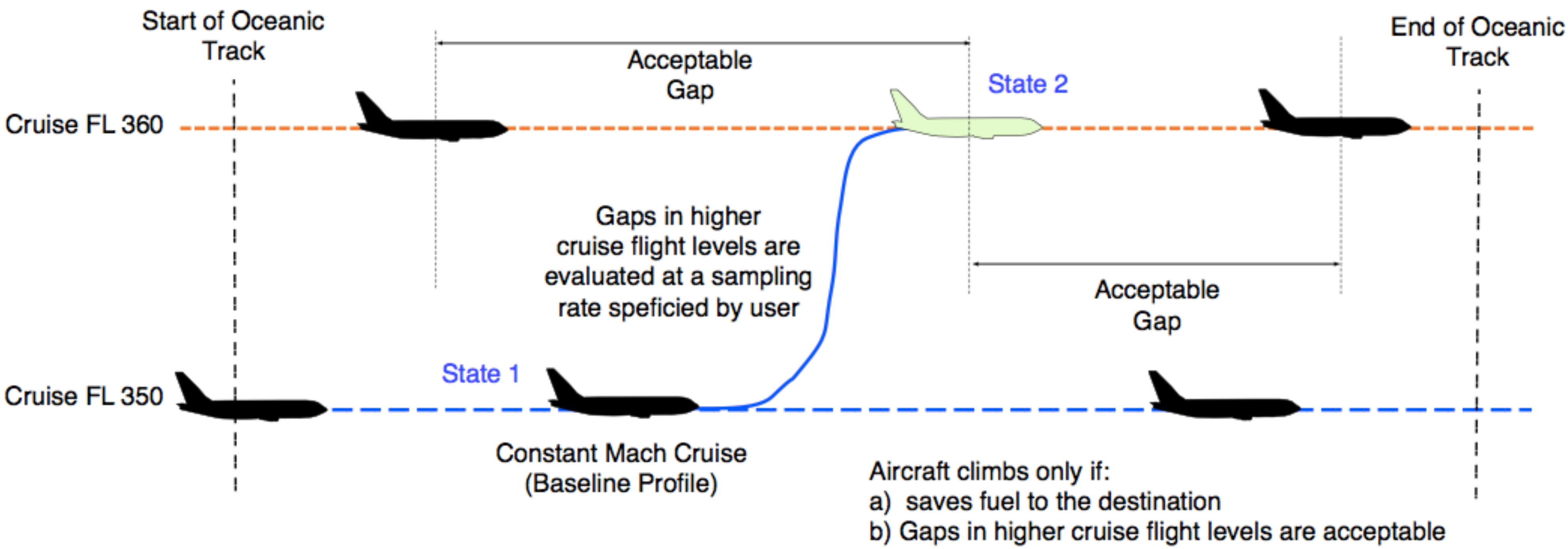
Conclusions

- A computer simulation model to estimate fuel savings, travel time and OTS track level of service metrics has been developed by NEXTOR Virginia Tech
- The model provides FAA and ICAO decision makers with a tool for making a business case for new space-based surveillance technologies such as ADS-B
- Preliminary results indicate that Atlantic Ocean flights could save 149 kg per flight if 15 nm oceanic separations are achieved with the use of space-based ADS-B technology (*baseline is 50 nm separation*)
- Preliminary results indicate that Pacific Ocean flights could save 171 kg per flight if 15 nm oceanic separations are achieved with the use of space-based ADS-B technology (*baseline is 50 nm separation*)
- Fuel savings range from 43 to 55 million kilograms of fuel annually for non-OTS flights. Savings of 37 million kilograms of fuel annually for North Atlantic OTS flights are anticipated.

