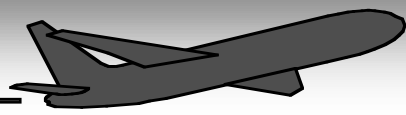
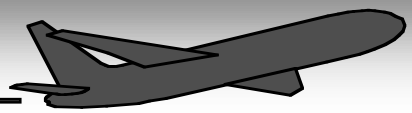


Impact of FFP1 on NAS Performance

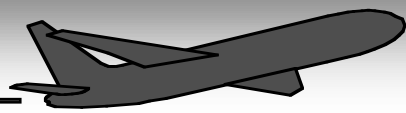
Mark Hansen, Geoff Gosling,
Chee Chou Ong, Tatjana Bolic,
Wenbin Wei

November, 2000



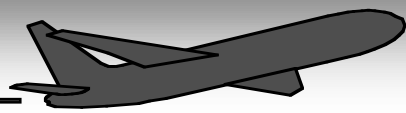
NEXTOR FFP1 Evaluation Work Overview

- Part of much broader effort
- Database Development (TASC)
- Simulation (Seagull)
- Normalization (UCB)
- Safety Impacts (UCB)
- Valuation (UCB)



Normalization

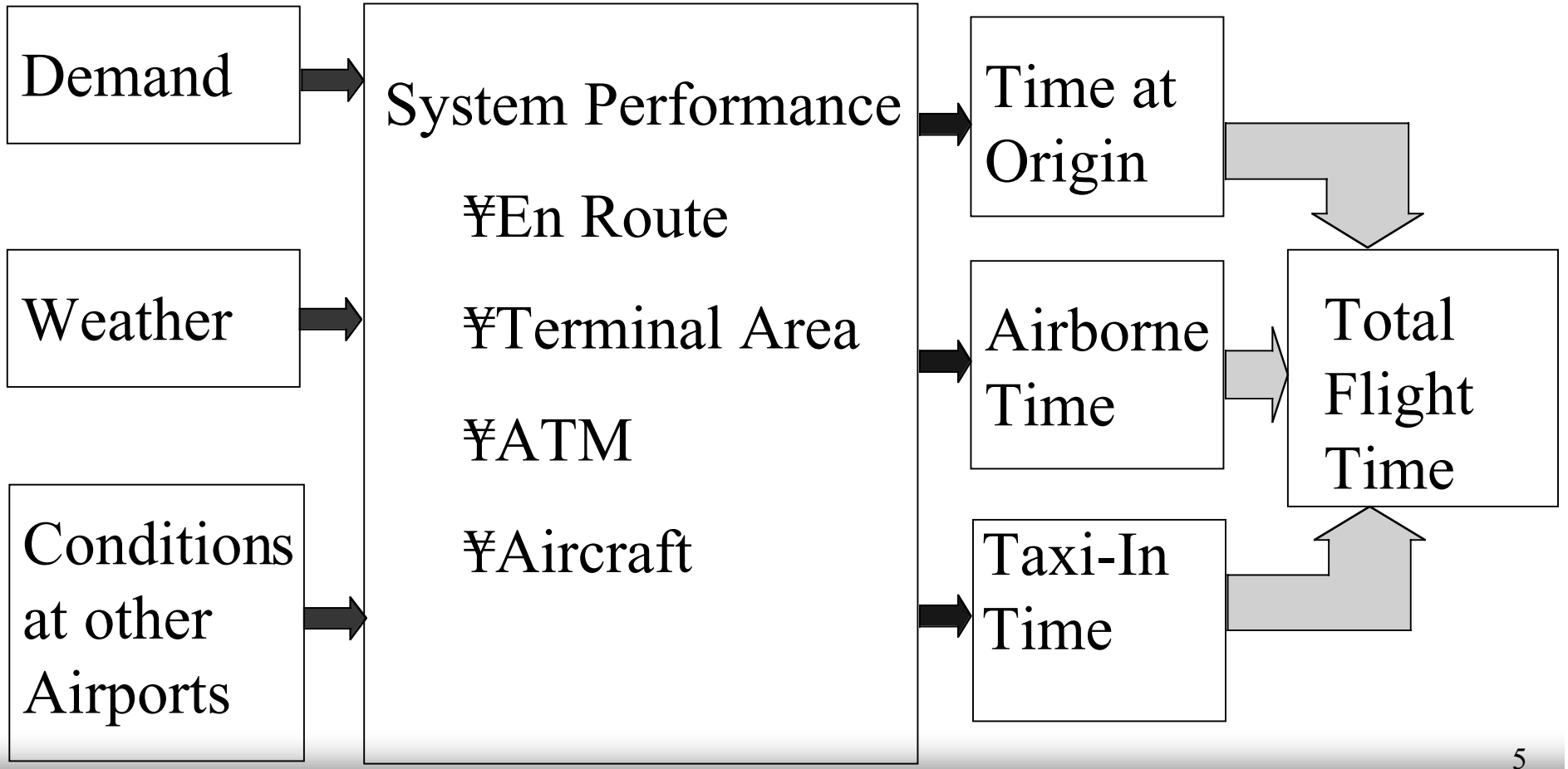
- Translate before/after performance comparisons to with/without comparisons
- Focus on FFP1 terminal sites where CTAS and/or SMA will be (has been) deployed
- NEXTOR focus to date on ATL, LAX, and DFW

