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Research to Reality in Air Traffic Management



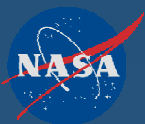
BENEFITS ASSESSMENT OF REDUCED SEPARATIONS IN NORTH ATLANTIC ORGANIZED TRACK SYSTEM

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Israel Greenfeld, NASA Glenn**

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Project Objective

- Determine benefits of reduced horizontal separations in the North Atlantic Track System as a function of equipage levels and demand growth for up to 2015
- Determine improvements in flight efficiency through metrics such as fuel and time cost savings, and additional cargo revenue potential (by flight and by airframe)
- Determine improvements in system performance through metrics such as approved alt. change requests, and duration at sub-optimal altitude



Project Scenarios

- Three Demand levels: 2005, 2010, and 2015
- Five Equipage levels: 0, 25, 50, 75, and 100
- 2 sets of tracks: early morning eastbound (V-Z) and early afternoon westbound tracks (A-F).
- Three types of track configuration:
 - *Regular*: current tracks with mixed equipage operations
 - *Segregated*: some tracks not accessible to non-equipped flights
 - *Additional Segregated*: new tracks established between two adjacent segregated tracks

=> 72 simulation scenarios (+9)

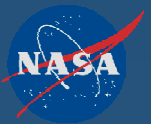


Modeling Requirements

- Future traffic generator to determine traffic demand levels, and fleet and equipage for the future years of interest
- Fuel consumption optimization model to determine optimal trajectories, step-climb and speed profiles for each of the flights (ISO atmosphere and forecasted wind data)
- Track selection model to determine user-preferred tracks for the future flights
- Track operations simulation models to impose restrictions due to traffic interactions (modify optimal altitude and speed profiles)
- Fuel consumption model to determine fuel requirements for the constrained trajectories

