US/Europe comparison of ATM-related operational performance

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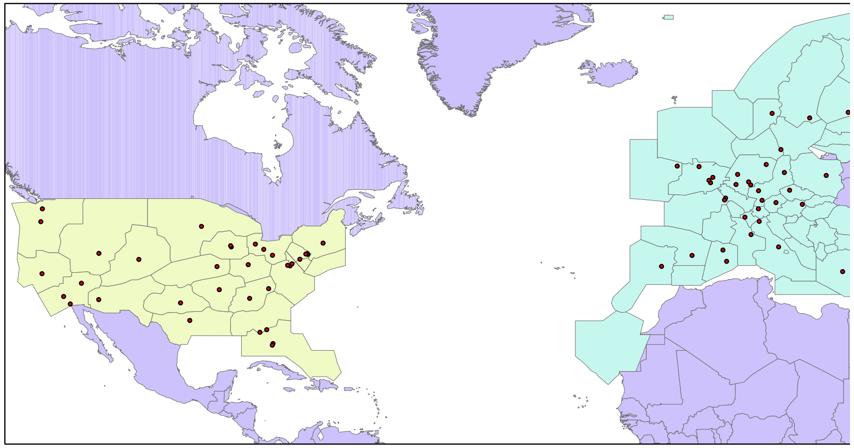
Objective & Scope

OBJECTIVES

- Provide a high-level comparison of operational performance between the US and Europe Air Navigation systems.
- Initial focus on the development of a set of comparable performance for high level comparisons between countries and world regions.

SCOPE

- Predictability and Efficiency of operations
- Link to "Environmental sustainability" when evaluating additional fuel burn.
- Continental airspace (Oceanic and Alaska excluded)
- Focus on data subset (traffic from/to top 34 airports) due to better data quality (OEP airports) and comparability (general aviation).
- Commercial IFR flights



NOT in SCOPE

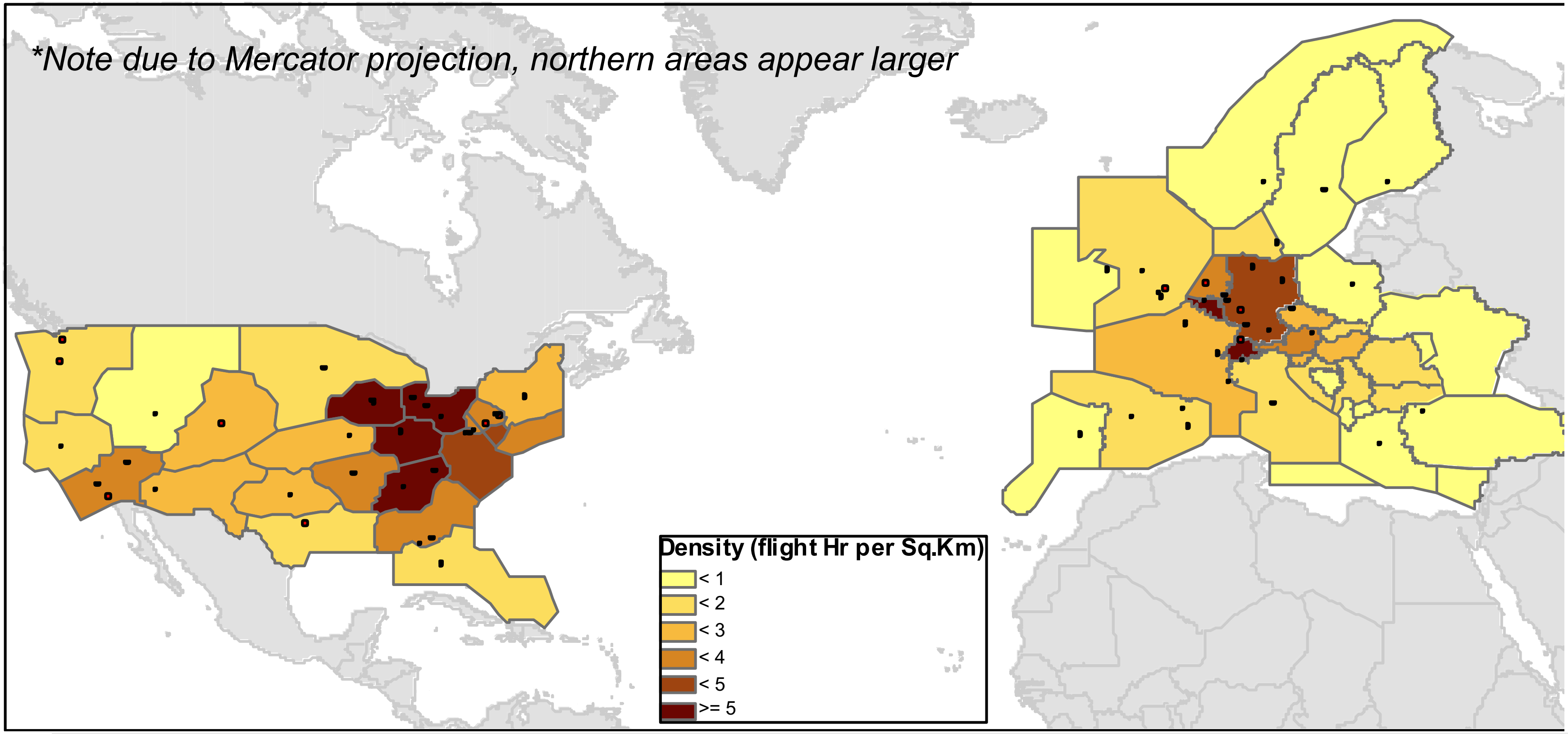
- Safety, Cost effectiveness, Capacity
- Trade-offs and other performance affecting factors (weather, etc.)

Overview Comparing USA & Europe

Calendar Year 2007	Europe[1]	USA[2]	Difference
Geographic Area (million km^2)	11.5	10.4	-10%
Number of en-route Air Navigation Service Providers	38	1	
Number of Air Traffic Controllers	17 000	17 000	0%
Total staff	56 000	35 000	-38%
Controlled flights (Instrumental flight rules IFR) (million)	10	18	+80%
Share of General Air Traffic	4%	18%	x4.5
Flight hours controlled (million)	14	25	+79%
Average length of flight (within region)	548 NM	490 NM	-11%
Nr. of en-route centers	66	20	- 70%
En-route sectors at maximum configuration	684	955	+40%
Nr. of airports with ATC services	450	503[3] (280)	+12%
Of which are slot controlled	> 73	3	
Source	Eurocontrol	FAA/ATO	

[1] Eurocontrol States plus the Estonia and Latvia, but excluding oceanic areas and Canary Islands.
[2] Area, flight hours and center count refers to CONUS only. The term US CONUS refers to the 48 contiguous States located on the North American continent south of the border with Canada, plus the District of Columbia, excluding Alaska, Hawaii and oceanic areas.
[3] All facilities of which 280 are FAA staffed and 223 contract towers.

Airspace Density Comparison (CONUS & European Centers)



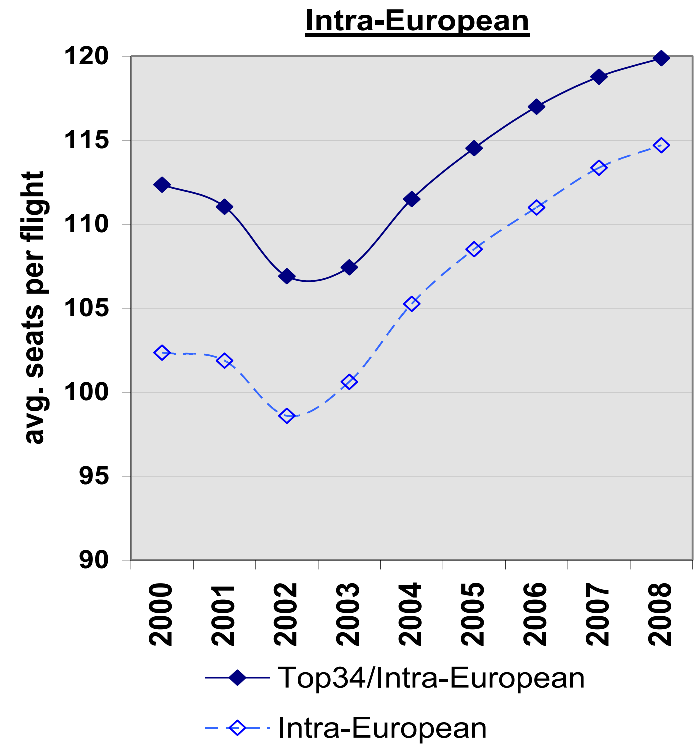
- Actual sizes are comparable (USA 10.4 vs Europe 11.5 M km^2)
- Relative density (flight hours per km^2) is 1.2 in Europe and 2.4 in US

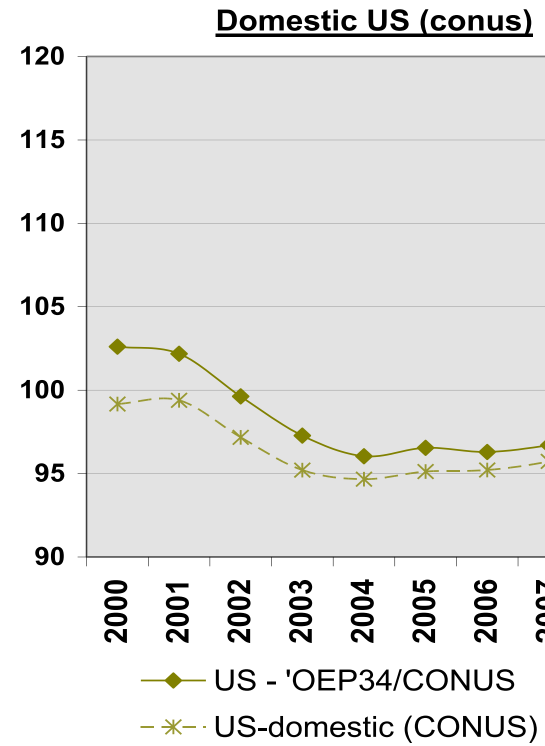
Some facts about the main airports in the US and in Europe

Main 34 airports in 2007	Europe	US	Difference US vs. Europe
Average number of annual movements per airport ('000)	**267**	**441**	**+65%**
Average number of annual passengers per airport (million)	**25**	**32**	**+28%**
Passengers per movement	**94**	**72**	**-23%**
Average number of runways per airport	**2.5**	**4.0**	**+60%**
Annual movements per runway ('000)	**108**	**110**	**+2%**
Annual passengers per runway (million)	**10.0**	**8.0**	**-20%**

- Traffic to/from the main 34 airports represents some 69% of all IFR flights in Europe and 64% in the US.
- The share of general aviation to/from the main 34 airports is more comparable with 4% in the US and 1.6% in Europe.
- Average number of runways (+60%) and the number of movements (+65%) are significantly higher in the US;
- Number of passengers per movement in the US (-23%) are much lower than in Europe.

Average seats per scheduled flight in the US and in Europe

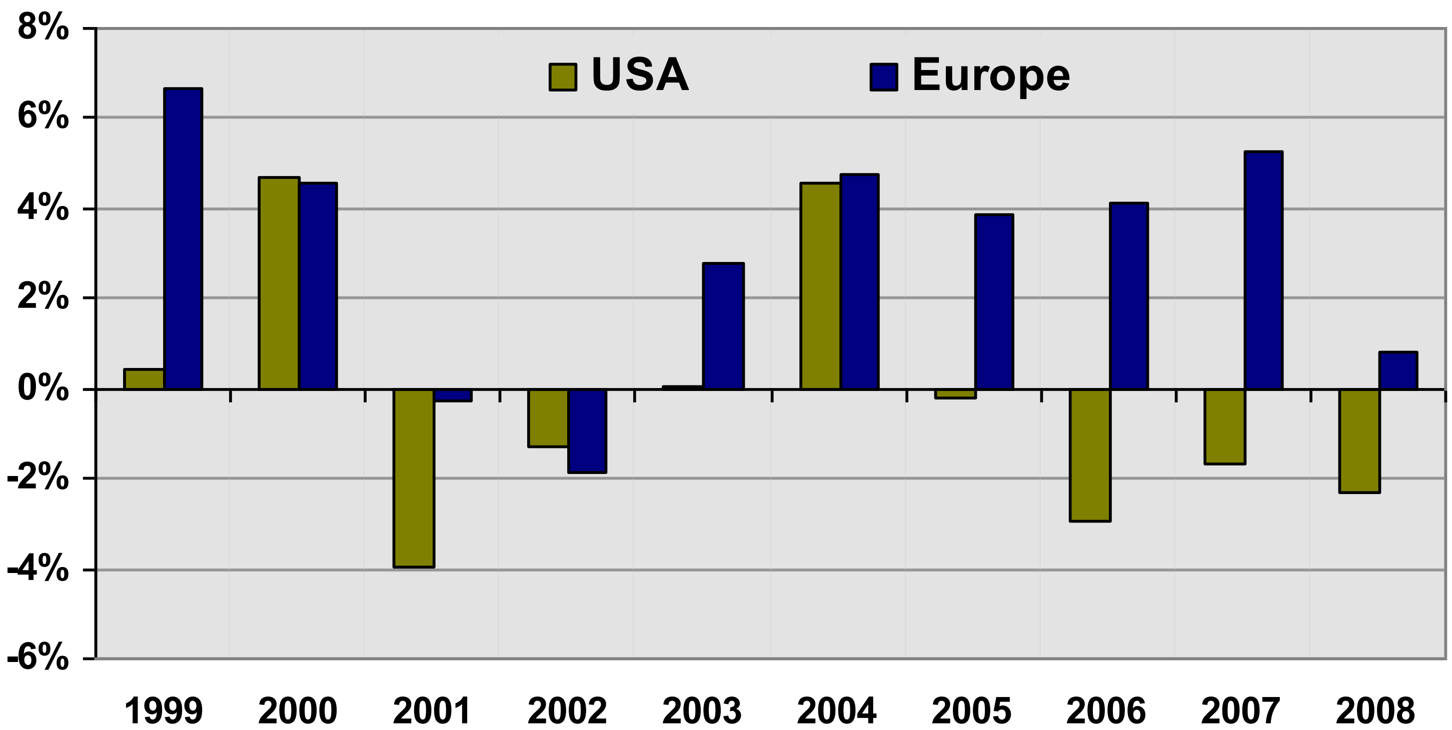




Source: FAA/ PRC analysis

- Average seat size per scheduled flight differs in the two systems with Europe having a higher percentage of flights using “Large” aircraft than the US.

