CDM and Oceanic Traffic Modeling

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Presentation to:
NEXTOR 20th Anniversary Workshop

University of Maryland
College Park
September 29-30, 2016

Presentation and Acknowledgement

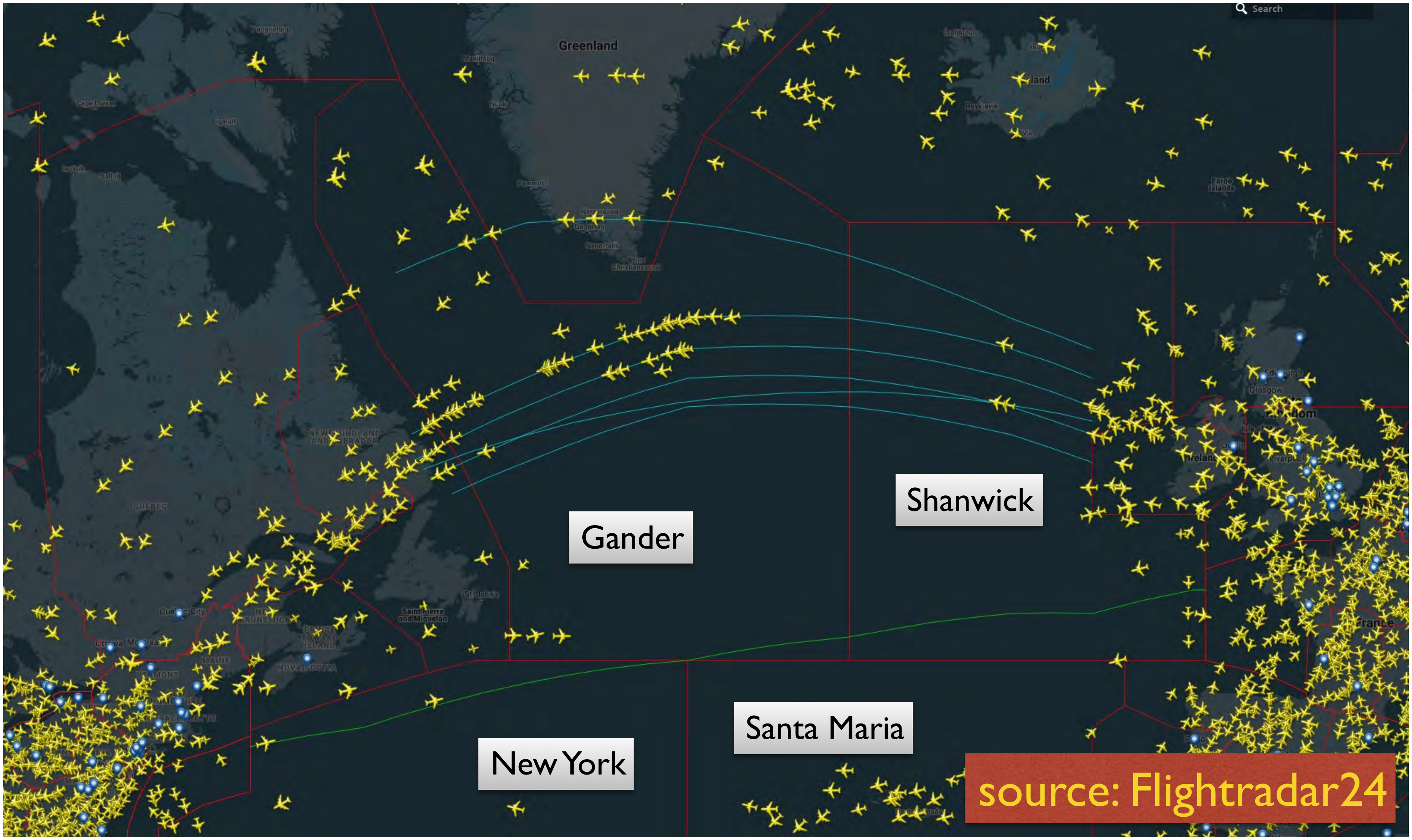
- Collaborative Decision Making
- Oceanic traffic samples and the need for CDM
- Review of the Global Oceanic Model
  - Key points about the model
  - Simulation analysis

National Center of Excellence for Aviation Operations Research project supported by the Federal Aviation Administration
Special thanks to Dr. Dave Chin, Dr. Thea Graham, Joe Post, J. Gulding, N. Campos, T. Choi and P. Truong.

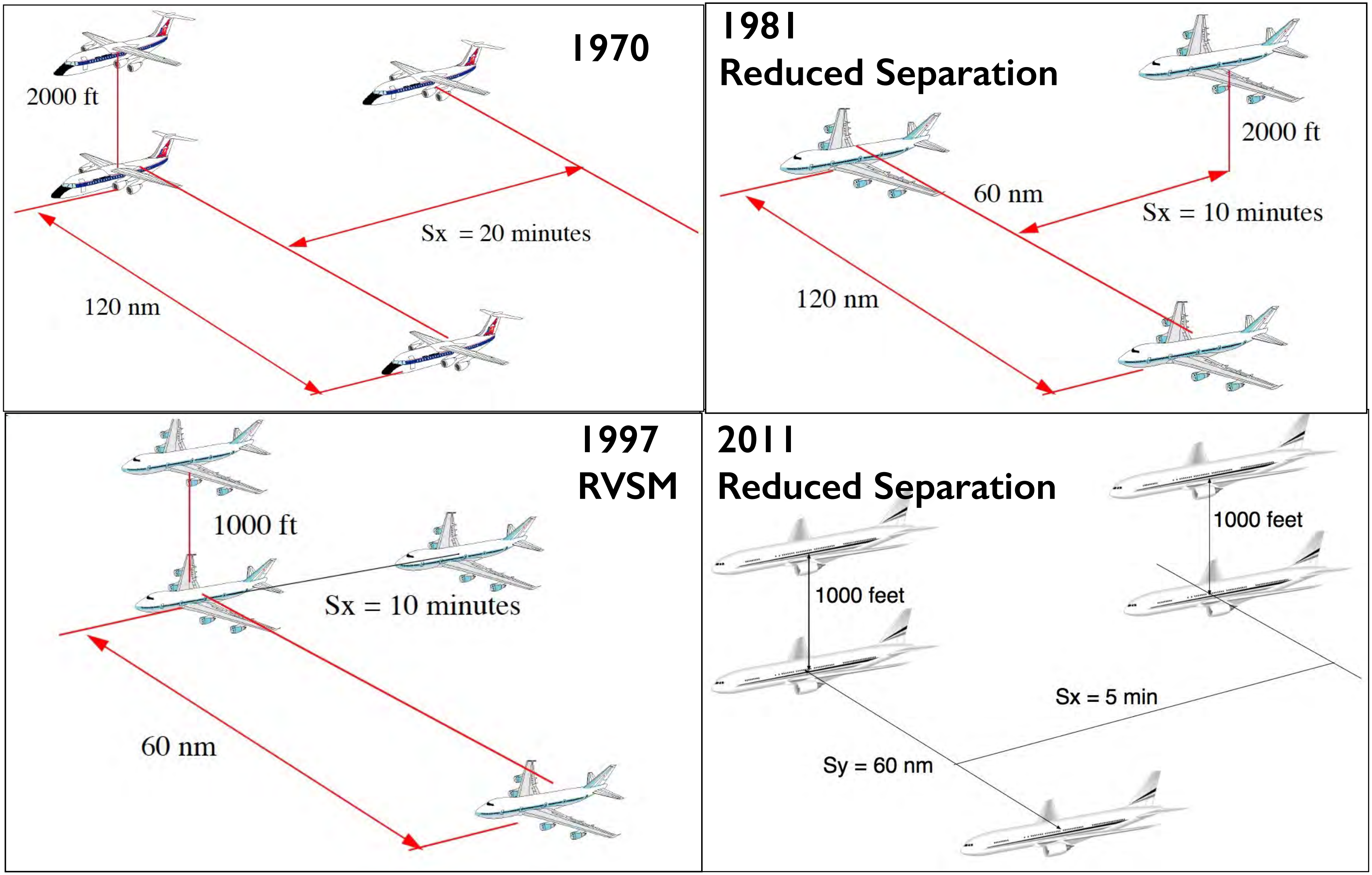
Collaborative Decision Making (CDM)

- A paradigm to improve Air Traffic Flown Management (ATFM)
  - "Information exchange among stakeholders" (FAA)
  - "Better information leads to better decision-making" (FAA)
  - "A set of tools and procedures needed to improve the level of service provided by air navigation service providers under dynamic conditions" (FAA)
- CDM has been applied successfully in the NAS and other parts of the World
- CDM techniques could equally apply to oceanic airspace