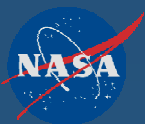


Benefits Mechanisms

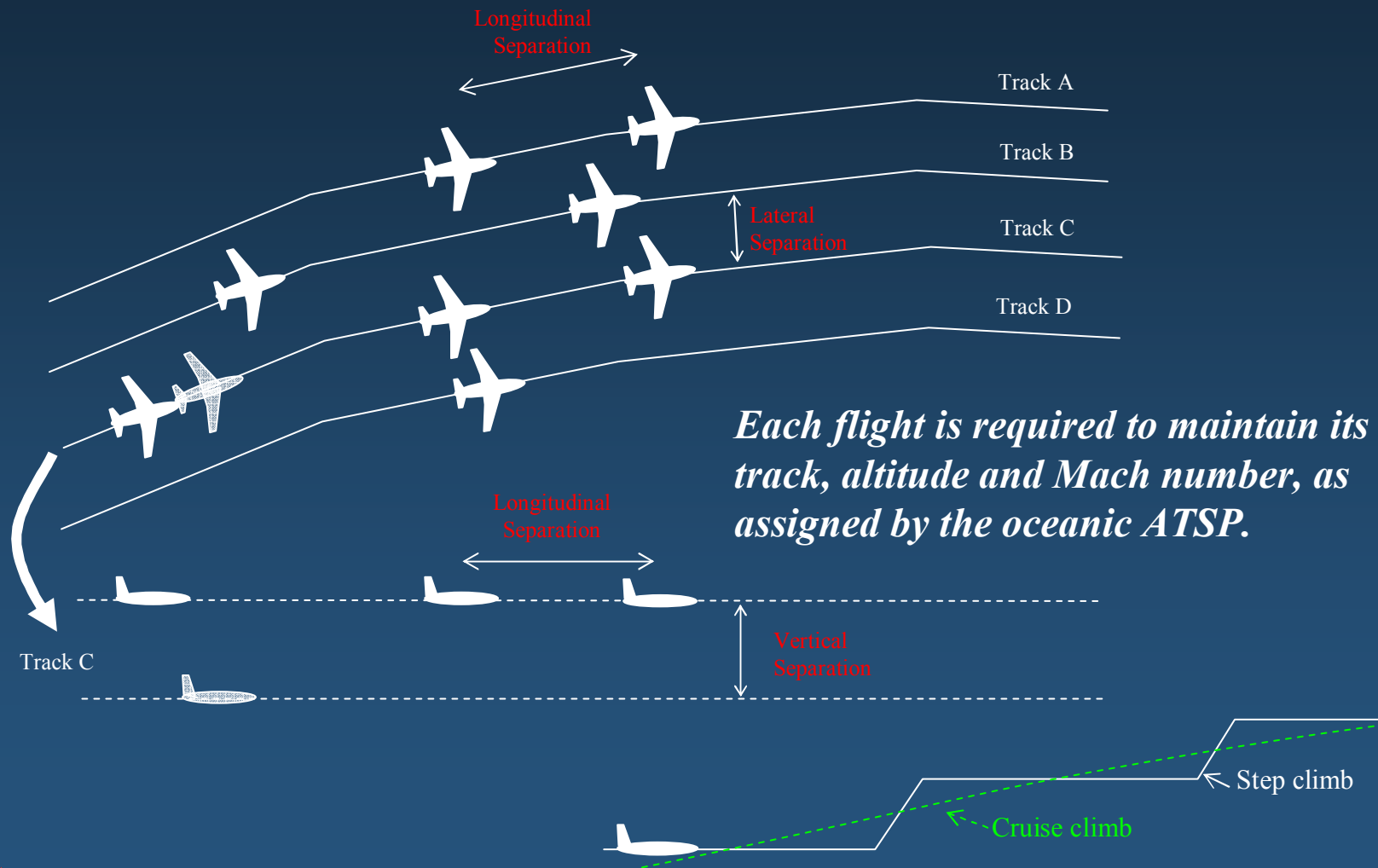


Benefits Mechanisms

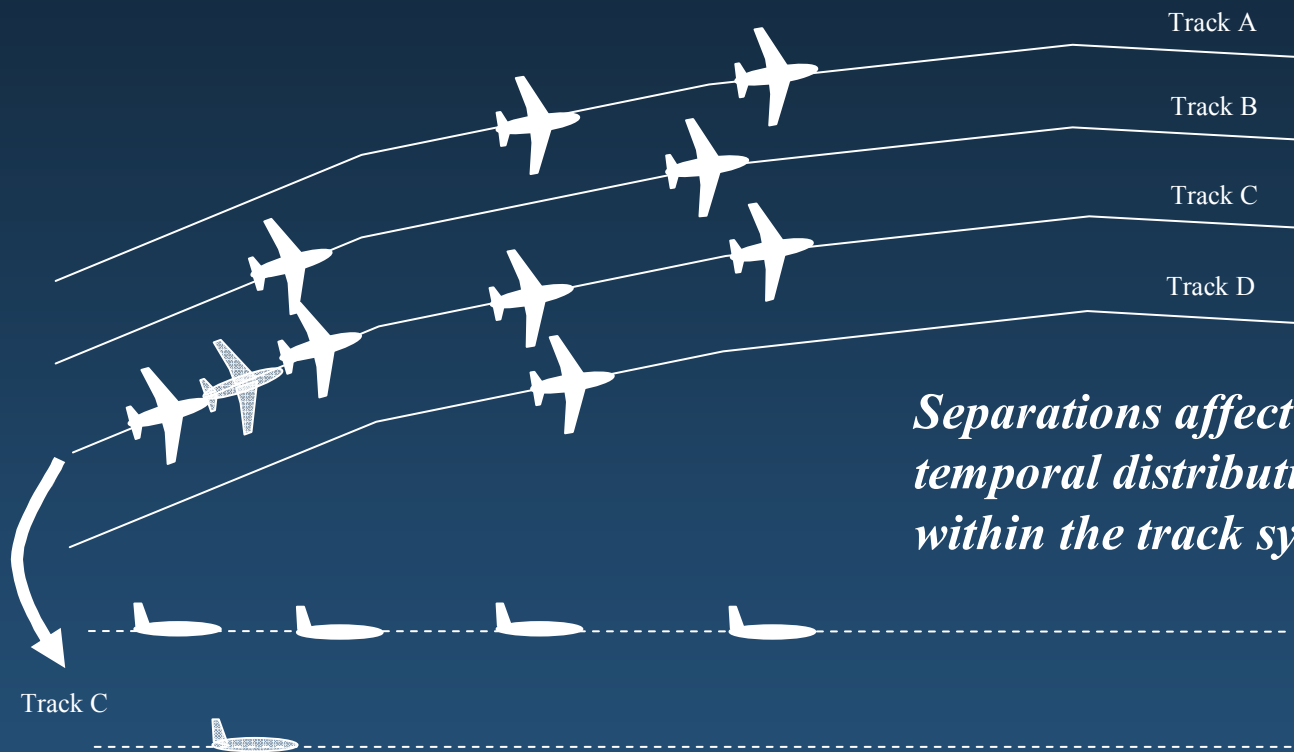
- Improved routes, altitude and speed profiles
 - Lower fuel consumption
 - Shorter flight times
 - Additional cargo potential
- Improved ability to estimate fuel requirements
 - Contingency fuel reduction
 - Improved schedules
 - Additional cargo potential
- Improved system performance
 - Accommodation of higher demand levels, accommodation of user preferred choices, including denied alt. change requests, duration at sub-optimal altitude, etc.



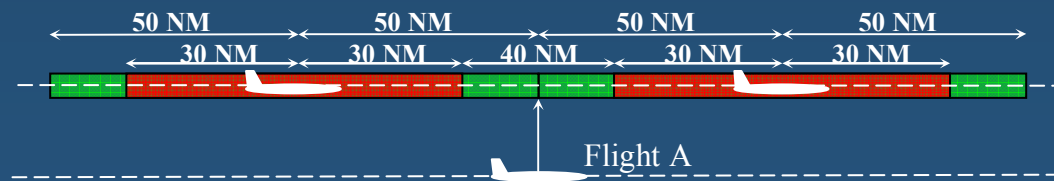
Benefits Mechanisms: Current Practices in NAT OTS



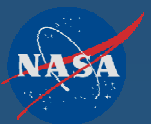
Benefits Mechanisms due to Separations Reduction



Separations affect both spatial and temporal distribution of flights within the track system

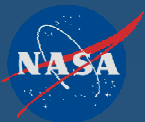


Benefits Calculations: Regular Tracks

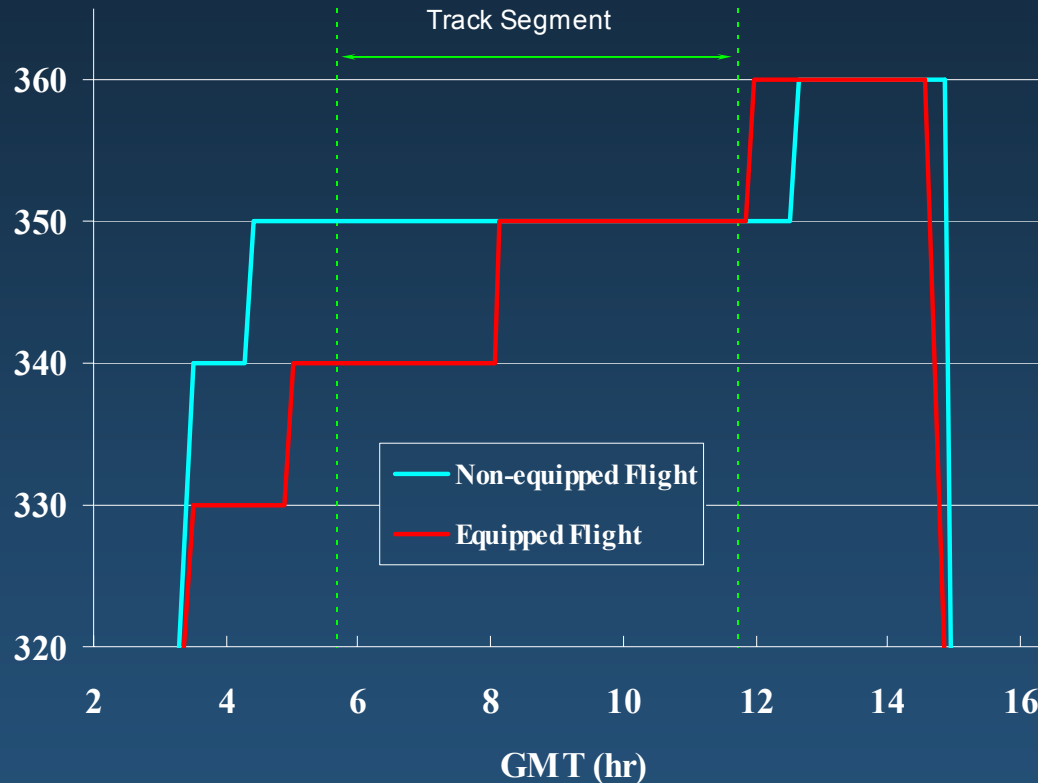


Assumptions Summary

- Flights cannot switch tracks once they entered the track system
- Traffic is conducted independently on each track
- Longitudinal separations: 30NM between two equipped flights, and 10 minutes Mach technique (~ 80 NM) otherwise
- 6-hour wind forecasts and ISO atmosphere
- Cost Index values are determined for each of the aircraft models
- Each flight takes off with MTOW
- Unit fuel cost: \$1.39/gallon (\$0.21/lb), and unit cargo revenue: \$1.60/lb
- Fuel and Time Cost Savings and Cargo Revenue Potential can be negative (penalties)

