Does Forecast Accuracy Affect NAS Delays? Yes and No…

Jing Xiong, Yu Zhang, Mark Hansen
University of California, Berkeley
September 6, 2007
Asilomar

Agenda

- Overview
- Model Description
- Model Estimation Results
- Conclusion
- Future Research

Background

- Effects of WX on NAS Operational Performance Have been Extensively Studied
- Less Work on the Effect Forecast WX on NAS Performance

NCWF Verification

- NCWF Forecast
  - 4x4 KM Grid
  - 1 hr time horizon
  - Six hazard Levels
- NCWF Verification
  - NCWD data defined on similar grid and scale
  - Each Square Classified as
    - YY(WX forecast and WX occurs (VIP>3))
    - YN(WX forecast and no WX occurs)
    - NY
    - NN

Daily Summarization--NCWF

- 1-hour forecast every hour
- Reported in UTC Time
- Converted to forecast effective times between 4am ET-4am ET
- Summed over each hour

CCFP Verification

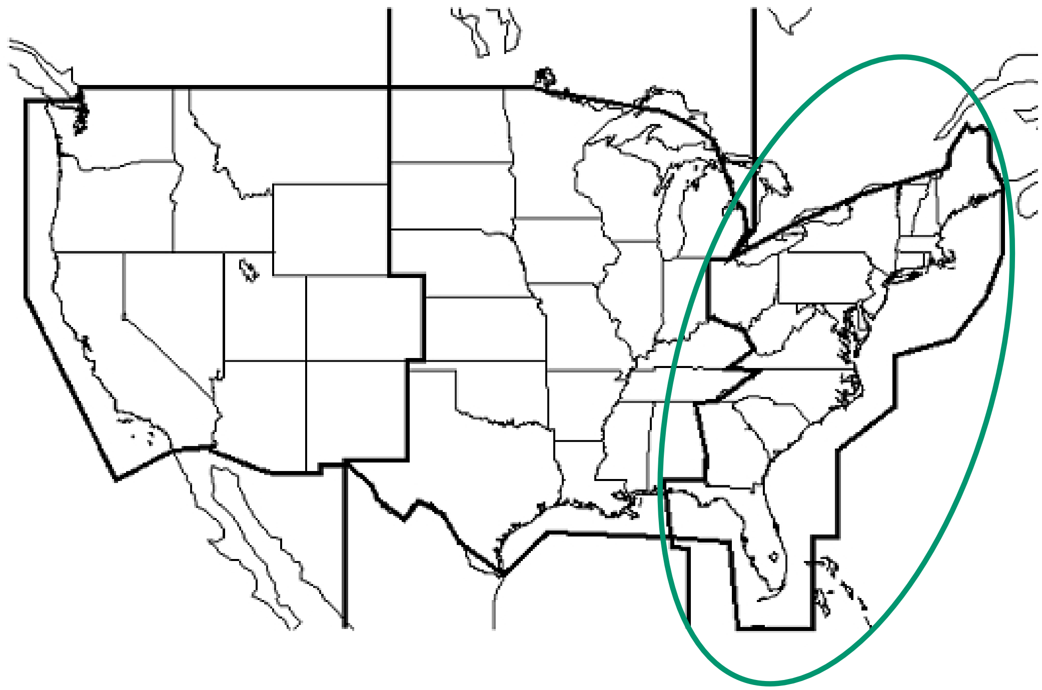
- Bi-hourly 2, 4, and 6 hr length
- 6am UTC Off
- Verification based on polygons of minimum size and forecast coverage (75%)
- Forecast Polygons compared to 40x40 km Grid based on NCWD
  - If 40x40 square includes one storm and intersects with CCFP polygon, then YY
  - If 40x40 square includes one storm and does not intersect with CCFP polygon, then NY
  - If 40x40 square includes no storm and intersects with CCFP polygon, then YN
  - If 40x40 square includes no storm and does not intersect with CCFP polygon, then NN

CCFP Verification

- All time horizons (2,4,6 hrs)
- 2 hr forecast effective time from 4am to 4am ET
- Sum results for 11 forecasts

“Northeast Corridor”

- Verification results reported for entire CONUS and for NE Corridor
- Expansive corridor definition



Verification Summary

- Four 2x2 tables
- Each table counts grid squares

	YES	NO
YES	WX forecast and realized	WX forecast and not realized
NO	WX not forecast and realized	WX not forecast and not realized

Statistical Delay Models

- Relate NAS performance (delay) to causal factors such as traffic, en route wx, terminal wx
- Based on daily or monthly data
- Motivations include
  - Understanding causes of delay
  - Tracking ANSP performance
- Active research area in US (Klein, Jehlen, Ball, Wieland, Sridhar, Post, Knorr, MITRE)