Example where some Elements of CDM have been Applied Successfully



North Atlantic Operations and Separations



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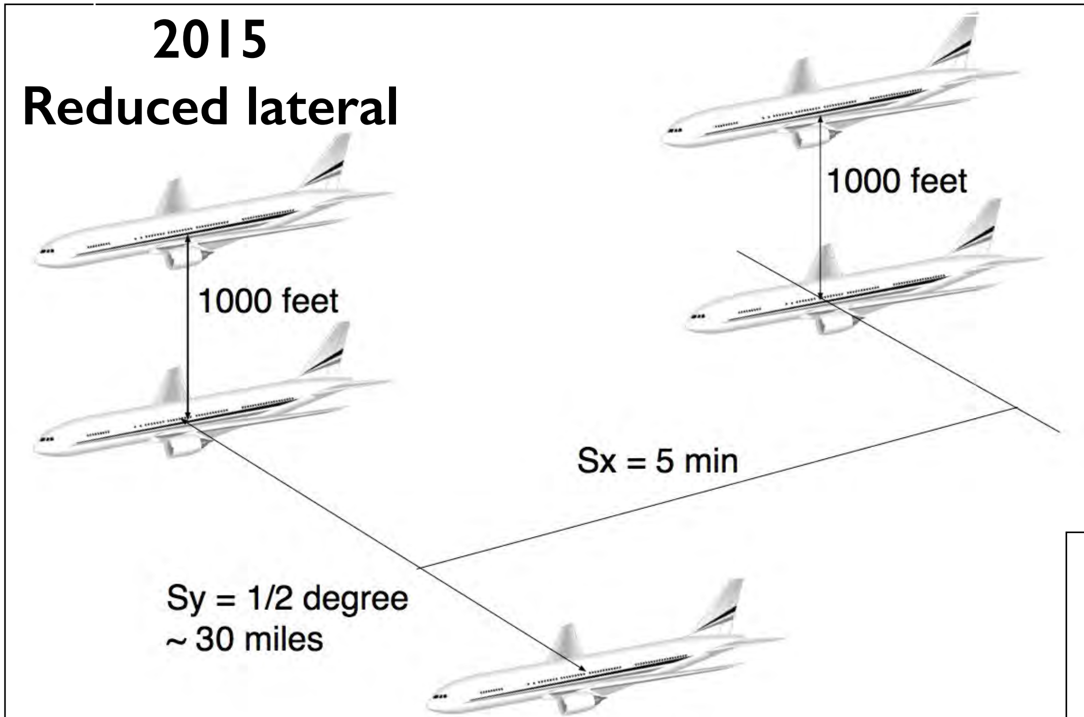
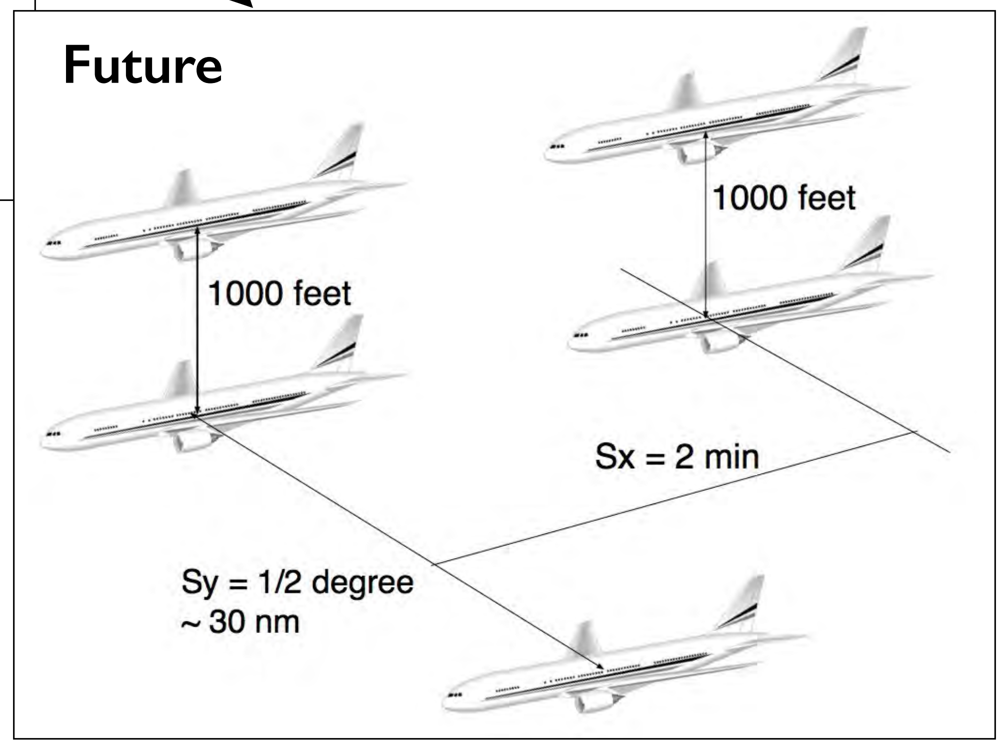




NEXTOR 2 Role in Oceanic Modeling

- Developing simulation tools to understand the benefits of improved surveillance using satellite-based ADS-B technology (**Virginia Tech**)
- Developing techniques to optimize the potential benefits of single flight trajectories across oceanic airspace (**MIT**)
- These approaches are complementary

- In the next few slides we provide some insight on the problem and models developed

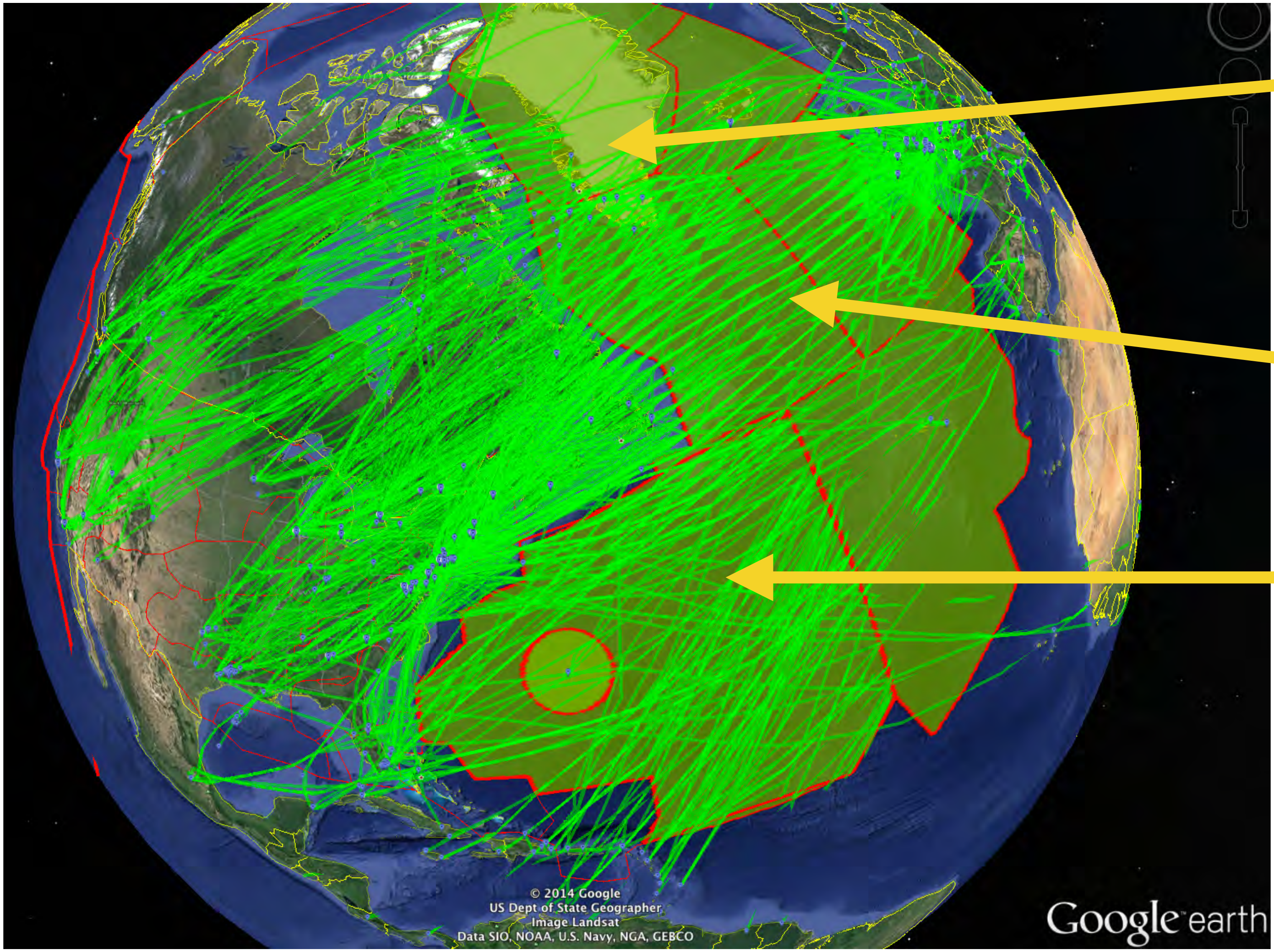
Potential Benefits of Advanced Surveillance Technology (e.g., Satellite-Based ADS-B)

- Reduced Longitudinal Separation Minima (RlongSM)
  - Allows aircraft flying in-trail to be spaced closer (below 5 minutes in-trail)
- 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
- Safety benefits (not quantified in this analysis)

Solution: Global Oceanic Model

- Estimate fuel, travel time and levels of service for flights crossing the Atlantic Ocean (North and Central parts of the Atlantic ocean)
- Estimate future fuel savings and 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
- Model can be applied to the Pacific Ocean or other regions (multi-region capability)

North Atlantic System



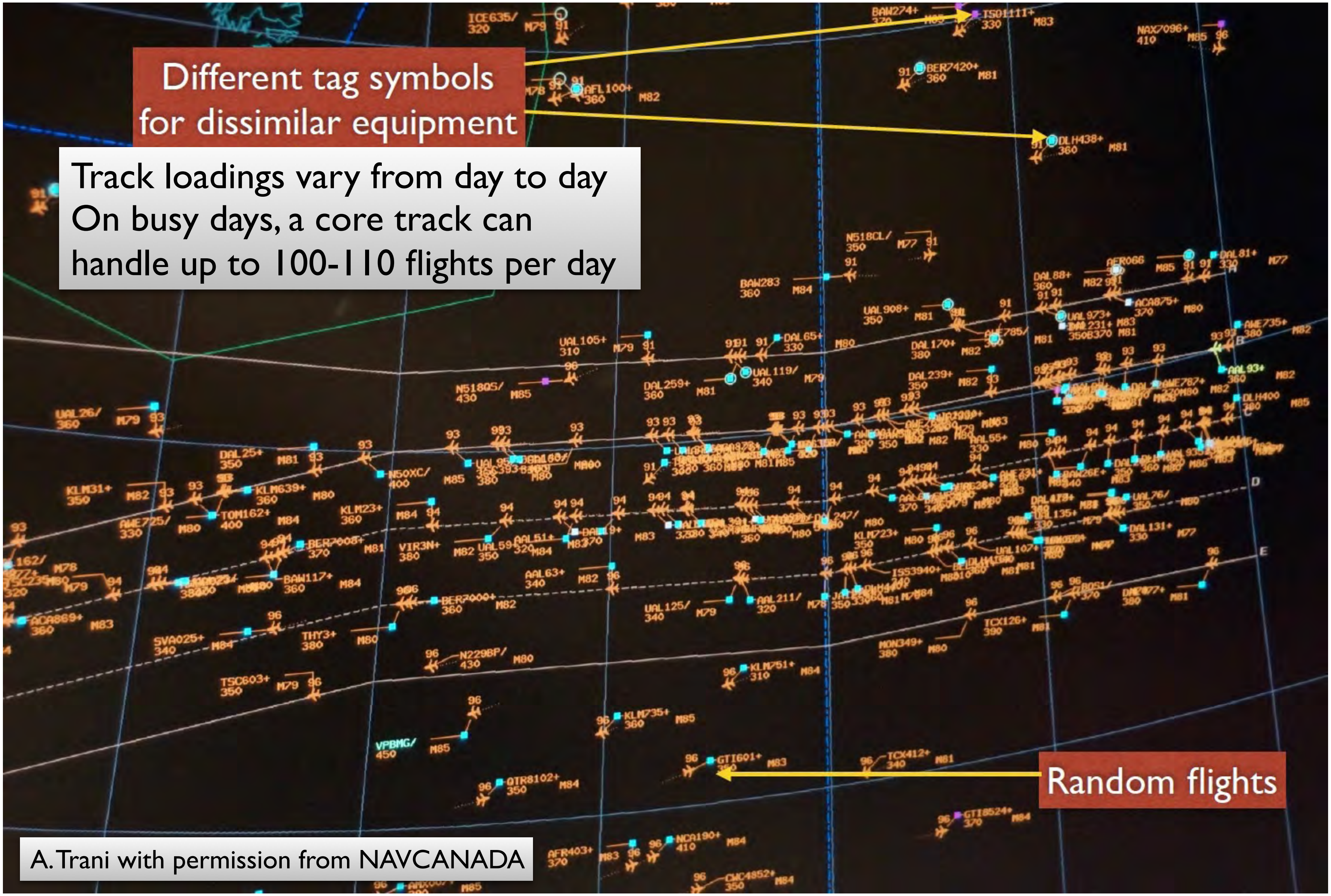
Northern flights (user-preferred routes)