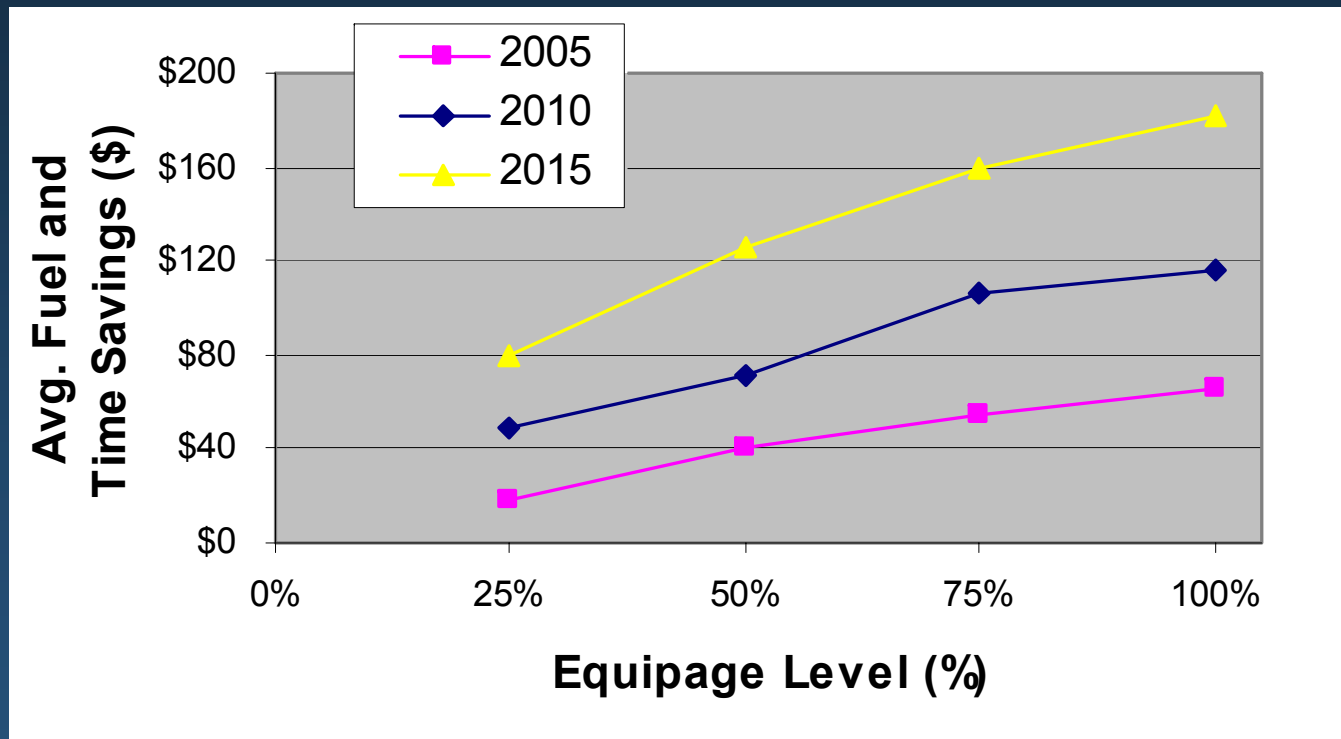


NAT OTS – Equipage Considerations

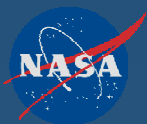
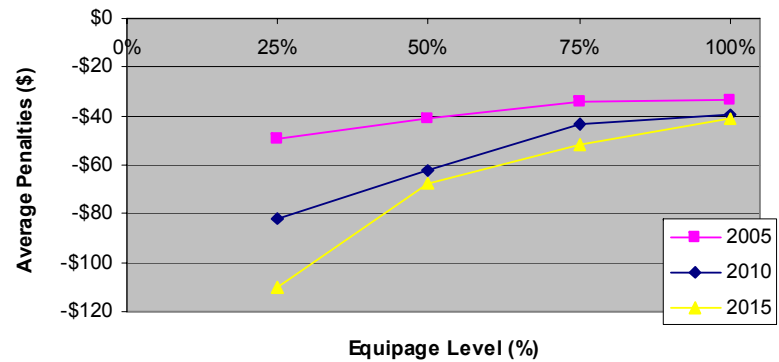
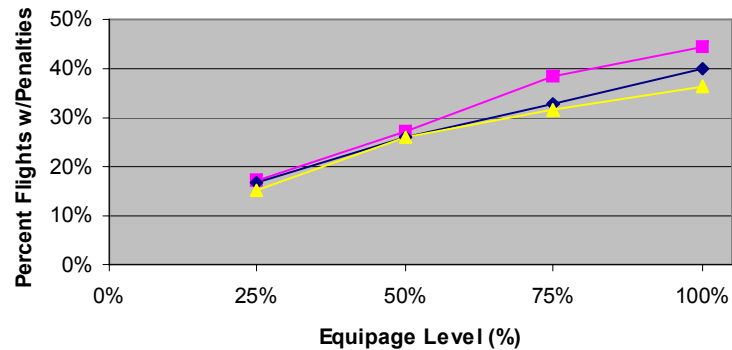
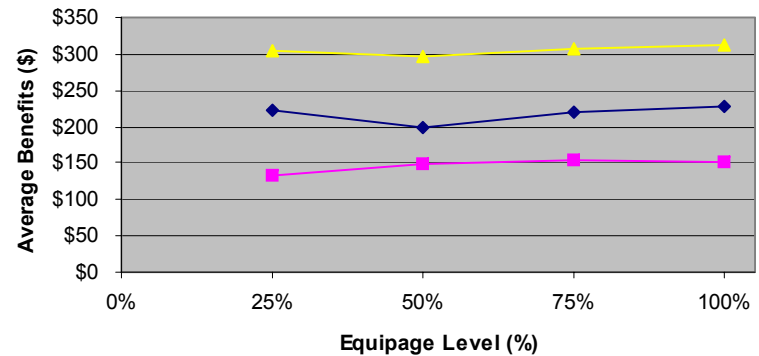
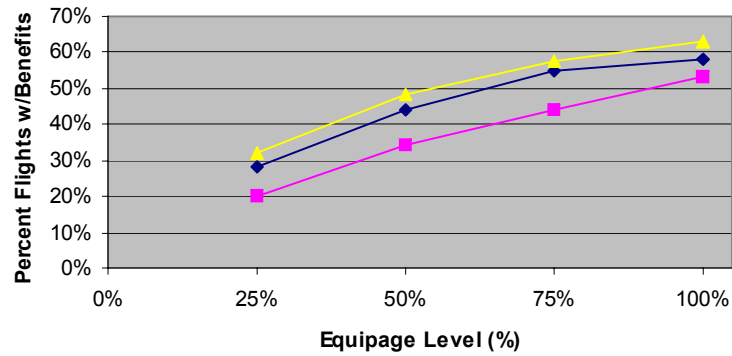