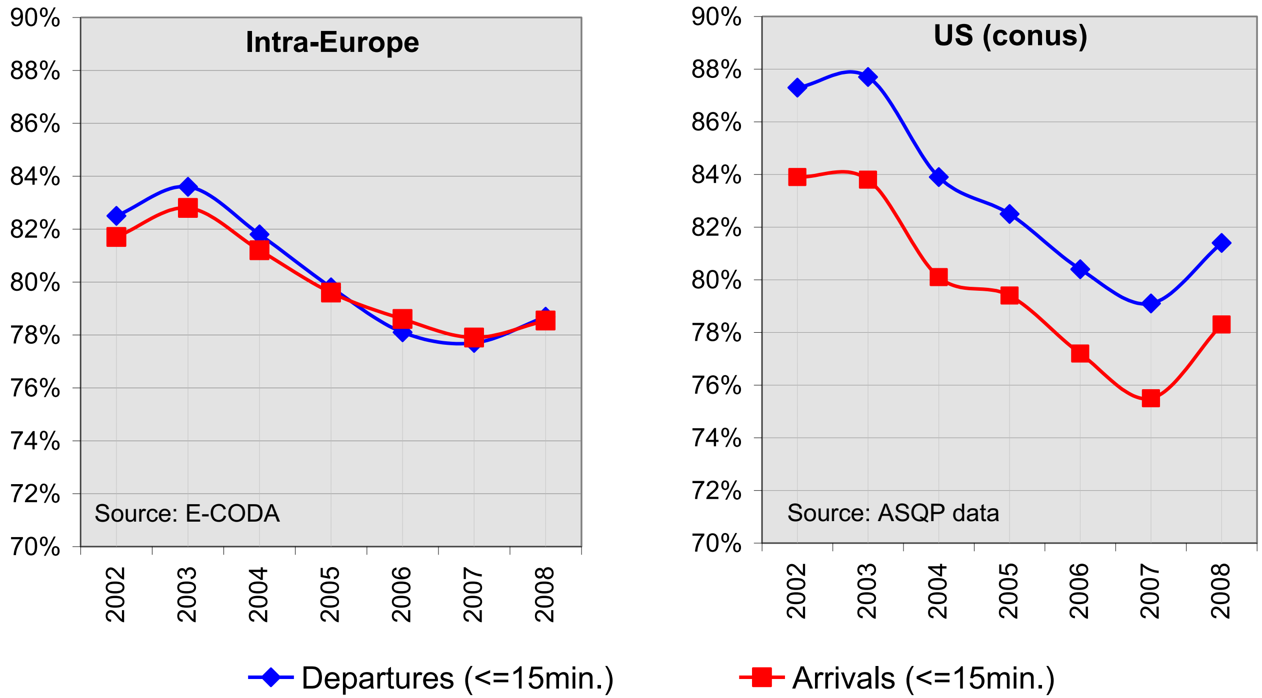
Air traffic growth in the US and in Europe (IFR flights)



- Until 2004, growth rates evolved in similar ways
- Notable decoupling since 2004

On-time performance in the US and in Europe

On-time performance compared to schedule
(flights to/from the 34 main airports)

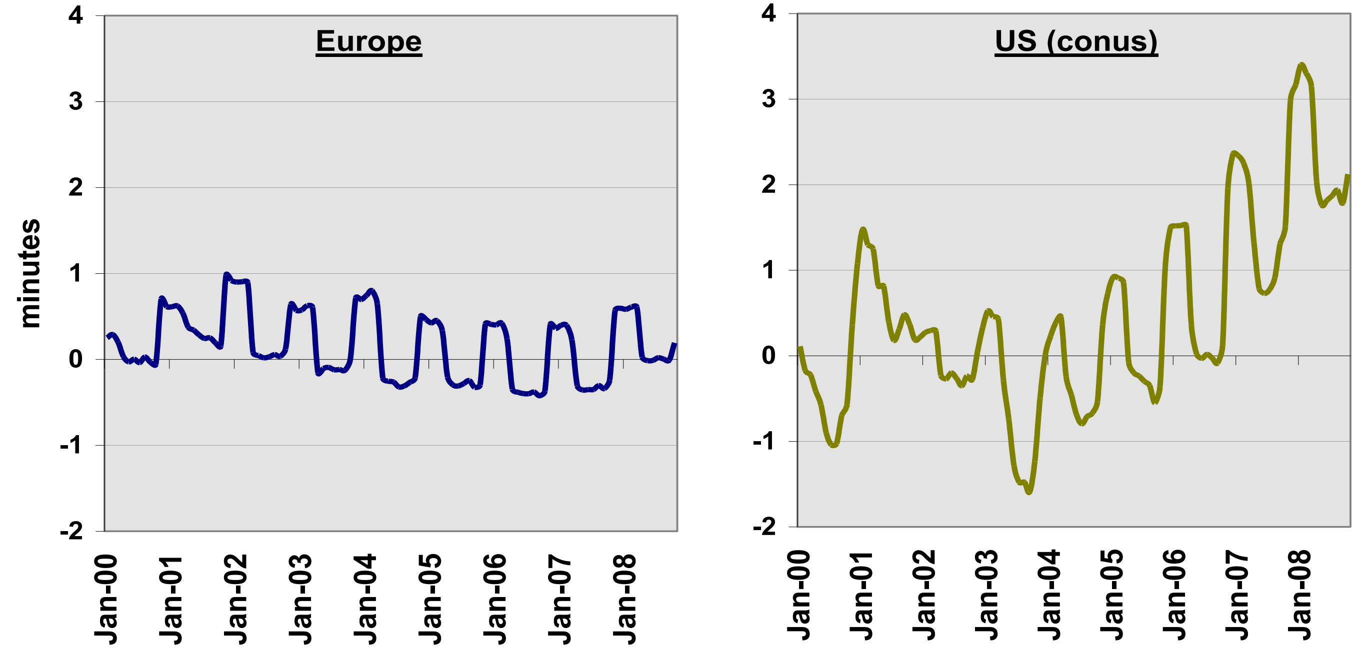


Arrivals/ departures delayed by more than 15 minutes versus schedule

- Similar pattern in US and Europe with a comparable level of arrival on time performance;
- The gap between departure and arrival punctuality is significant in the US and quasi nil in Europe suggesting differences in flow management strategies

Airline Scheduling: Evolution of block times

Evolution of Scheduled Block Times
(flights to/from 34 main airports)



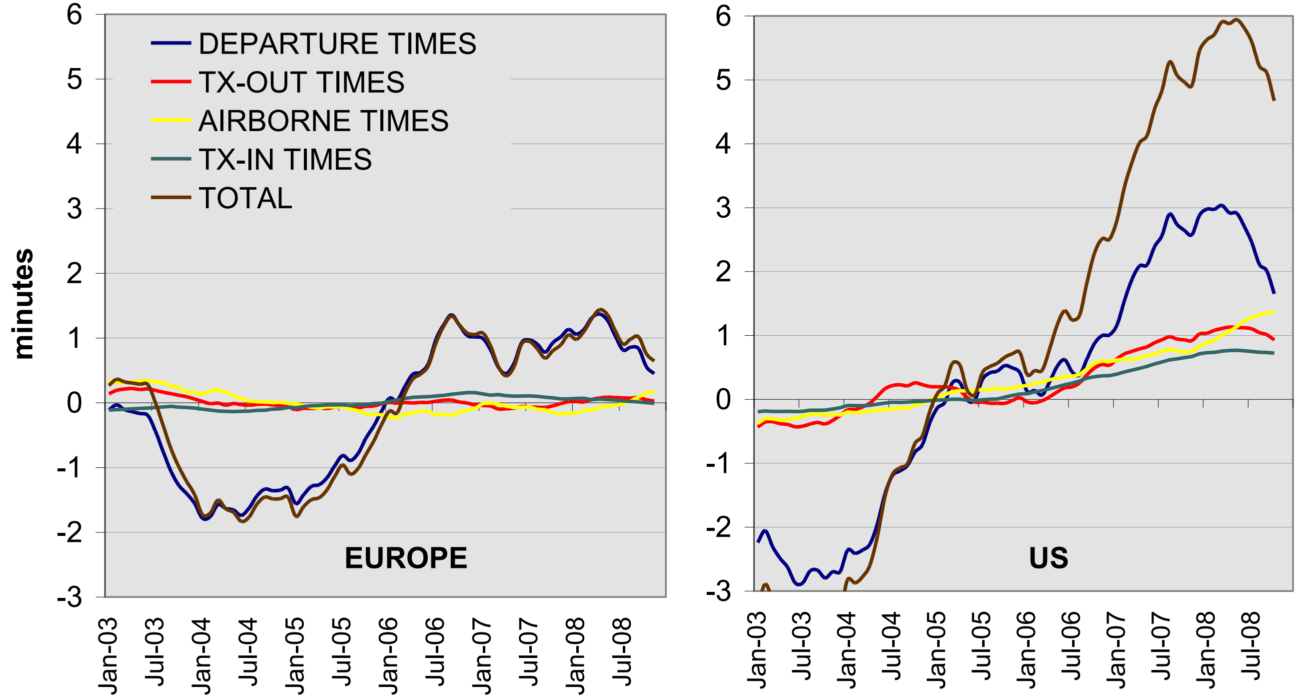
Scheduled block times compared to the long term average at city pair level.

Source: FAA/PRU

- ➔ **Europe:** Block times remain relatively stable (left side)
- ➔ **US:** In addition to decreasing on time performance (previous slide), there is a clear increase in scheduled block times (right side)
- ➔ Seasonal effects are visible in the US and in Europe

Efficiency: Trends in the duration of flight phases

Trends in the duration of flight phases
(flights to/from main 34 airports)



Actual times are compared to the long term average for each city pair.

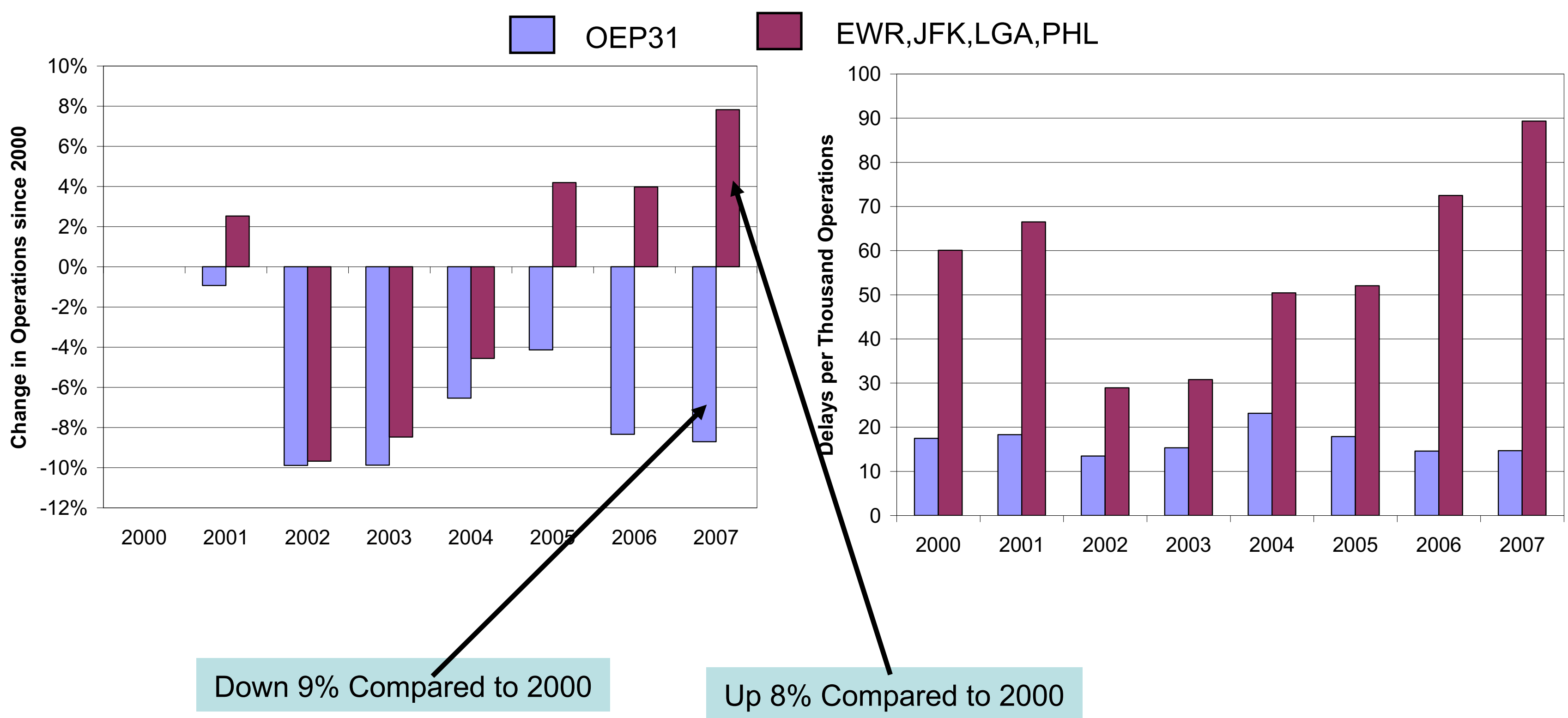
Data Source: CODA/ FAA

- ➔ **Europe:** performance is driven by departure delays with only very small changes in the gate-to-gate phase.
- ➔ **US:** in addition to a deterioration of departure times, there is a clear increase in average taxi times and airborne times.