Organized Track System (OTS flights)

Southern flights (user-preferred routes)

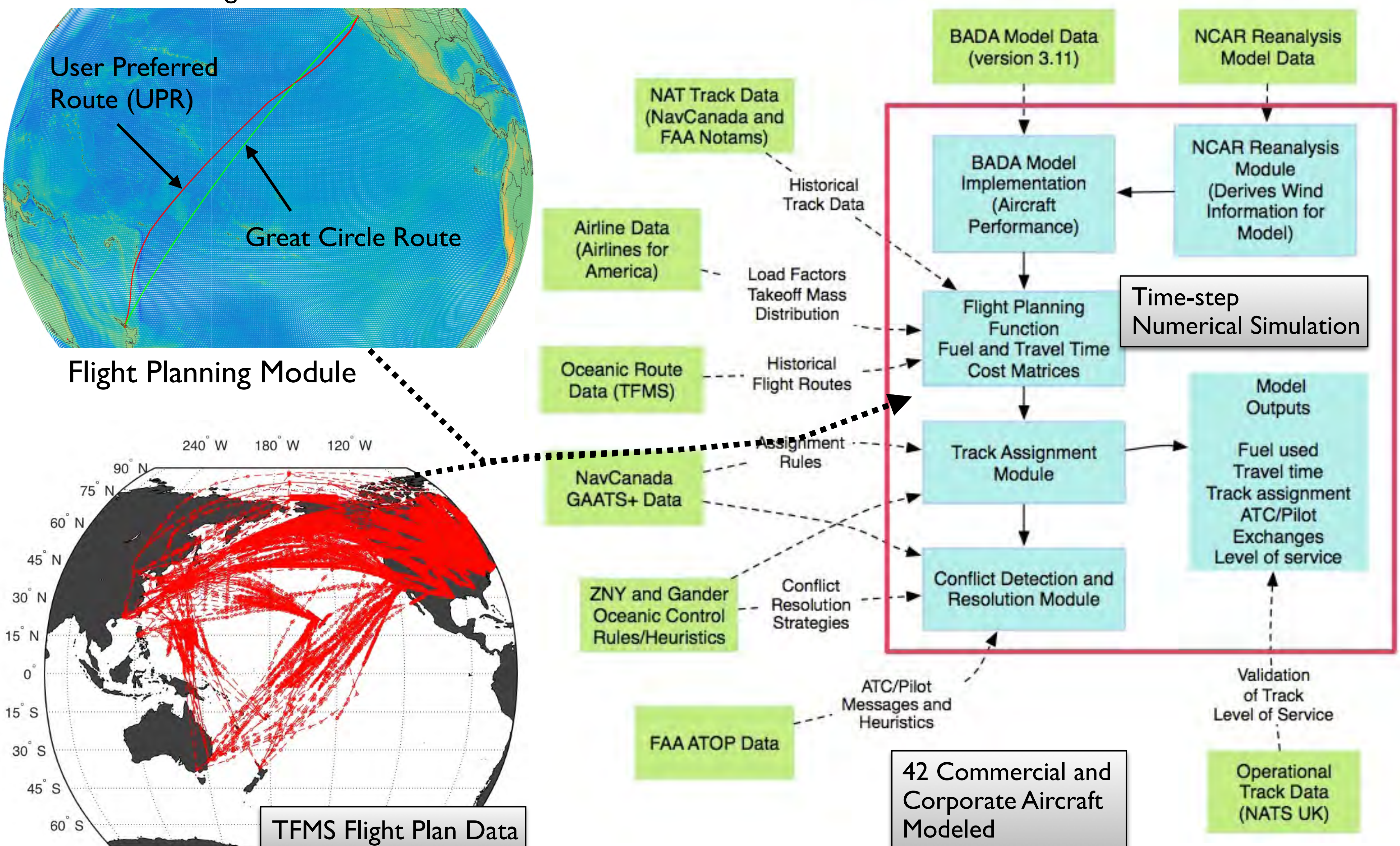
FAA TFMS data
Google Earth

ATC View of Organized Track System

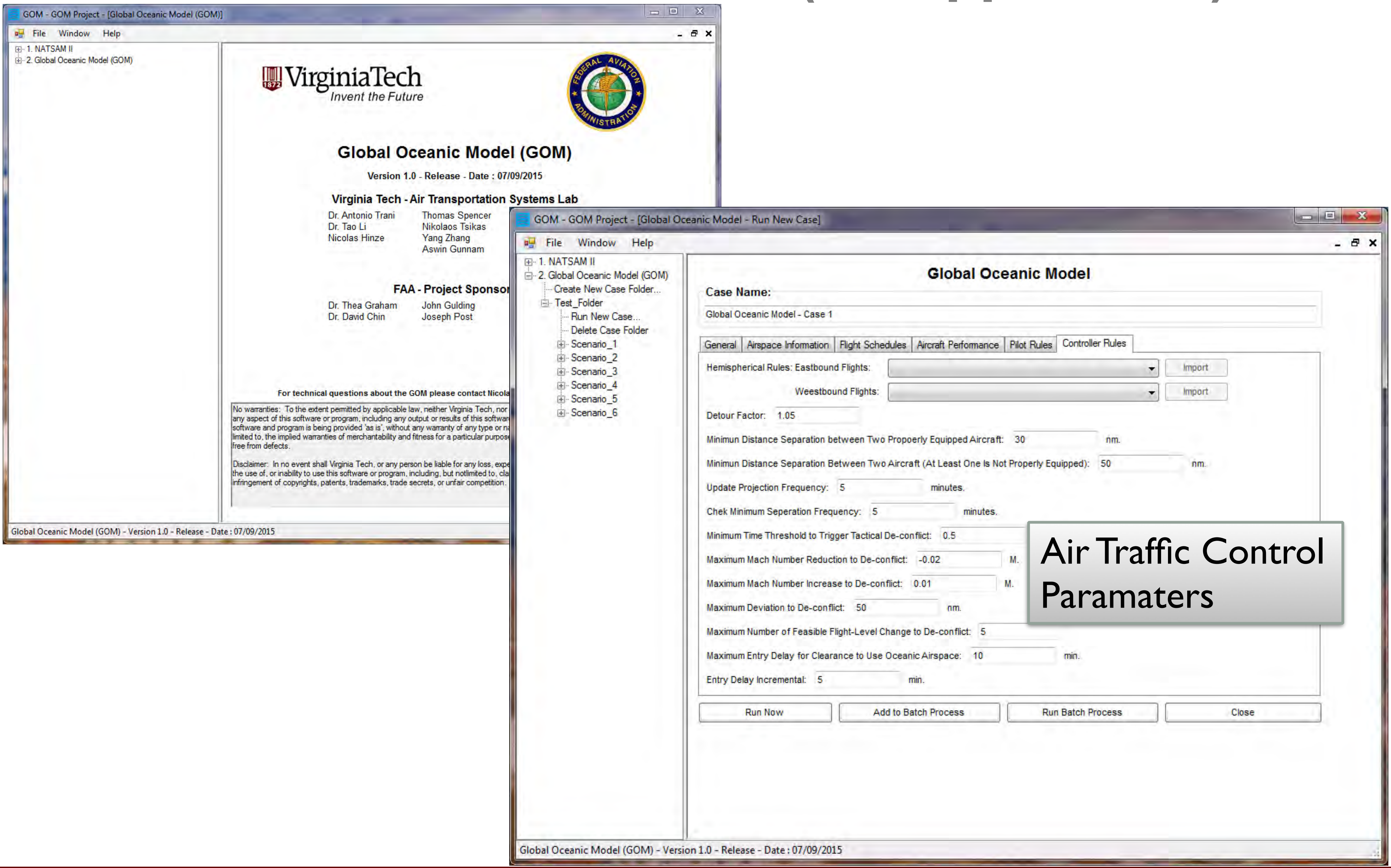


Global Oceanic Model

Los Angeles - Auckland

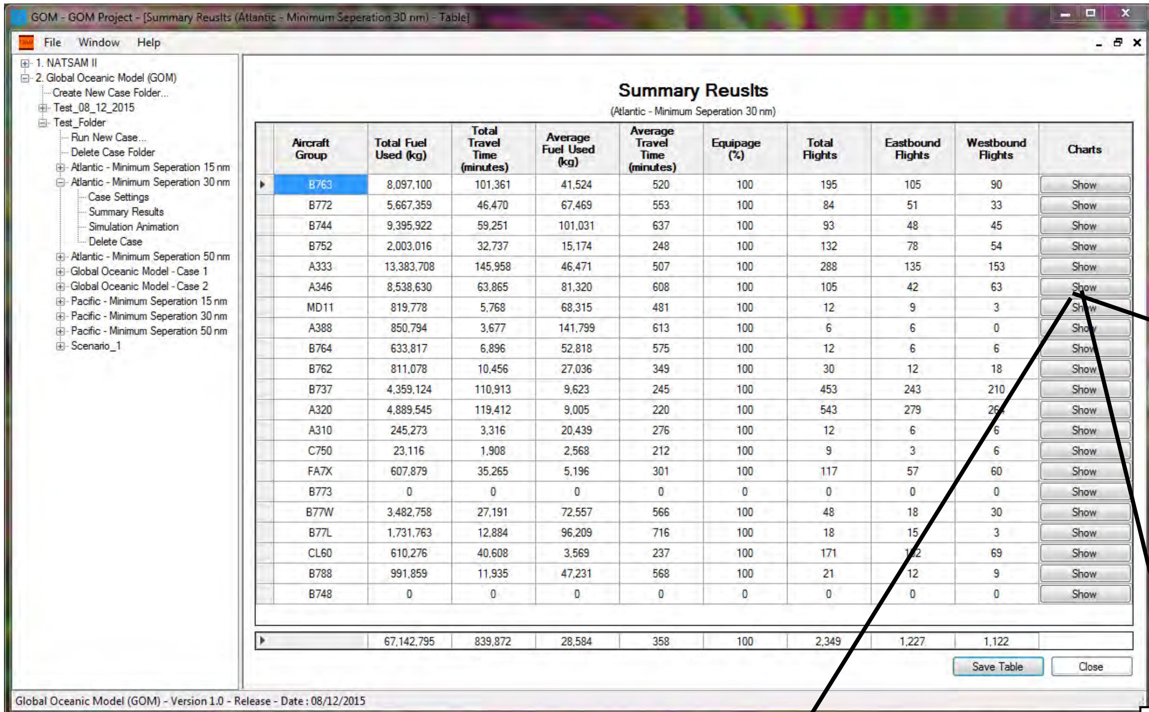


Global Oceanic Model (An Application)