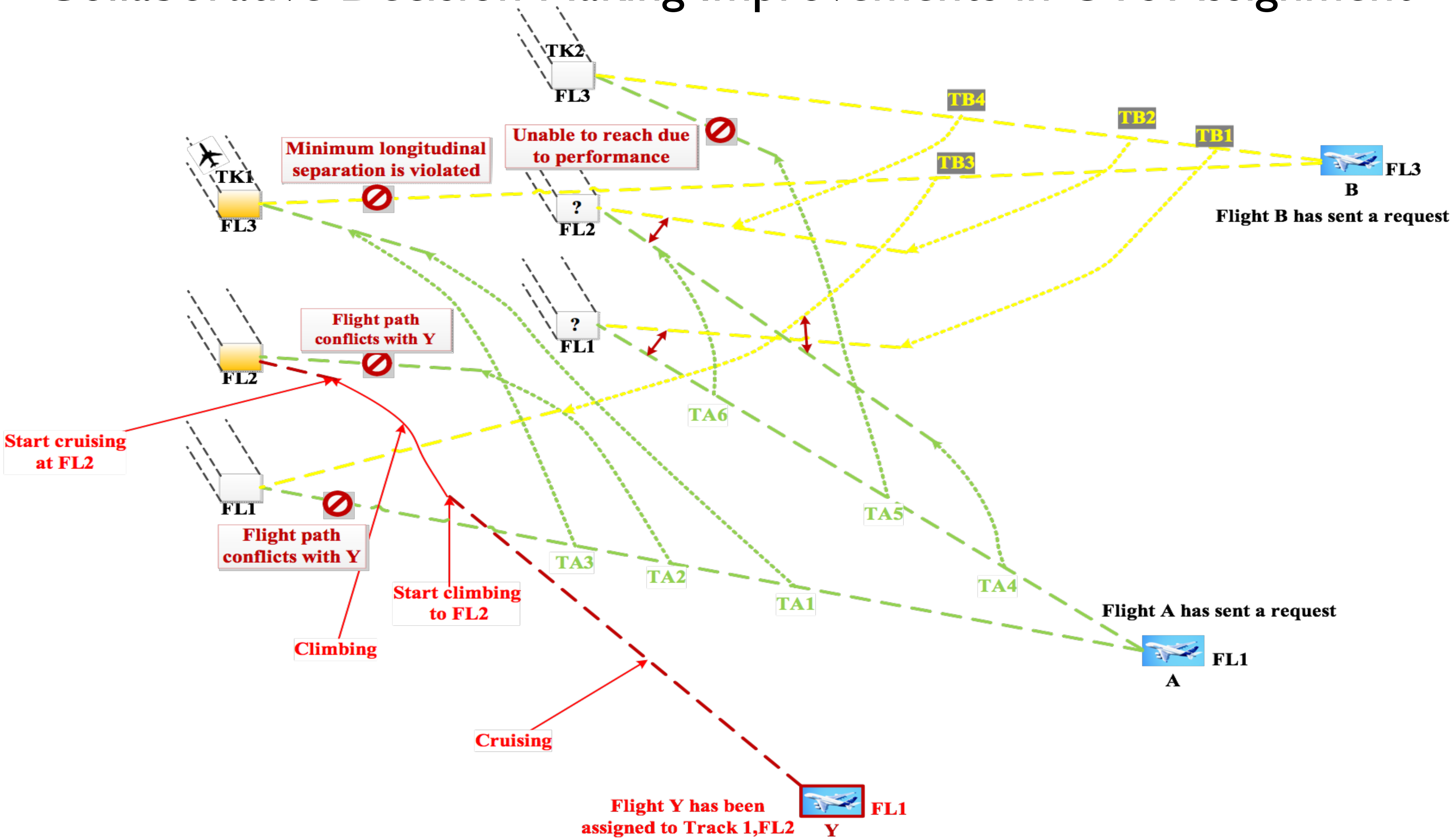
Backup Slides

Estimating Aircraft Climb Benefits Inside OTS

- Climbs inside the OTS are modeled to quantify the improvement in fuel efficiency in more advanced concepts of operation
- Dynamic headway rules and minimum acceptable gap rules apply



Collaborative Decision Making Improvements in OTS Assignment



- The current OTS assignment procedure is similar to a first-request-first-assigned method.
- For off-peak periods, this procedure could produce OTS assignments close to the optimal assignment