FAA-NEXTOR

NAS/ATM Performance Indexes

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Acknowledgments

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Project Objectives

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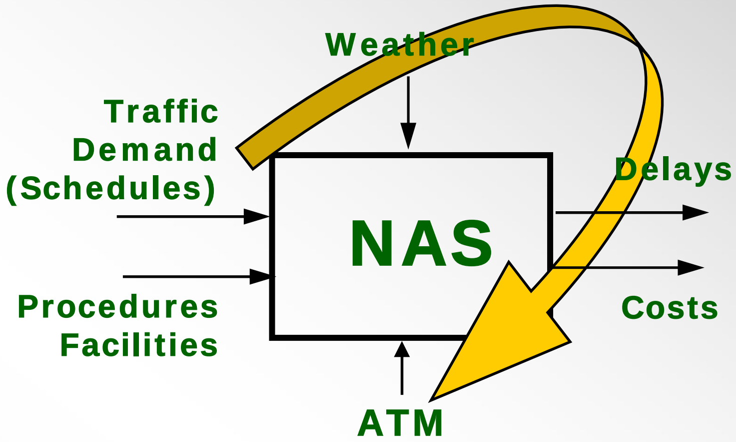
Develop a framework for assessing NAS/ATM performance on a recurring / daily basis

- Come up with a simple yet informative index of weather-related ATM performance on a given day ("one number")
- Produce charts for each season
- Compare different seasons: "Did we do better this year than last year?"



Account for major external factors:

- Weather
- Traffic Demand

Enhance existing methods for NAS performance analysis

- Refine computation of the effects of both en-route and terminal weather
- Consider additional metrics alongside Delay

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Operational Response Index (ORI), 2004

Components, Excluding Highest-Cost Days

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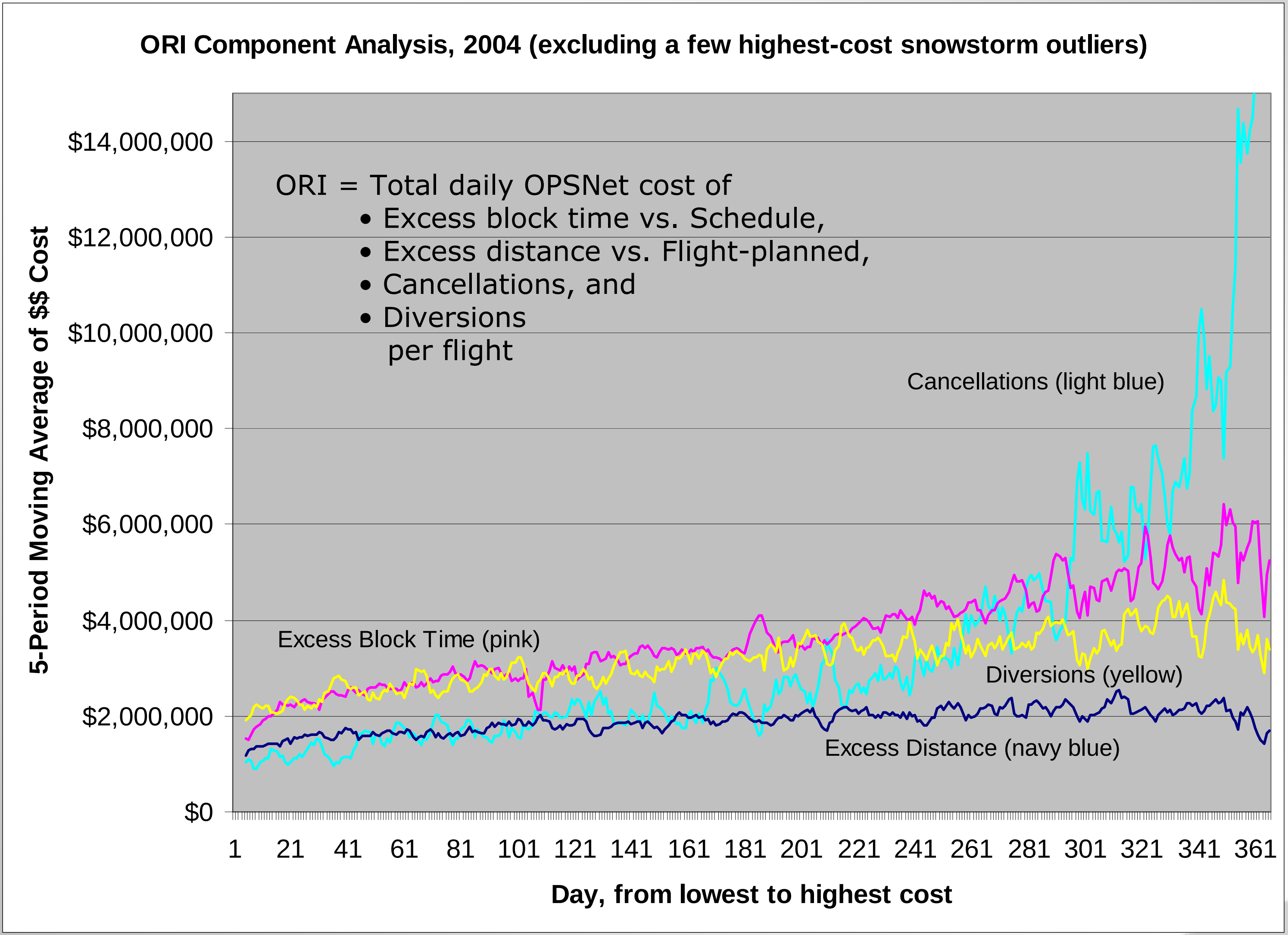

ORI:

Direct airline operating costs per flight for an "averaged" narrowbody fleet

All OPSNet flights daily

A cost-*derived* metric

Computation details here

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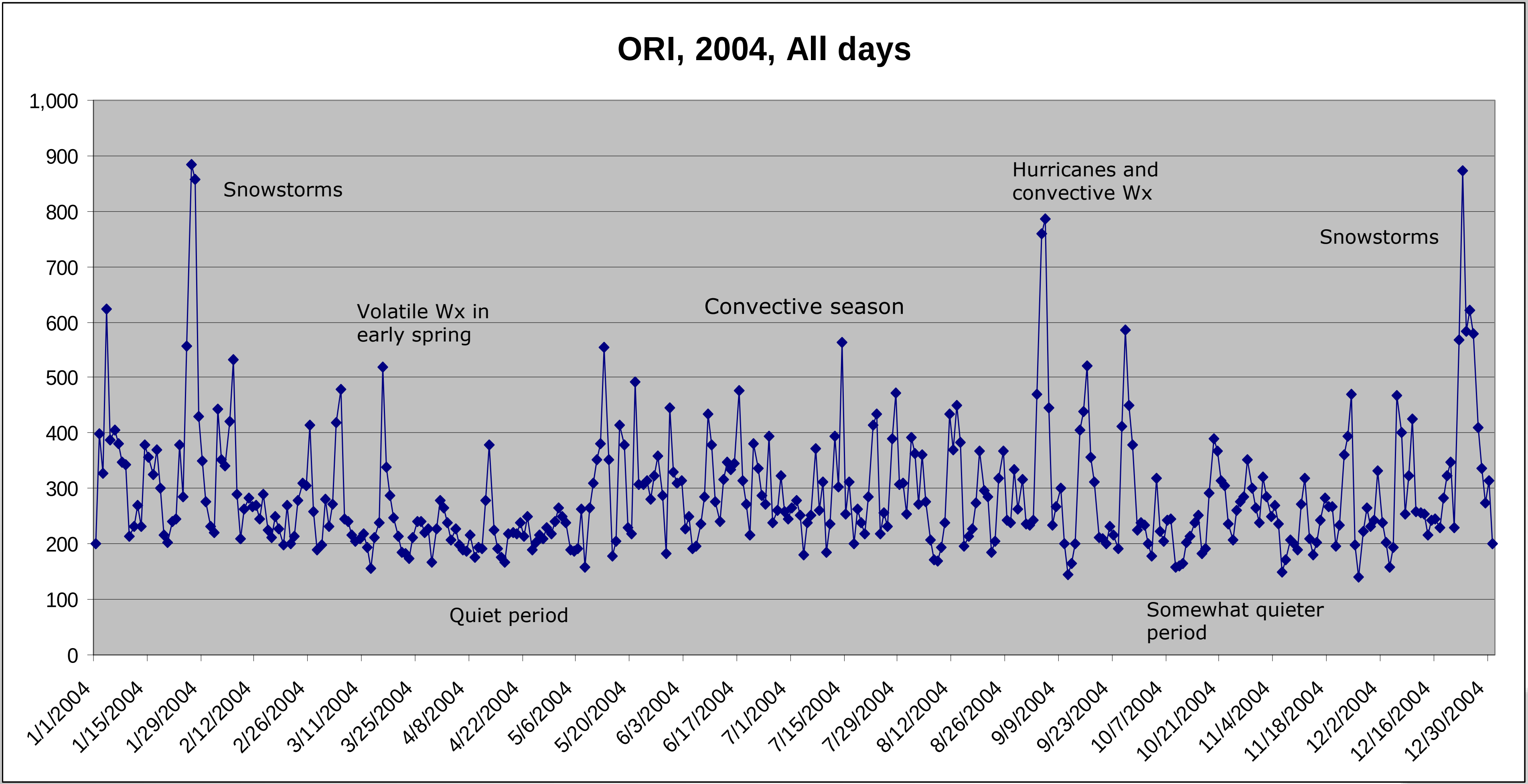
ORI for 366 Days

01/01 – 12/31/2004, sorted by Date



Weather-Impacted Traffic Index (WITI)