Equipped flights can climb throughout their flights, whereas the non-equipped flights cannot climb while on NATOTS

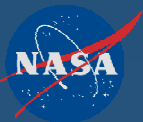
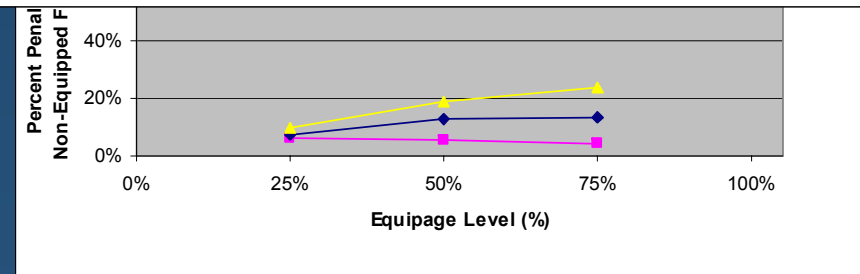
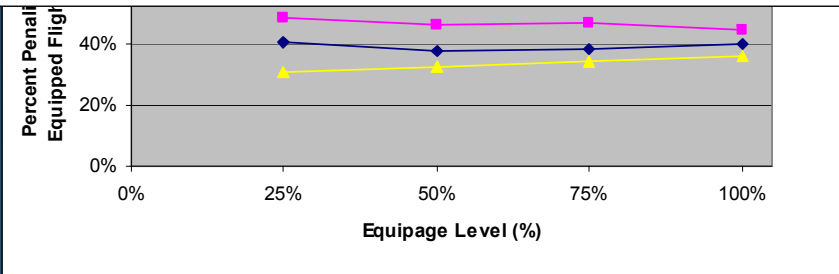
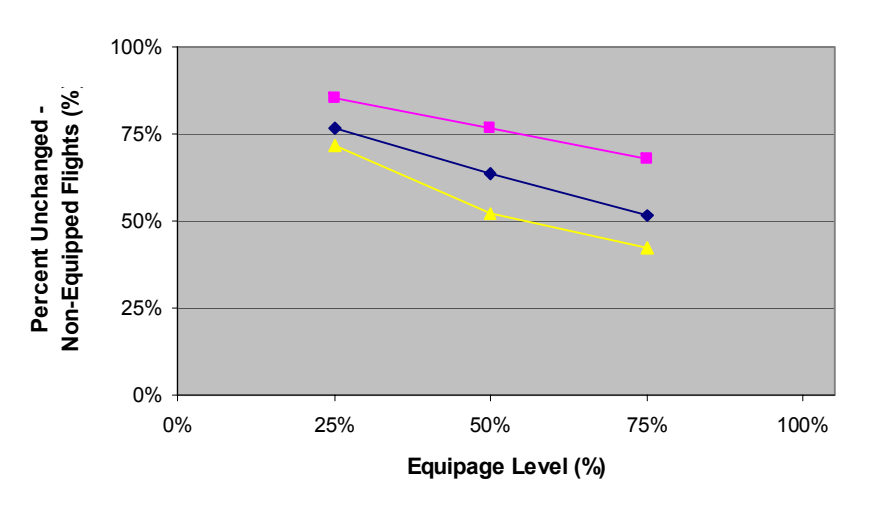
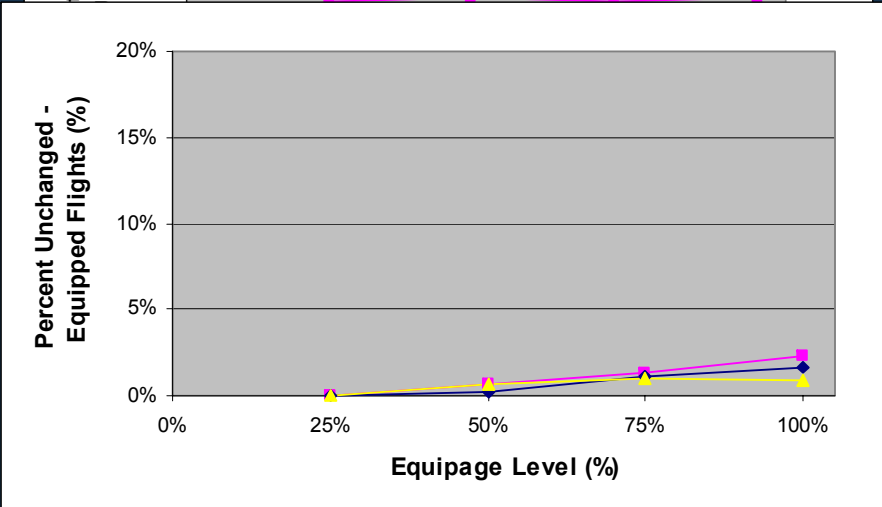
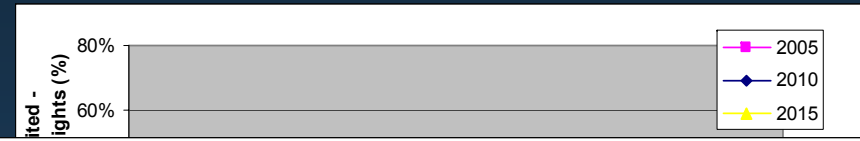
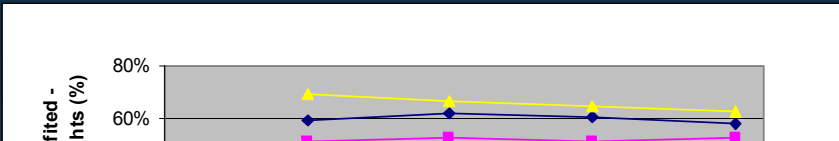
Regular Tracks: Average Fuel and Time Savings (per flight)