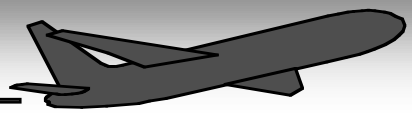


Normalization Approach

- Macroscopic
  - Analysis at daily lev el
  - Incorporate all flight phases
- Exploratory
- Statistical
- Transferable
  - Use widely available data sources
  - Applicable to any terminal area

Conceptual Framework

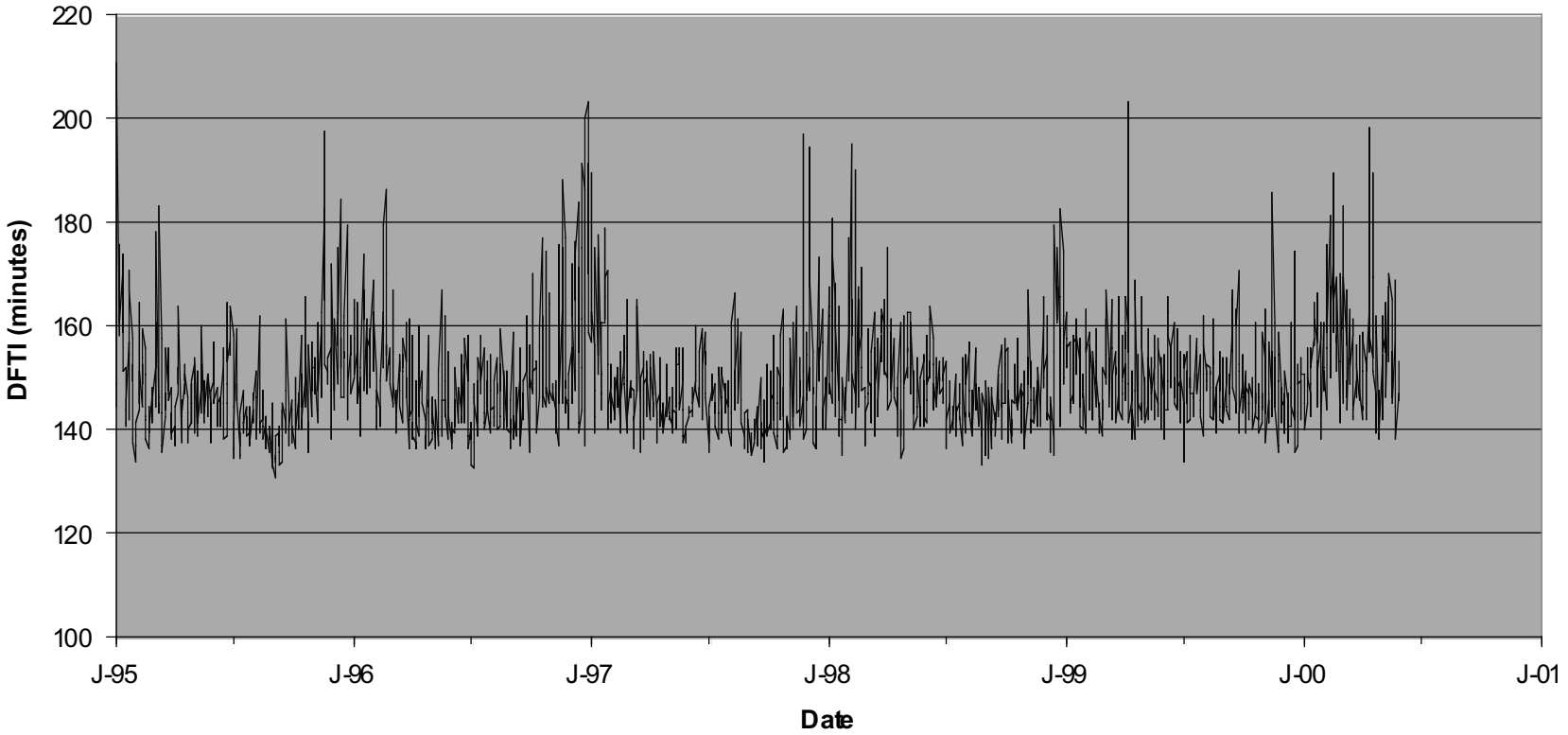




Daily Flight Time Index (DFTI)