Combined En-Route and Terminal Wx

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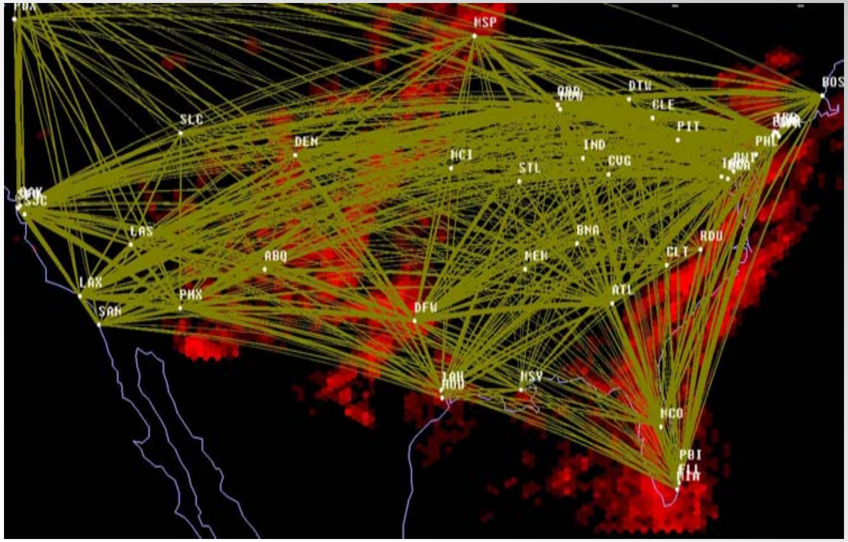

En-Route WITI:

- Find intersections of each flow (GC track) with hex cells where convective Wx was reported
- Multiply by each hex cell's total NCWD count (reflects Wx duration) and by # of daily flights on this flow
- Add up all flows: *En-Route WITI*

Terminal WITI:

- Hourly surface Wx observations at major airports
- Capacity degradation % for each Wx type * hourly movement rate
- Add up all airports: *Terminal WITI*

Combined WITI (CWITI):

- Weighted sum of En-route and Terminal WITI
- Reflects "front-end" impact of Wx on intended flights

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Combined WITI and NAS Performance Metrics

Example: ORI & Delays, June-Oct 2004 Including Outliers

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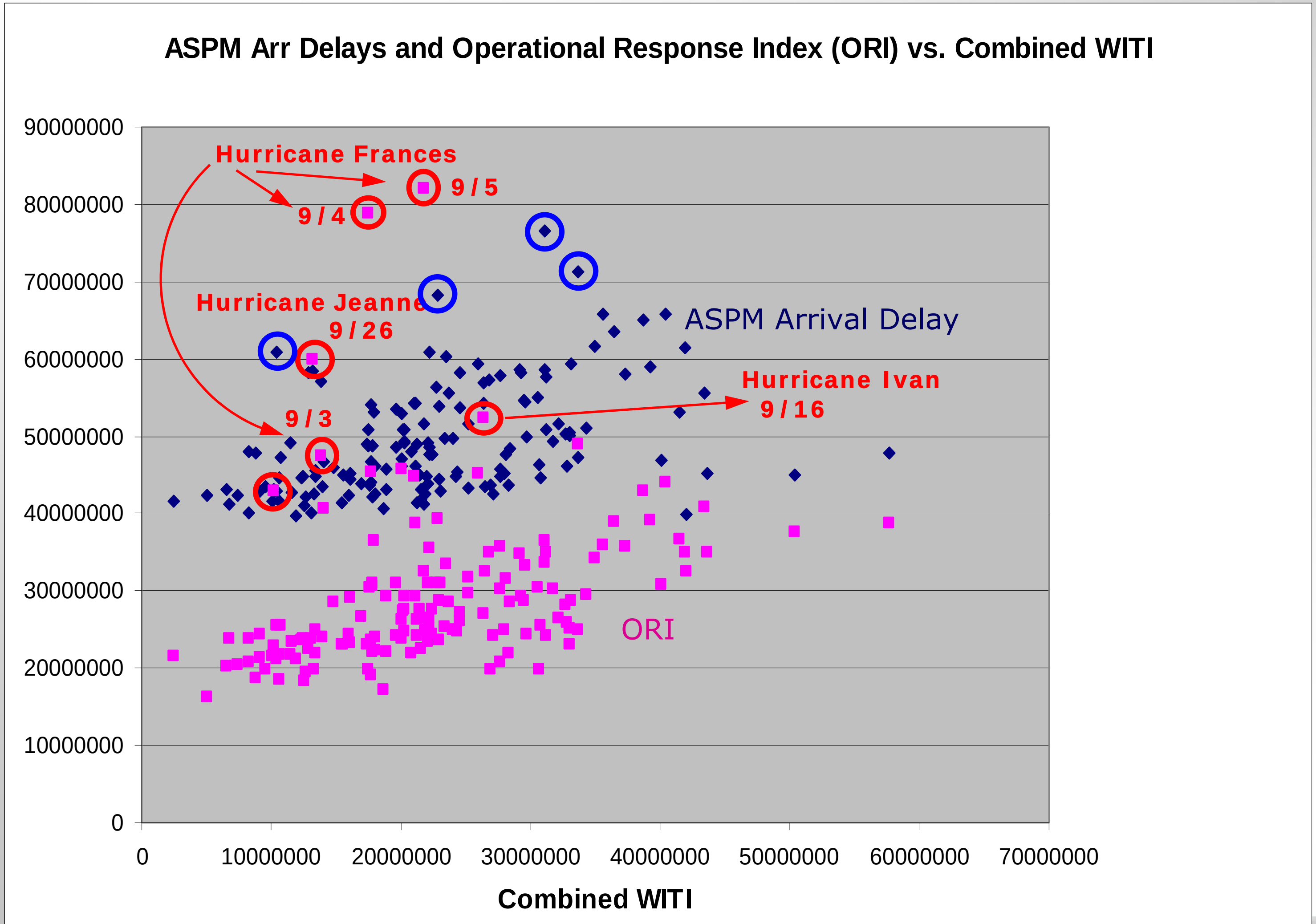

Even in ideal weather, there are significant "residual" delays and costs

ORI and Delays vs. Combined WITI

Example 1: Convective Weather

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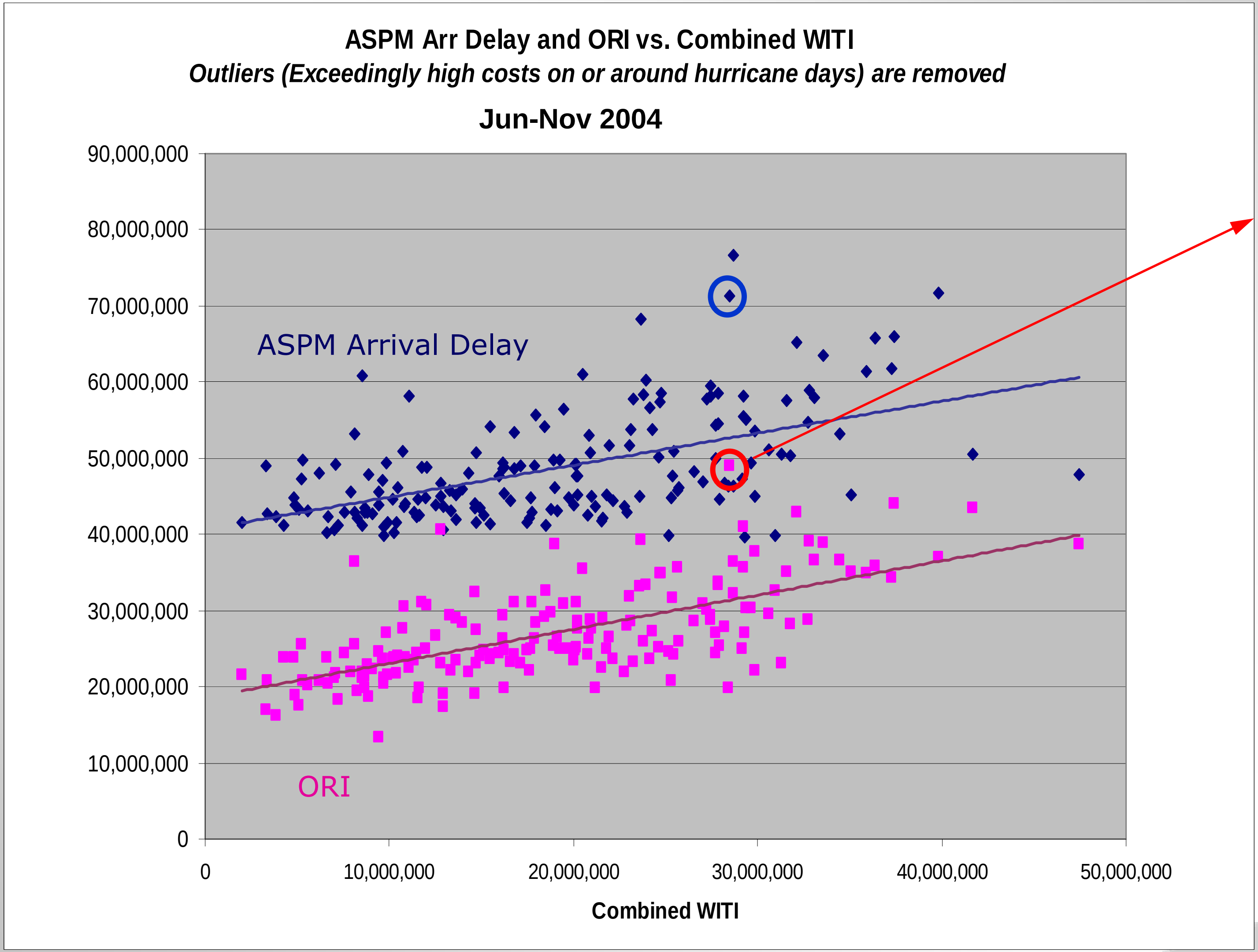

July 14, 2004

Very high ORI ($485/flight)

Very high delays

Medium-high WITI

Checking…

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Zooming In on July 14, 2004…