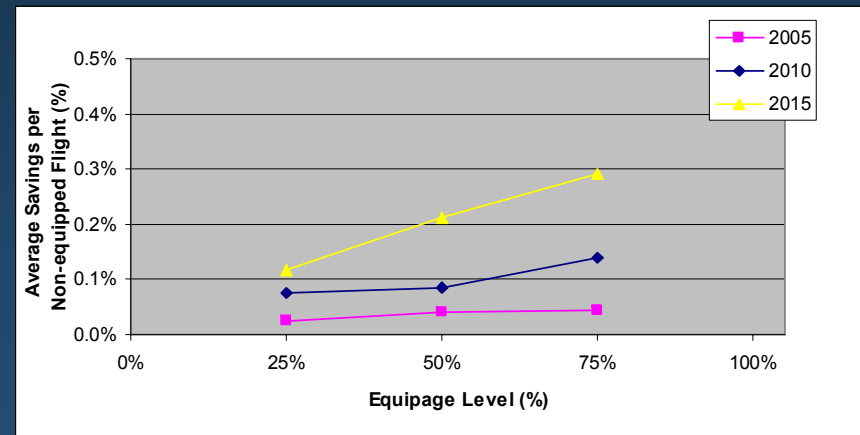
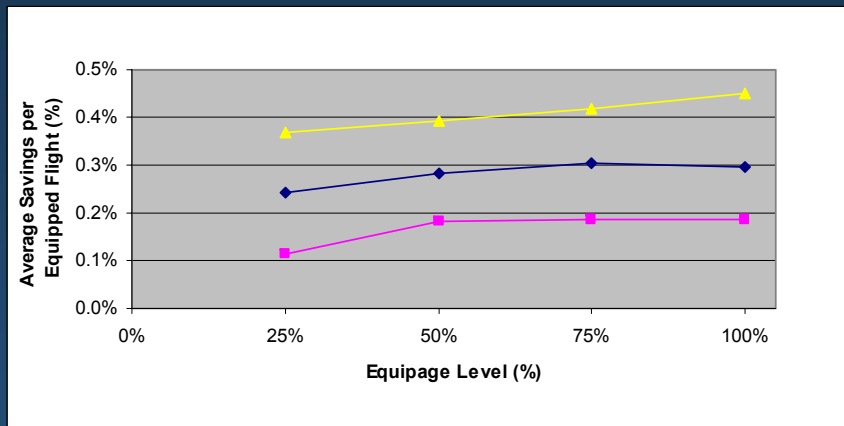
Regular Tracks – Fuel and Time Savings: Benefits vs. Penalties



Regular Tracks – Fuel and Time Savings: Equipped vs. Non-equipped Flights



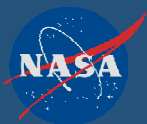
Regular Tracks: Equipped vs. Non-equipped Flights (cont.)



Regular Tracks: Total Annual Benefits

- If operators do not want to carry extra cargo, but want to take maximum advantage of potential fuel savings instead, the total annual benefits system-wide are ...

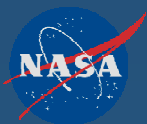
	2005				2010				2015			
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Total Annual Fuel And Time Benefits	\$ 4 M	\$ 9 M	\$ 12 M	\$ 14 M	\$ 13 M	\$ 19 M	\$ 29 M	\$ 31 M	\$ 26 M	\$ 41 M	\$ 52 M	\$ 60 M
Total Annual Add.Fuel Benefits	\$ 3 M	\$ 7 M	\$ 11 M	\$ 12 M	\$ 10 M	\$ 14 M	\$ 18 M	\$ 19 M	\$ 19 M	\$ 30 M	\$ 40 M	\$ 47 M
Total Annual Benefits	\$ 7 M	\$ 16 M	\$ 23 M	\$ 27 M	\$ 23 M	\$ 34 M	\$ 47 M	\$ 51 M	\$ 46 M	\$ 72 M	\$ 92 M	\$ 106 M



Regular Tracks: Total Annual Benefits (cont.)

- If operators do want to carry extra cargo, the total annual benefits will be 4.7 to 5.5 time higher!

	2005				2010				2015			
	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Daily Fuel and Time Savings	\$ 11 K	\$ 24 K	\$ 33 K	\$ 40 K	\$ 36 K	\$ 53 K	\$ 79 K	\$ 86 K	\$ 72 K	\$ 113 K	\$ 143 K	\$ 163 K
Daily Add. Cargo Revenue	\$ 87 K	\$ 189 K	\$ 276 K	\$ 325 K	\$ 253 K	\$ 390 K	\$ 608 K	\$ 674 K	\$ 512 K	\$ 802 K	\$ 1,062 K	\$ 1,239 K
Total Daily Benefits	\$ 99 K	\$ 214 K	\$ 309 K	\$ 365 K	\$ 289 K	\$ 443 K	\$ 686 K	\$ 759 K	\$ 584 K	\$ 914 K	\$ 1,205 K	\$ 1,402 K
Total Annual Benefits	\$ 36 M	\$ 78 M	\$ 113 M	\$ 133 M	\$ 106 M	\$ 162 M	\$ 251 M	\$ 277 M	\$ 213 M	\$ 334 M	\$ 440 M	\$ 512 M