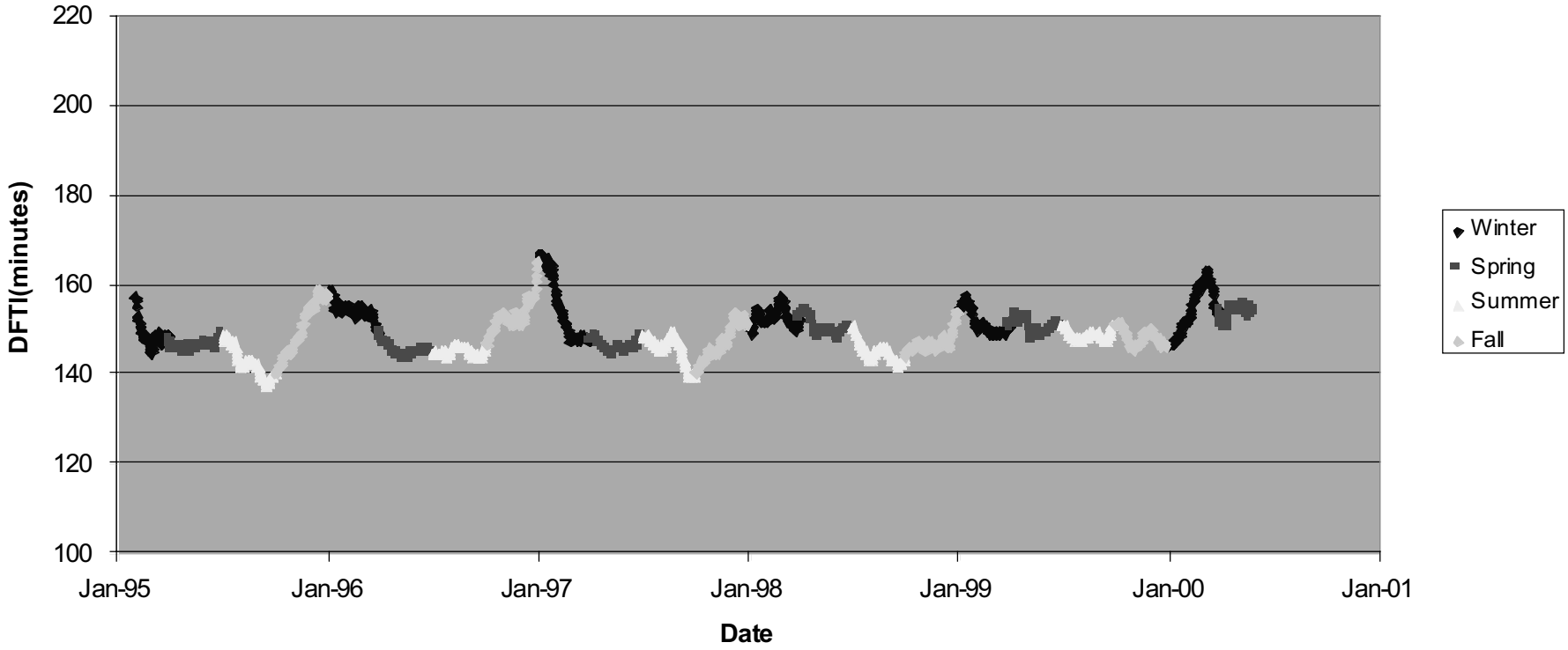
- Daily weighted average of flight times to a given airport from a set of origins
- Flight time=
  - Actual Arrival Time - Scheduled Departure Time
  - Scheduled Flight Time+Departure Delay+Flight Time Delay
  - Time-at-Origin+Airborne Time+Taxi-In Time
- Origins have at least one completed flight in each day of sample
- Weights reflect origin share of flights to study airport over study period