Air Traffic Control Paramaters

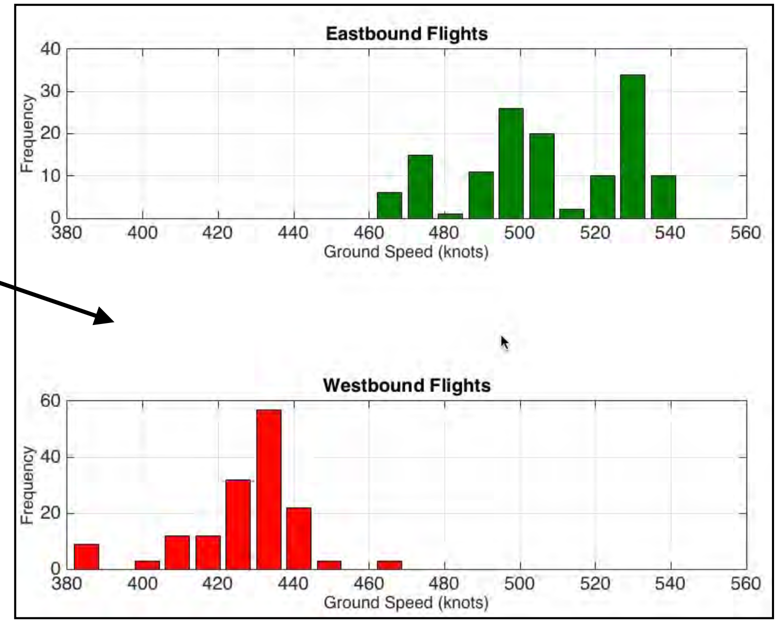
Global Oceanic Model Results: Summary by Aircraft Group

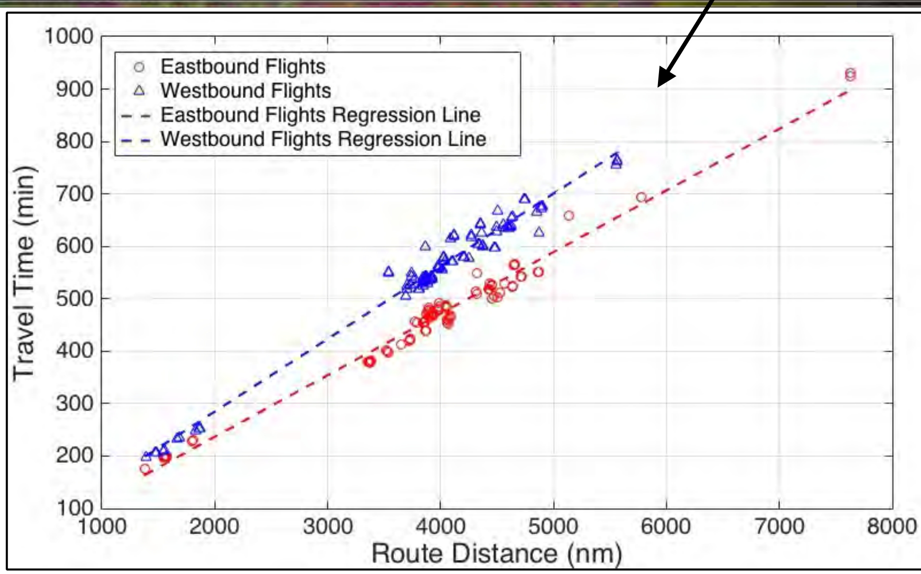


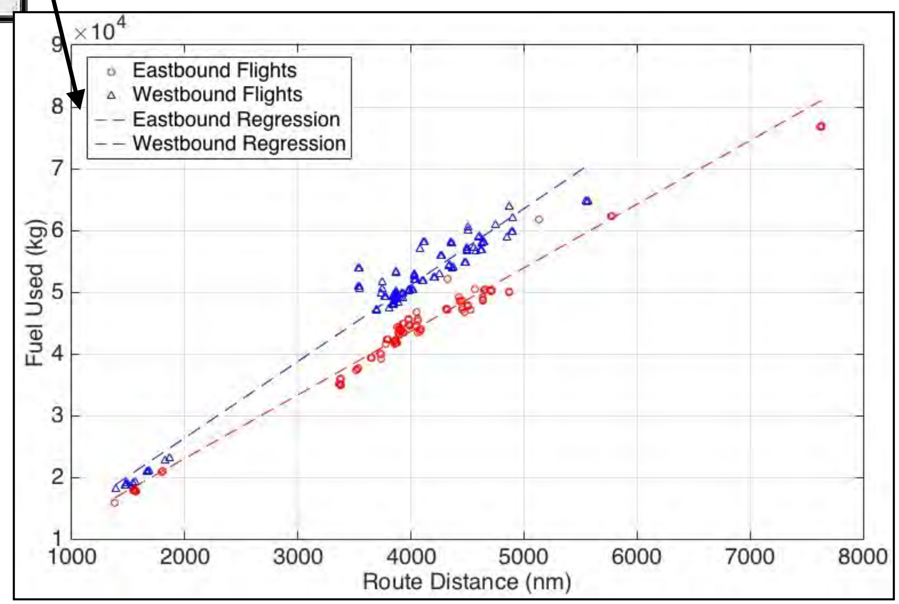
Summary Reuslts

(Atlantic - Minimum Seperation 30 nm)

Aircraft Group	Total Fuel Used (kg)	Total Travel Time (minutes)	Average Fuel Used (kg)	Average Travel Time (minutes)	Equipage (%)	Total Flights	Eastbound Flights	Westbound Flights	Charts
B763	8,097,100	101,361	41,524	520	100	195	105	90	Show
B772	5,667,359	46,470	67,469	553	100	84	51	33	Show
B744	9,395,922	59,251	101,031	637	100	93	48	45	Show
B752	2,003,016	32,737	15,174	248	100	132	78	54	Show
A333	13,383,708	145,958	46,471	507	100	288	135	153	Show
A346	8,538,630	63,865	81,320	608	100	105	42	63	Show
MD11	819,778	5,768	68,315	481	100	12	9	3	Show
A388	850,794	3,677	141,799	613	100	6	6	0	Show
B764	633,817	6,896	52,818	575	100	12	6	6	Show
B762	811,078	10,456	27,036	349	100	30	12	18	Show
B737	4,359,124	110,913	9,623	245	100	453	243	210	Show
A320	4,889,545	119,412	9,005	220	100	543	279	264	Show
A310	245,273	3,316	20,439	276	100	12	6	6	Show
C750	23,116	1,908	2,568	212	100	9	3	6	Show
FA7X	607,879	35,265	5,196	301	100	117	57	60	Show
B773	0	0	0	0	0	0	0	0	Show
B77W	3,482,758	27,191	72,557	566	100	48	18	30	Show
B77L	1,731,763	12,884	96,209	716	100	18	15	3	Show
CL60	610,276	40,608	3,569	237	100	171	102	69	Show
B788	991,859	11,935	47,231	568	100	21	12	9	Show
B748	0	0	0	0	0	0	0	0	Show
	67,142,795	839,872	28,584	358	100	2,349	1,227	1,122	