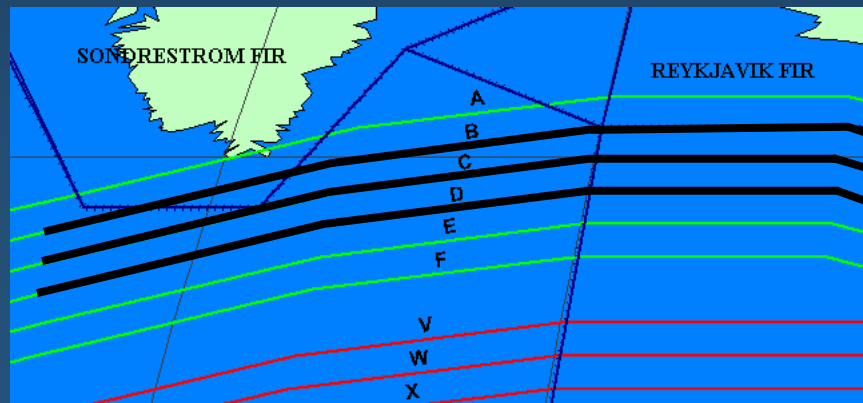


Benefits Calculations: Segregated and Additional Segregated Tracks

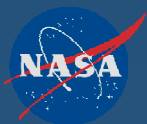
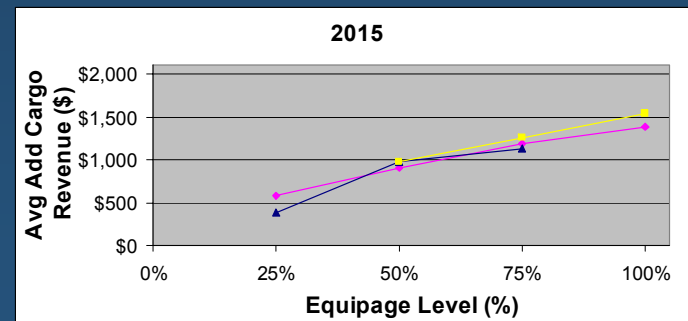
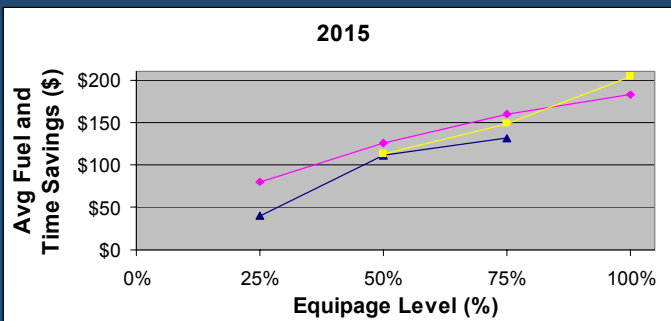
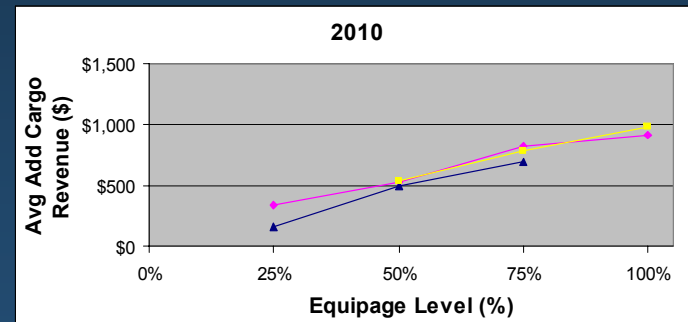
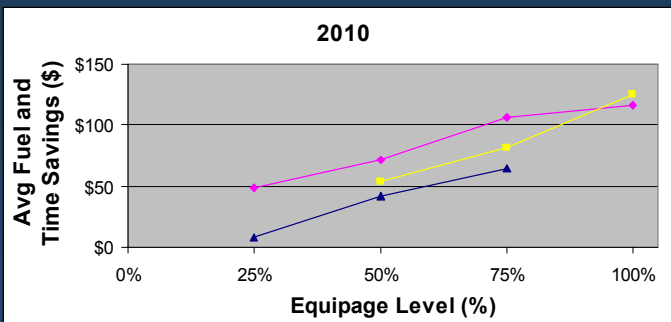
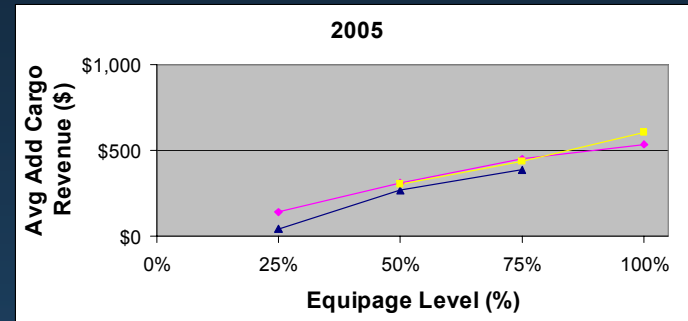
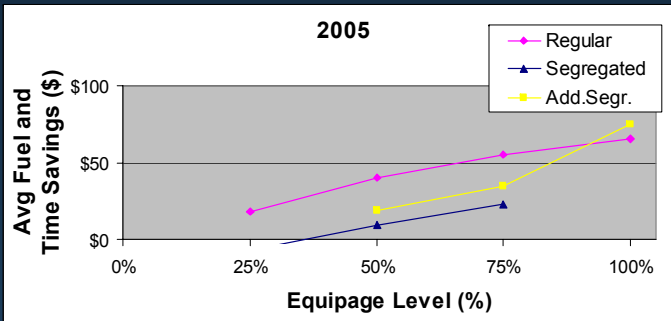


Assumptions

- Segregated Tracks are chosen based on:
 - Preferences of the equipped flights
 - Equipage level: 25% equipage - one, 50% equipage – two, and 75% equipage three segregated tracks
- Potential candidates for segregated tracks do not include outside tracks
- Additional tracks can be established only between two adjacent segregated tracks

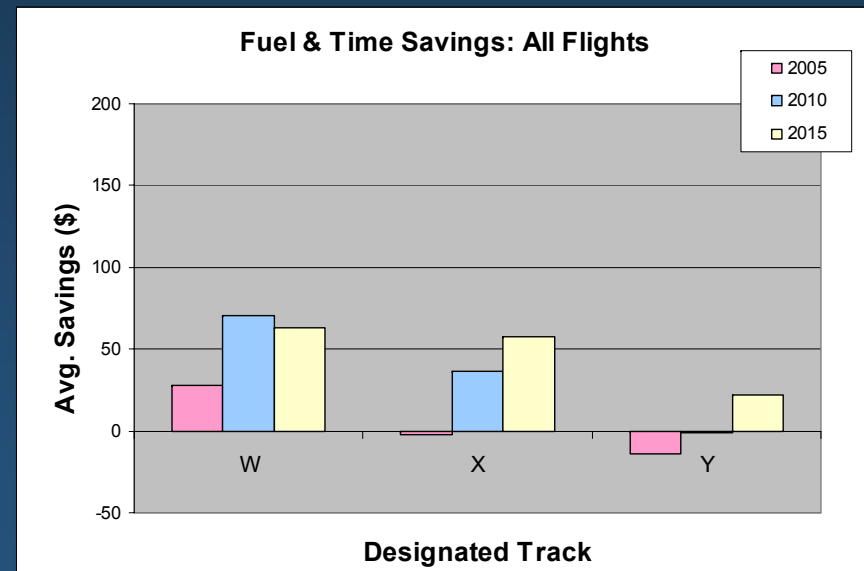
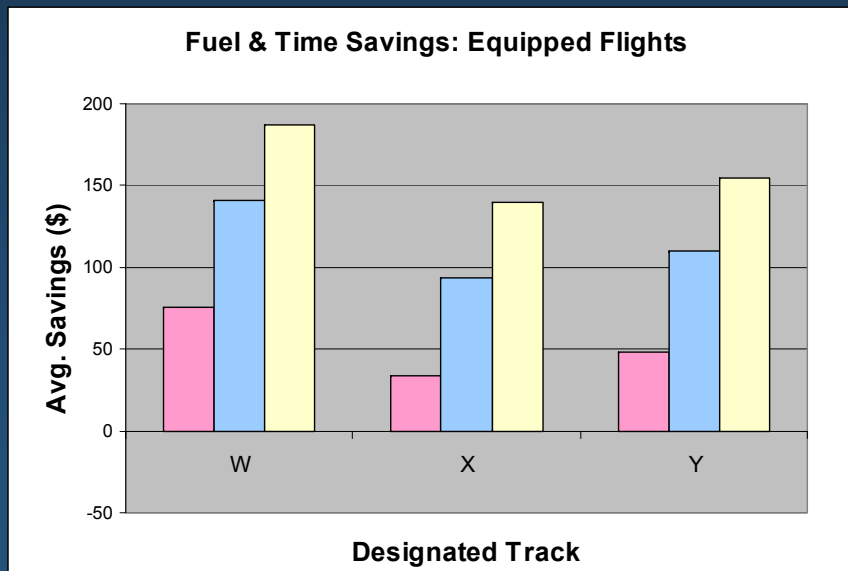


Average Fuel and Time Savings Comparison (per flight)