ORI, En-Route and Terminal WITI

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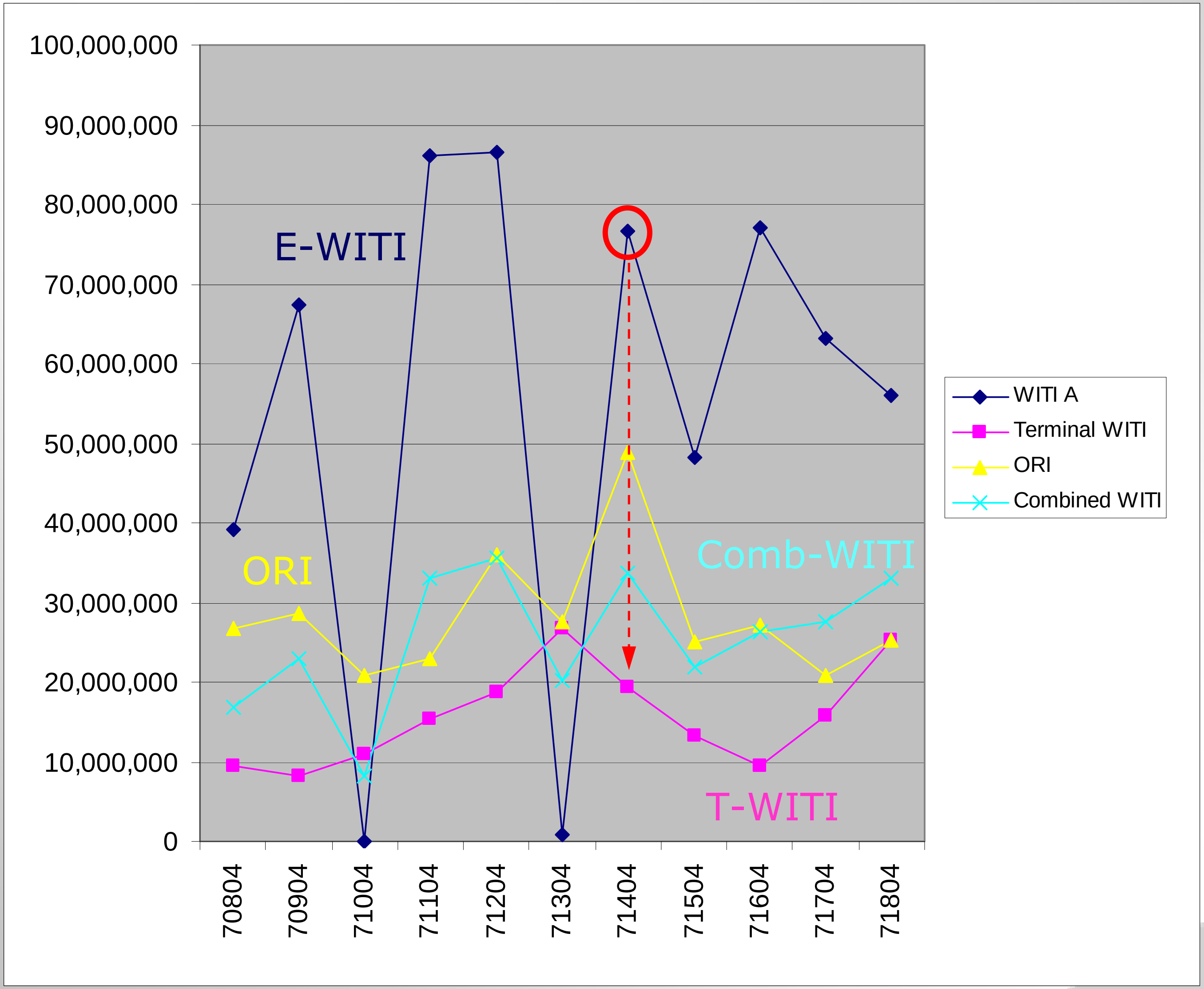

En-route WITI is high (July…)

Terminal WITI is low

Combined WITI is medium-high

Very high % of cancellations: 3x the usual

High "operational response cost" (ORI) was caused by en-route thunderstorms leading to delays and cancellations

NAS performance was *worse* than usual on this day

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ORI and Delays vs. Combined WITI

Example 2: Non-Convective Weather

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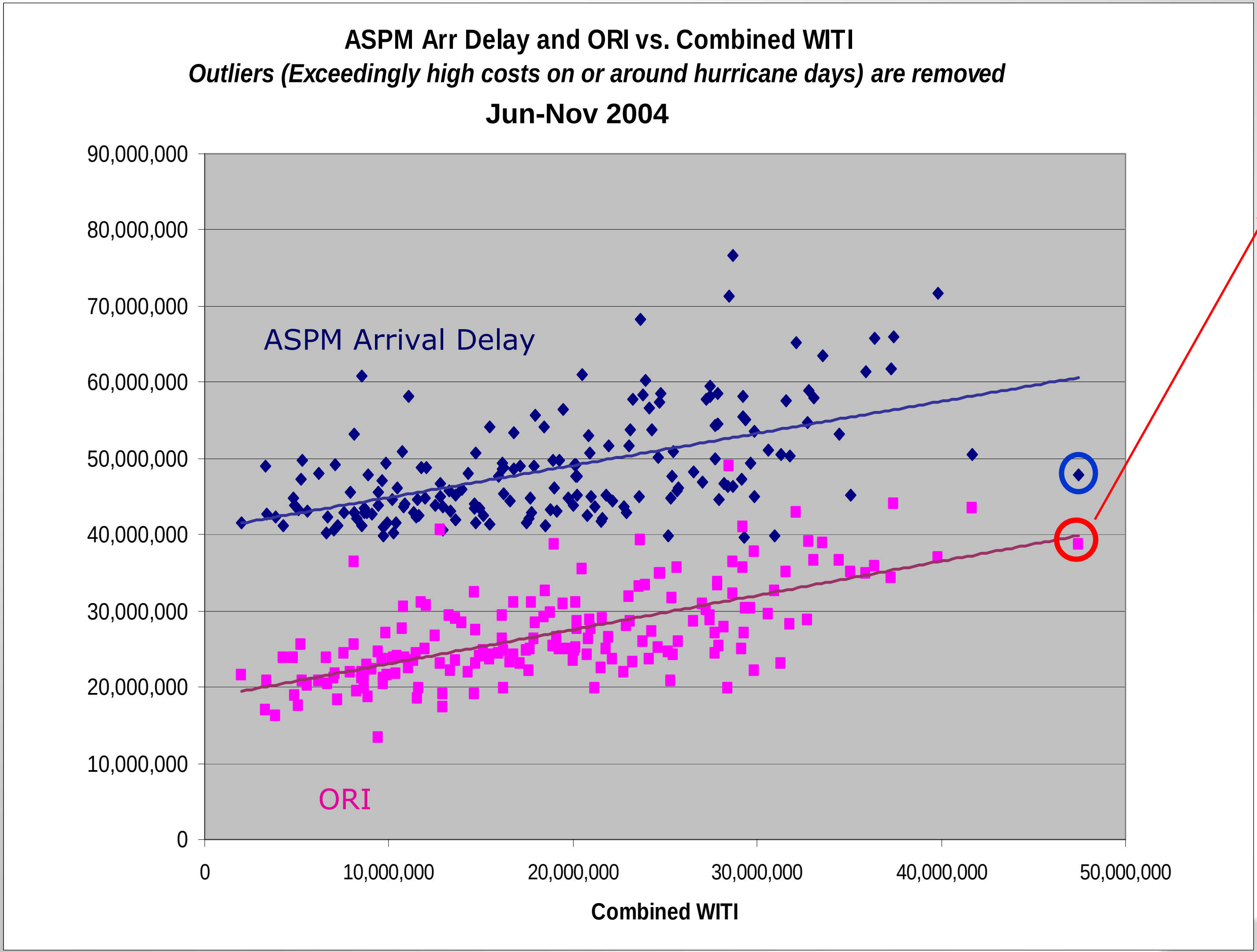

October 20, 2004

ORI is high but in line with average trend

Relatively low delays

Very high WITI

Checking…

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Zooming In on October 20, 2004…