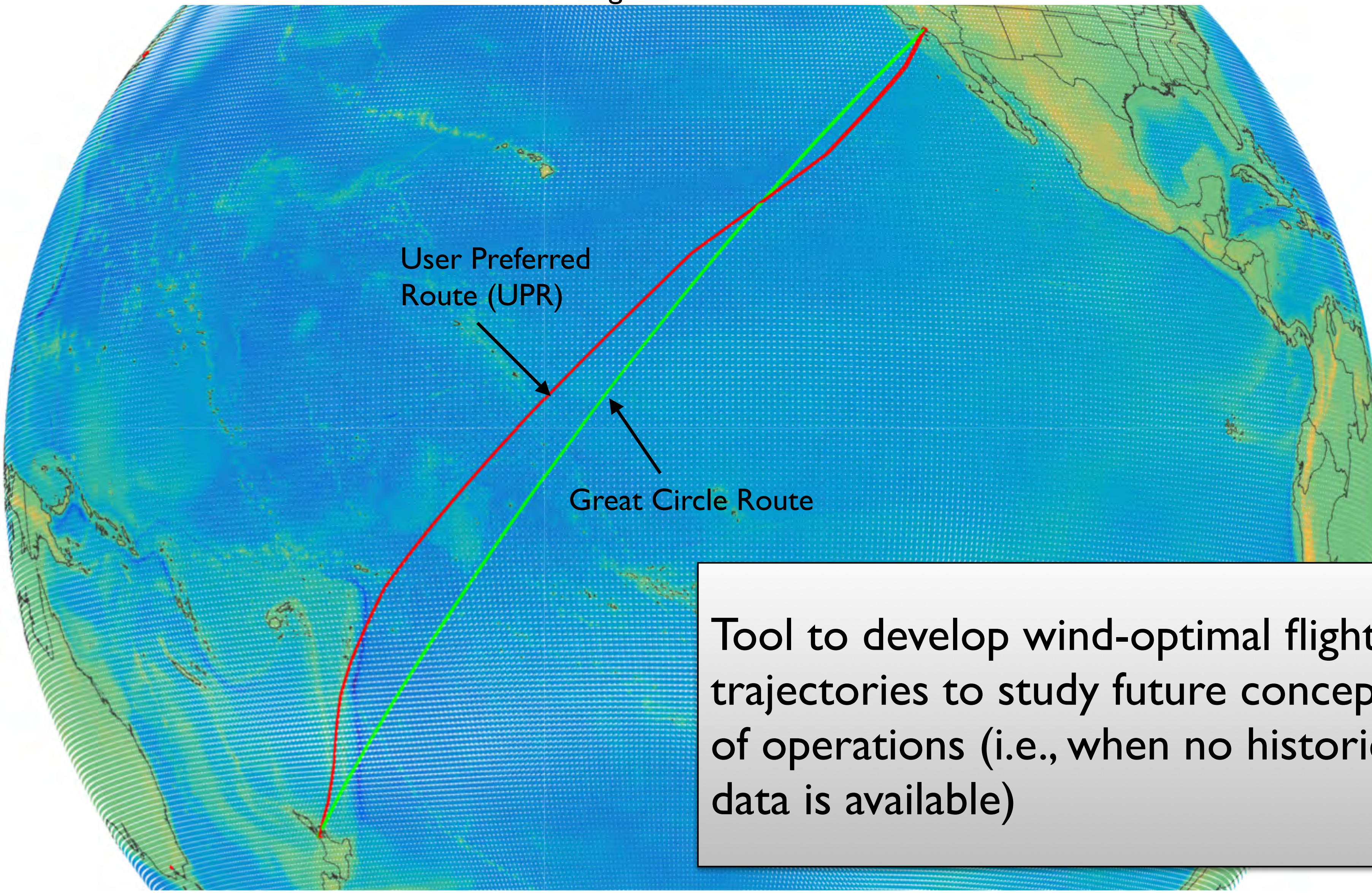






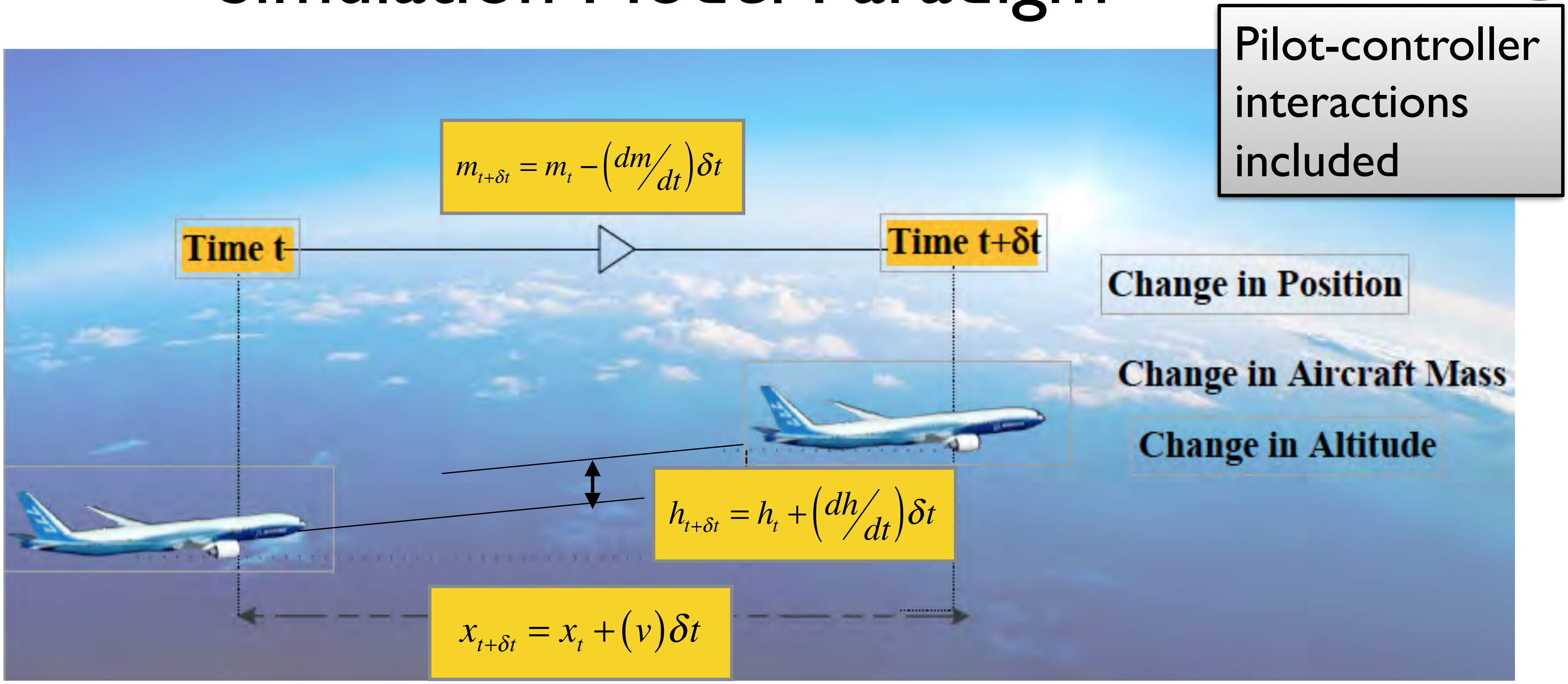
Global Oceanic Model : Flight Planning Tool

Los Angeles - Auckland



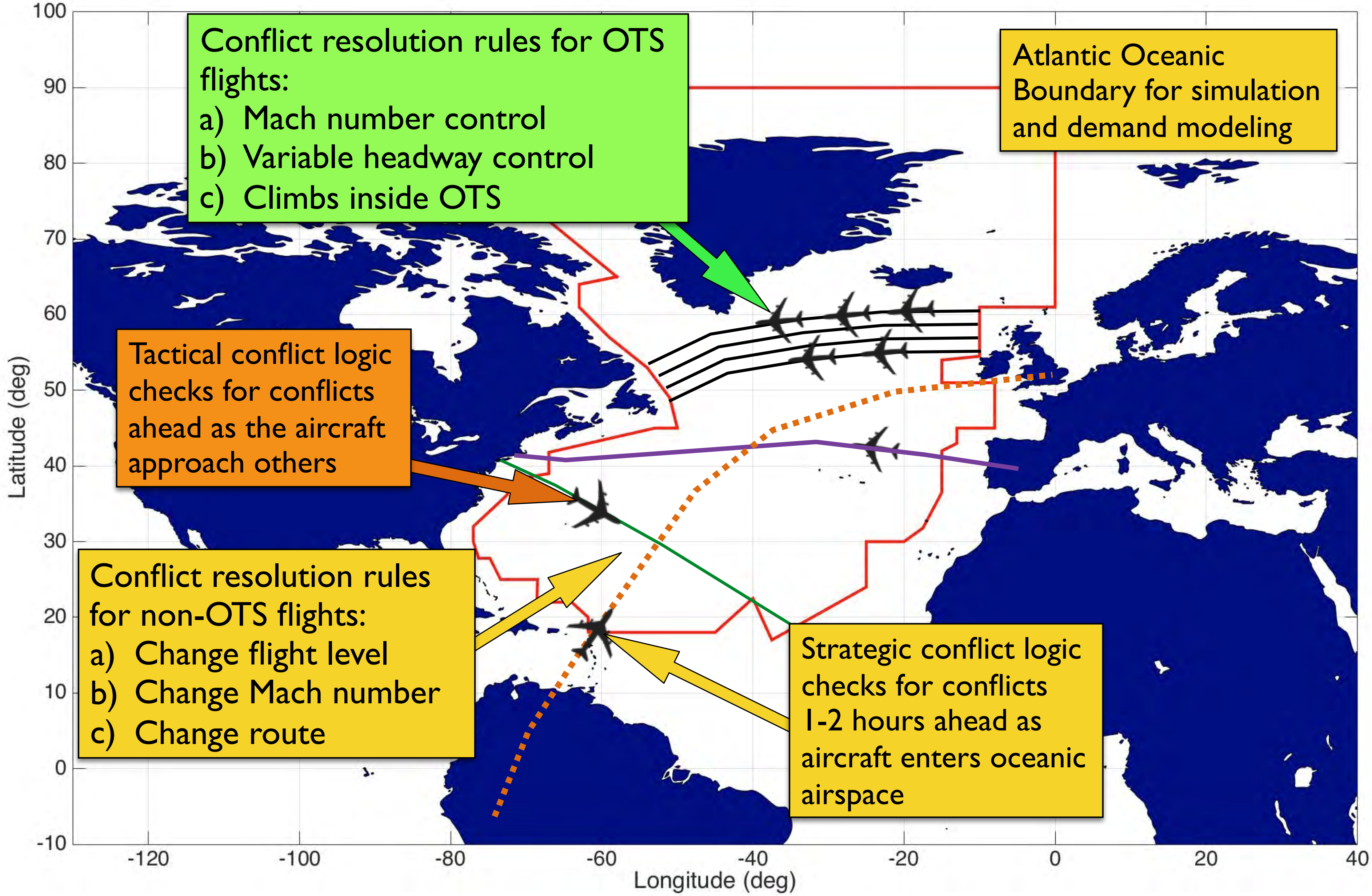
Tool to develop wind-optimal flight trajectories to study future concepts of operations (i.e., when no historical data is available)

Simulation Model Paradigm



- Aircraft states are evaluated every 5 seconds (sampling rate)
- Model solves the aircraft equations of motion numerically
- BADA aerodynamic model (version 3.13.1)
- Distance traveled, mass and altitude are aircraft state variables tracked
- NCAR Reanalysis wind model developed by NOAA
- Pilot and controller interactions modeled

Strategic and Tactical Conflict Algorithms in the Model



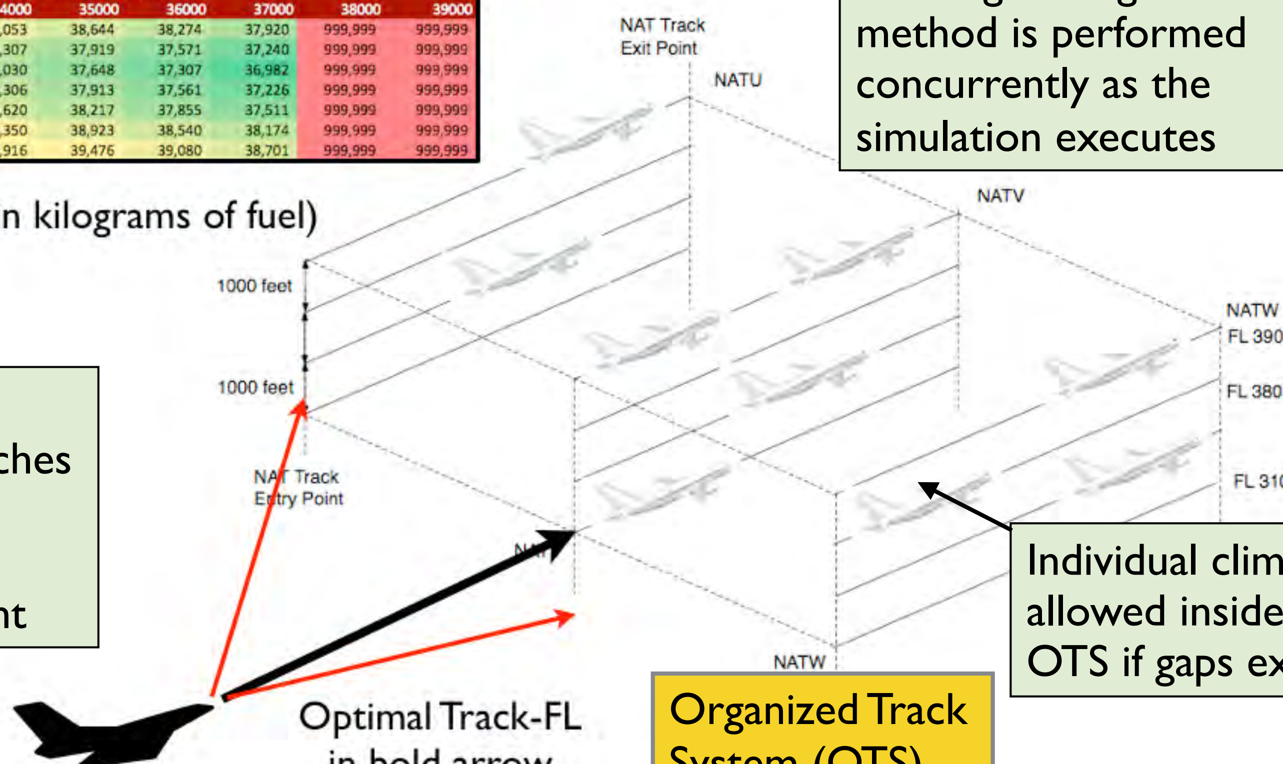
OTS Track Assignment Logic

- The track assignment module assigns flights to NAT OTS and random tracks based on their relative costs compared to an optimal track selected as preferred alternative
- Flights are assigned to a track considering competing flights requesting the same track