Schedule Growth Shifts Delays – NY&PHL vs. Rest of OEP

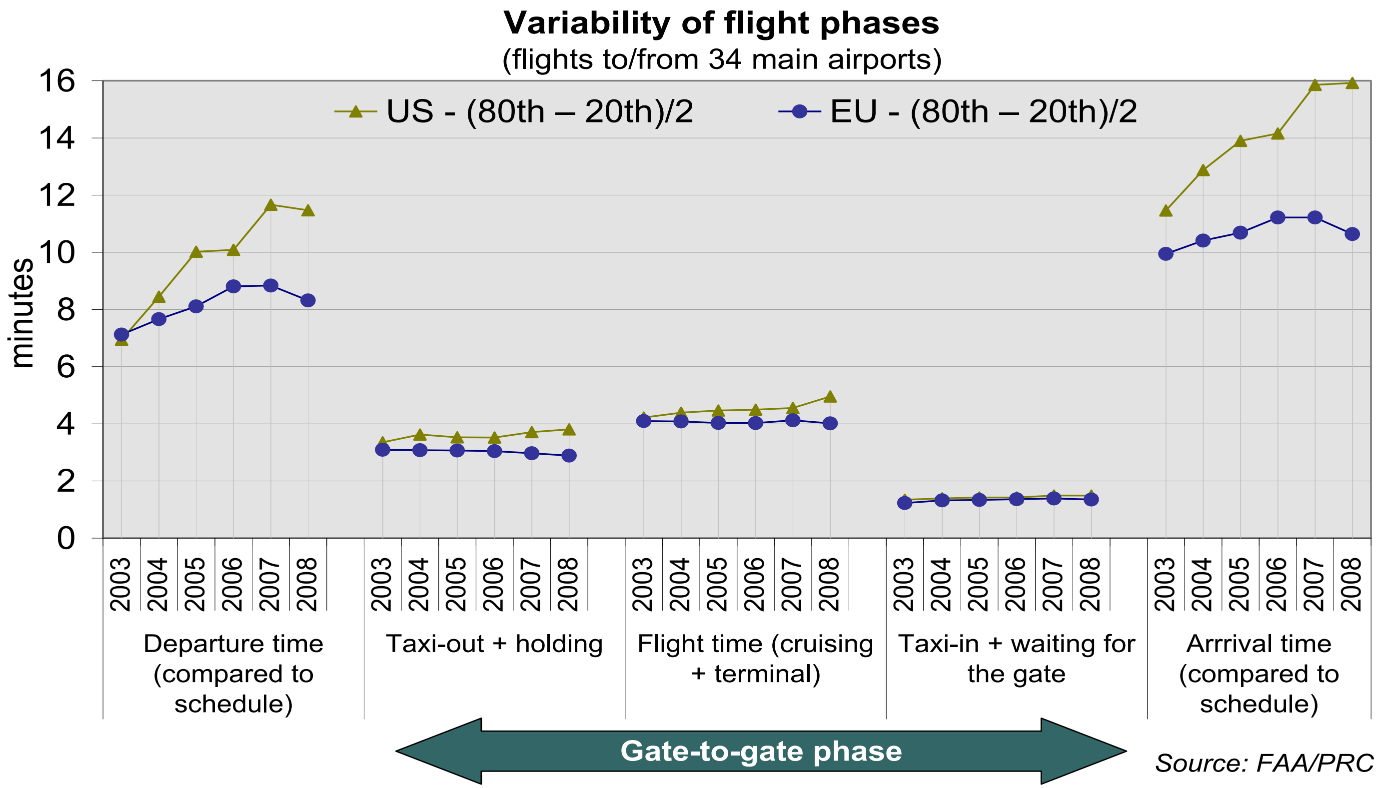
Traffic Change

Delayed Flights



October-July

Predictability: Variability of flight phases



- *Predictability is measured in from the single flight perspective (i.e. airline view) as the difference between the 80th and the 20th percentile for each flight phase.*

➔ Arrival predictability is mainly driven by departure predictability.

➔ With the exception of taxi-in, variability for all flight phases is higher in the US.

What We are Measuring Today (w/ Large Data Sets)

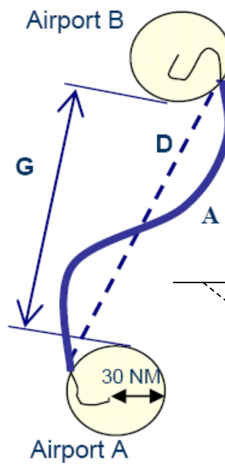
FAA/ATO and PRU both establishing consistent measures

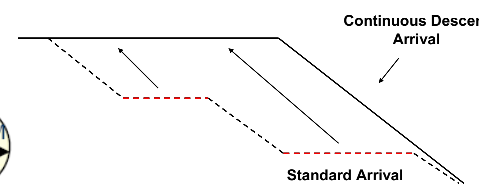
IFR flights To/from Main 34 airports

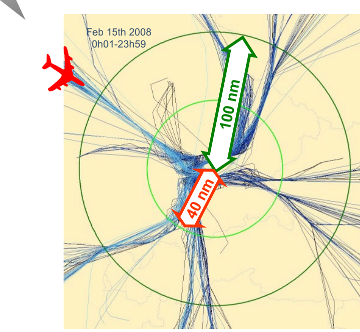
DEPARTURE
- ANS-related Holding at the Gate (ATFM/ EDCT)

GATE-to-GATE
- Taxi-out efficiency
- En-route Flight efficiency
- Efficiency In last 100NM
- Taxi-in efficiency

IFR flights To/from Main 34 airports







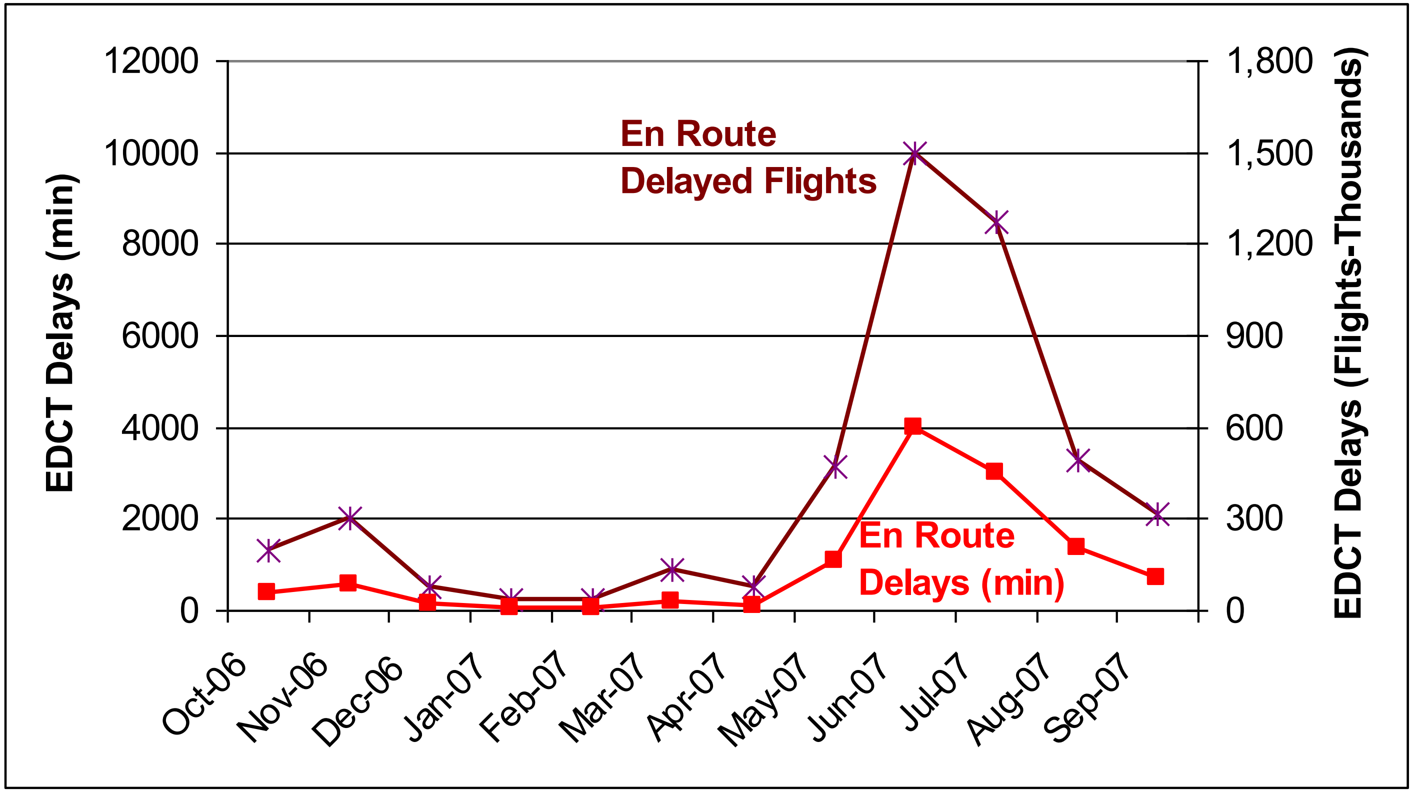
Efficiency: ANS-related departure delays

DEPARTURE: ANS-related Holding at the Gate (ATFM/ ...)
GATE-to-GATE: Taxi-out efficiency | En-route Flight efficiency | Efficiency In last 100NM

	2007	En-route related (EDCT/ATFM)			Airport related (EDCT/ATFM)		
	IFR flights (M)	% of flights delayed	delay per flight (min.)	delay per delayed flight (min.)	% of flights delayed	delay per flight (min.)	delay per delayed flight (min.)
US	9.7	0.2%	0.1	53	1.7%	1.1	68
Europe	5.7	7.8%	1.4	18	6.8%	1.4	21

- ➔ **US:** En-route delays are much lower per flight, but the delay per delayed flight is significantly higher;
- ➔ **Europe:** Higher share of flights affected (than US) but with a lower average delay.
- ➔ In the US, ground delays (EDCT) are used when other options are not sufficient, whereas, in Europe ground delays (ATFM) are the main ATM tool for balancing demand with capacity

En Route Driven Ground Delays (ATO)



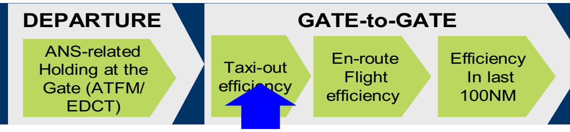
Excess Taxi Fuel Burn Calculation Methodology

- **Calculate taxi-in/taxi-out delay from ASPM/ASQP**

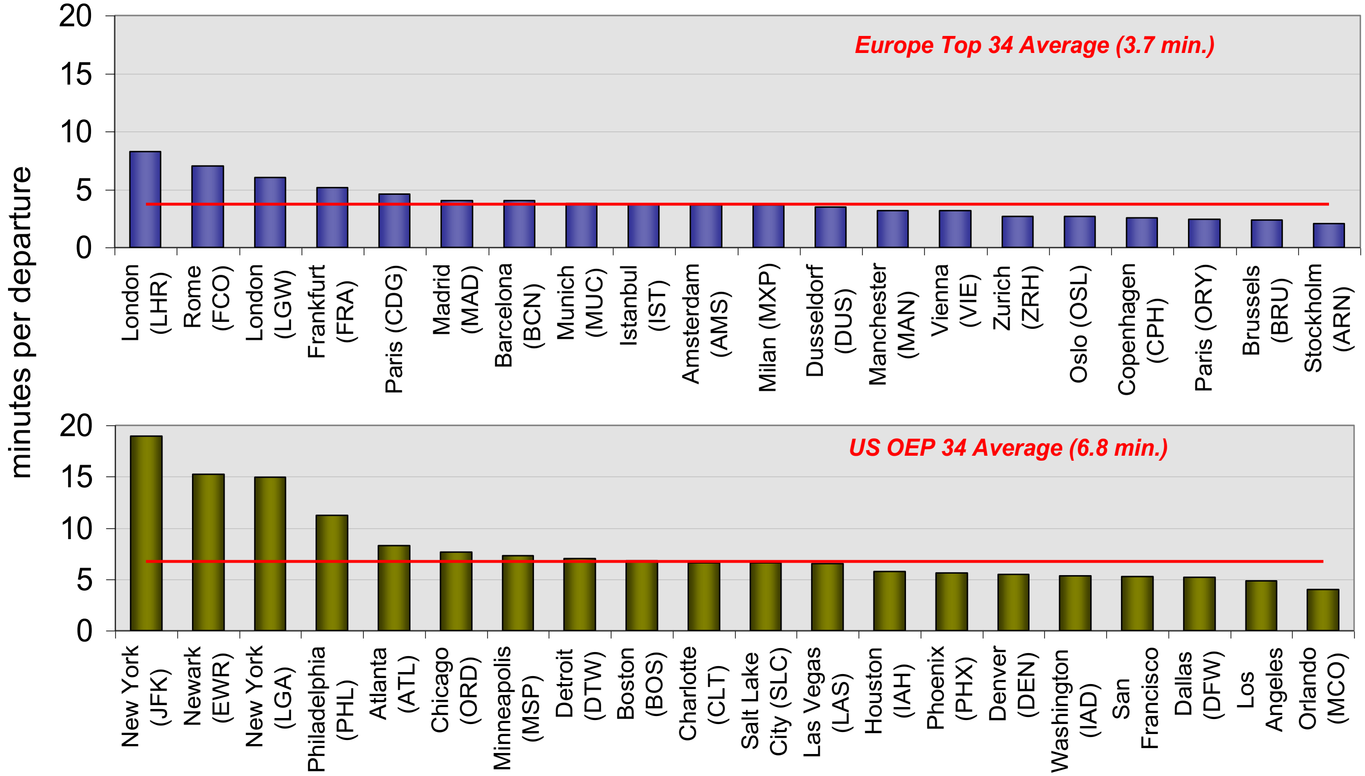
  -using actual taxi time and nominal taxi time from ASPM
  Nominal taxi time statistically calculated by APO
  -Taxi-delay = actual time – nominal time
  -Negative delay truncated to zero