Model Specification

- *Perf(t)=f(Tra(t),WITI(t), Wind(t), IFR(t), Fcst(t))+v(t)*
  - *Where:*
  - *Perf(t)* is some NAS performance metric in day *t*;
  - *f(.)* is a deterministic function;
  - *Tra(t)* is air traffic demand in day t;
  - *WITI(t)* is a vector characterizing the en-route WITI in day *t*;
  - *Wind(t)* is average wind speed at major airports in day *t*;
  - *IFR(t)* is proportion of flights scheduled to land under IFR conditions in day *t*;
  - *Fcst(t)* is a vector capturing the weather forecast errors in day *t*;
  - *v(t)* is stochastic error term;

Variables Description

- Performance metrics
  - ASPM 75 daily average delay
  - Deviation of Average Flight Time Index (DAFT)
- Air traffic demand
- En route convective weather (WITI)
- Terminal weather (Wind and IFR)
- Weather forecast performance metrics

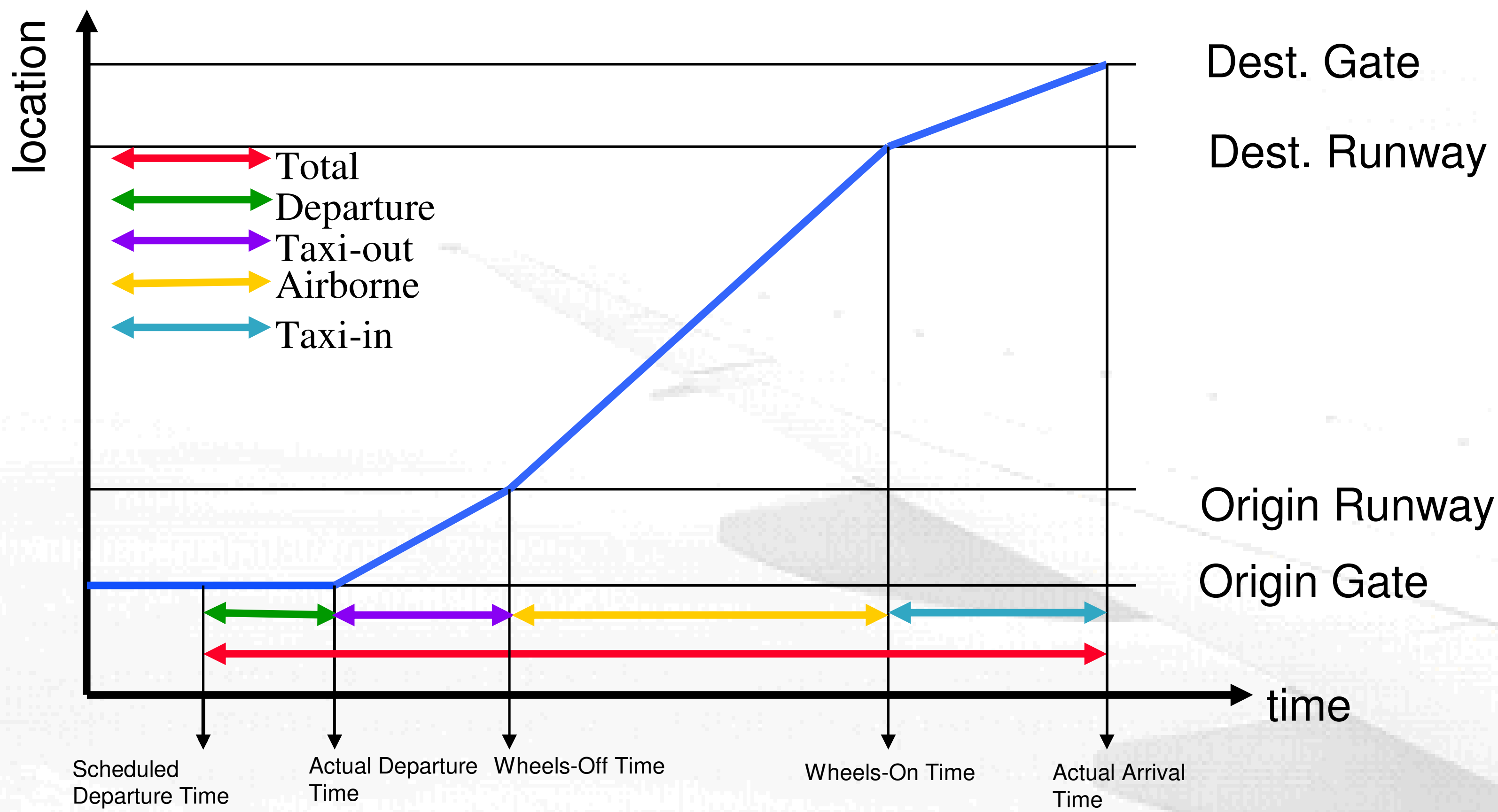
ASPM Daily Average Delay

- Total arrival delay against schedule divided by total completed arrivals
- Negative delay (arrive early) counted as zero
- 75 benchmark airports