	Cruise Altitude (feet)								
Track	31000	32000	33000	34000	35000	36000	37000	38000	39000
NATT	40,912	40,246	39,625	39,053	38,644	38,274	37,920	999,999	999,999
NATU	40,264	39,563	38,910	38,307	37,919	37,571	37,240	999,999	999,999
NATV	40,041	39,321	38,650	38,030	37,648	37,307	36,982	999,999	999,999
NATW	40,325	39,602	38,928	38,306	37,913	37,561	37,226	999,999	999,999
NATX	40,662	39,931	39,249	38,620	38,217	37,855	37,511	999,999	999,999
NATY	41,384	40,655	39,976	39,350	38,923	38,540	38,174	999,999	999,999
NATZ	41,984	41,243	40,553	39,916	39,476	39,080	38,701	999,999	999,999

Fuel Cost Matrix (in kilograms of fuel)

OTS flight assignment method is performed concurrently as the simulation executes



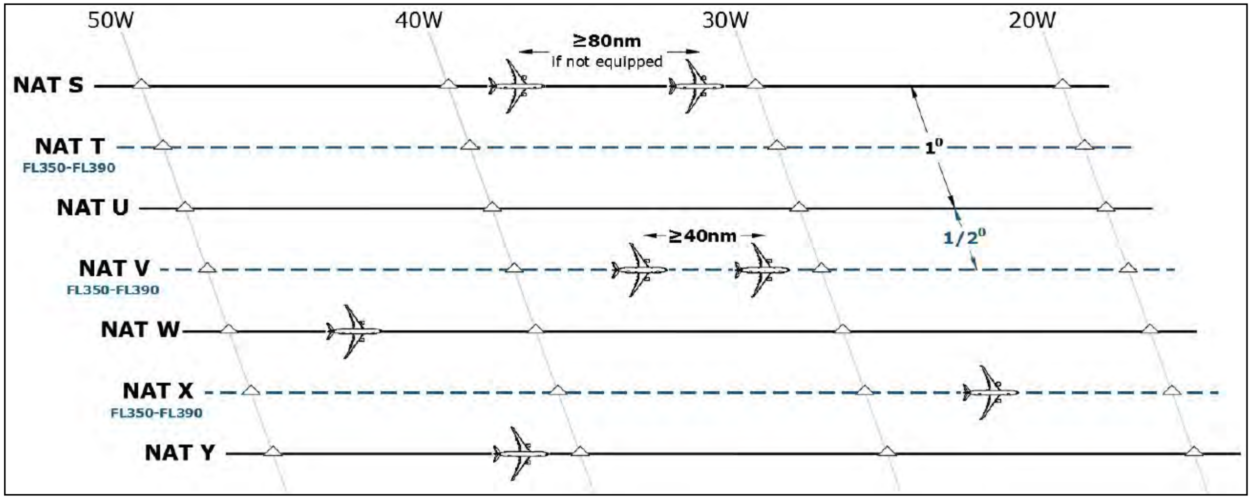
Optimal Track-FL in bold arrow

Flight Plan Changes
Necessary when a flight approaches the OTS entry point
Use of variable Mach number headway rules in OTS assignment

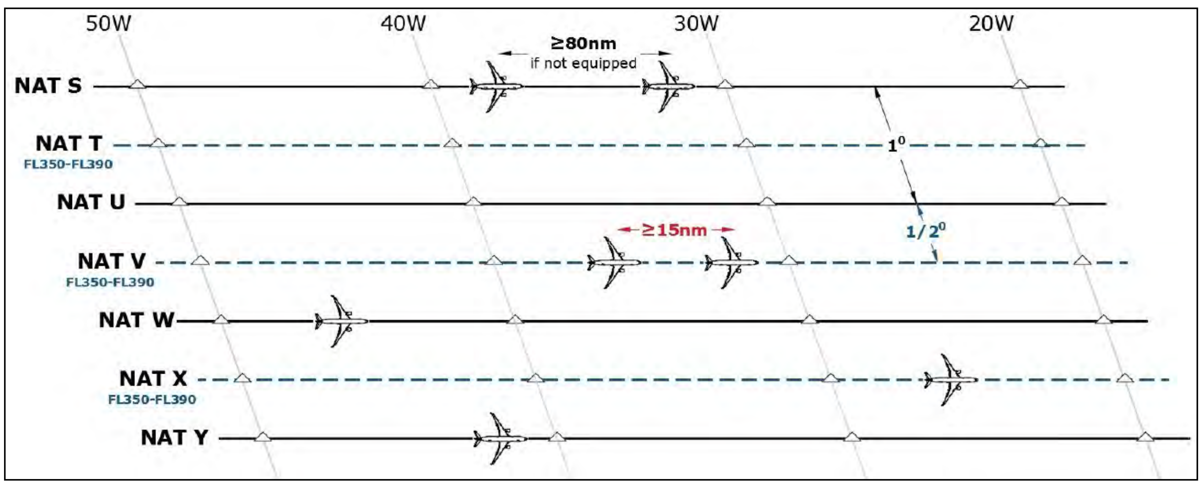
Individual climbs allowed inside the OTS if gaps exists

Organized Track System (OTS)

Model Can Study Many Variations of OTS Track System



2013 Time Frame



Mid-Future State

Far-Future State (no tracks)

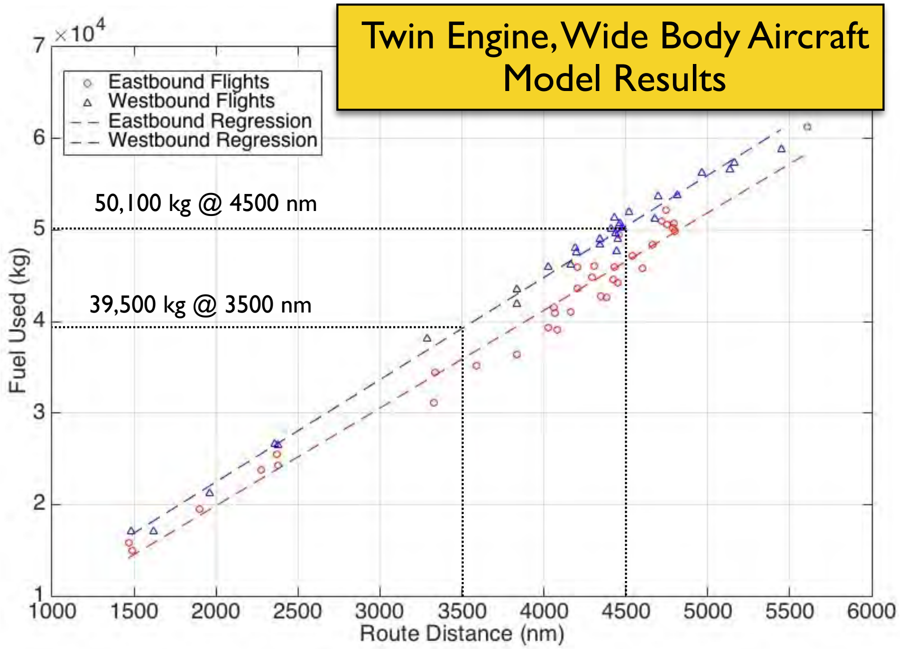
OTS Track configuration specified via an Excel input file

Global Oceanic Model Outputs

Model Output	Remarks
Fuel consumption	Total fuel used for all flights (NAT OTS and non-OTS) from origin to destination
Travel time	Total travel time for all flights (non-OTS and NAT OTS) from origin to destination
Emissions (GHG)	Reported as a multiplier to fuel consumption
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

Model Validation

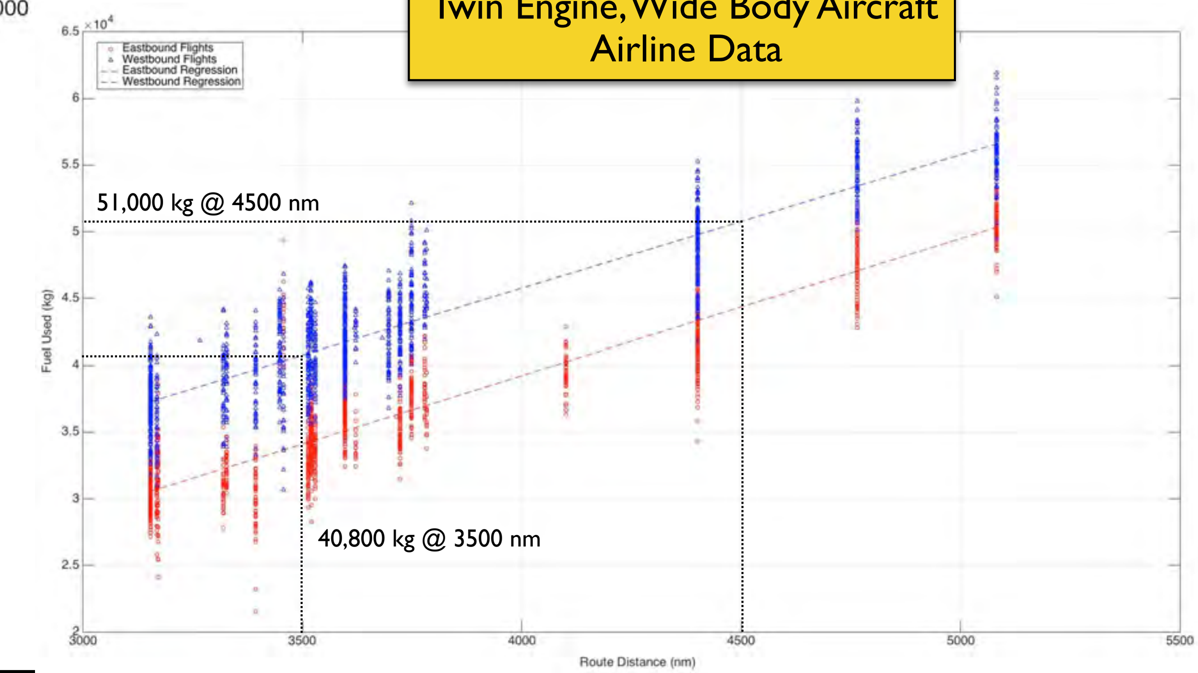
Twin Engine, Wide Body Aircraft
Model Results



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)