DFTI Time Series for LAX



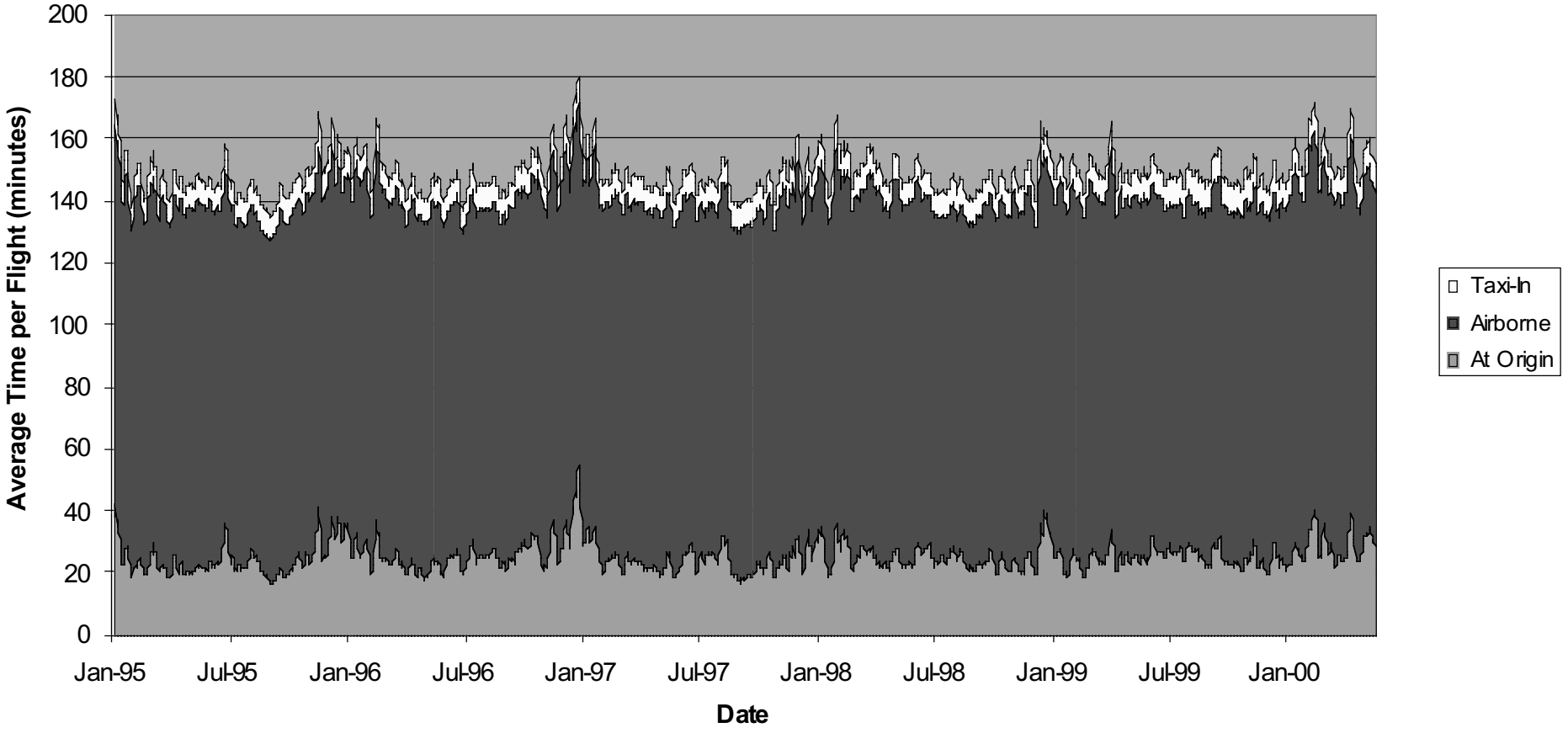
- Generally 140-160 minutes
- Spikes to over 180 minutes
- Seasonal Pattern

30-Day Moving Average

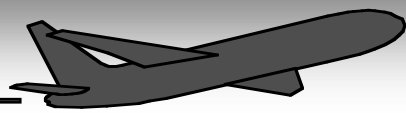


- Later fall and winter generally worst
- Summer 1999 worse than previous ones
- Delayed onset of typical winter pattern in 2000