ORI, En-Route and Terminal WITI

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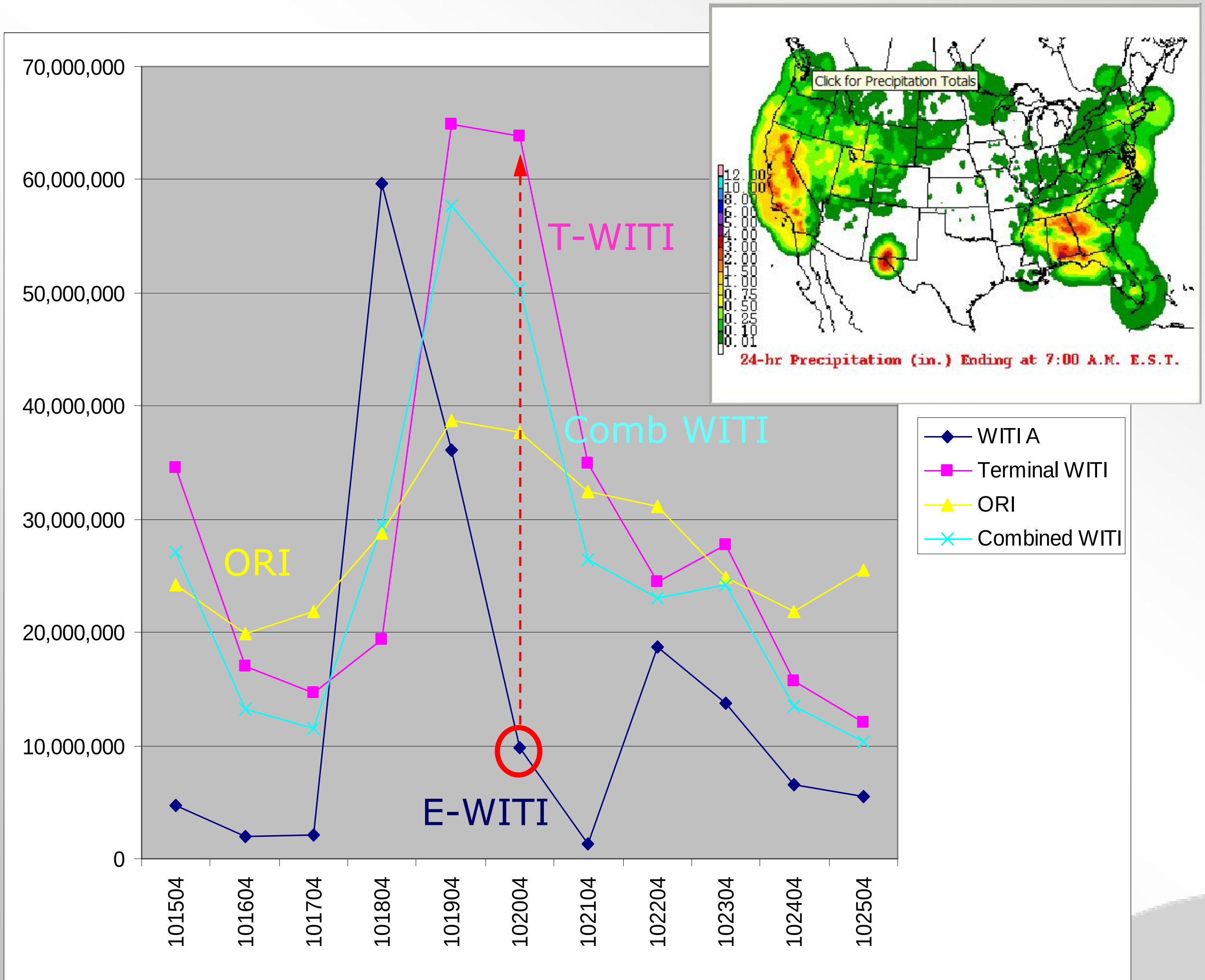

En-route WITI is low (late October)

But Terminal WITI is very high (rain, low ceilings etc)

So the Combined WITI is high

That is, high ORI ($/flight) and delays were caused mostly by terminal Wx

NAS performance was actually *good* for this "IMC day"

(Better in terms of delays than costs)

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ORI and Delays vs. Combined WITI

Example 3: Two Metrics Yield Different Results

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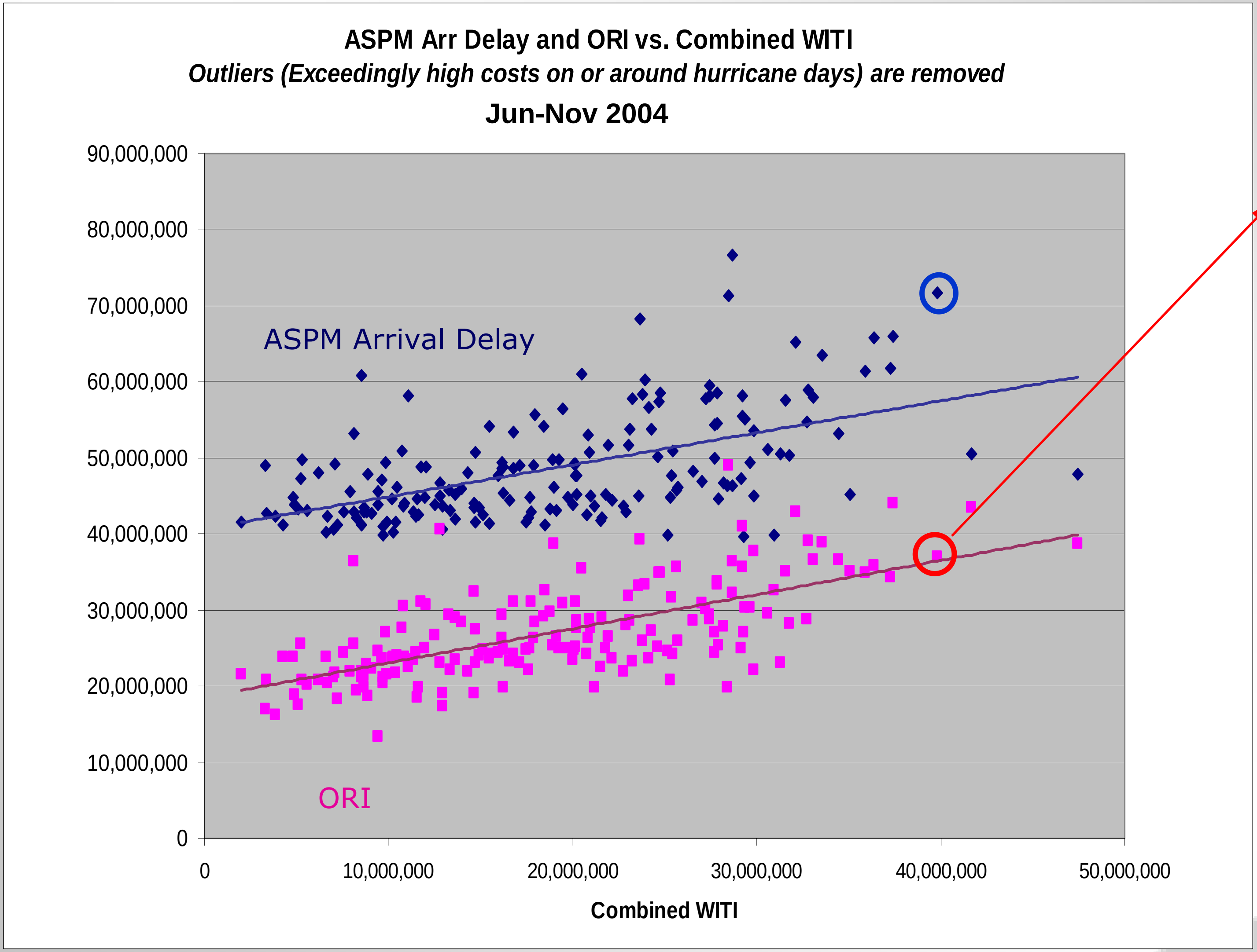

November 23, 2004

High CWITI

High delays but just average ORI

NAS performance could be judged as "poor" if only delays were considered

But considering costs (ORI), it was about average given the weather and the demand

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Comparing Delays for 2004 and 2005

May-September

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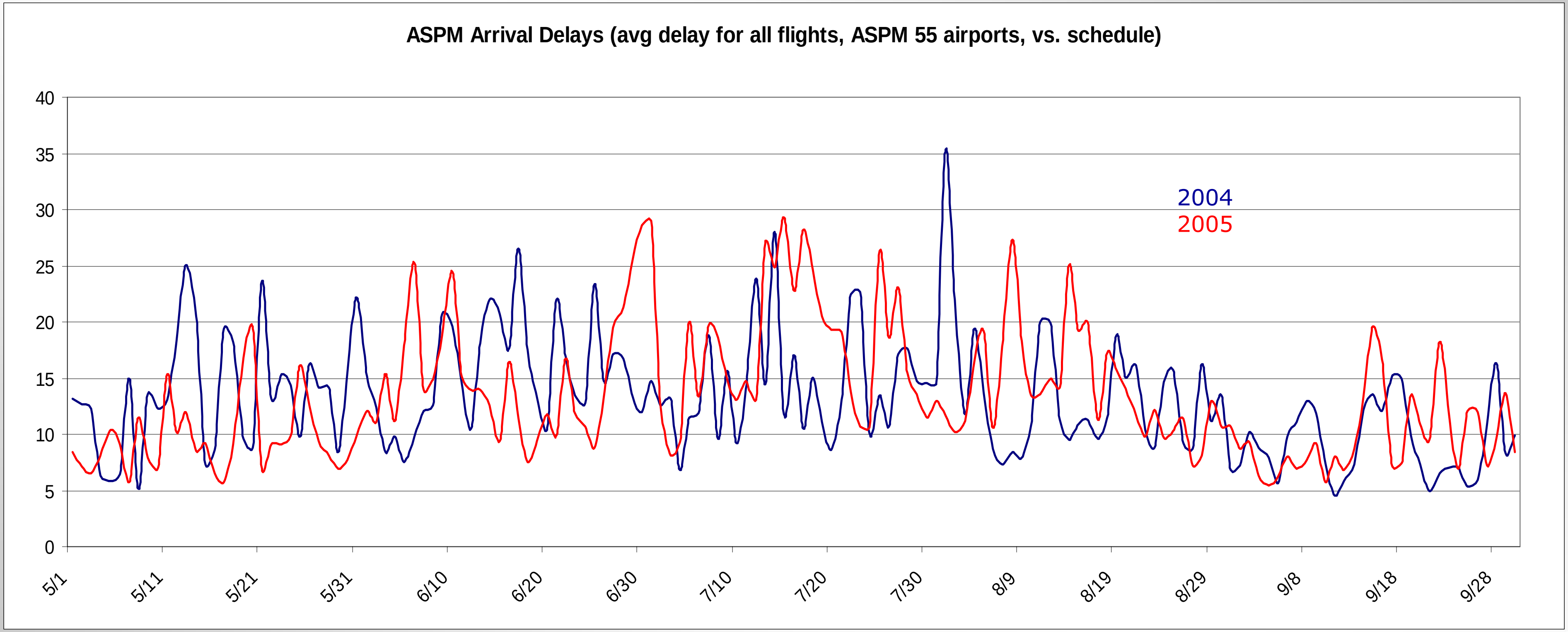
2005 delays were on average about the same as in 2004 (1% diff.)