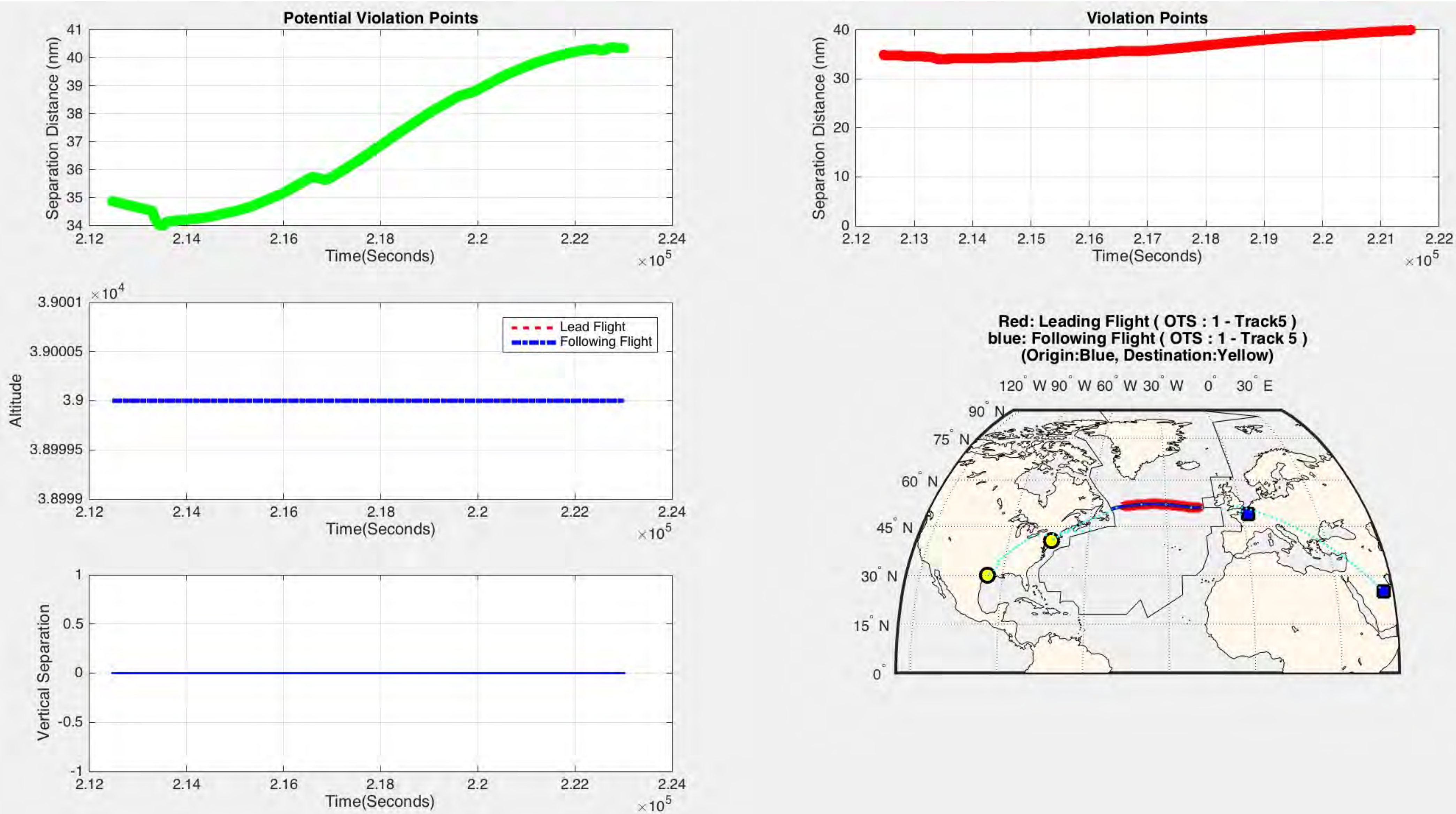
Twin Engine, Wide Body Aircraft
Airline Data



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

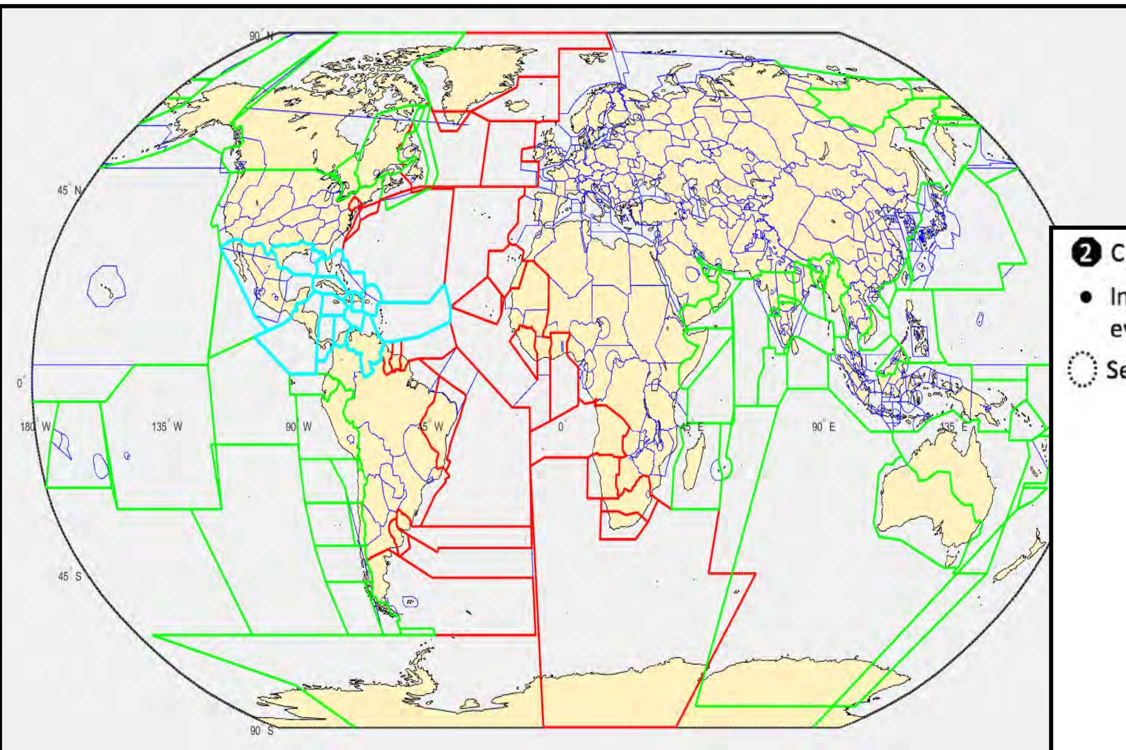
Thanks to A4A and IATA airlines for providing the data

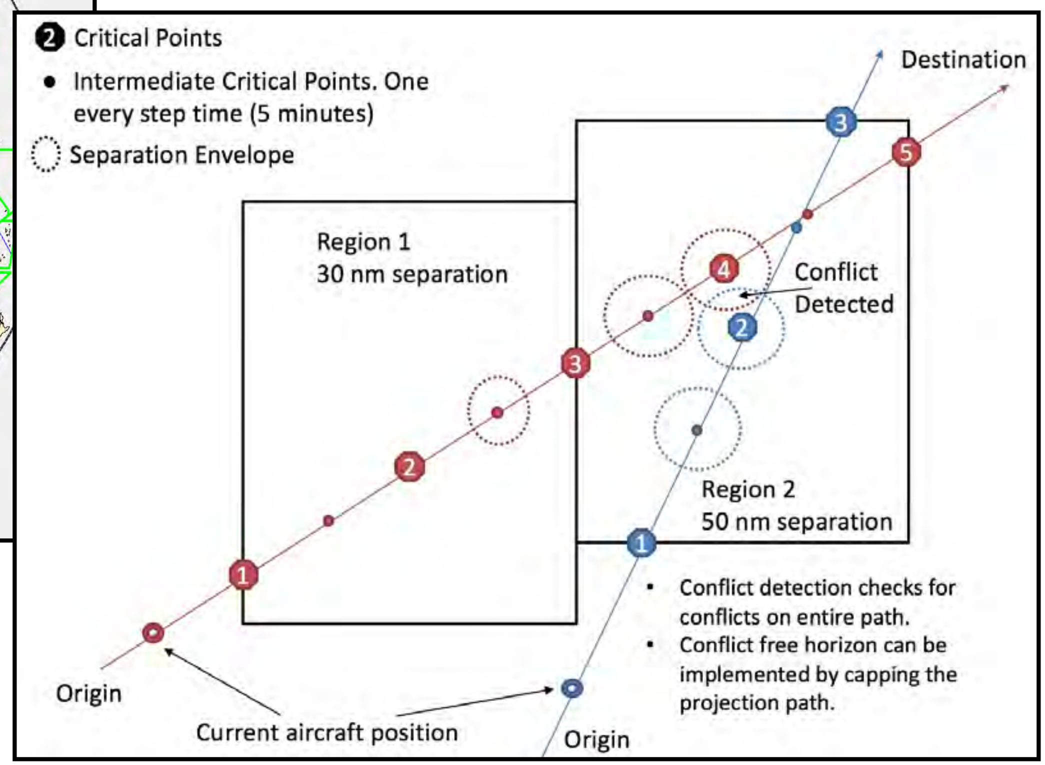
Global Oceanic Model: Conflict Analysis Post-processor



Global Oceanic Model: Multi-Region Simulation

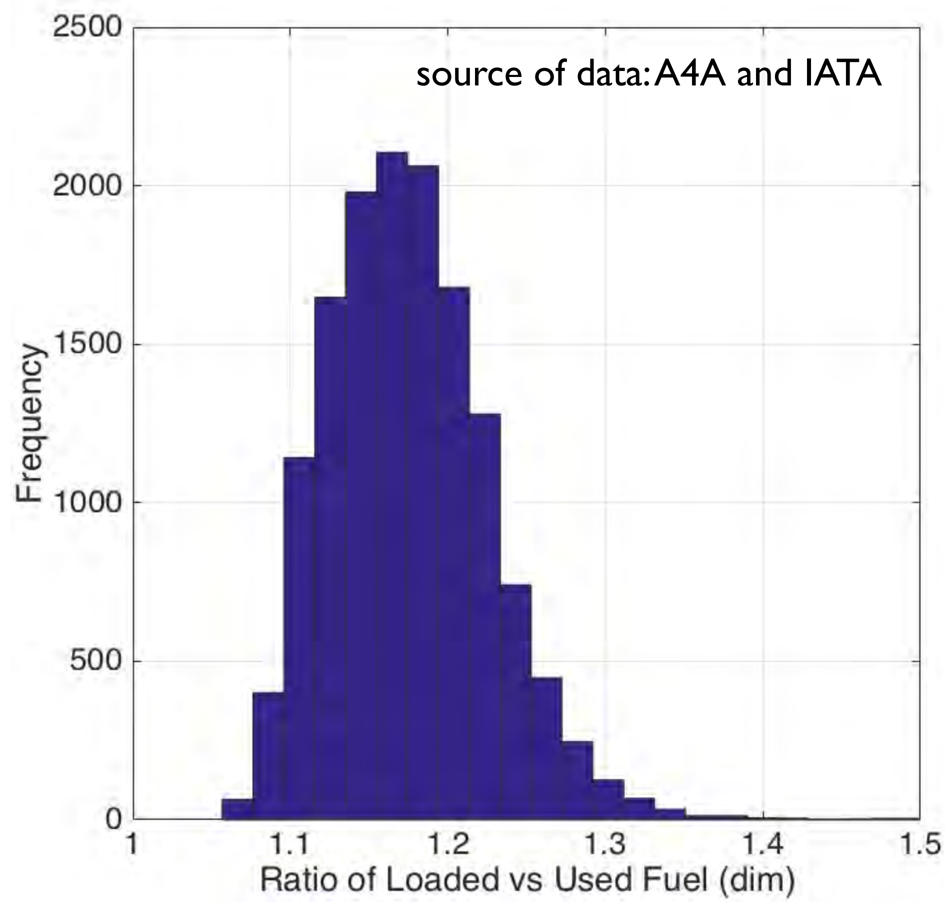
- Model can accommodate "local" FIR separation rules
  - Aircraft equipage levels defined via input demand file