7-Day Moving Average with Components



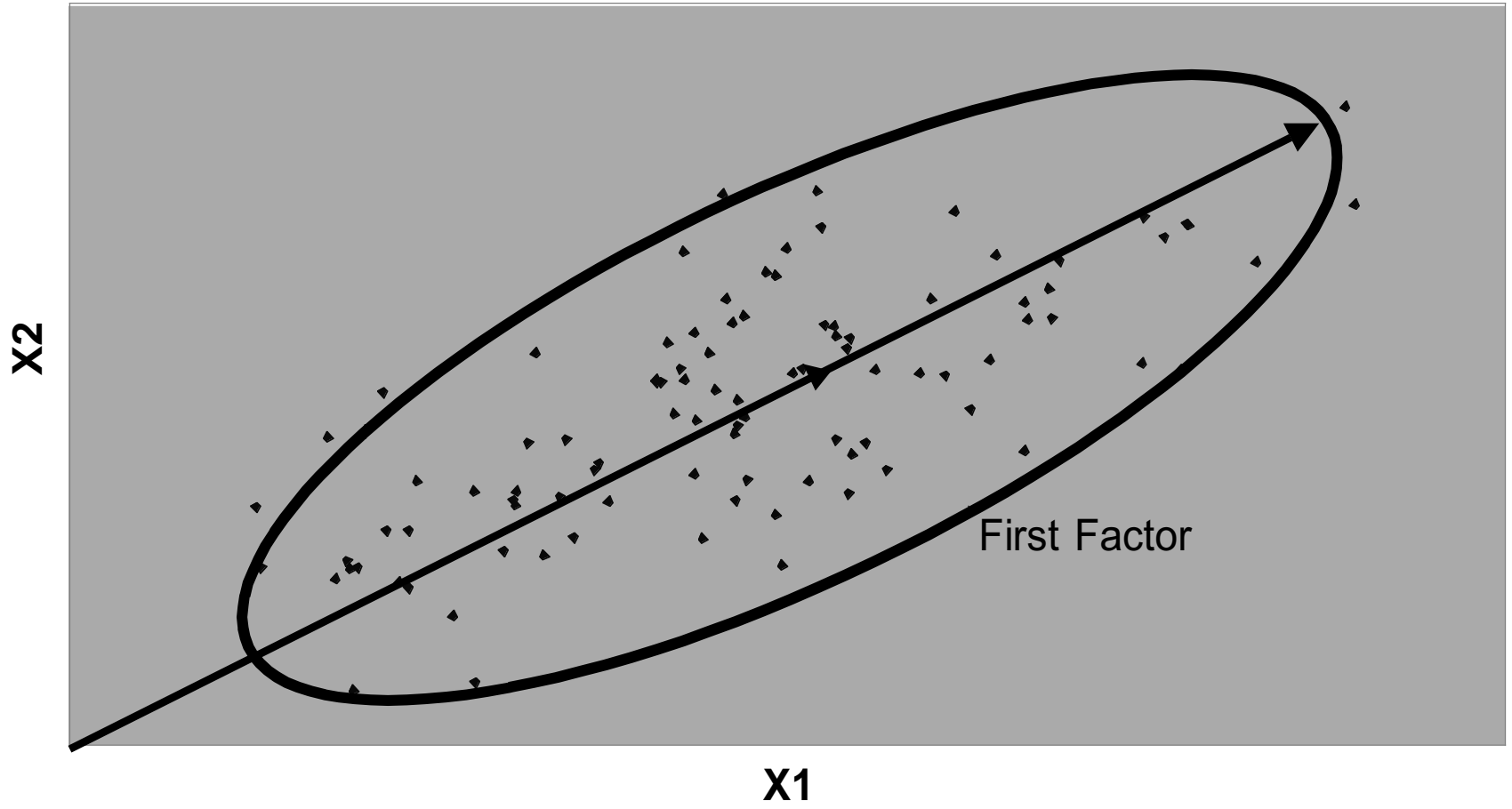
- Time-at-origin is major source of variation
- Correlation betweem time-at-origin and airborne time

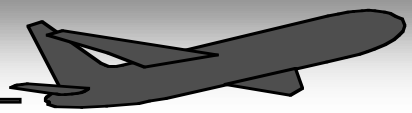


Weather Normalization

- Based on CODAS hourly weather observations for LAX
- Factor analysis of weather data
  - Create small number of factors that capture variation in large number of variables
  - Factors are linear combinations of original variables
  - Factors correspond to principal ax es of N-dimensional data elipse

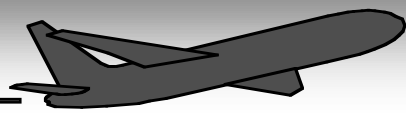
Factor Analysis with Two Variables





9-Factor Representation of LAX Daily Weather

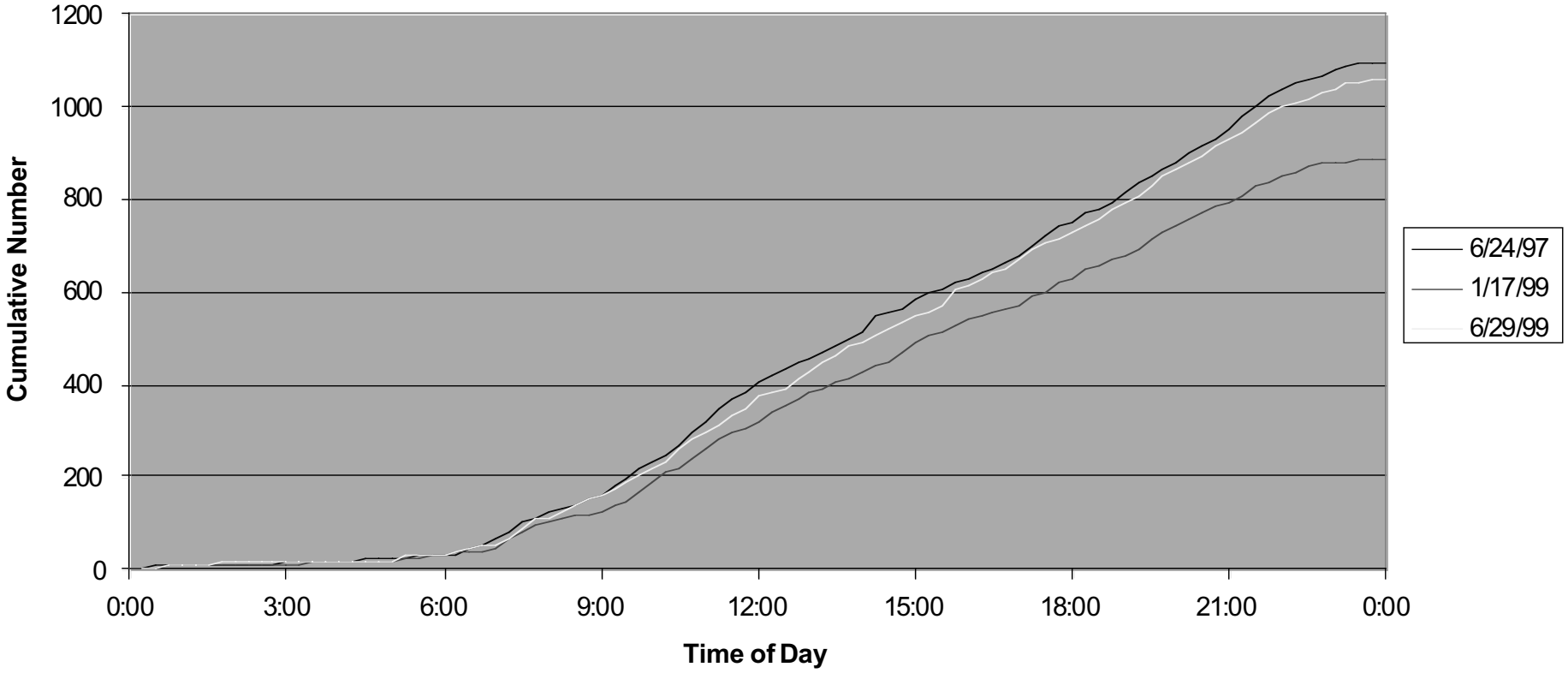
Factor	Interpretation
1	Warm temperatures throughout day.
2	VFR operations and absence of low cloud ceiling in the morning.
3	VFR operations and absence of low cloud ceiling in the afternoon.
4	High visibility throughout day.
5	Medium cloud ceiling throughout day.
6	High winds throughout day.
7	High ceiling cloud ceiling throughout day; evening precipitation.
8	Precipitation in late morning and afternoon.
9	Precipitation in early morning.