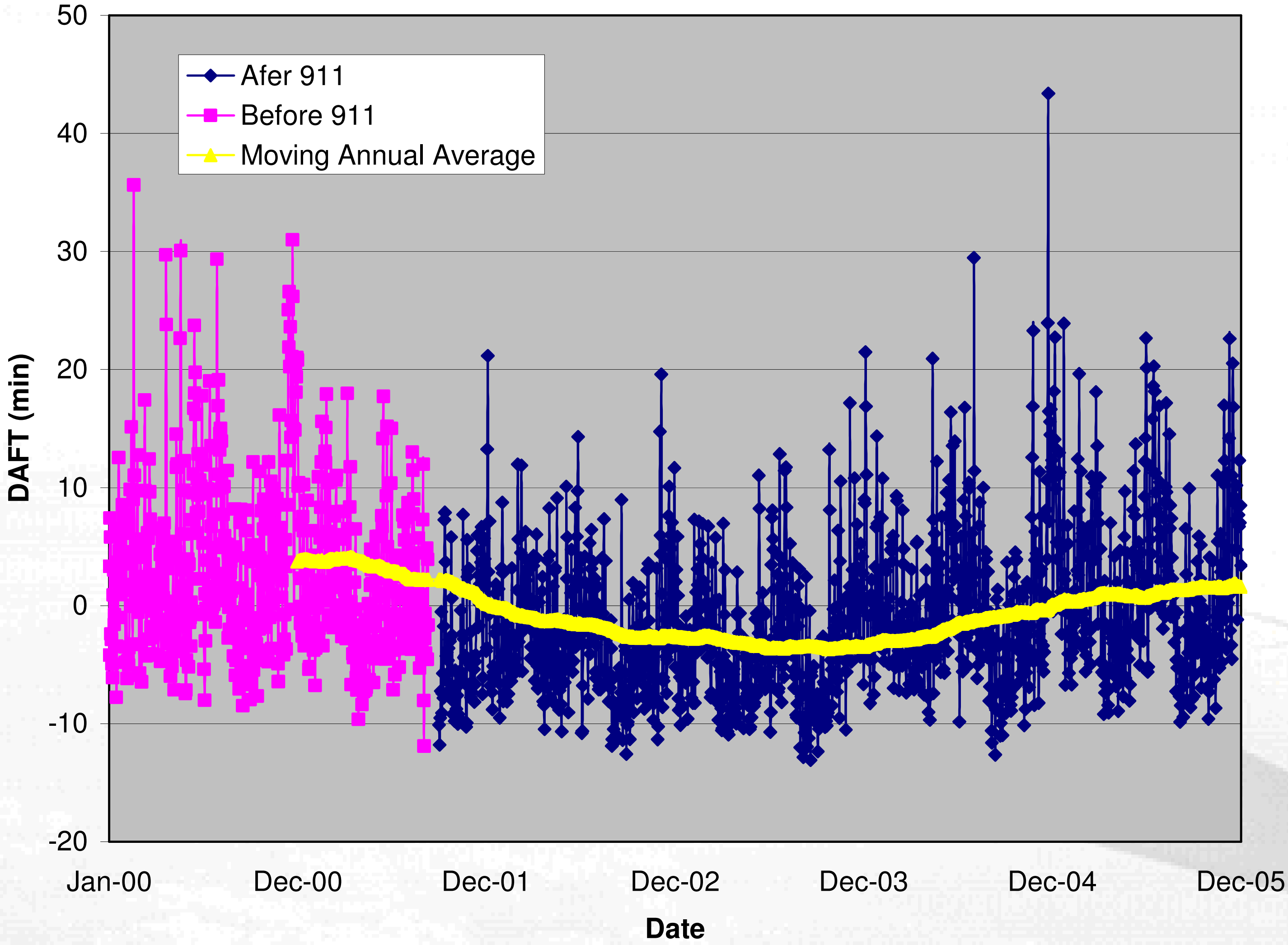
DAFT (Deviation of Average Flight Time)