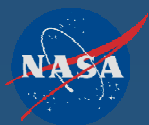


Sensitivity of Benefits to Segregated Track Selection

- 9 test scenarios
 - 25% equipage level
 - One segregated track (candidates: inside tracks)
 - Eastbound tracks early morning tracks



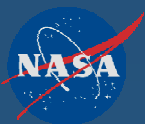
Conclusions



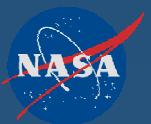
Conclusions

- Yes, both equipped and non-equipped flights will benefit
- Equipped flights are 2-5 times more likely to experience savings than non-equipped flights, and on average save 1.5-4.6 times more
- The sooner an air carrier equips its fleet, the better off it will be (provided that sufficient overall equipage is reached)
- Designating certain tracks for exclusive use by equipped flights is controversial and will require careful examination

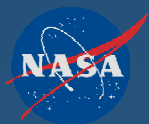
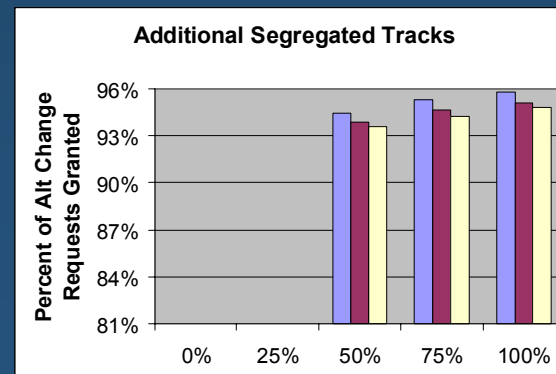
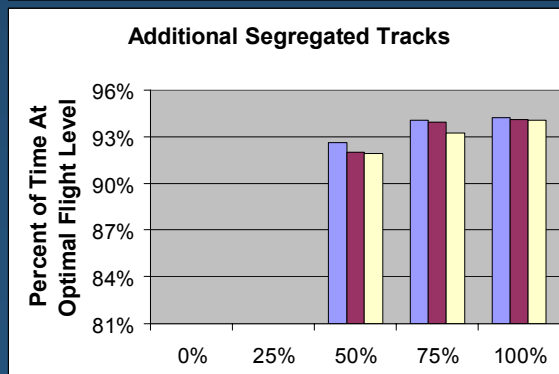
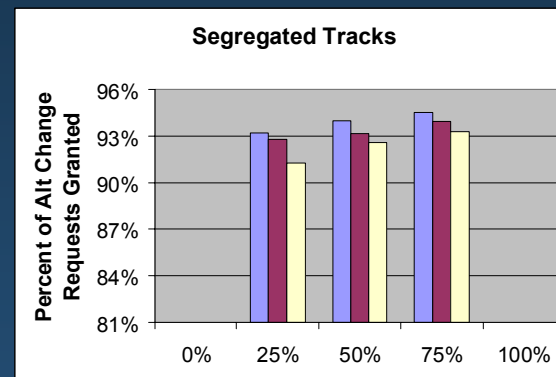
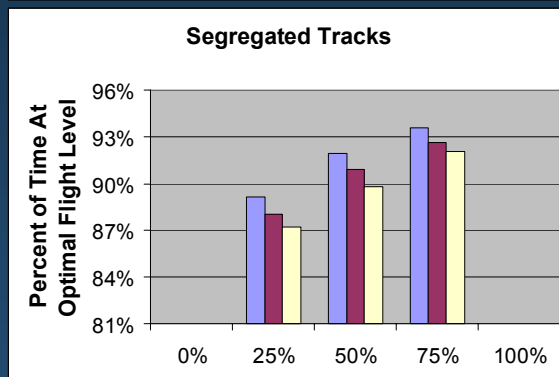
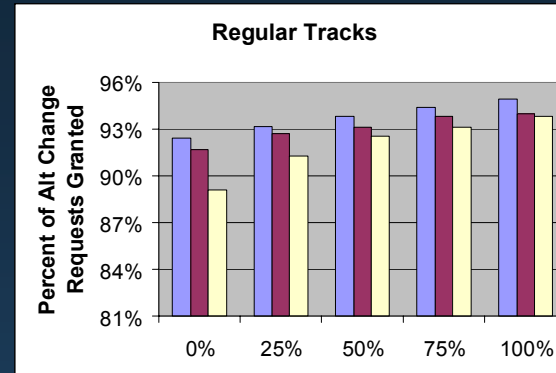
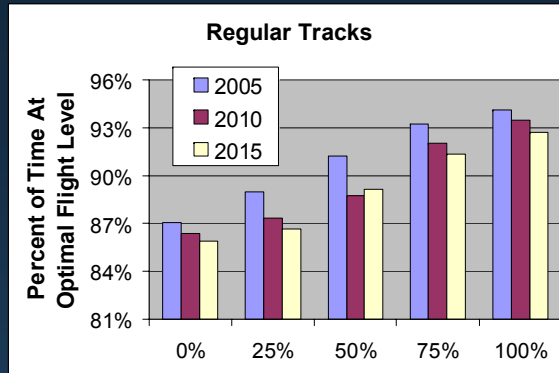
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	25%	50%	75%	100%	25%	50%	75%	100%	25%	50%	75%	100%
Regular Tracks	\$ 36 M	\$ 78 M	\$ 113 M	\$ 133 M	\$ 106 M	\$ 162 M	\$ 251 M	\$ 277 M	\$ 213 M	\$ 334 M	\$ 440 M	\$ 512 M
Segregated Tracks	\$ 8 M	\$ 62 M	\$ 91 M		\$ 45 M	\$ 146 M	\$ 205 M		\$ 139 M	\$ 353 M	\$ 413 M	
Additional Segregated Tracks		\$ 71 M	\$ 105 M	\$ 151 M		\$ 160 M	\$ 233 M	\$ 300 M		\$ 354 M	\$ 459 M	\$ 569 M