But, weather (CWITI) was on average *better* in May-Sep 2005

(If 2004 average = 100, then 2005 average = 83)

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Normalized Delay-to-Wx Ratio Comparison

Delay-Based NAS/ATM Performance Index, '05 vs.'04

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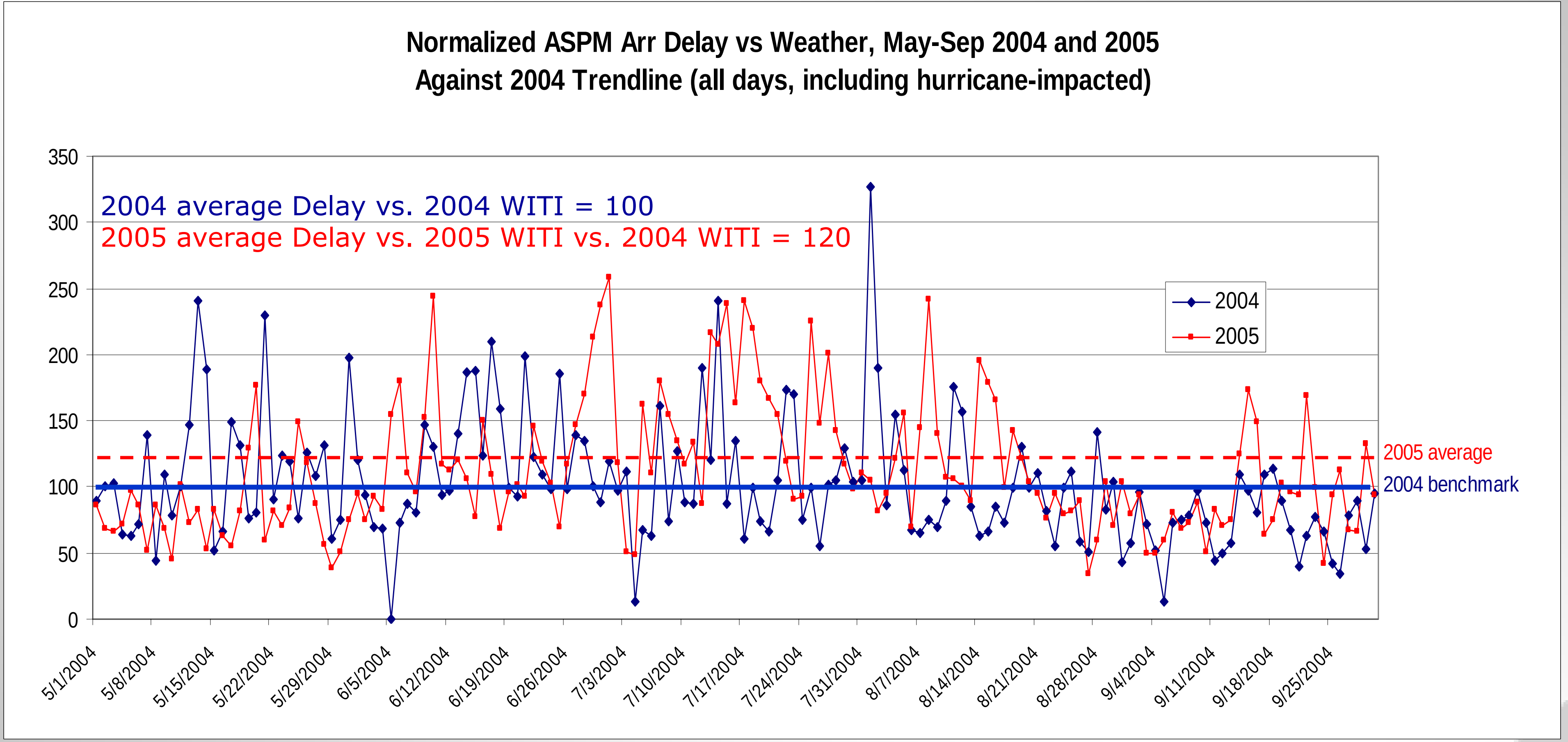

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Delays and Traffic Demand

Taking Exponential Delay-vs.-Demand Factor into Account

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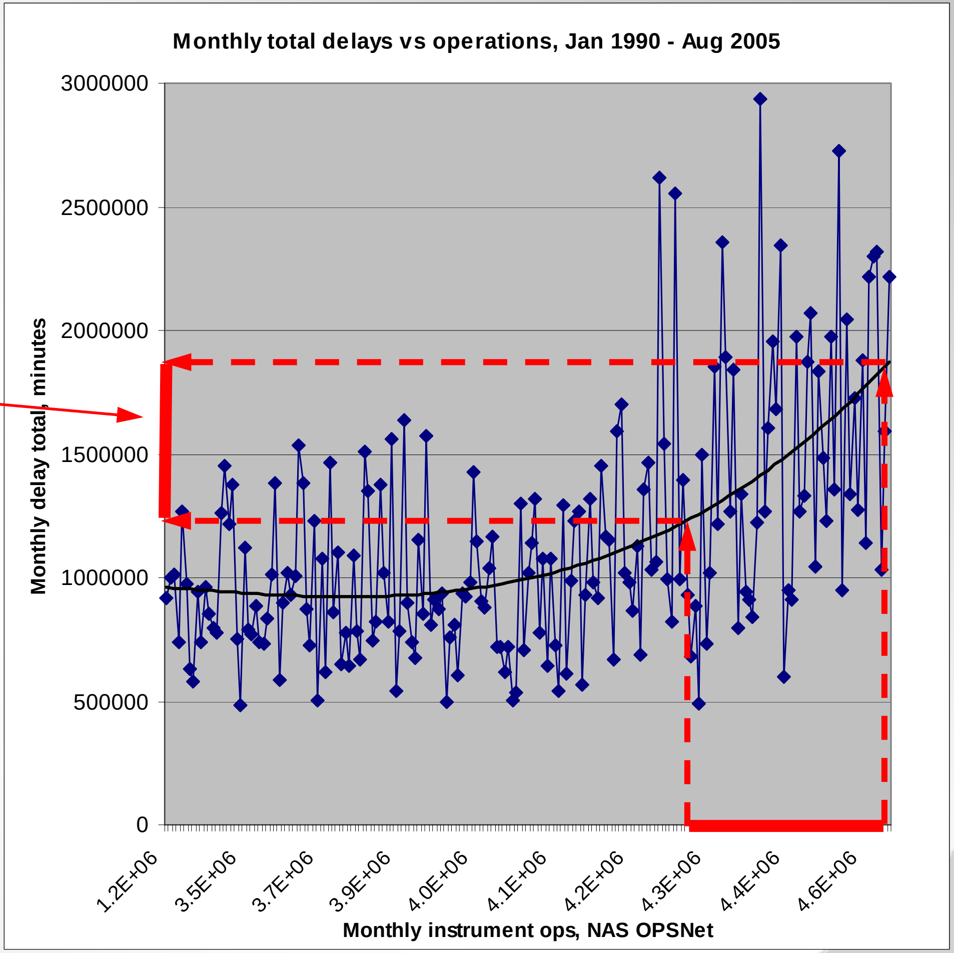
- Looking at 1990-2005 historical monthly averages…
- 2005: a 10% traffic increase
- <u>10%</u> increase in traffic (from 4.3M to 4.7M ops) can lead to a <u>45%</u> increase in delays (from 1.25M to 1.8M minutes)
- **This factor ought to be taken into account when we talk about NAS / ATM performance**
- The trend <u>doesn't</u> depend on weather
- Adjusted chart is shown on next slide



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ATM Performance Index, 2005 vs. 2004
Adjusted by Exponential Delay-vs-Demand Factor

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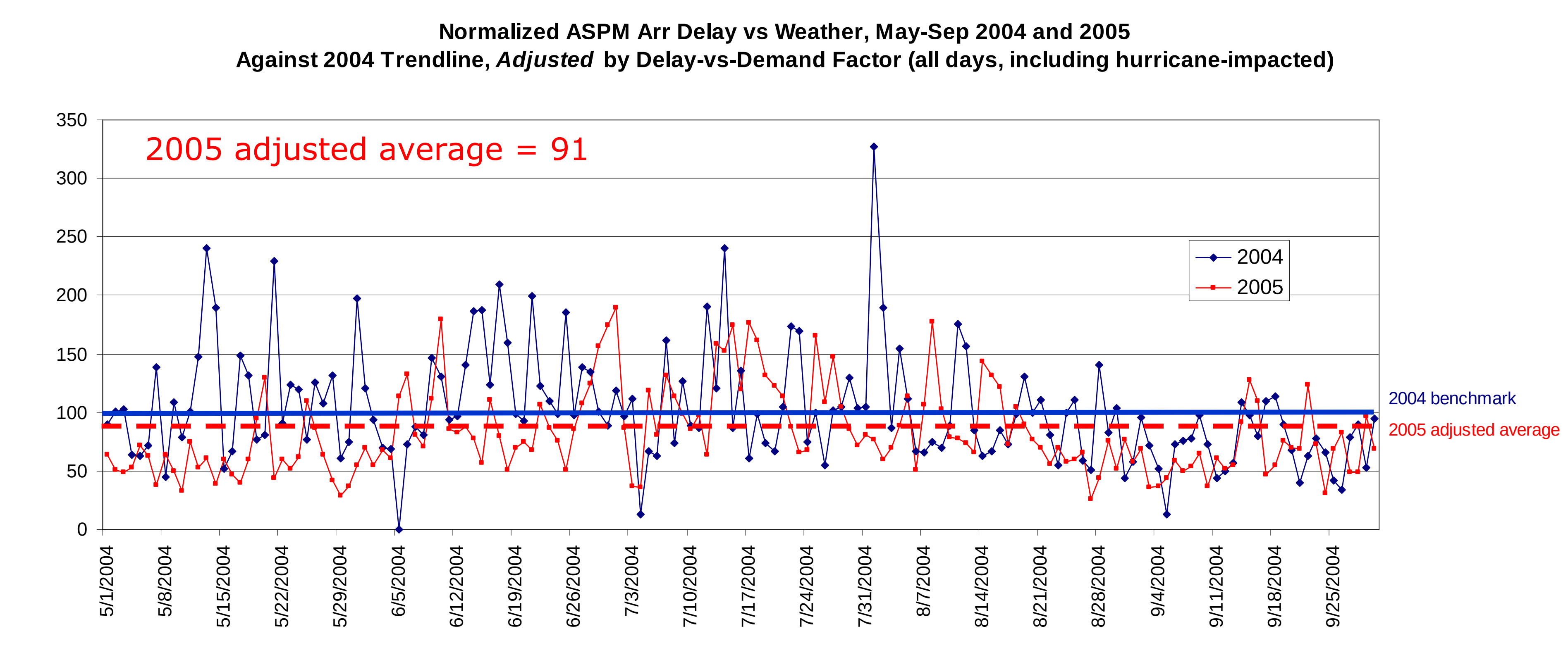
2004 benchmark = 100
2005 average *adjusted for Weather only* = 120