- "Consumer price index" of flight times
- Market basket of OD pairs with fixed weights based on flight volume
- 0 values corresponds to average over 2000-2006 period
- Contains different phase of flight: gate delay, taxi-out time, airborne time, taxi-in time

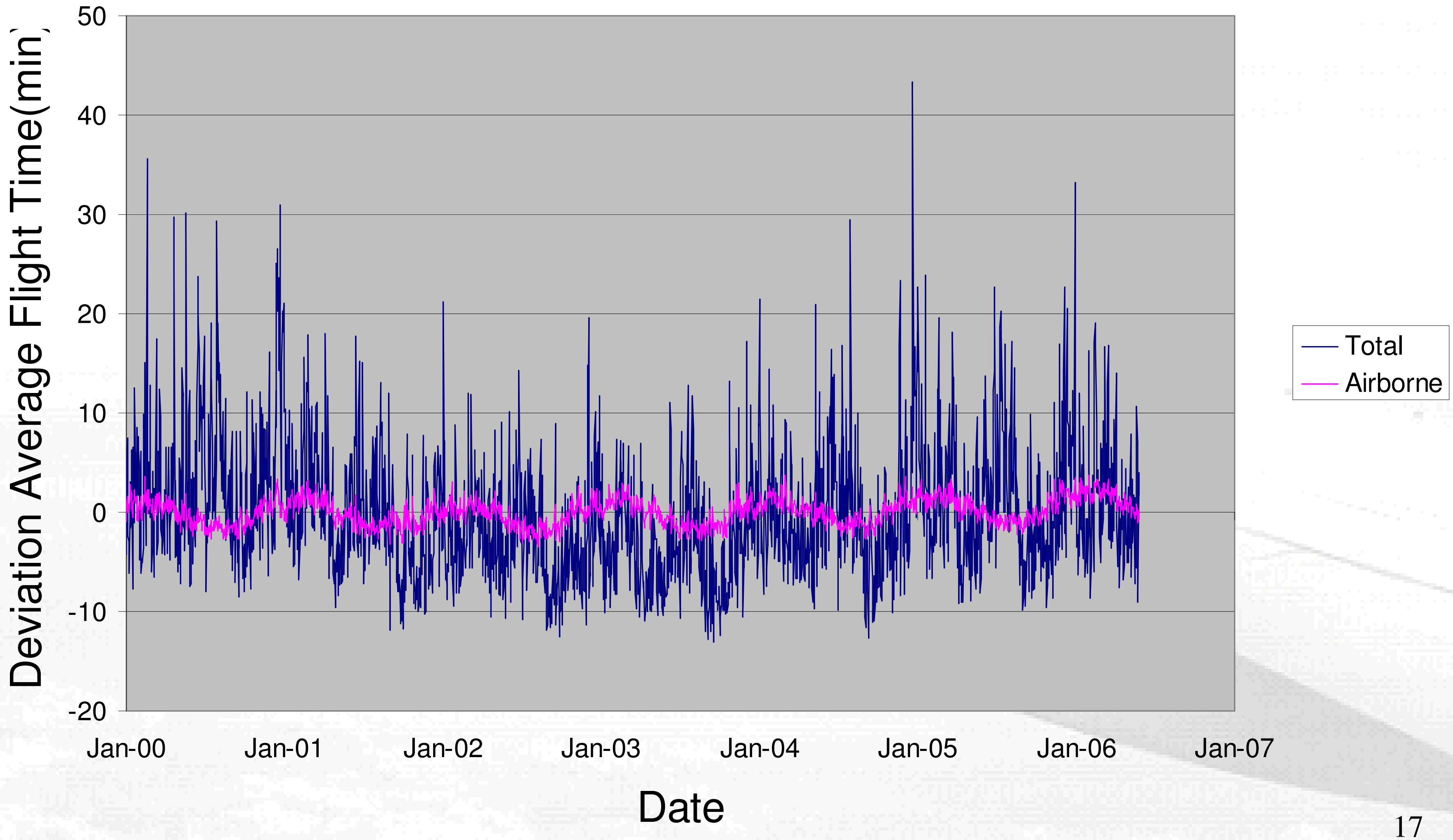
DAFT and its Components



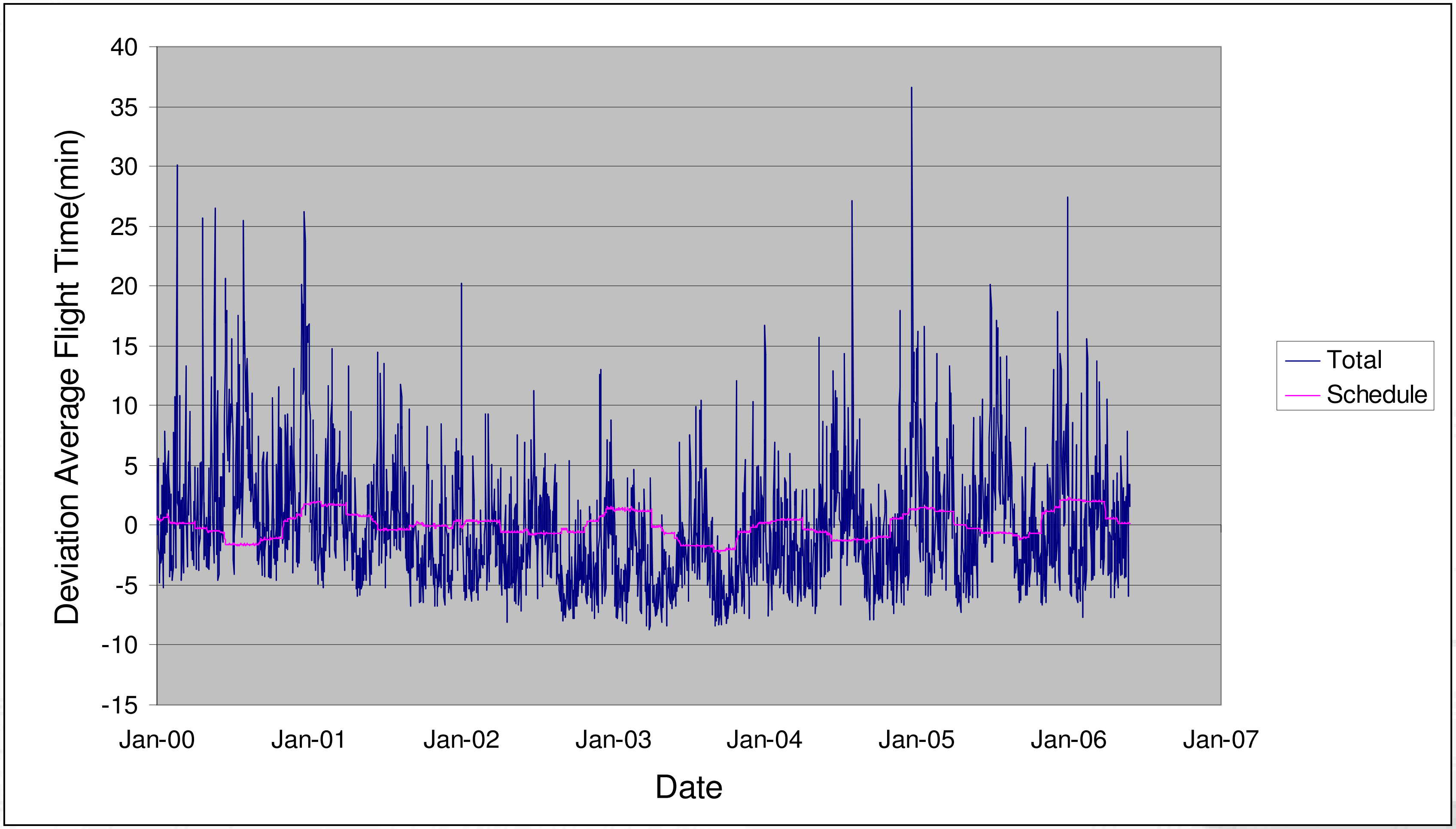
DAFT Trends 2000-2005



DAFT Total and Airborne



DAFT Total and OAG Schedule

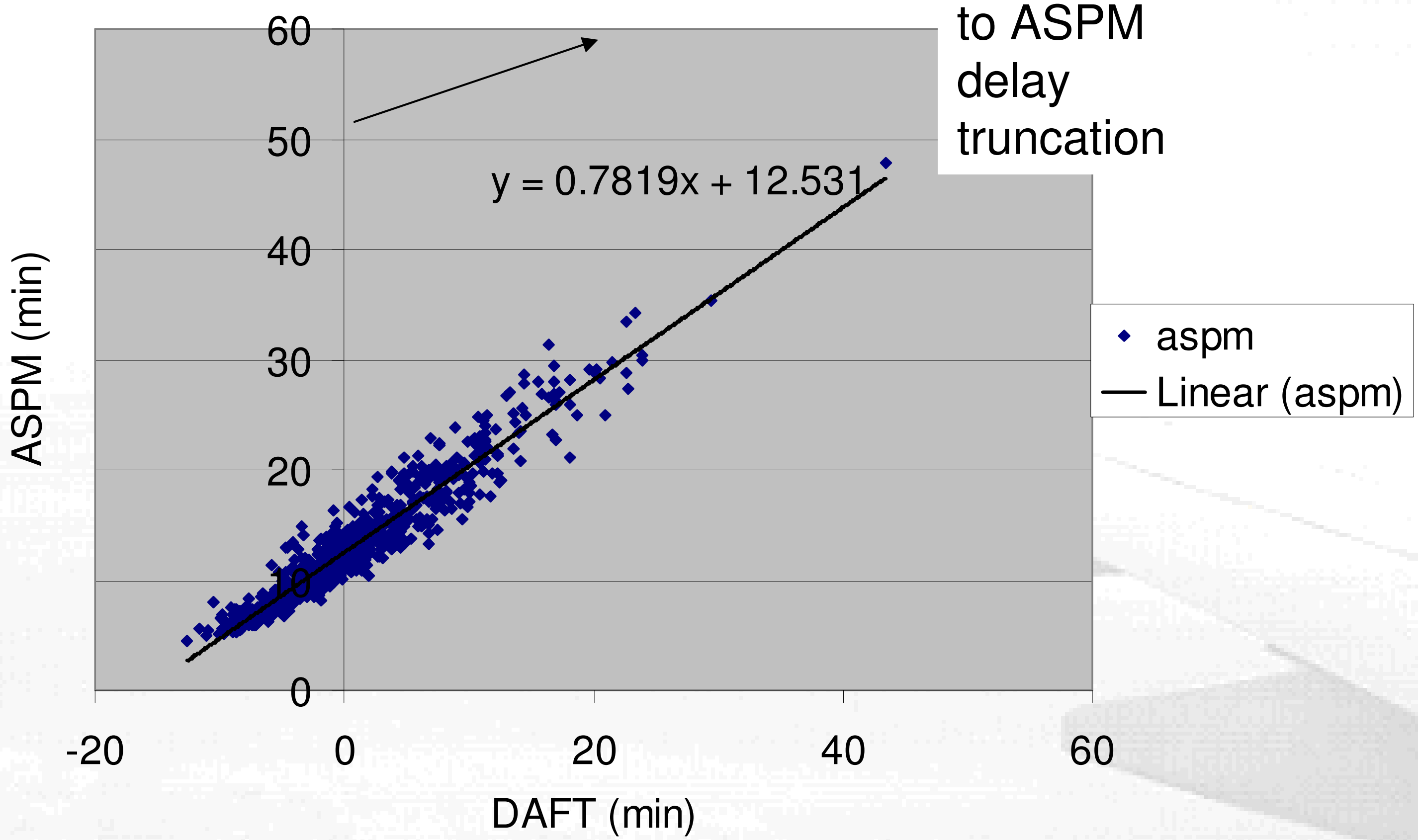


ASPM Daily Average vs DAFT

- Comparing with schedule vs Comparing with "Average" over the analysis period
- Padding effect vs no padding
- Truncation of negative delay vs no truncation
- Total delay vs decomposed to four phases of the flight