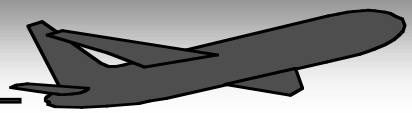


Demand Normalization

- Based on CODAS OAG data
- Capture number, strength, and duration of demand surges above a given baseline rate
- Set of 12 metrics using baseline rates from 10 to 120 arrivals per hour
- Summarized by two demand factors: one for higher baseline rates and one for higher rates

Flight Schedule Comparison

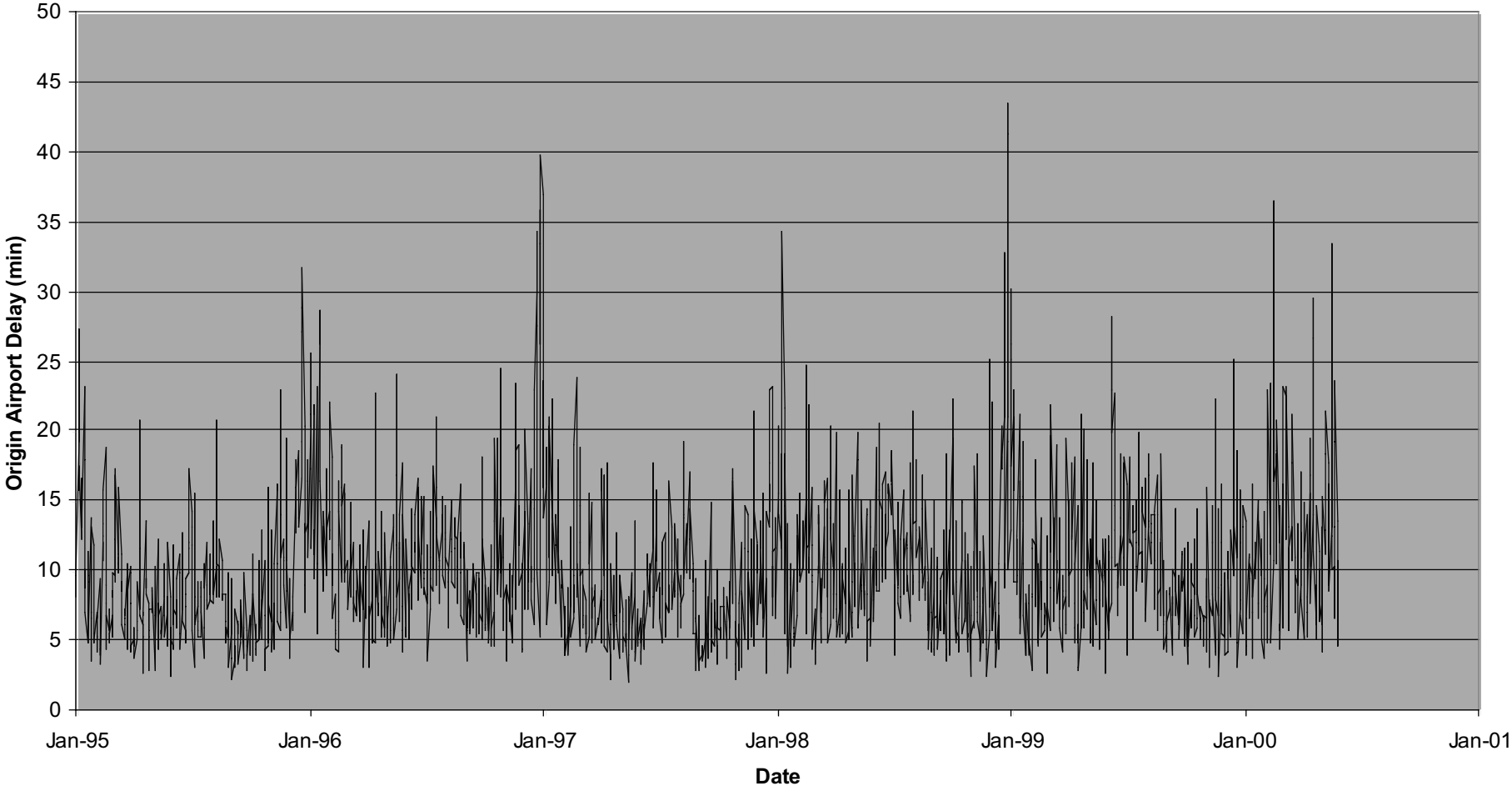


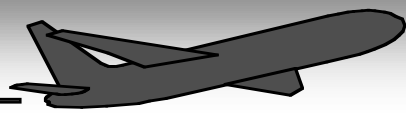


Normalization for Conditions at other Airports

- Consider airports included in DFTI average
- For each compute daily average departure delay for flights not bound to LAX region
- Average airport departure delays using DFTI weights