Adjustment factor: divide by 145% (exponential delay increase rate), multiply by 110% (traffic increase rate; need to pro-rate 2005 back to 2004)

2005 *adjusted-for-Weather-and-Demand* average = 120 / (1.45 / 1.1) = 91



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Discussion
Delays

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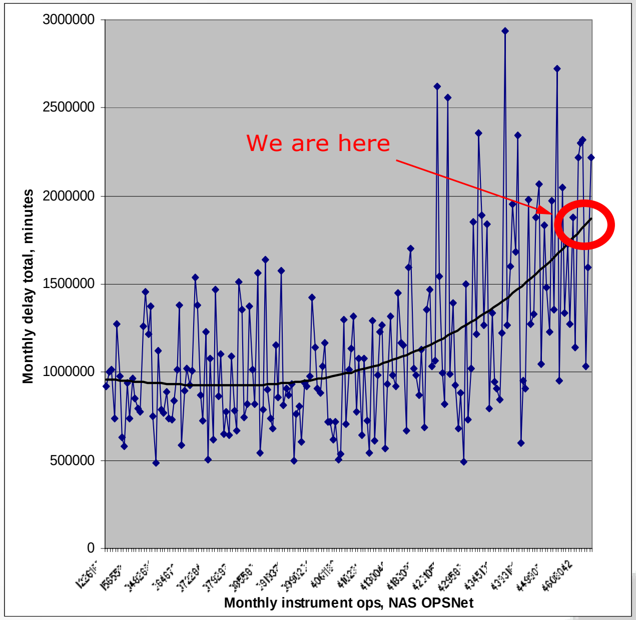
Did the NAS/ATM do 9% better in 2005 than in 2004?

- NAS delays were similar; delays vs. weather were worse in 2005…
- But, relative to weather *and* traffic demand, the ATM component of the NAS *did* do better in 2005 than in 2004
- D-RVSM and other measures may have helped

Even so,

- We are on the ascending slope of the exponential delay curve
- Peak delays in bad weather (July 2005) were highest ever
- Delay *variance* is significant
- The exact proportion (45% delay increase due to 10% traffic demand growth) needs to be fine tuned



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ORI: Cost-to-Wx Ratio

*The Ruler for ORI (100) is an **Averaged** Day*

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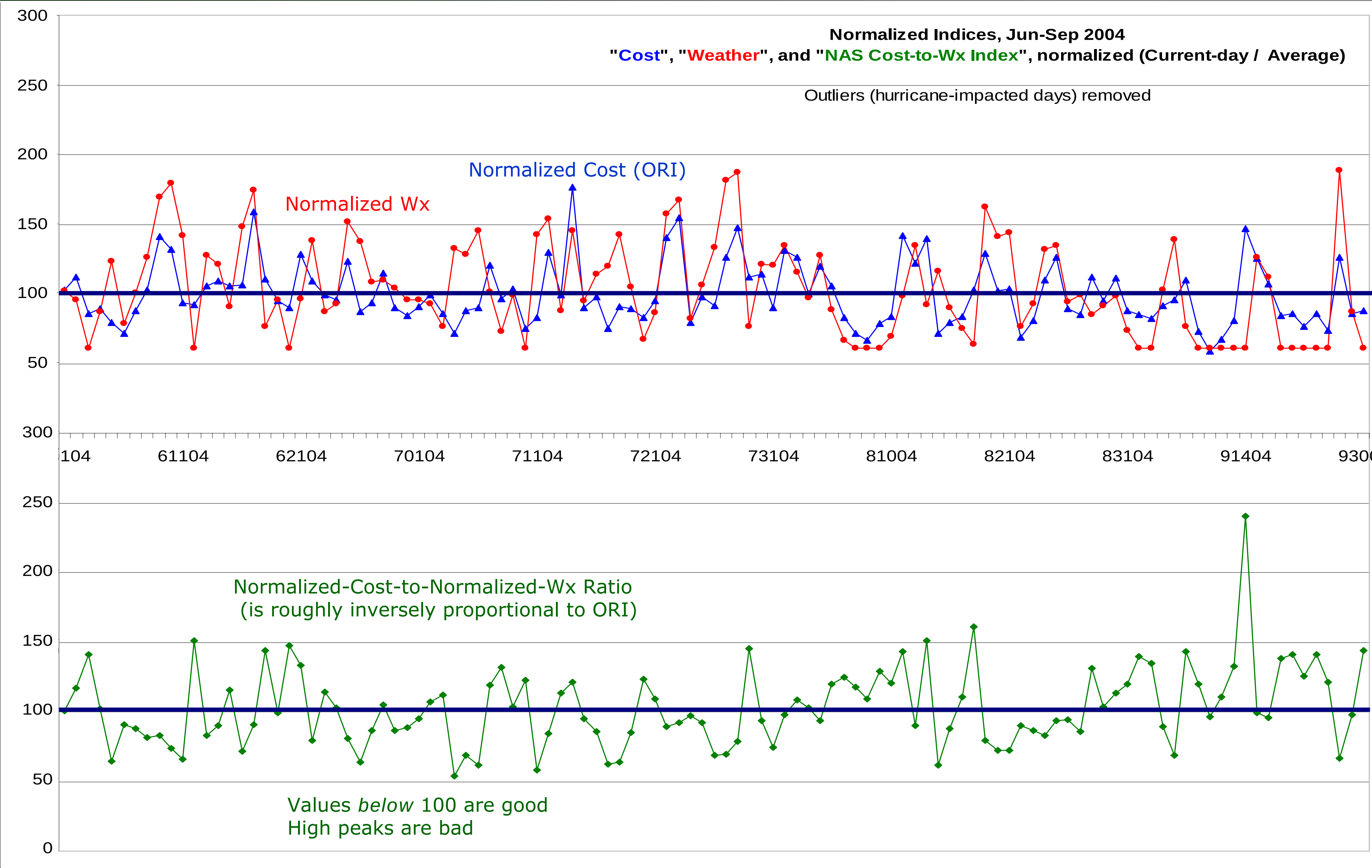

Conclusions

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Delay, cost (ORI) and weather (WITI) metrics computed for 2004 and 2005

- Delay metric can be normalized vs. seasonal-average (e.g. 2004's)
- Normalized *cost* (ORI) is a useful additional metric

WITI calculation refined for both en-route and terminal parts

Delay/Cost metrics should account for traffic demand, not just weather, if used as NAS/ATM performance indicators

- 10-15% traffic demand increase can cause 45-60% increase in delays
- Slightly better NAS/ATM performance in 2005 if *both* weather *and* traffic demand are taken into account

These metrics can advance our understanding of NAS response to external impacts ⇨

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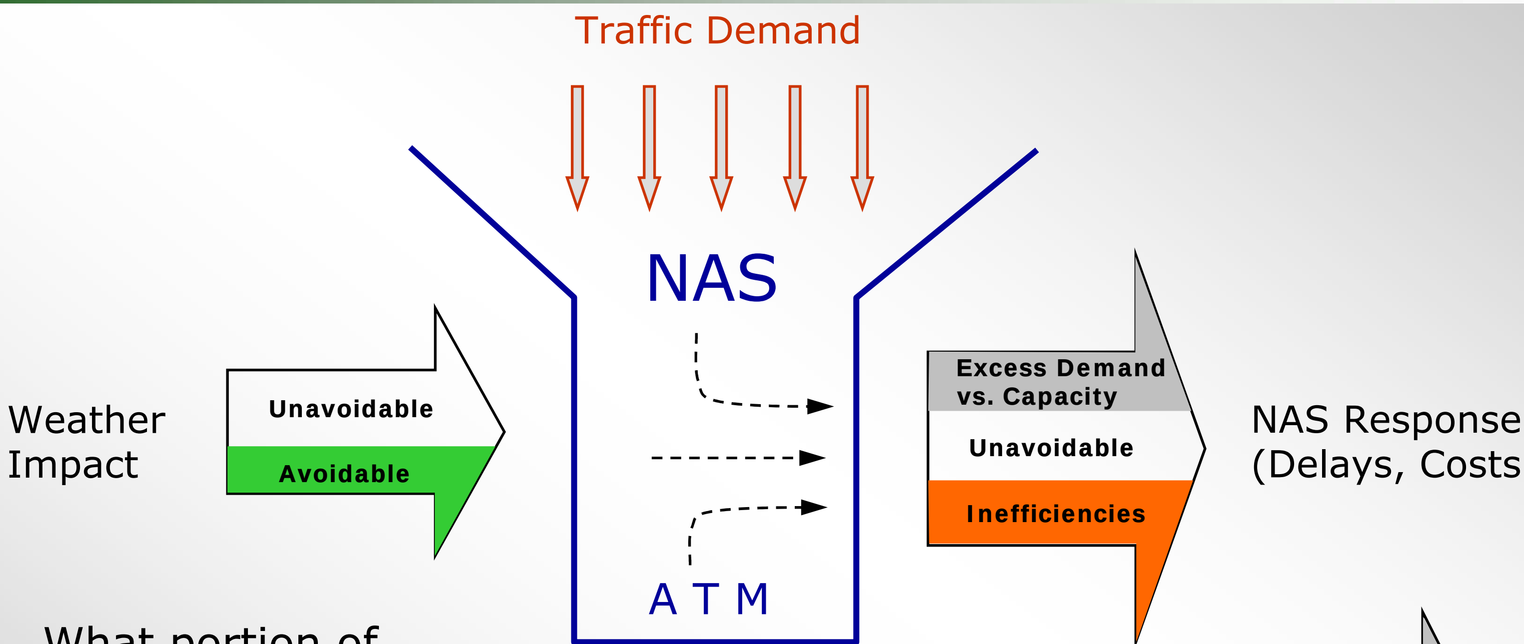
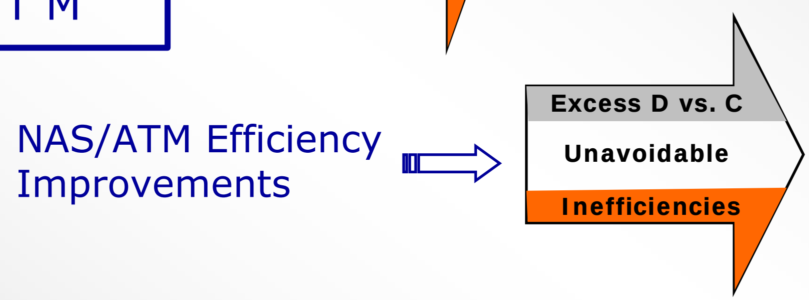
NAS Response to External Impacts