DAFT vs ASPM (2004 and 2005)

Slope<1 due to ASPM delay truncation



WITI Development (Sridar et al)

- WITI (t) = $\sum_{i,j} W_{i,j}(t) \cdot T_{i,j}(t)$
- $W_{i,j}(t)$ is
  - Severe convective weather incidence in cell *(i,j)* at time *t*
  - Binary data developed from NOWRAD
  - Five-minute interval
  - Extended to 20 miles
- $T_{i,j}(t)$ is
  - traffic counts in cell *(i,j)* at time *t*
  - Reference day ETMS actual trajectories
  - One-minute interval
- Reference day
  - a day with low OPSNET delay but high traffic

Other Variables

- Air Traffic Demand
  - Total daily scheduled arrivals at ASPM 75 airports
  - Obtained from ASPM
- Wind
  - For each flight, find wind speed at destination airport when it is scheduled to land
  - Average over all flights
- IFR
  - MC is binary data, 1 when airport is operated under IFR condition, 0 otherwise
  - Fraction of flights scheduled to land in IFR conditions

NEXTOR

Regression Results

	ASPM NCWF NEC	ASPM NCWF USA	ASPM CCFP NEC	ASPM CCFP USA	DAFT NCWF NEC	DAFT NCWF USA	DAFT CCFP NEC	DAFT CCFP USA
Intercept	-17	-17	-18	-21	-46	-47	-48	-53
Traffic	59	61	66	74	127	131	134	147
IFR	17	16	14	15	18	20	15	18
Wind	0.89	0.87	0.95	1.01	0.84	0.91	0.89	1.06
WITI	0.025	0.022	0.019	0.022	0.027	0.022	0.021	0.022
YN	0.00022	0.00011	0.00052	0.00015	0.00025	0.00012	0.00063	0.00023
NY	-0.00027	-0.00010	0.000018	-0.000012	-0.00030	-0.000088	0.000039	0.00013
R-sq	0.61	0.59	0.57	0.55	0.64	0.63	0.60	0.59

Significant at 0.01 level.