Origin Airport Delay Time Series





Performance Models

$$Y_t = f(WX_t, DMD_t, ODEL_t) + \varepsilon_t$$

Where:

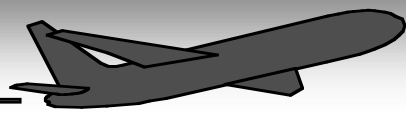
Y_t is DFTI or DFTI component for day t;

WX_t is vector of weather factors for day t;

DMD_t is vector of demand factors for day t;

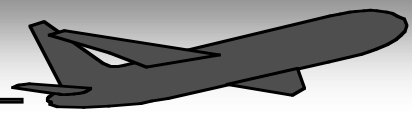
$ODEL_t$ is average origin departure delay for day t;

ε_t is stochastic error term.



Functional Forms Considered

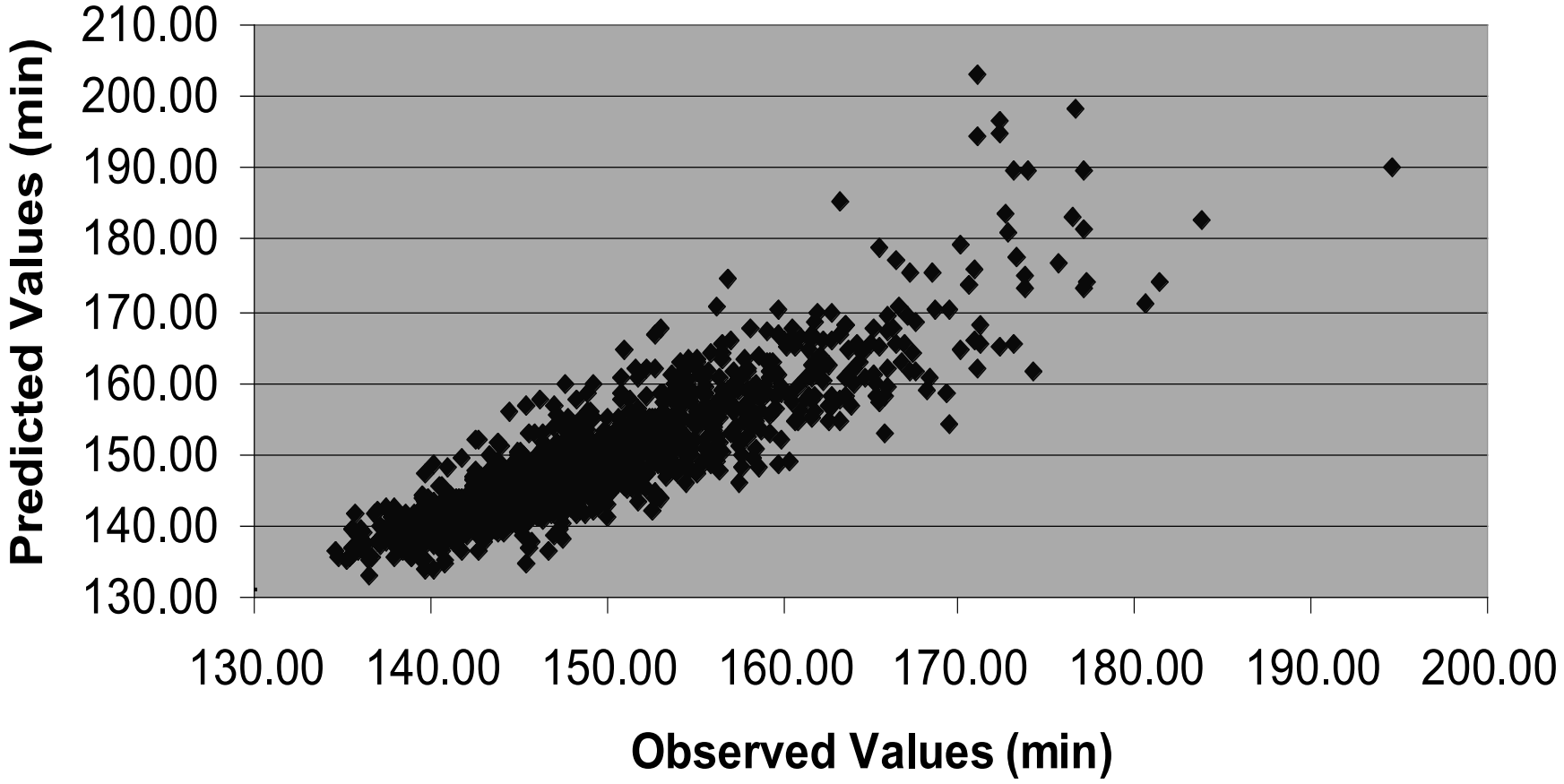
- Parametric
  - Linear (with 3, 6, 9, and 12 weather factors)
  - Quadratic response surface
  - Non-linear
- Non-parametric
  - 9 clusters based on 3 weather factors
  - 12 clusters based on 9 weather factors