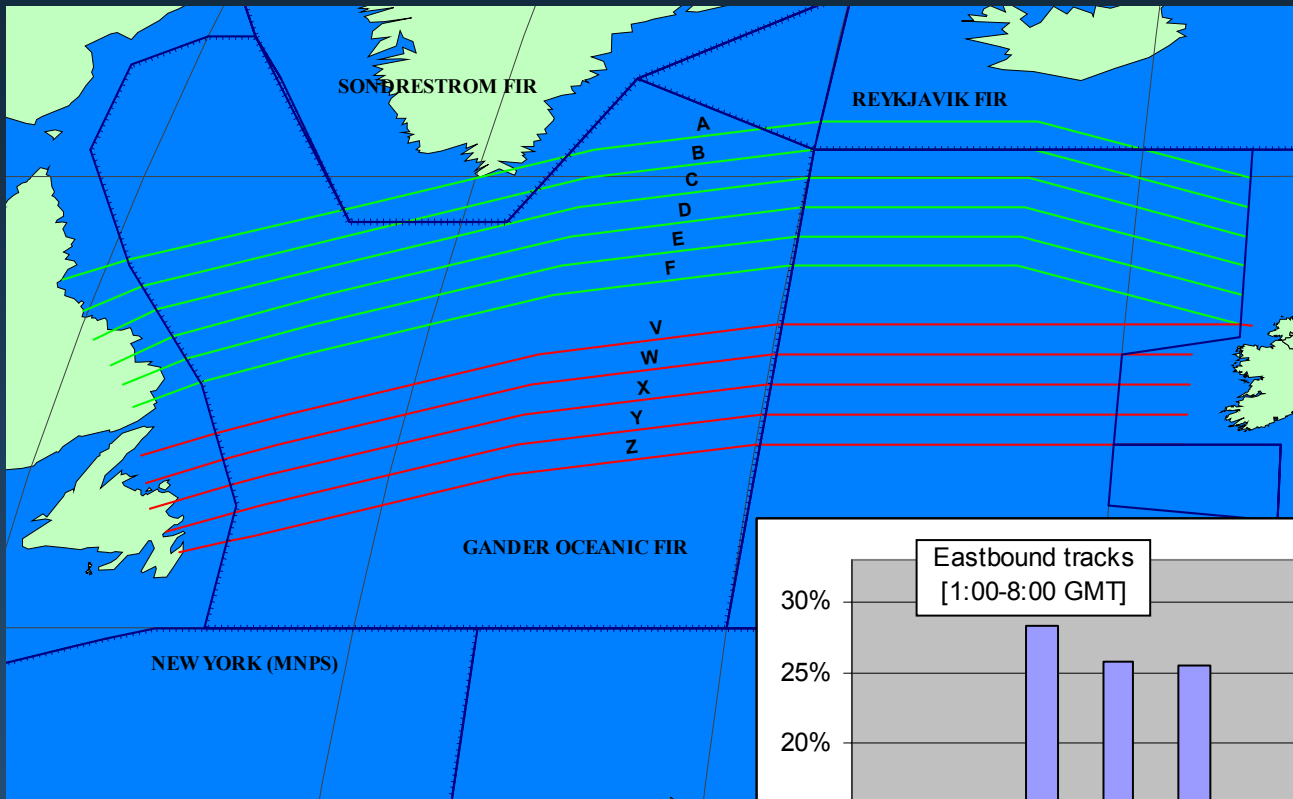
Additional Slides



System Performance Metrics Summary



NAT OTS Baseline Traffic Data



Scheduled: 88%

Non-sch.: 6%

Military: 2%

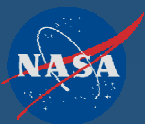
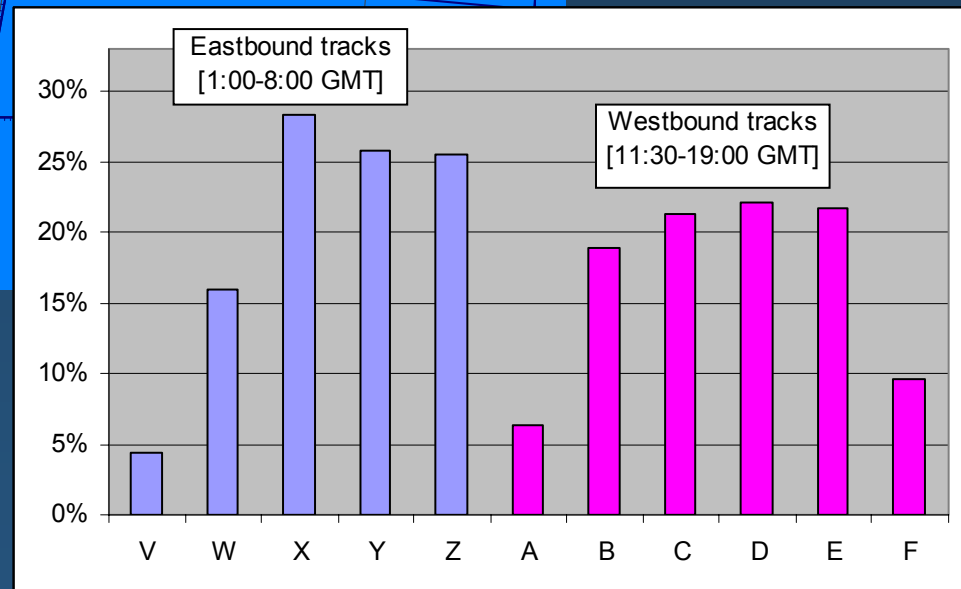
GA: 2%

Cargo: 1%

ADS: 27%

Datalink: 34%

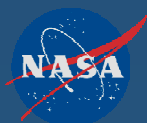
RNP: 99%



NAT Traffic Growth Parameters

- Average annual growth rate
 - Scheduled: 4.5%
 - Cargo: 4.3%
 - GA: 3.7%
 - Non-scheduled: 2.68%
 - Military: -1.95%
- Overall traffic growth rate
 - 7.6% by 2005
 - 30.4% by 2010
 - 58.9% by 2015
- Equipage assumptions
 - New airframes enter the system already equipped
 - Newer models are equipped before old

	2004	2005	2010	2015
B767	32%	33%	30%	29%
B777	19%	19%	22%	22%
A330	15%	15%	16%	17%
B747	14%	13%	12%	8%
A340	7%	8%	7%	7%
B757	3%	3%	3%	3%
MD11	2%	2%	-	-
DC10	1%	1%	-	-
GLF4	1%	1%	1%	1%
CL60/CL6				
4	1%	1%	1%	1%
A380	-	-	3%	6%
B787	-	-	3%	5%



Equipage Assumptions

AC Type	2005 Overall Equipage			2010 Overall Equipage			2015 Overall Equipage		
	25%	50%	75%	25%	50%	75%	25%	50%	75%
A330-200/300	-	50%	100%	-	50%	75%	-	50%	75%
A340-300	75%	100%	100%	50%	75%	100%	40%	60%	75%
A340-500/600	100%	100%	100%	100%	100%	100%	100%	100%	75%
A380	-	-	-	100%	100%	100%	100%	100%	100%
B747-400	50%	75%	100%	50%	75%	100%	33%	70%	75%
B757-200	-	-	30%	-	-	30%	-	-	30%
B767-300/400	-	25%	75%	-	25%	75%	-	25%	75%
B777-200	75%	100%	100%	50%	75%	75%	40%	60%	75%
B777-300	75%	100%	100%	50%	100%	100%	40%	60%	100%
B7E7	-	-	-	100%	100%	100%	100%	100%	100%
CL60/CL64	-	-	100%	-	-	100%	-	-	100%
GLF4	-	100%	100%	-	100%	100%	-	100%	100%