- **Derive excess fuel usage from taxi-in/taxi-out delay**
  - Excess fuel used in kg = taxi delay in minute * fuel burn kg/min
  - Assuming all engines on at idle power for entire delay period
  - Alternative to truncate delay at maximum of 30 minutes
  - Idle power from ICAO Emissions databank

Excess time in the taxi out phase



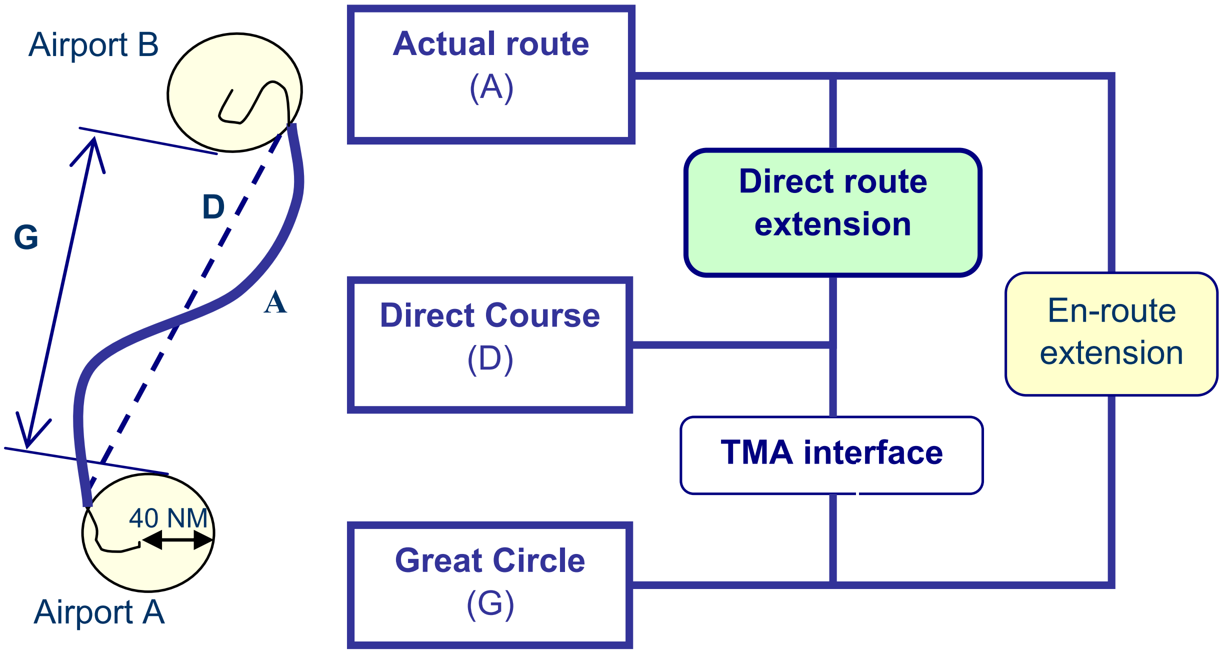
Average excess time in the taxi out phase
(Top 20 in terms of annual movements in 2007 are shown)



Source: FAA/ PRC analysis/ CODA/ CFMU

- ➔ Excess times in the taxi out phase are higher in the US
- ➔ For the US, excess times also include delays due to local en-route departure and miles in trail restrictions. .

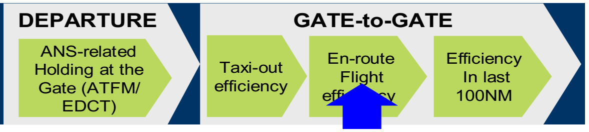
En-route flight Efficiency: Approach

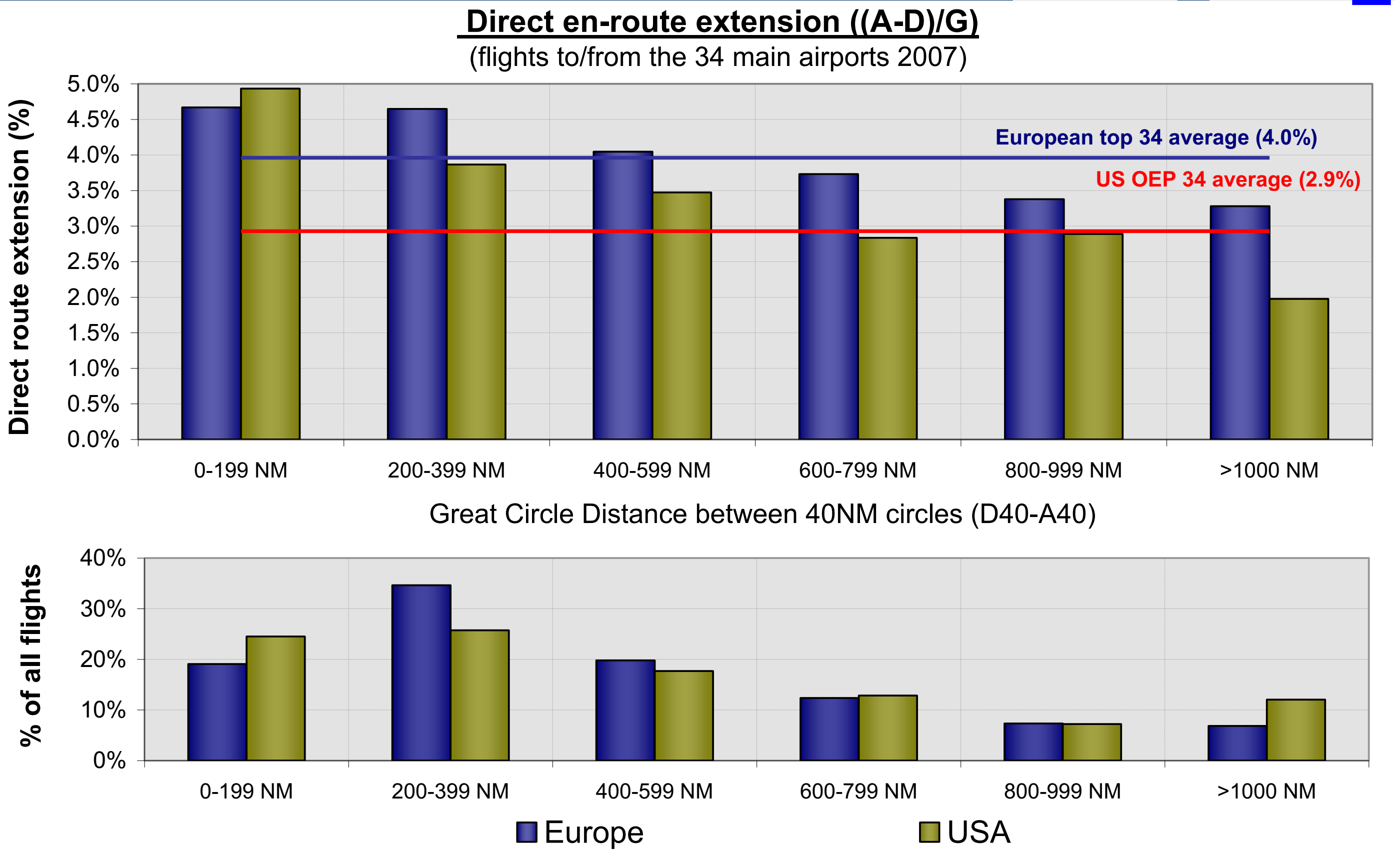


- *Focus on horizontal flight efficiency*
- *Distance based approach*

- Indicator is the difference between the length of the actual trajectory (A) and the Great Circle Distance (G) between the departure and arrival terminal areas.
- Direct route extension is measured as the difference between the actual route (A) and the direct course between the TMA entry points (D).
- This difference is an ideal (and unachievable) situation where each aircraft would be alone in the sky and not subject to any constraints (i.e. safety, capacity).

Flight efficiency: Direct Route Extension



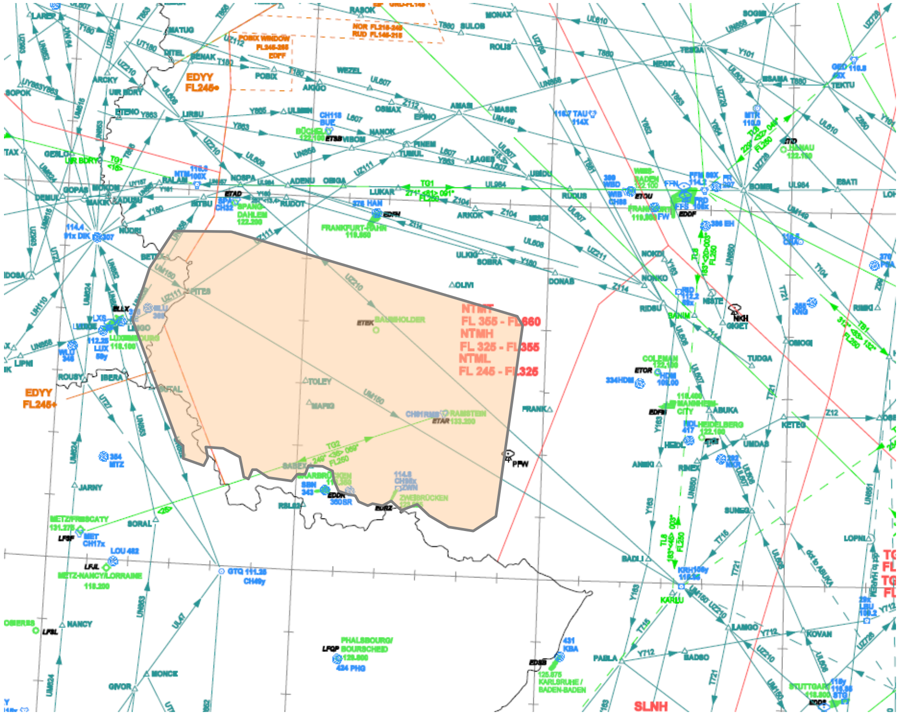


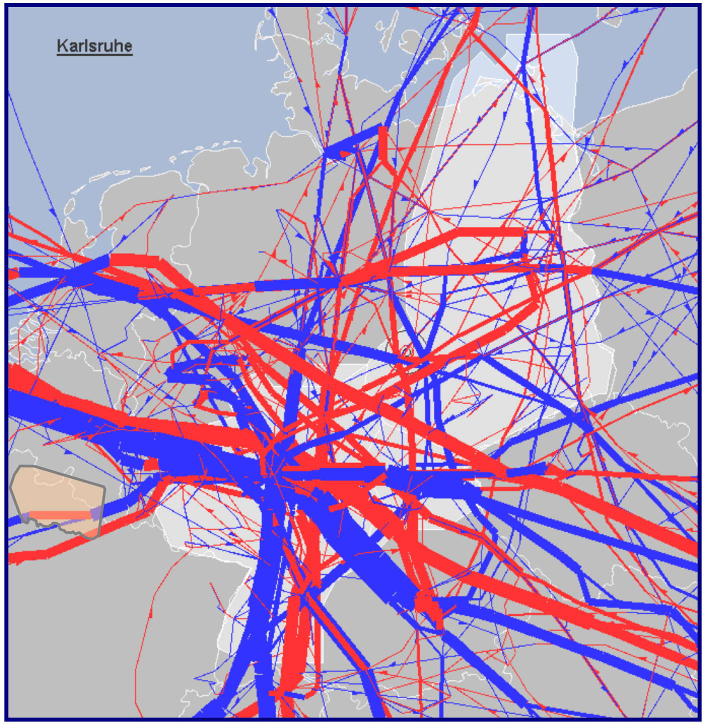
- Direct route extension is approximately 1% lower in the US
- **US:** Miles in trail restrictions are passed back from constrained airports
- **Europe**: Fragmentation of airspace, location of military airspace

Impact of Military Airspace SW of Frankfurt

DEPARTURE: ANS-related Holding at the Gate (ATFM/ EDCT)