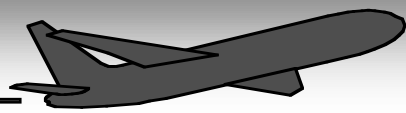


Linear Model Estimation Results

Variable	Description	Estimate	T - statistic	P - value
INTERCEPT	Intercept	138.055	567.065	0.0001
ODEL	Origin airport departure delay	1.128	44.351	0.0001
WX_1	Warm daily temperatures	-1.357	-12.101	0.0001
WX_2	VFR ops, no low cloud ceiling in the morning	-0.988	-7.116	0.0001
WX_3	VFR ops, no low cloud ceiling in the afternoon	-1.123	-7.583	0.0001
WX_4	High visibility throughout day	-0.449	-3.575	0.0004
WX_5	Medium cloud ceiling throughout day	1.440	10.555	0.0001
WX_6	High winds throughout the day	0.512	4.531	0.0001
WX_7	High cloud ceiling throughout day	0.911	4.172	0.0001
WX_8	Precipitation in late morning and afternoon	1.871	8.324	0.0001
WX_9	Precipitation in early morning	-0.379	-2.614	0.0091
DMD_1	Peak demand	0.075	0.725	0.4685
DMD_2	Base demand	0.440	4.574	0.0001
ADJUSTED R^2			0.743	

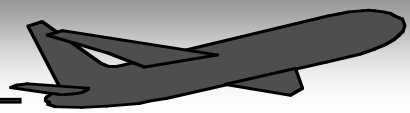
Predicted vs Actual Values





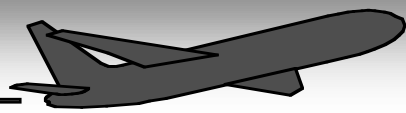
Outliers

- Used TMU logs to investigate days for which predictions have large errors
- Reasons for higher than predicted DFTI
  - East flow
  - Radar outages
  - Air Force One
  - Over-stringent ground delay program
- No clear explanations for lower-than-average DFTI: No news is good news



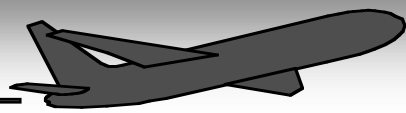
FFP1 Safety Impact

- Need to Address Safety Impact of FFP1 Tools
- Operational Error Rate Selected as Safety Metric
- Significant Variation in Operational Error Rate
  - Over time at a given facility
  - Across facilities
- Need to Better Understand Causes of Variation
  - Account for factors other than FFP1 tools
  - Measure contribution of FFP1 tools



NEXTOR Research on Safety Impact

- Identify Potential Safety-Related Effects of FFP1 Tools
  - Better information for cont rollers
  - Changes in controller activities
  - Changes in traffic patt erns
  - Increase in traffic handled
- Review Previous Research on Factors Associated with High Rates of Operational Errors
- Statistical Analysis of Operational Error Data



Valuation Research

- Translate operational impact to economic value
- Avoid traditional delay-centric approach
- NEXTOR work on two areas
  - Buffered vs non-buffered delay
  - Infering value from increases in observed throughput rates