1) What portion of delays/costs is due to system inefficiencies as opposed to unavoidable weather and traffic demand outside ATM's control?

2) Can we quantify positive impact of NAS/ATM efficiency improvements?

Back-up Slides

Operational Response Index (ORI)
Components

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Using *direct* carrier costs only

- Passenger impact (value of pax time, 'ill will', re-issuing tickets etc) *excluded*

Flights per day: OPSNet daily totals (varies between 37,000 and 50,000)

- Simplifying assumption: all aircraft are *narrowbodies*

Cost of 1 Minute of Delay

- Used $22/min (based on total non-fuel operating costs averaged for a narrowbody jet)

Cost of 1 Extra Mile Flown (expressed in $/min)

- Equivalent to $18/min (based on 2004 fuel cost average for a narrowbody in cruise at $1.25 / gallon)

Cost of a [Narrowbody] Cancellation

- US carrier-reported average cost was $4,500 in '94 which equates to $6,000 per cancellation in 2004

Cost of a [Narrowbody] Diversion

- Assuming 4 hrs extra block time and a $2,500 hourly operating cost for a narrowbody, we get $10,000 per diversion

Sources: OIG; BTS; MITRE CAASD; FAA APO; FAA OPSNet database

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Operational Response Index (ORI)

Calculation

ORI = (Num_fl * Avg Δ_{dist} * Avg_fuelburn * Fuel_cost +
Num_fl * Avg Δ_{time} * Avg_nonfuel_oper_cost
Num_diversions * Avg_cost_of_diversion +
Num_Cancellations * Avg_cost_of_cancellation) / Num_fl

where:

Δ_{dist} = average excess distance per flight (actual vs. flight-planned)

Δ_{time} = average excess block time per flight (actual vs. scheduled)

Avg_fuelburn = fuelburn for a generic narrowbody jet in cruise at FL330

Num_fl = daily number of OPSNet flights

Sources of data: FAA APO Lab; FAA ASPM

Operational Response Index – Reality Check

Comparison with $$ Quoted in Literature

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For OPSNet flights:

- Total "excess airline cost" for 2004 (all flights, all days) is $4.6B
- For a baseline "ideal" day (ORI = $150/flight):

  if *all* days in 2004 were like it, total cost would have been $2.7B

Difference = $1.9B in *direct* operating costs

References show comparable excess-cost estimates:

- "Some figures have indicated that the total average *direct* annual costs of the irregular operations of ten U.S. major airlines for the period 1996-1999 have been about **$1.9B**" (M.Janic – TRB Report, 2003)
- "…the Air Transport Association estimated that delays cost the air carriers approximately **$2.0B** in *direct* operating costs in 1999": OIG Report, 2000
- "The Air Transport Association's amount increases to nearly **$5B** when **in**direct costs and the value of passengers' lost time are included": OIG Report, 2000 (*extrapolation of our calculations to include indirect costs produces comparable numbers – AK)*
- Total operating costs of delays: **$1.8-2.4B** in 1987-94: FAA APO-130, "Total Cost for Air Carrier Delay Report", 1996
- 1999 total cost of disruptions estimated at **$1.8B** (Z.Shavell – Effects of Schedule Disruptions on the Economics of Airline Operations. In: Air Transportation Systems Engineering, 2001, Chapter 8).

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2005 Delay/Wx: Linear vs. Exponential Trend

A Sign of a Worsening Delay Situation?

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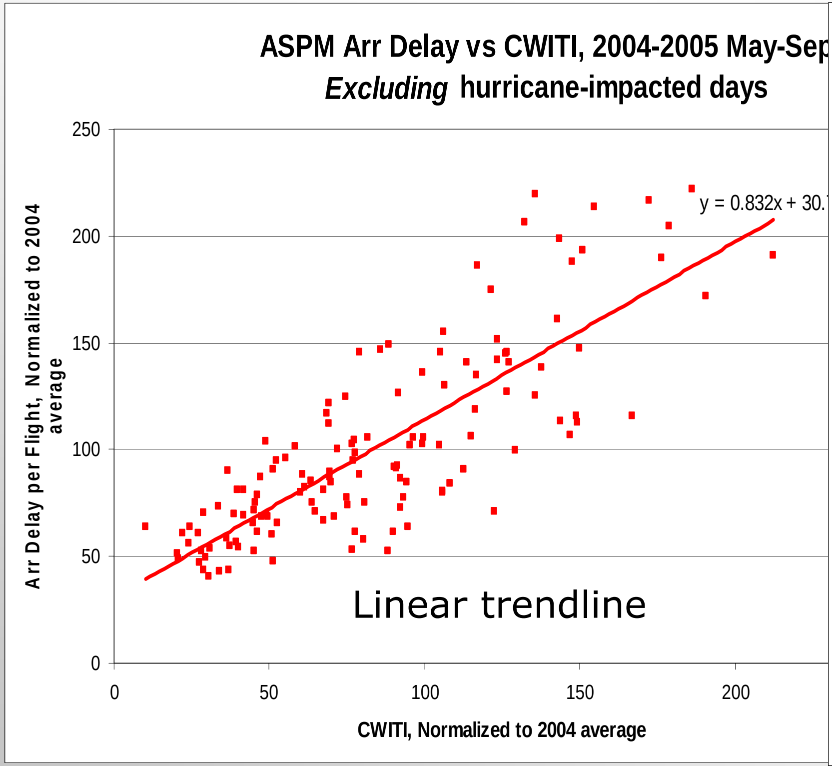
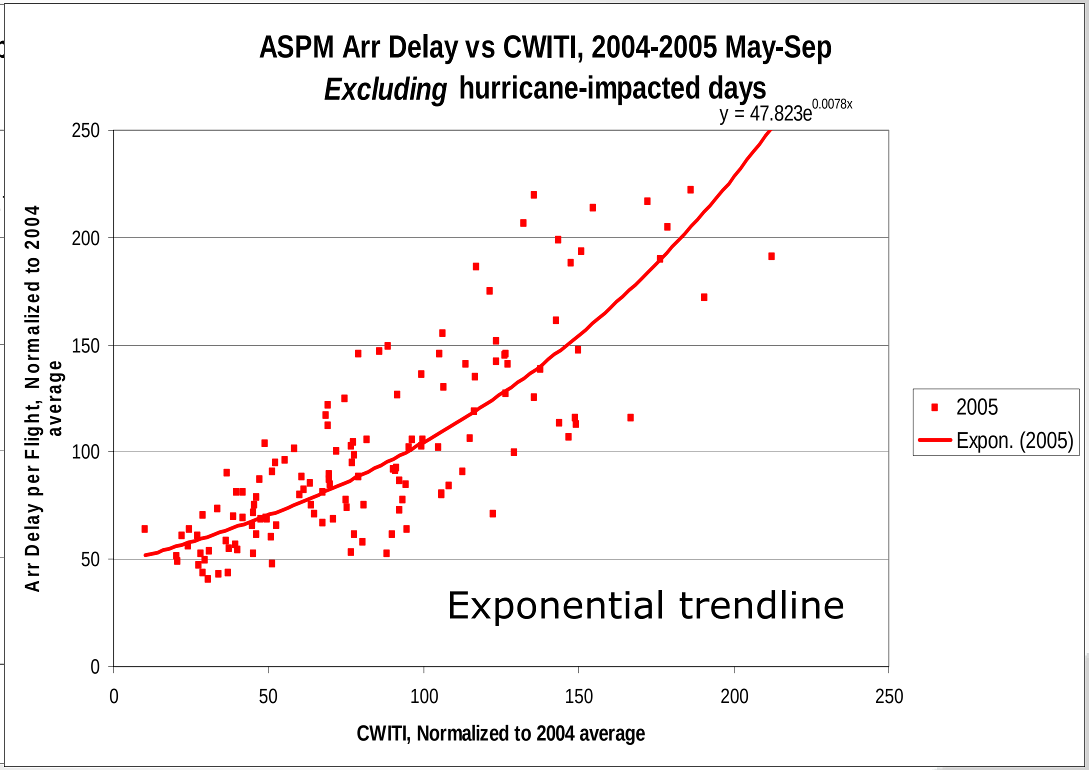
Exponential trendline: a better fit for 2005 Delay-vs-Weather Plot?