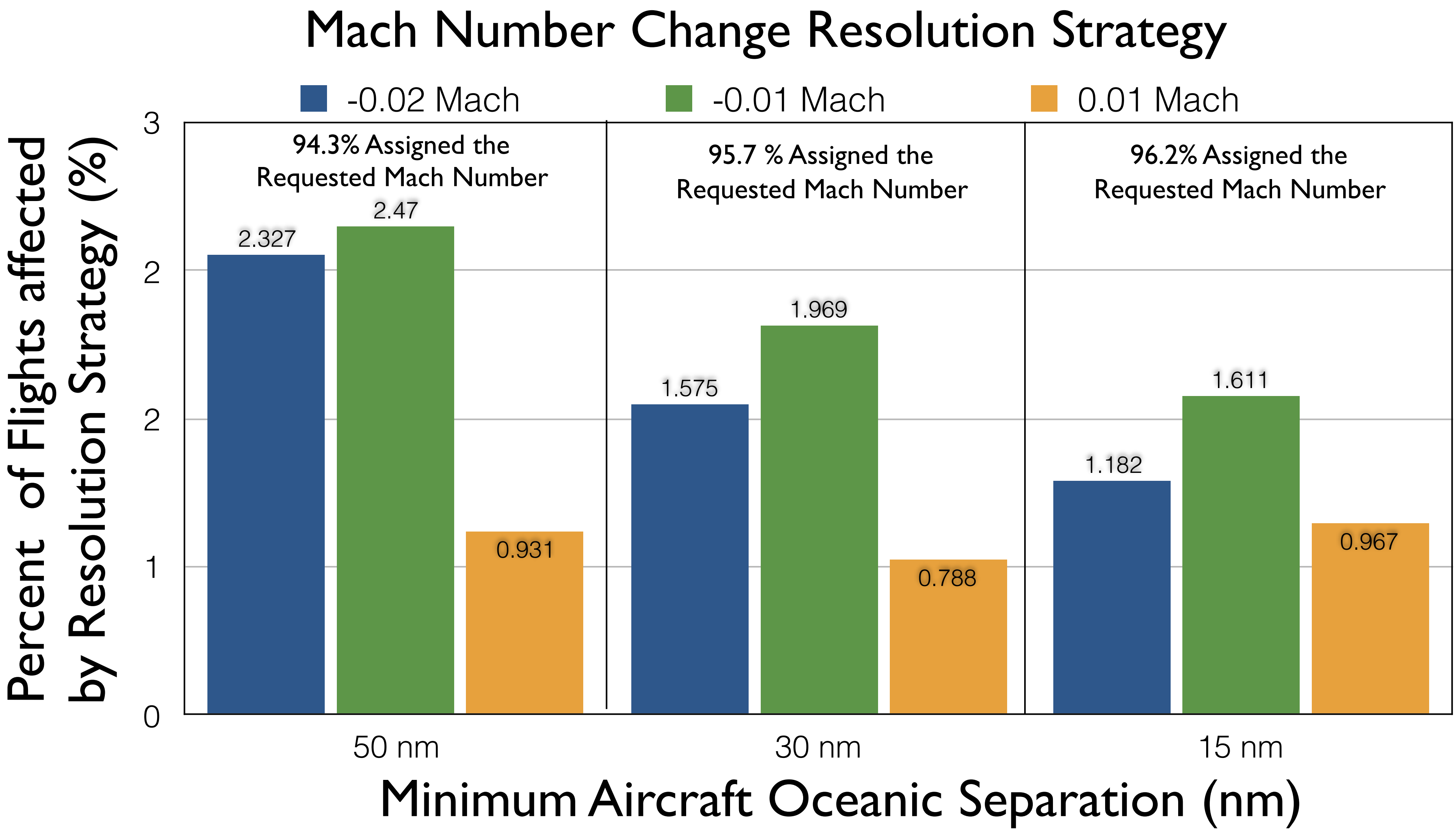
Connections with MIT Work

- Predictability/flexibility aspect of the flight
  - Today's North Atlantic flights carry around **18% more fuel than used** in the actual flight (using data provided by **A4A** and **IATA**)
    - Contingency fuel carried could be off-loaded thus providing a small but quantifiable benefit
    - MIT analysis provides more insight into the speed and altitude profiles that would allow individual aircraft to save fuel



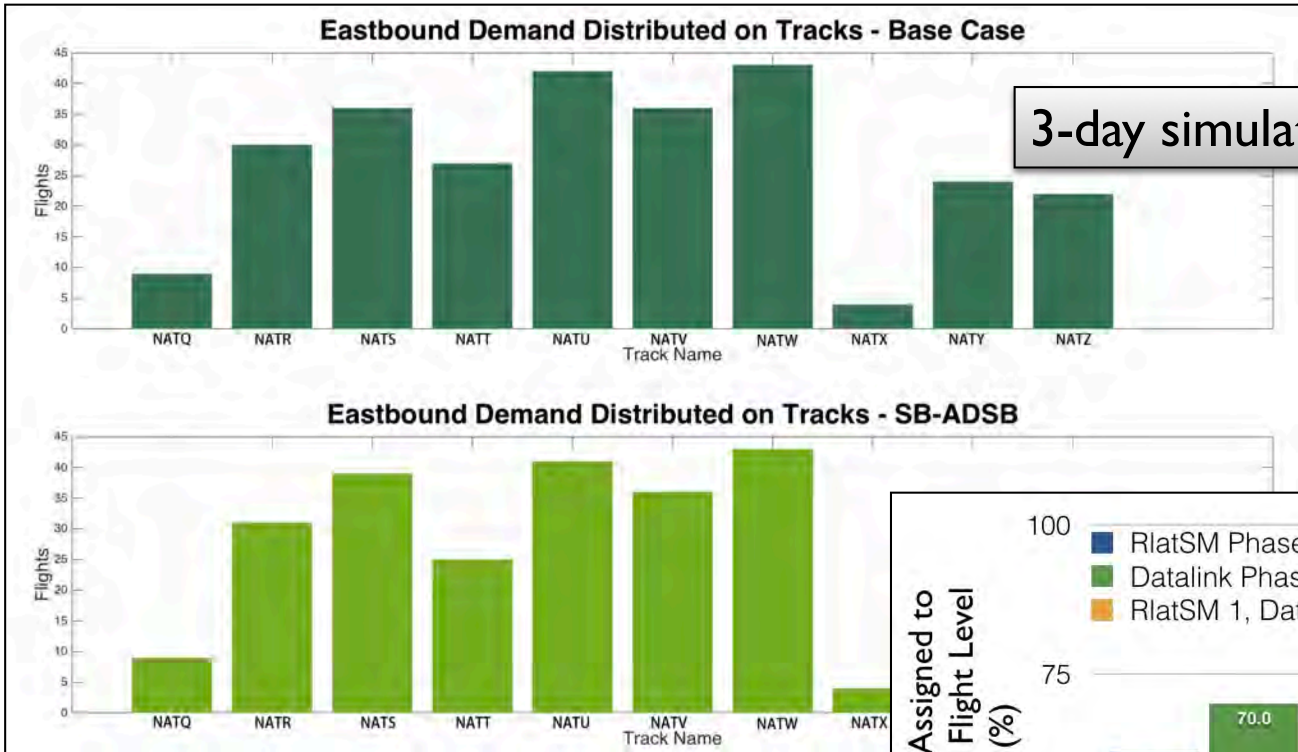
Sample Results for Oceanic Flights

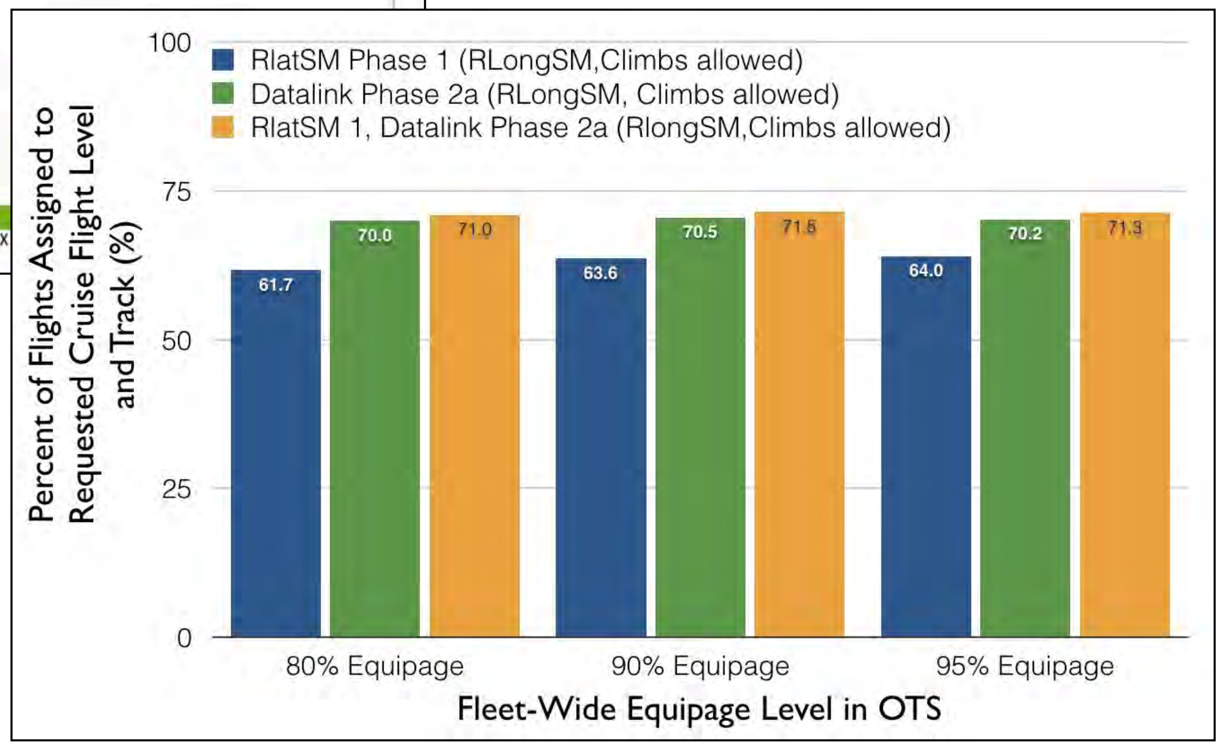
3-day simulation



Organized Track Utilization and Level of Service

3-day simulation, Organized Track System flights





In Summary

- NEXTOR 2 (Virginia Tech) in collaboration with FAA (and contractors) developed a computer simulation model to estimate fuel savings, travel time in oceanic areas
- 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
- The model is being adapted to model multi-regions allowing seamless simulation of flights across FIR regions with distinct separation standards