Significant at 0.05 level.

Significant at 0.01 level.

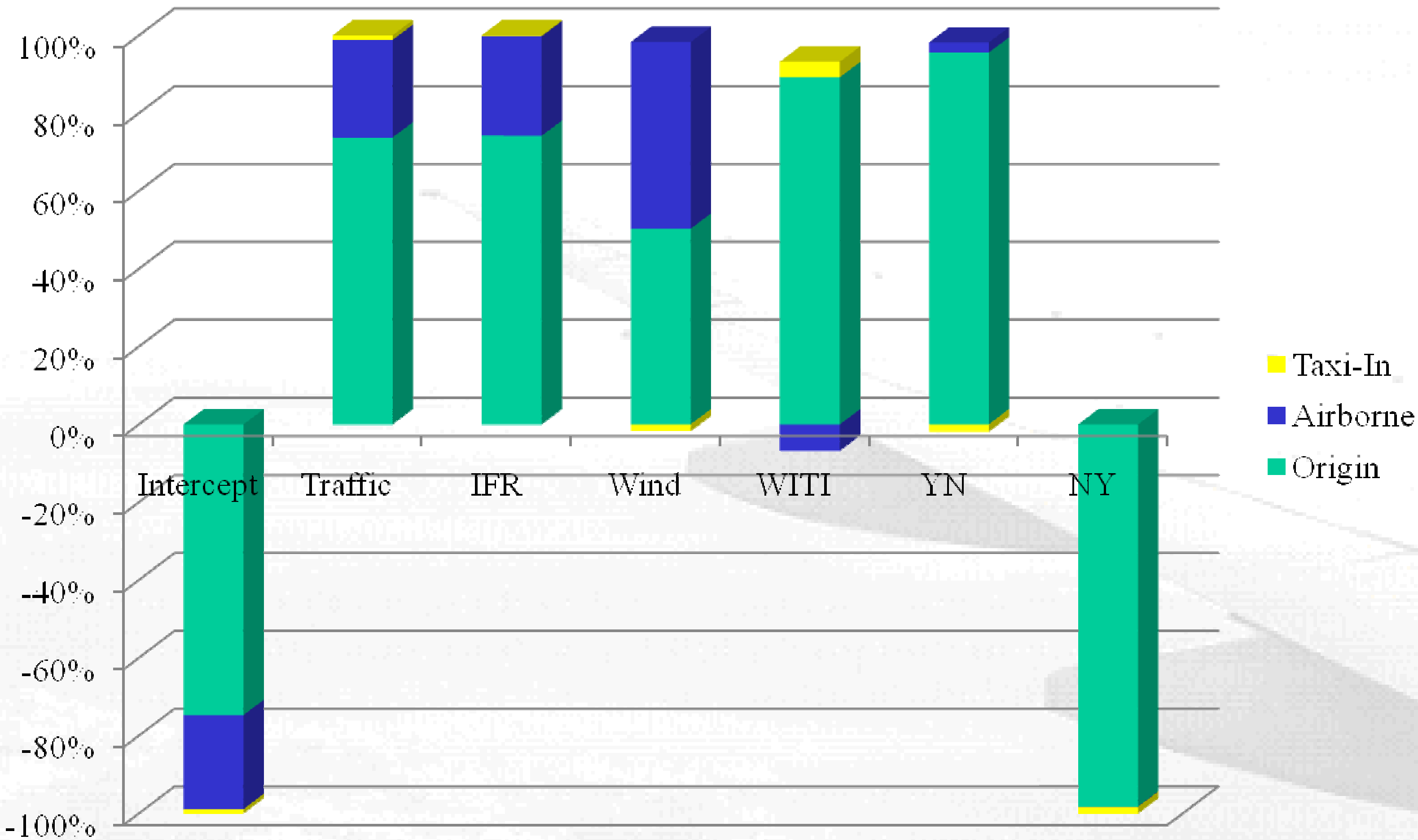
Discussion

- False Positive (YN) Counts Generally Significant and Positive
- False Negative (NY) Counts Sometimes Significant and Negative
- NCWF forecast results stronger explanator than CCFP
- NEC forecast results stronger explanator than USA results