Linear trendline is a better fit for 2004 data





“Quiet Period” Monthly ASPM Delays vs. Ops
1995-2005

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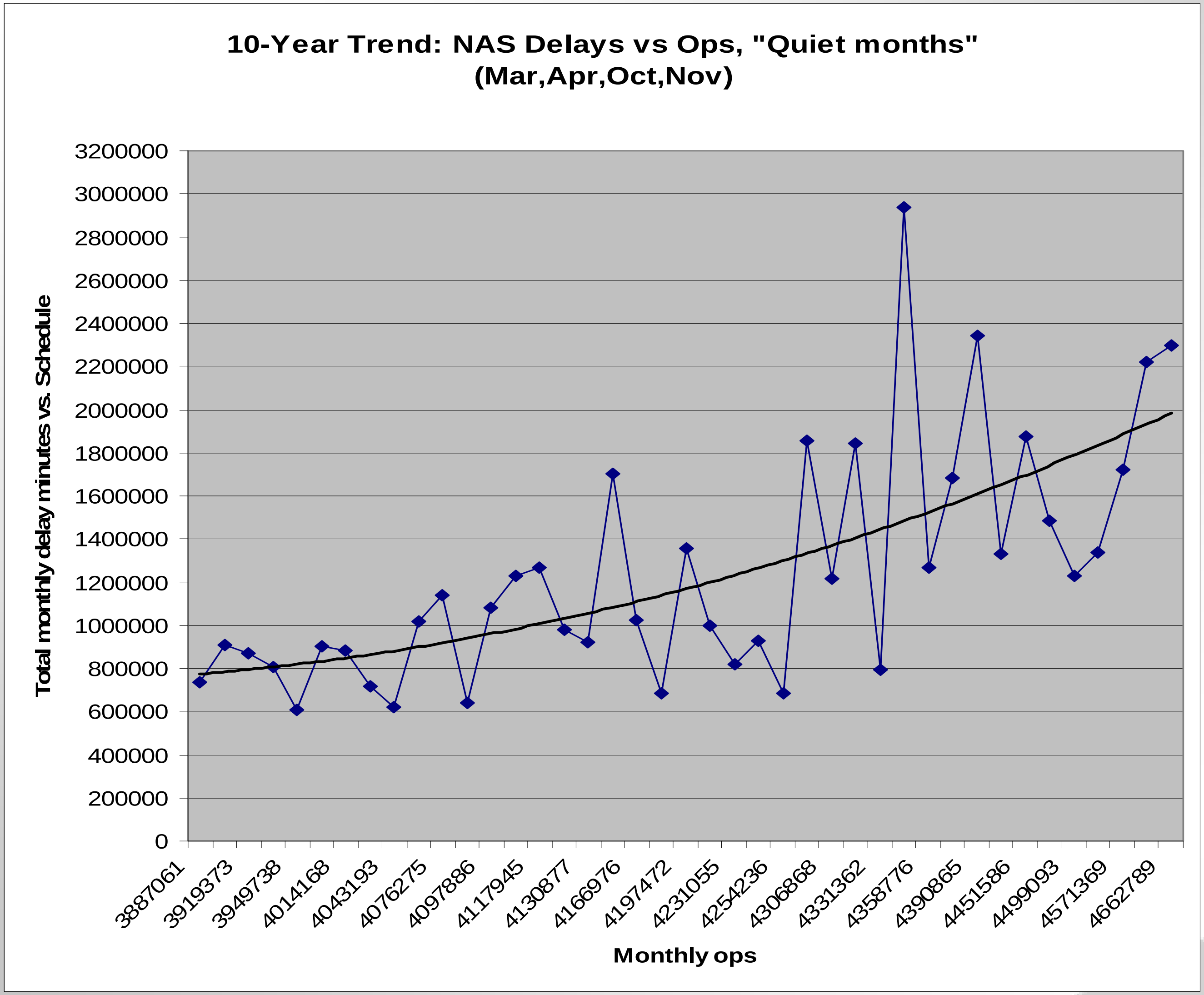

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Terminal Capacity Degradation

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Weather factor	Available airport capacity, % nominal
THUNDERSTORM	10
HEAVY_SNOW	30
HIGH_WIND (>30 kt)*	30
HEAVY_RAIN	40
LOW_VISIBILITY	70
LOW_CEILING	70
SNOW	70
RAIN	70
WIND (20-30 kt)	70
NO_WEATHER	100

*sustained wind above 30 kt, higher gusts

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“Flows” and Actual Tracks

Similarity

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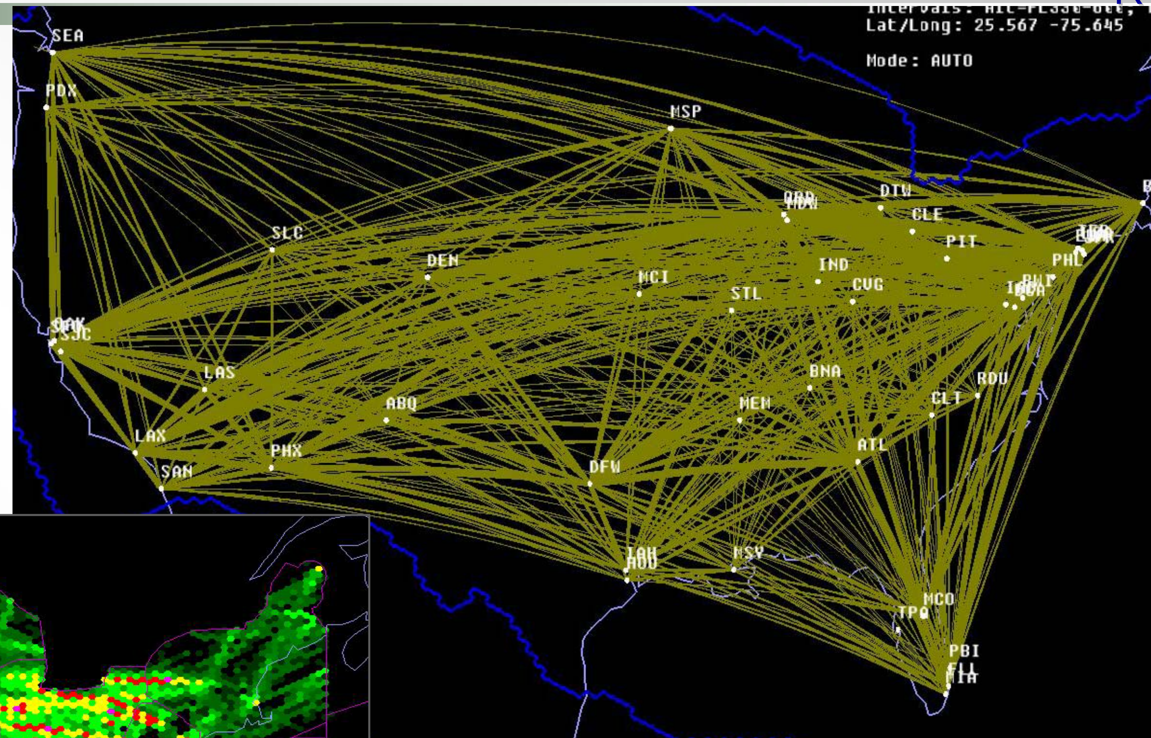

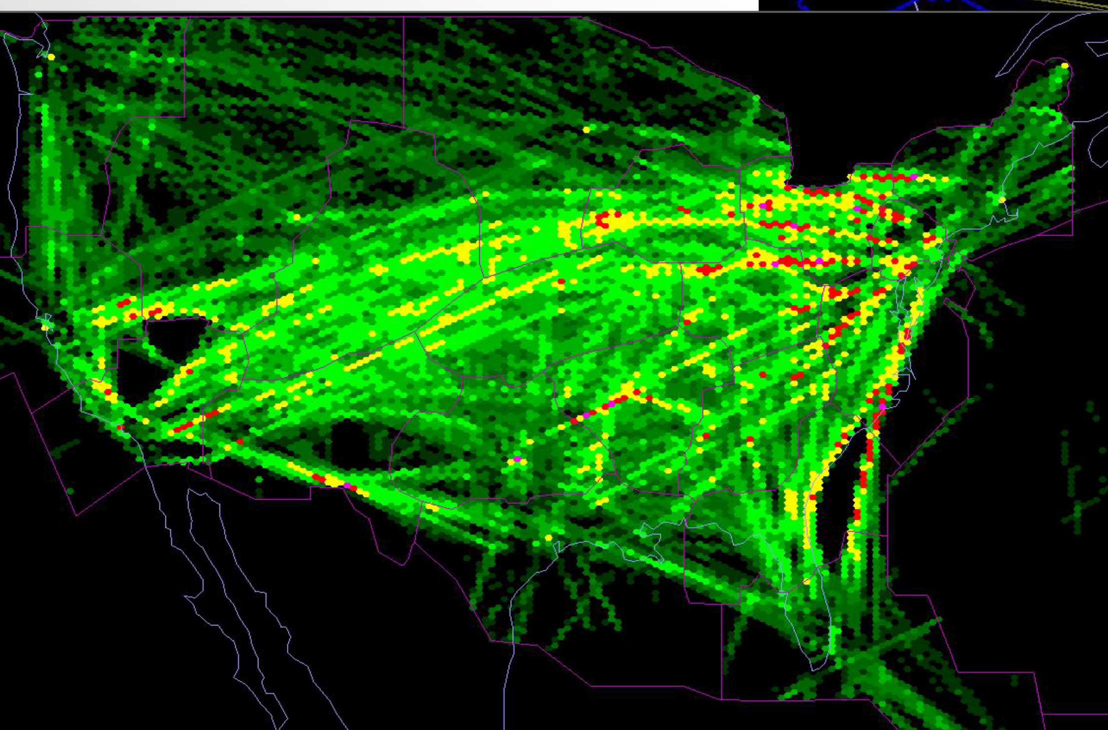

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