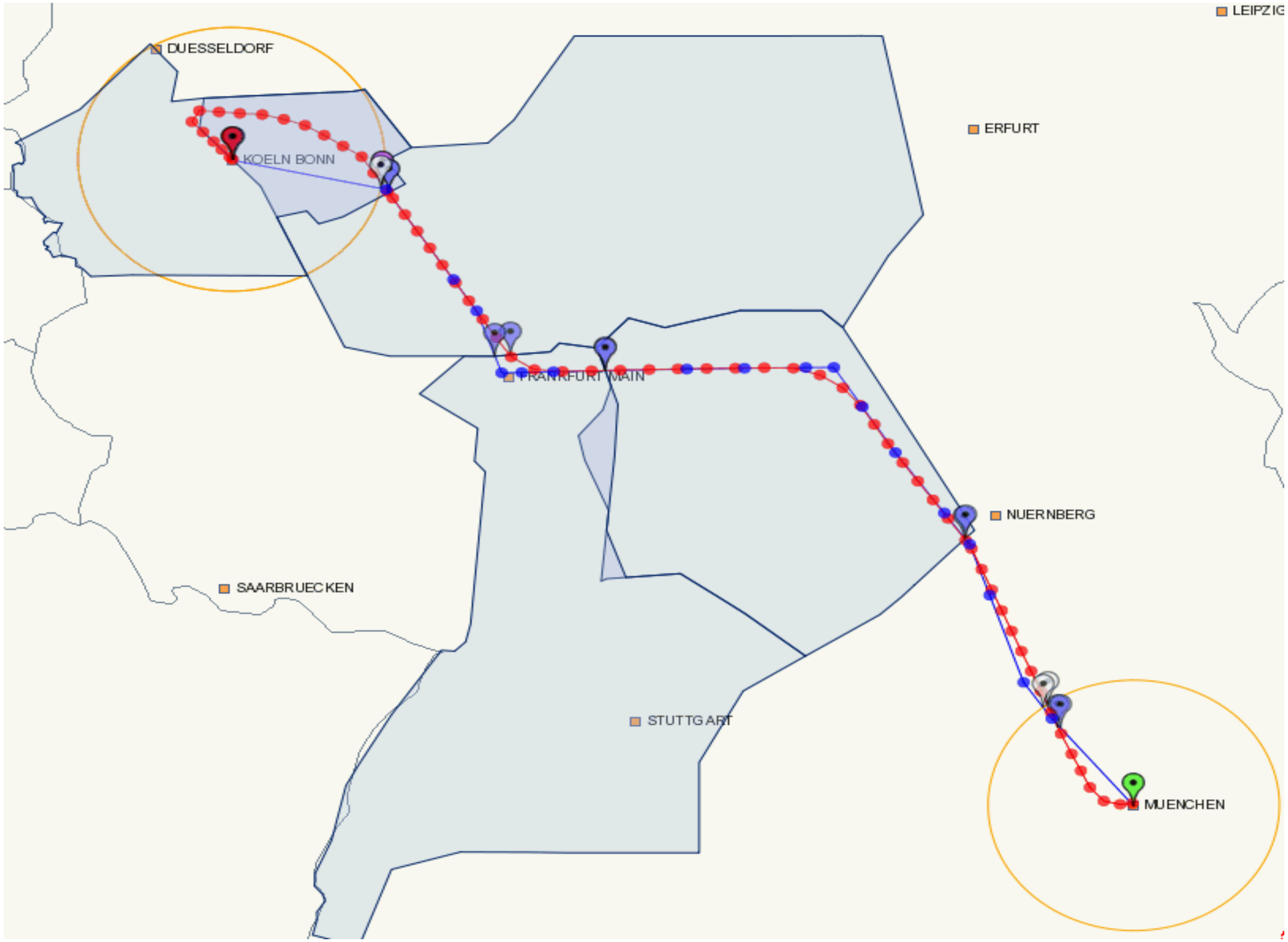
GATE-to-GATE: Taxi-out efficiency | En-route Flight efficiency | Efficiency In last 100NM





- Military airspace is a significant driver of excess distance
- Area southeast of Frankfurt is a major contributor
- Adjoining French Military airspace further increases problem

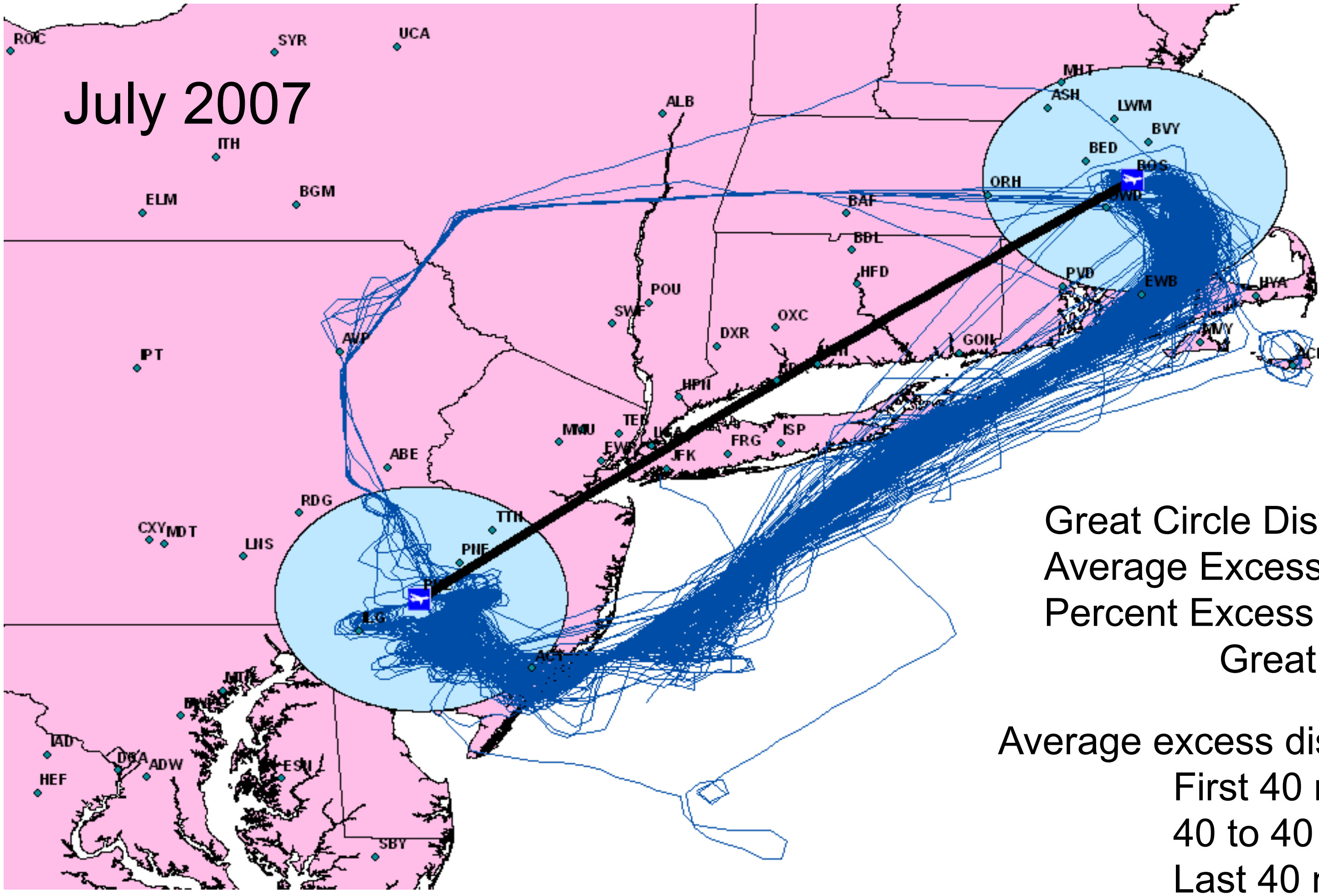
Second Most “Inefficient” Route in Germany



Boston (BOS) to Philadelphia (PHL) Flights

DEPARTURE: ANS-related Holding at the Gate (ATFM/ EDCT)

GATE-to-GATE: Taxi-out efficiency → En-route Flight efficiency → Efficiency In last 100NM

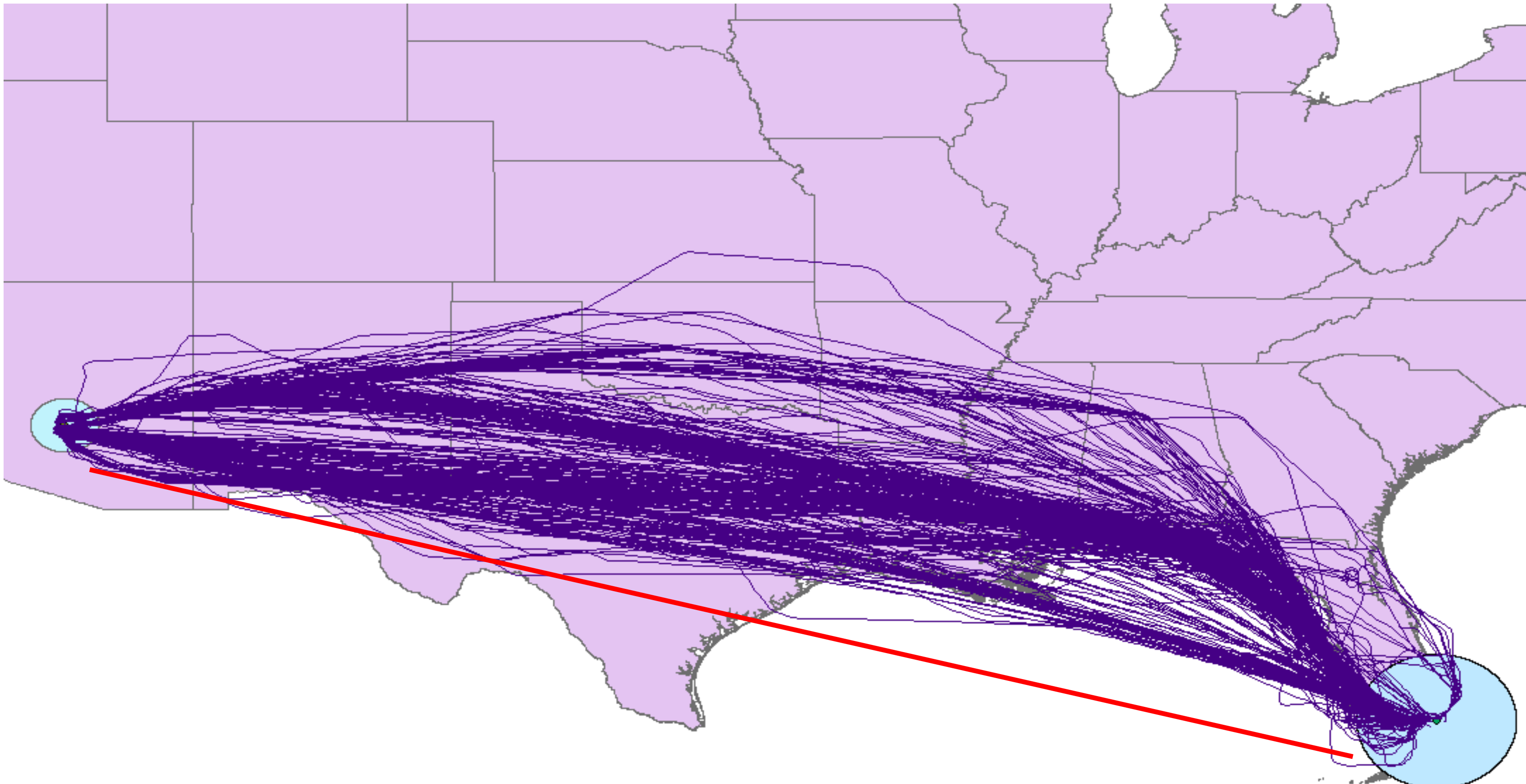


Great Circle Distance: 242 nmi
Average Excess Distance: 102 nmi
Percent Excess Distance over Great Circle: 42.1%

Average excess distance per stage:
- First 40 nmi: 12 nmi
- 40 to 40 nmi circles: 63 nmi
- Last 40 nmi: 27 nmi

Phoenix (PHX) to Fort Lauderdale (FLL)

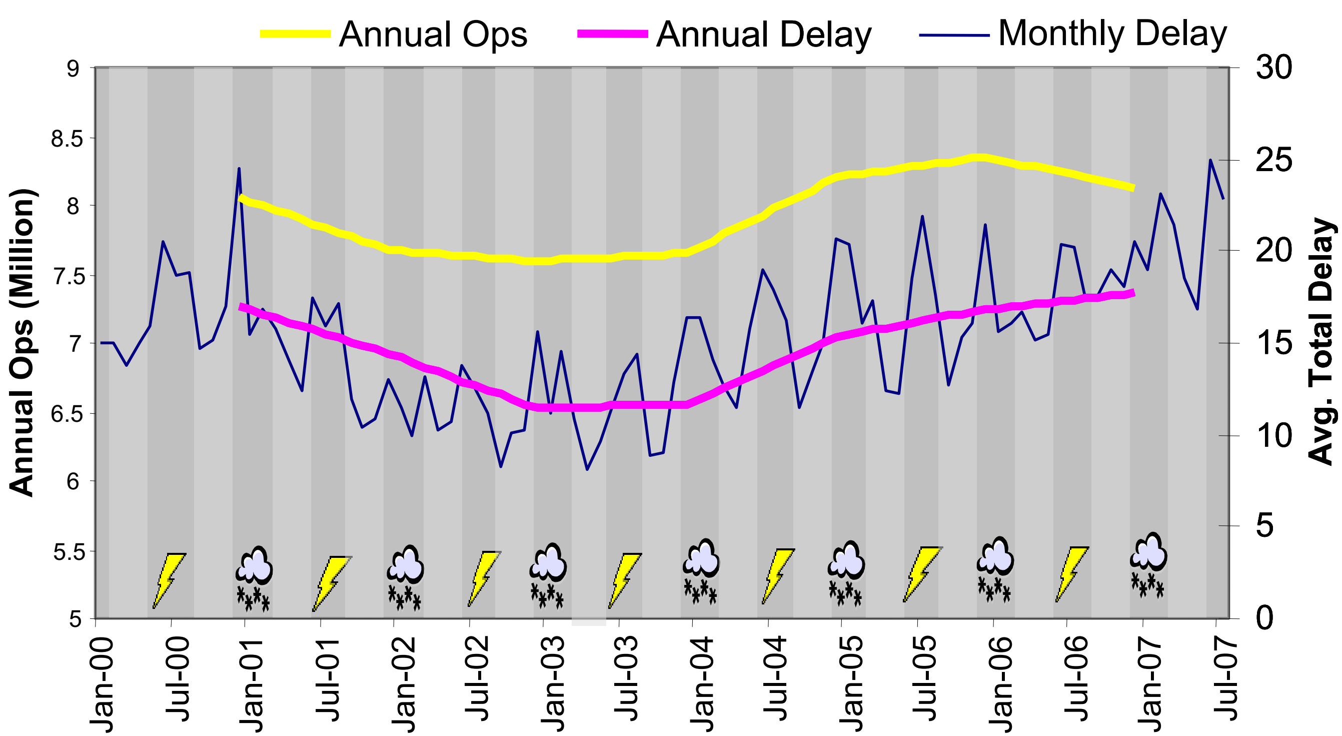
DEPARTURE
ANS-related Holding at the Gate (ATFM/ EDCT)
GATE-to-GATE
Taxi-out efficiency
En-route Flight efficiency
Efficiency In last 100NM