Interpretation

- YN's Increase Delay by Causing Unnecessary TFM Actions
- NY's Decrease Delay by Suppressing TFM Actions, which on Average Increase Delay Even if Justified
- To Minimize Delay, Don't Forecast Weather

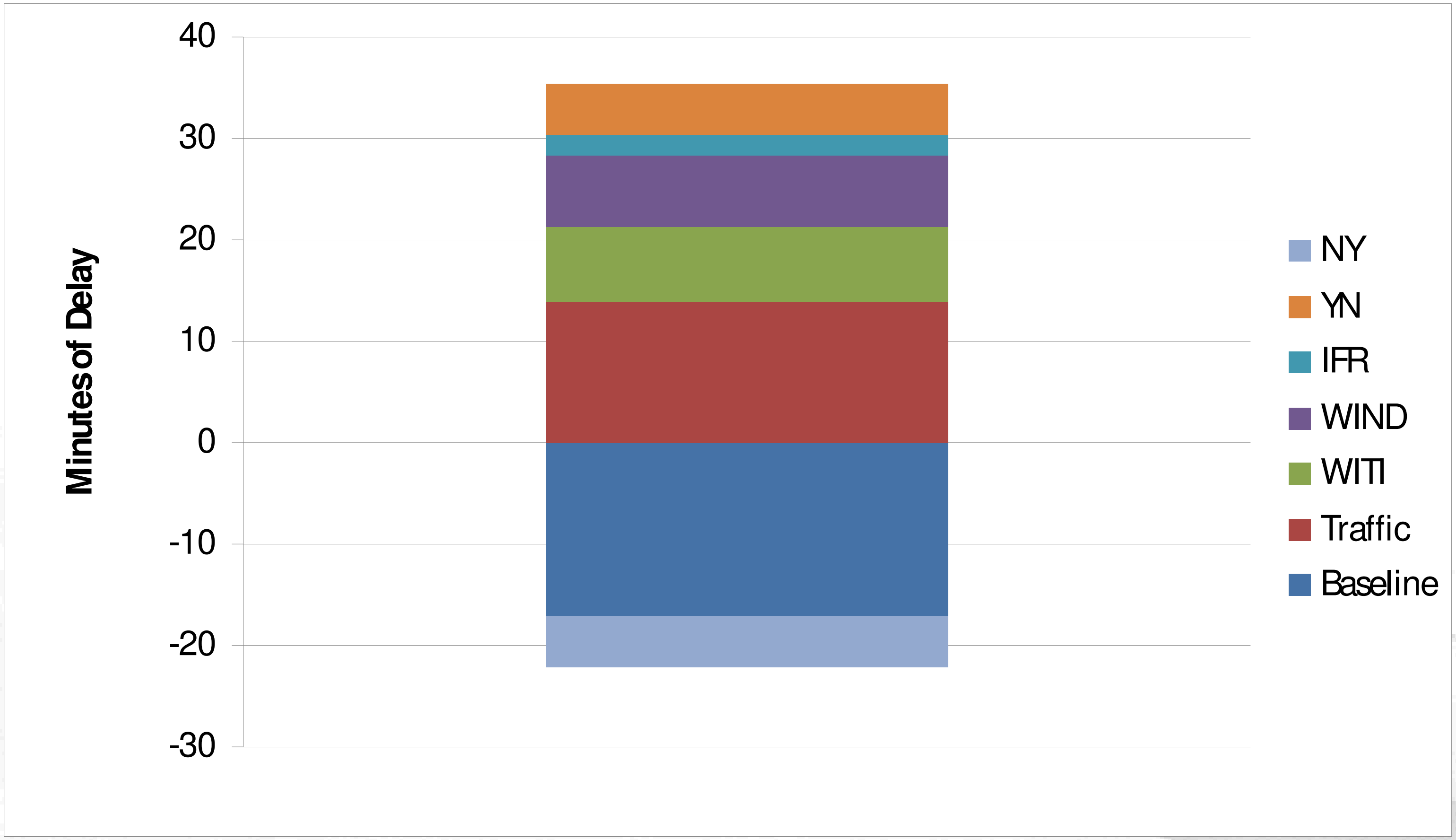
Decomposition of Effects by DAFT Component



But…

- YN’s and NY’s are highly correlated
- On typical high error days both are high and effects offset
- Impact becomes important on days when there is forecast bias

Contributions to Delay



Conclusions

- Does forecast accuracy affect delays? “Yes and No”
- What errors affect delays? “Yes and No” and “No and Yes”