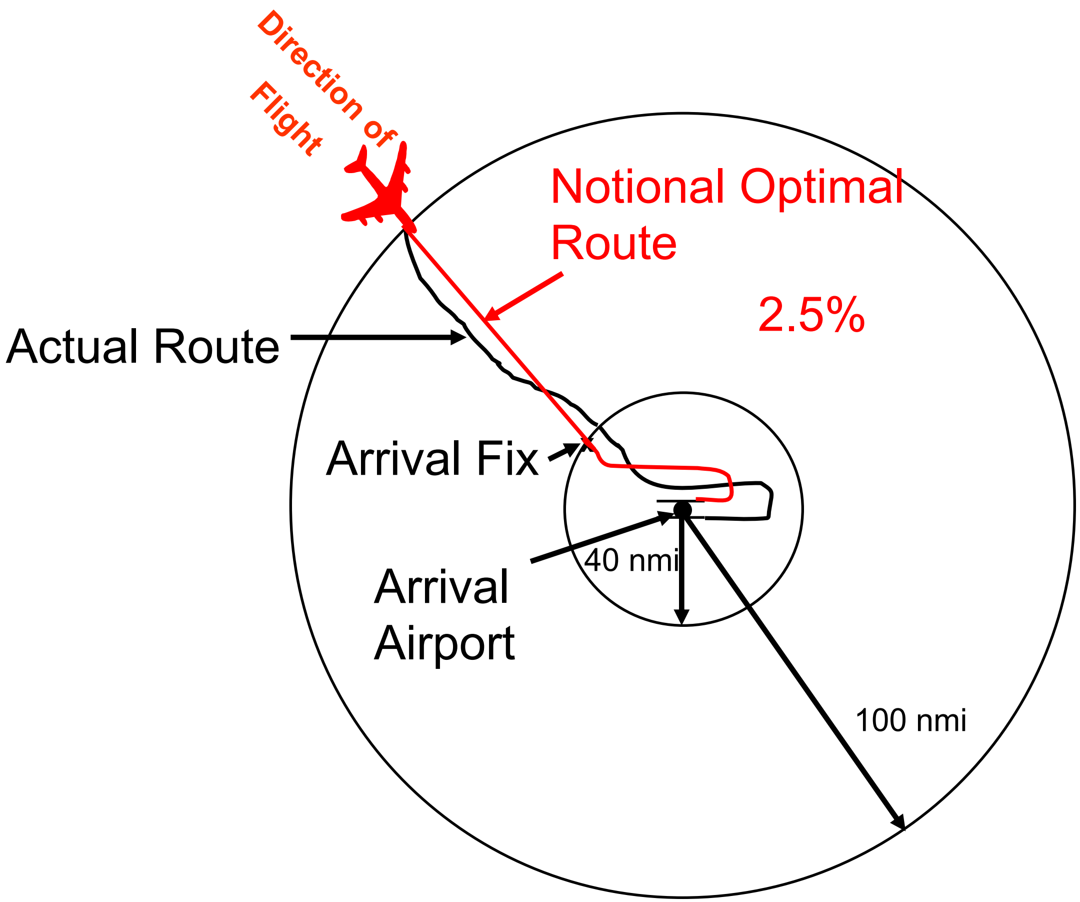
Number of Flights		668
Direct Flight Indicator	Total (A-G)	70.9
	Direct Between TMA (A-D)	64.6
	TMA Interface (G-D)	6.3

FAA/ATO Delays

- Most En Route Delays during Convective Weather



Efficiency: Excess time in the last 100NM



- **Time based measure**
- **Captures type of A/C**
- **ARC Entry point and runway configuration**
- **Nominal derived from 20th percentile**
- **Excess – time above nominal for each category**

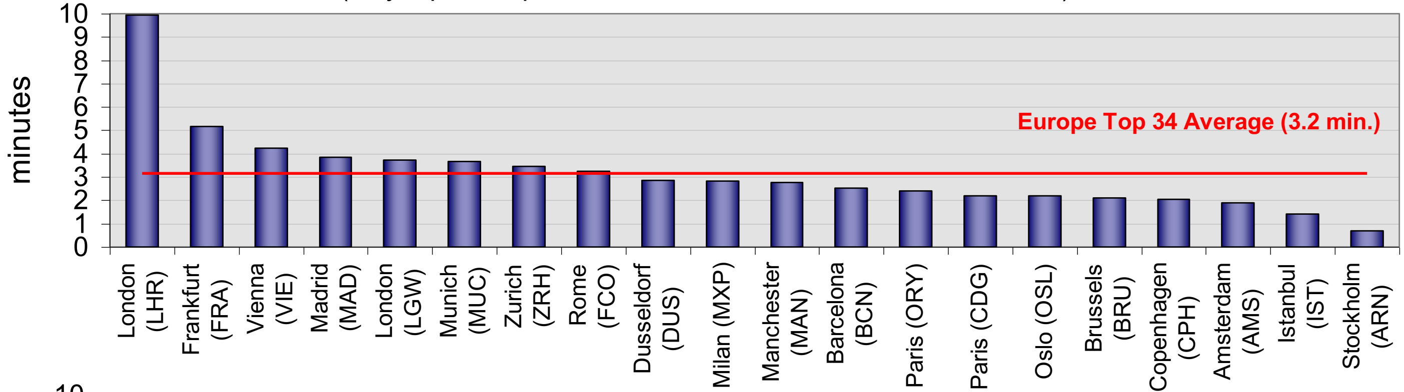
Excess time within the last 100NM

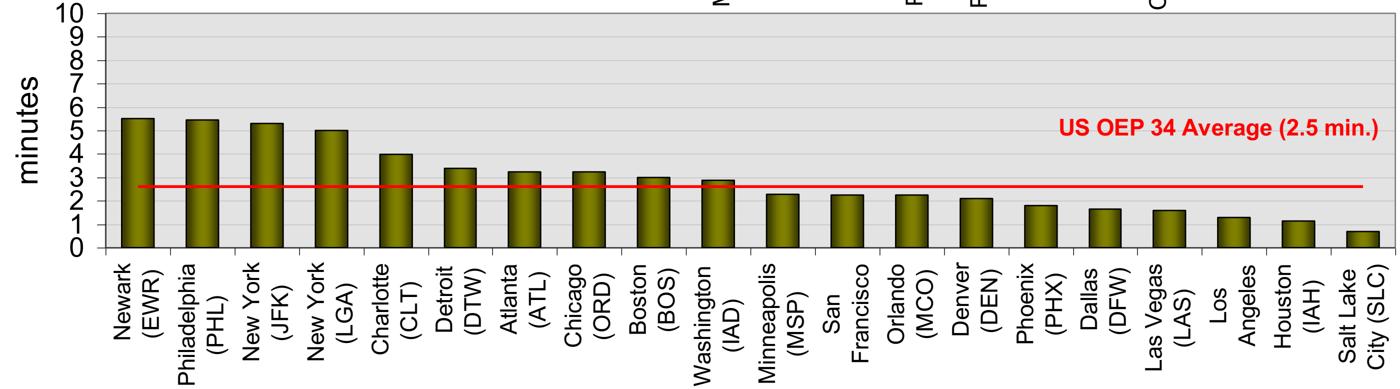
DEPARTURE: ANS-related Holding at the Gate (ATFM/ EDCT)

GATE-to-GATE: Taxi-out efficiency | En-route Flight efficiency | Efficiency In last 100NM

Average Excess Minutes within the last 100NM miles
(only top 20 airports in terms of movement 2007 are shown)

Source: FAA/ PRC analysis





- ➔ Average excess time for main 34 airports is higher in Europe
- ➔ Mainly driven by London Heathrow (LHR) which is clearly an outlier
- ➔ Performance at LHR is consistent with the 10 minute average delay criteria agreed by the airport scheduling committee.

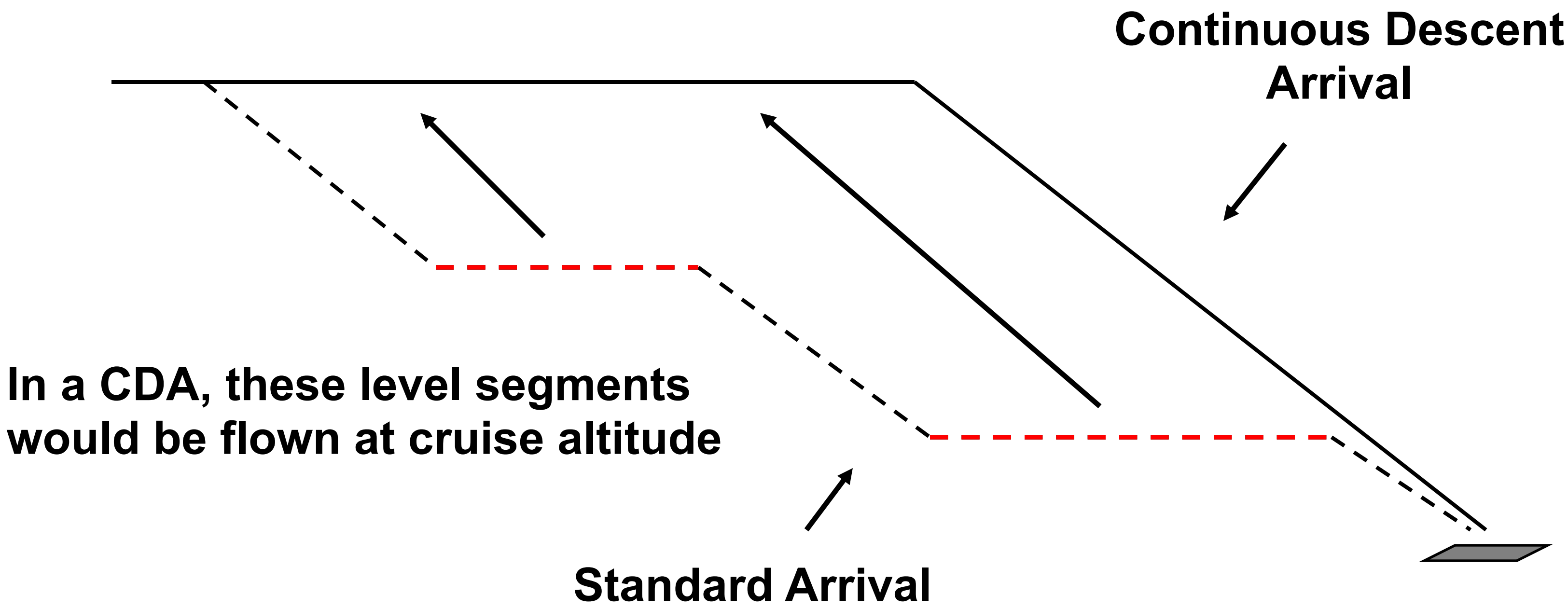
Estimated total benefit pool

Estimated excess time on flights to/from the main 34 airports (2007)		TIME per flight (minutes)		Predictability
		EUR	US	
Gate/ departure holdings	*en-route-related*	**1.4**	**0.1**	**Low**
	airport-related	**1.4**	**1.1**	**Low**
Taxi-out phase		**3.7**	**6.8**	**Medium**
Horizontal en-route flight efficiency		**2.2-3.8**	**1.5-2.7**	**High**
Terminal areas (ASMA/TMA)		**3.2**	**2.5**	**Medium**
Total estimated excess time per flight		**11.9-13.5**	**12.0-13.2**	

- The benefit pool represents a theoretical optimum. Safety and capacity constraints limit the practicality of ever fully recovering these “inefficiencies”
- Similar total estimated excess times in US and Europe but with differences in the distribution along the phase of flight. Inefficiencies have a different impact (fuel burn, time) on airspace users, depending on the phase of flight (airborne vs. ground) and the level of predictability (strategic vs. tactical).

Vertical Inefficiency - Continuous Descent Arrival

CDA is an arrival procedure designed to eliminate level segments flown below cruise altitude, thus minimizing fuel burn, emissions and noise.



FAA 2007 Inefficiency* Estimates

Assume 3875 kg Average Fuel per Flight

	Time	Fuel	
Horizontal Flight Efficiency	**1.5-2.7 min**	**63.9kg - 115.0 kg**	**1.6% - 3.0%**
TMA transit (Airborne Delay)	**2.5 min**	**98.1 kg**	**2.5%**
Vertical Flight Efficiency	**0**	**29.4kg - 31.7kg**	**0.76% - 0.82%**
Taxi Delay	**5.4-6.3 min**	**62.6kg - 74.5 kg**	**1.6% - 1.9%**
Total Flight Efficiency**			**6.6% - 8.2%**

*Inefficiencies includes safety related routings

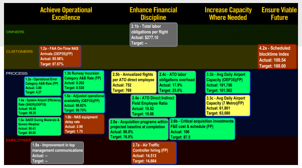
**With no action the inefficiency pool will grow with traffic

Conclusions

- High value in global comparisons and benchmarking in order to drive performance and identify best practice;
- Arrival punctuality is similar in the US and in Europe, albeit with a higher level of variability in the US.
- Overall, the estimated average excess time in the US and Europe appear to be similar, but with notable differences in the distribution along the phase of flight.
- Inefficiencies have a different impact (fuel burn, time) on airspace users, depending on the phase of flight (airborne vs. ground) and the level of predictability (strategic vs. tactical). Further work is needed to assess the impact of efficiency and predictability on airspace users.
- A more comprehensive comparison of service performance would also need to address Safety, Capacity and other performance affecting factors such as weather and governance.

Mapping ATO Framework to DFS

ATO Dash Board



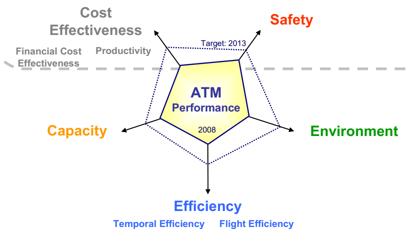
ATO Strategic Pathways

- Enhance **Financial** Discipline
- Achieve **Operational** Excellence
- Increase **Capacity** Where Needed
- Ensure Viable **Future**
- **Employees**

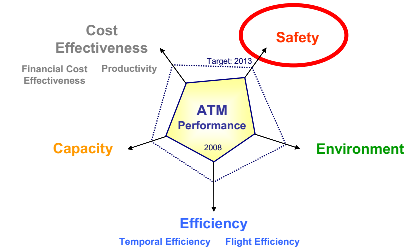
Cost Effectiveness | **Safety** | **Efficiency** | **Environment** | **Capacity** | **Employees & Development**

ATM Performance Framework

Balanced Scorecard



KPA: Safety



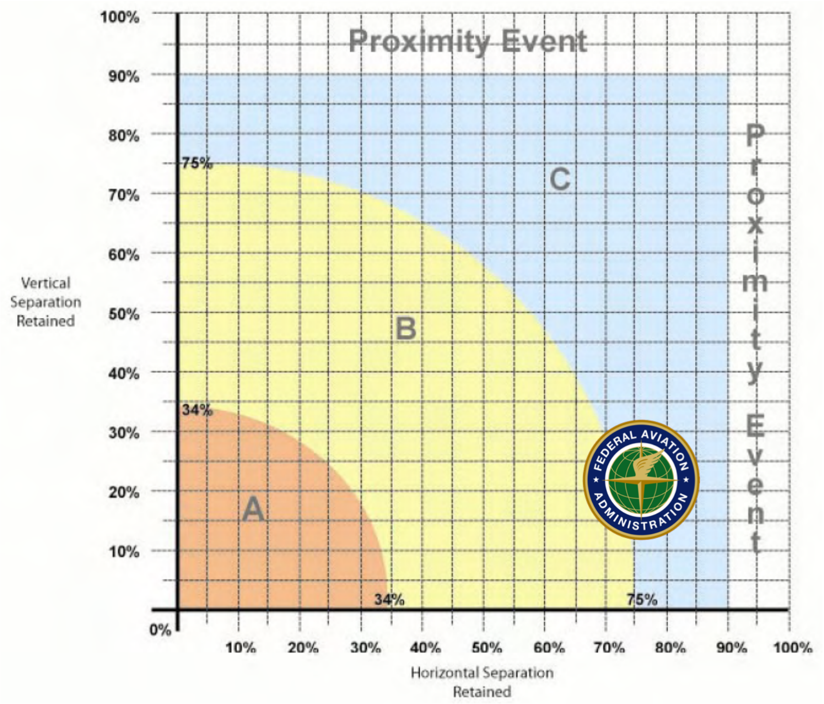
- **FAA/ATO**

KPI	Category A or B OE's per 1,000,000 operations

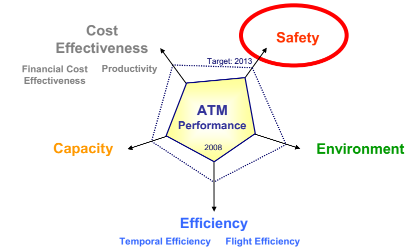
– Based on % of vertical and lateral separation distance lost

– Measured automatically

– Target (2008):
< 2.15 Category A or B OE's
per 1,000,000 Ops



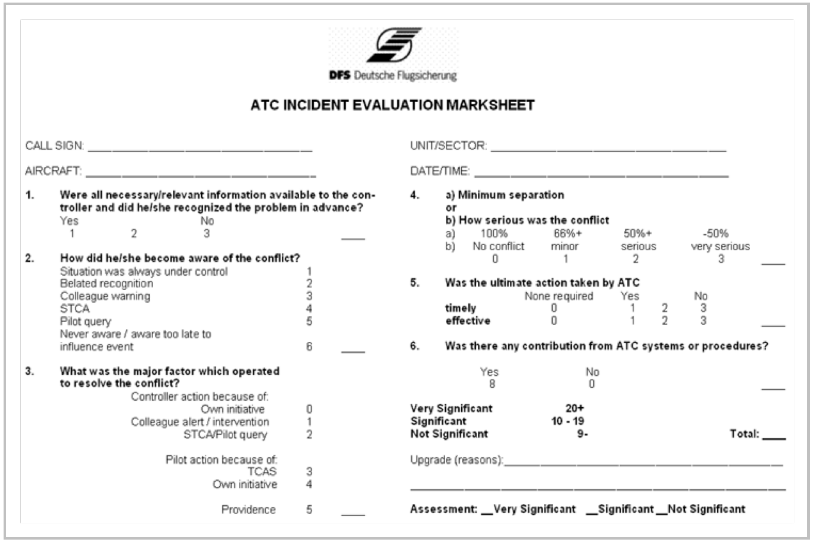
KPA: Safety



- **DFS (BU CC)**

KPI	Number of significant and very significant separation minima infringements per 100,000 flights

  - Based on scoring system taking into account subjective and quantitative inputs
  - Reported by ATCOs
  - Target (2008): < 2.28 significant and very significant separation minima infringements per 100,000 flights



DFS Deutsche Flugsicherung

ATC INCIDENT EVALUATION MARKSHEET

CALL SIGN: ____________ UNIT/SECTOR: ____________

AIRCRAFT: ____________ DATE/TIME: ____________

1. Were all necessary/relevant information available to the controller and did he/she recognized the problem in advance?
   Yes 1 2 No 3 ___

2. How did he/she become aware of the conflict?
   Situation was always under control 1
   Belated recognition 2
   Colleague warning 3
   STCA 4
   Pilot query 5
   Never aware / aware too late to influence event 6 ___

3. What was the major factor which operated to resolve the conflict?
   Controller action because of:
   Own initiative 0
   Colleague alert / intervention 1
   STCA/Pilot query 2
   Pilot action because of:
   TCAS 3
   Own initiative 4
   Providence 5 ___

4. a) Minimum separation
   or
   b) How serious was the conflict
   a) 100% 66%+ 50%+ -50%
   b) No conflict minor serious very serious
   0 1 2 3 ___

5. Was the ultimate action taken by ATC
   None required Yes No
   timely 0 1 2 3
   effective 0 1 2 3 ___

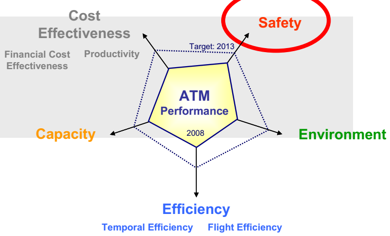
6. Was there any contribution from ATC systems or procedures?
   Yes 8 No 0 ___

Very Significant 20+
Significant 10 - 19
Not Significant 9-
Total: ___

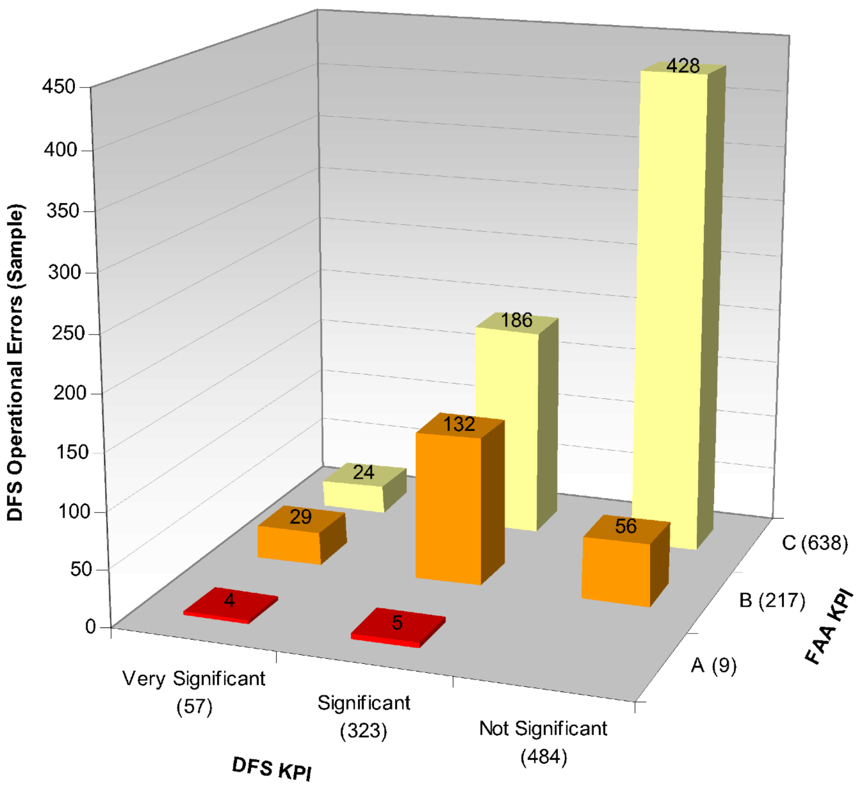
Upgrade (reasons): ____________

Assessment: __Very Significant __Significant __Not Significant

KPA: Safety



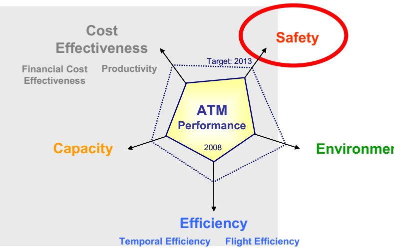
- **Comparison**
  - Both DFS and ATO use Operational Error rates as primary measure
  - FAA/ATO and DFS Categorization of Operational Errors is Significantly Different
  - Categorization has an impact on findings derived from measures



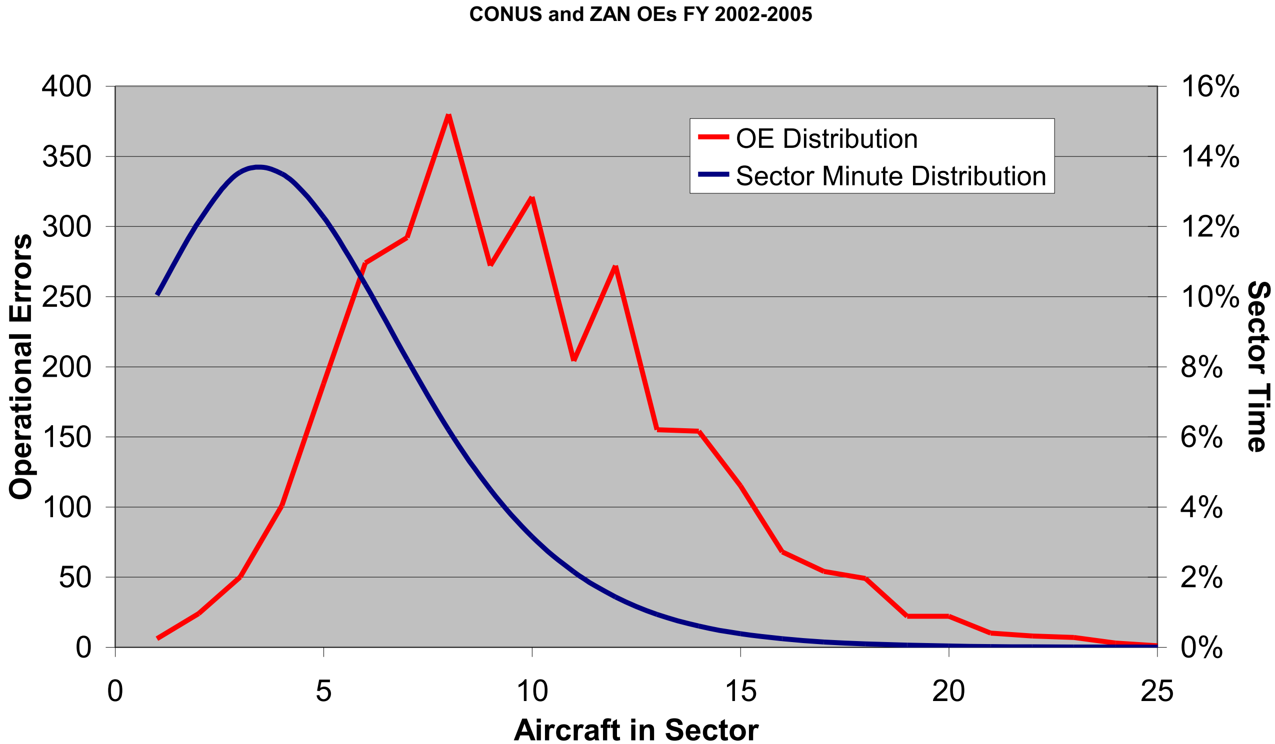
Severity of Errors
DFS Data using FAA and DFS Methodology

Backup Slides

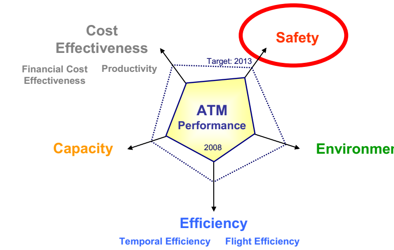
FAA/ATO
Operational Errors and Sector Traffic



OE data from ATO-A
OEs are all OEs, not just category A&B
Sector time is sum of total minutes sectors are controlling aircraft, normalized to 1
Sector time computed from Host Aircraft Management Execs (HAME) data
All data FY02-FY05



⇨ **Operational Errors happen most often when controllers are handling 8-10 aircraft …**



FAA/ATO
Operational Errors and Sector Traffic

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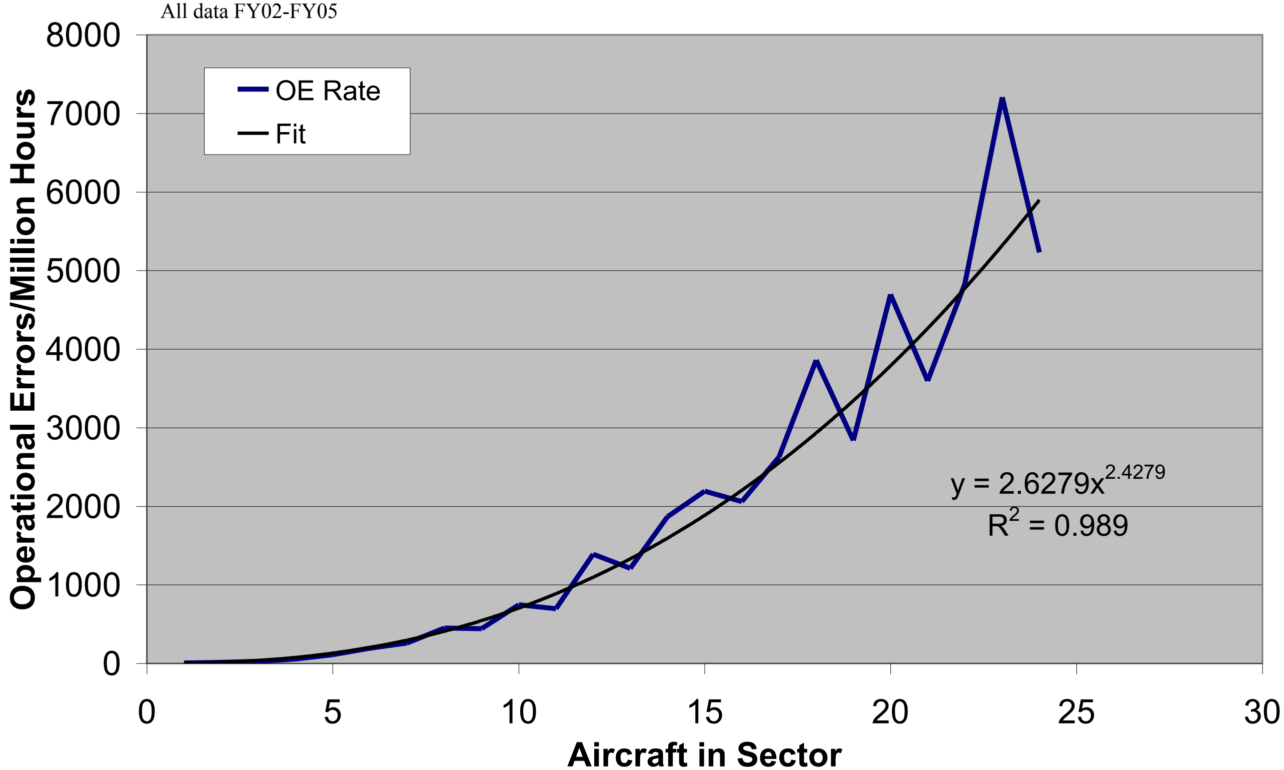
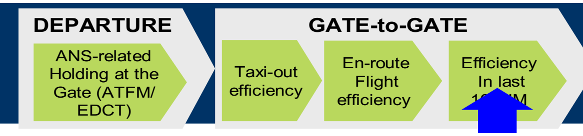
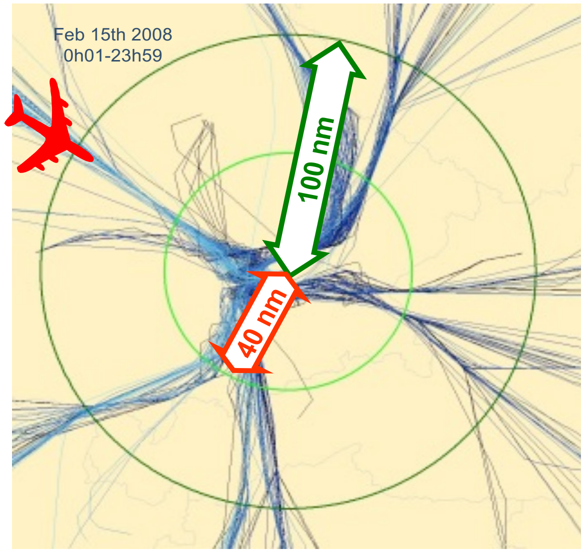
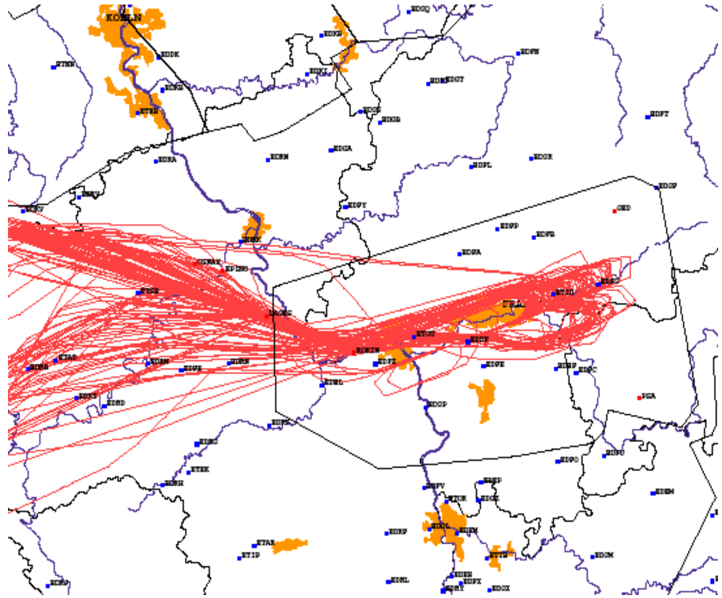


⇨ **… but Operational error rate increases with traffic after correction for sector traffic frequency (> than square of traffic)**

Efficiency: Excess time in the last 100NM



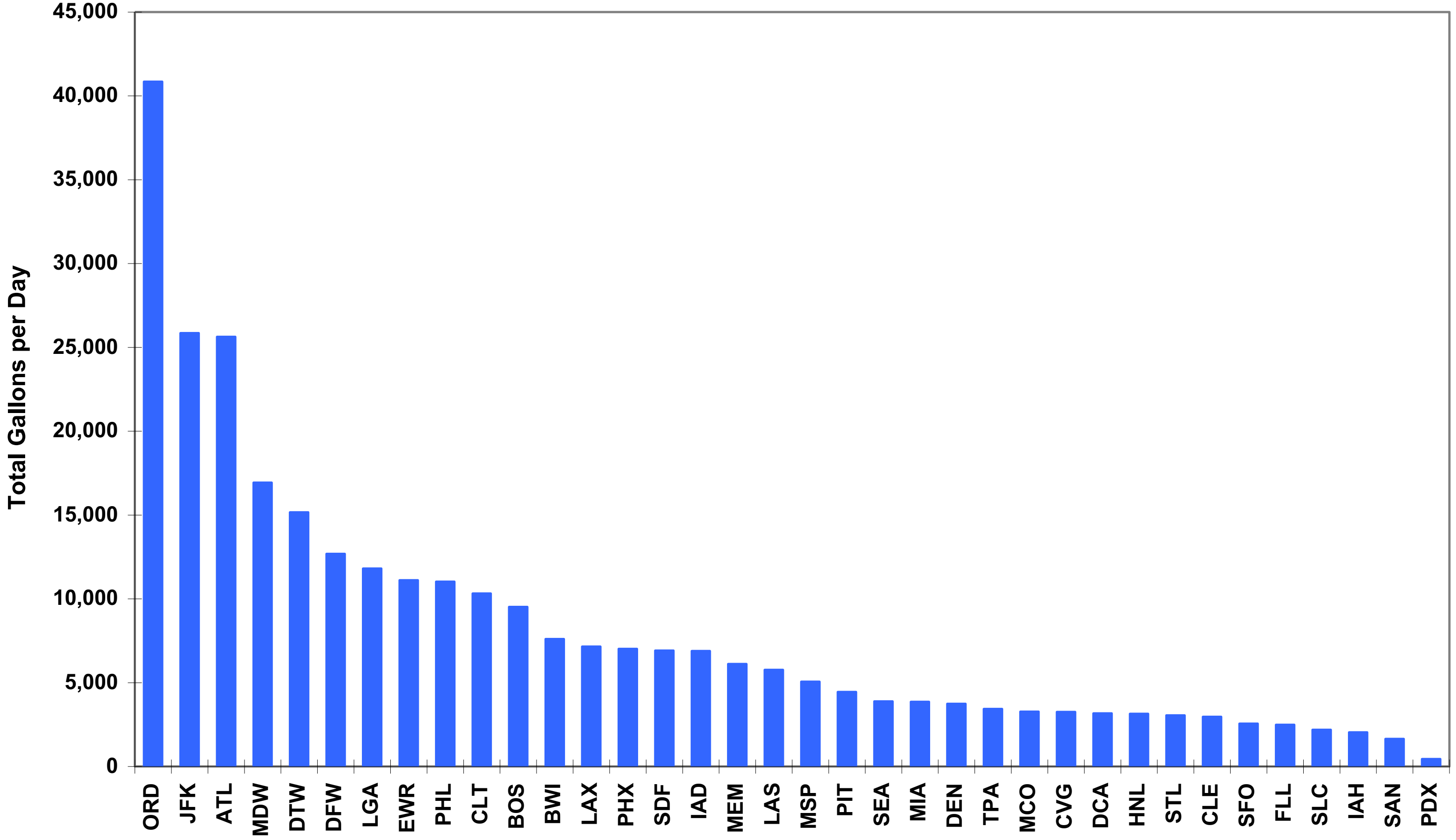




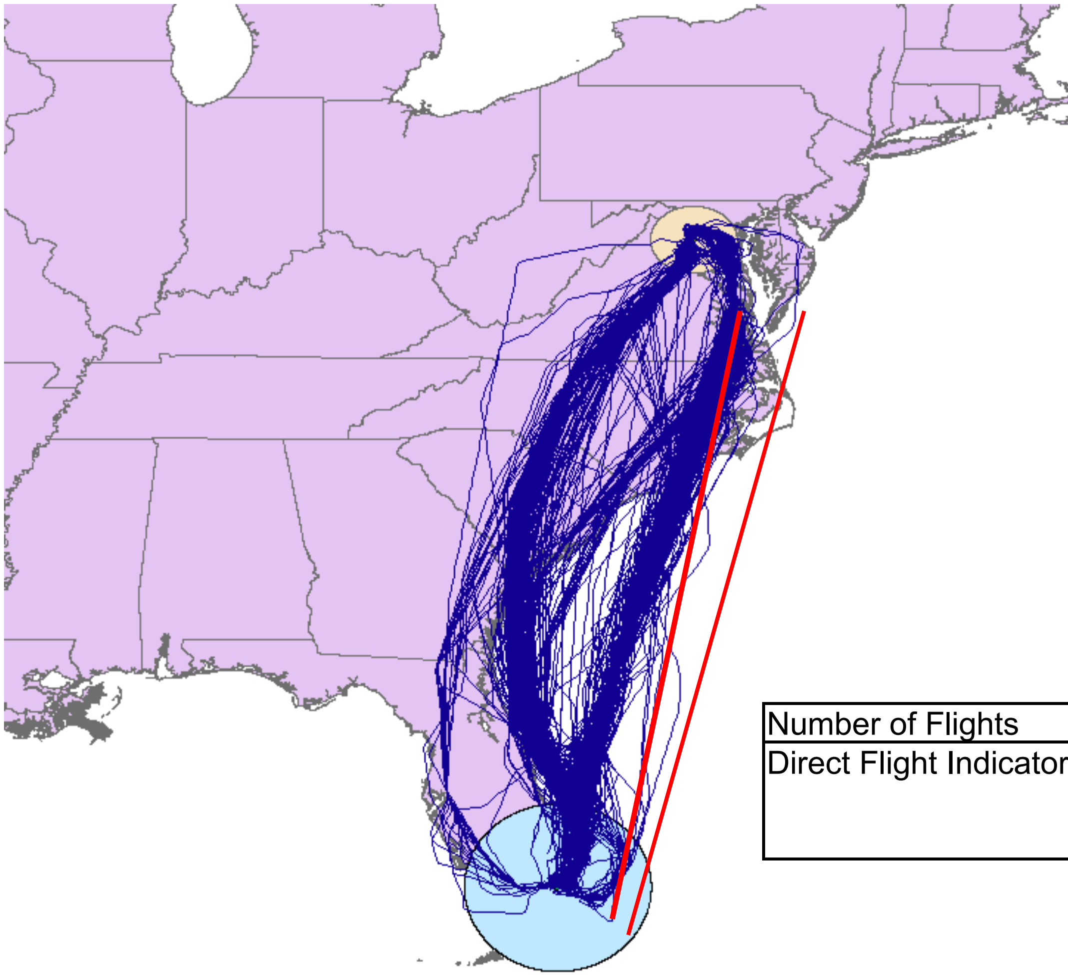
- At Frankfurt as much as an extra 15 minutes can be absorbed inside the Terminal Airspace
- Long Final alternative to holding stacks like in Heathrow

- Capture tactical arrival control measures (sequencing, flow integration, speed control, spacing, stretching, etc.), irrespective of local strategies.
- Standard “Arrival Sequencing and Metering Area” (ASMA) is defined as two consecutive rings with a radius of 40NM and 100NM around each airport.
- In Europe delay absorption at departure airport or around the arrival airport while in the US sequencing can span back to the departure airports (MIT)

Potential Fuel Savings from CDAs



IAD to FLL



Number of Flights		1488
Direct Flight Indicator	Total (A-G)	41.9
	Direct Between TMA (A-D)	20.3
	TMA Interface (G-D)	21.5