



*Capacity Utilization Metrics
Revisited: Delay Weighting vs
Demand Weighting*

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Outline

- Introduction
- Existing metrics examination
- Proposed metrics
- Comparisons: existing vs. proposed scores
- Remarks



Introduction

□ Airport Performance

- Assessment of the use of the airport's capacity, taking into account the **relative importance** of **meeting** arrival and depart **demand** in each time period (FAA (1999), Documentation for airport utilization metrics)
- **Meeting demand** is considered by "utilization"
- **Relative importance** is accounted by "weight" (demand)



Existing metrics examination

□ Utilization Formula (Applied to Arrivals)

$$Arrival_Utilization_t = \frac{Actual_Arrivals_t}{Min(Arrival_Demand_t, Arrival_Rate_t)}$$

- Actual Arrivals: Arrival count for 15-minute time period t (based on wheels-on time)
- Arrival Demand: estimated number of arriving flights “available” in 15-minute time period t, based on flight plan or actual arrival time
- Arrival Rate: Airport Acceptance Rate for period t
- Get full score when the service meets all demand or AAR
- Utilization score is taken as the minimum of the formula result and 1 (no credit for exceeding AAR)



Existing metrics examination

□ Arrival Score Formula

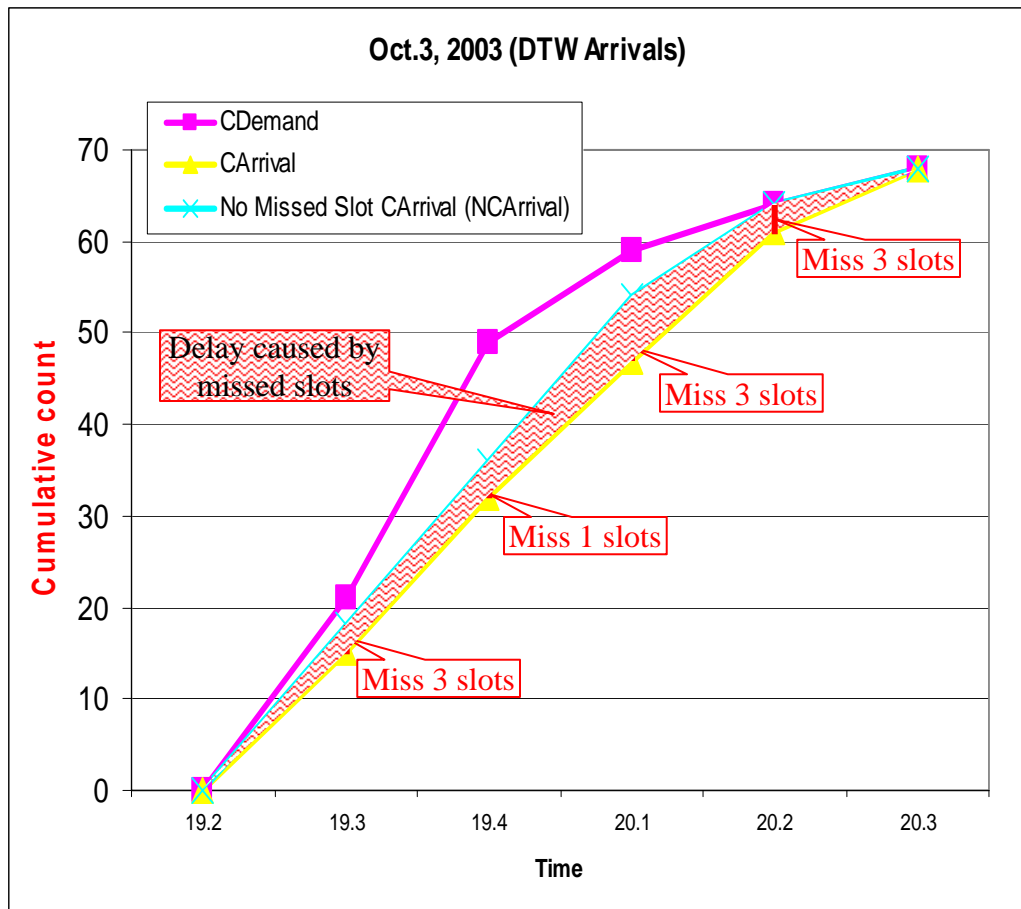
$$Arrival_Score = \frac{\sum_t Arrival_Utilization_t * Arrival_Demand_t}{\sum_t Arrival_Demand_t}$$

- **Utilization** to capture the **missed slots** of each period
- **Arrival Demand** to represent the **relative importance (missed slot effects)** of each period



Existing metrics examination

- Graph representation



$$\begin{aligned}
 CDemand_t &= CDemand_{t-1} + Arrival_Demand_t \\
 &\quad - (CDemand_{t-1} - CArrivals_{t-1}) \\
 &= CArrivals_{t-1} + Arrival_Demand_t
 \end{aligned}$$

$$CArrivals_t = CArrivals_{t-1} + Actual_Arrival_t$$

$$NCArrival_t = \text{Min}\{CDemand_t, NCArrival_{t-1} + \text{Min}(Arrival_Demand_t, Arrival_Rate_t)\}$$



Existing metrics examination

- ❑ Major Drawback: **Arrival Demand** may not appropriately reflect the **relative importance (missed slot effects)** of each period
 - Some periods, although their demands are low, are important because if we miss slots in these period there will be huge delays
 - In contrast, some high demand periods are not so important because the impacts of missed slots can be recovered very soon



Proposed metrics

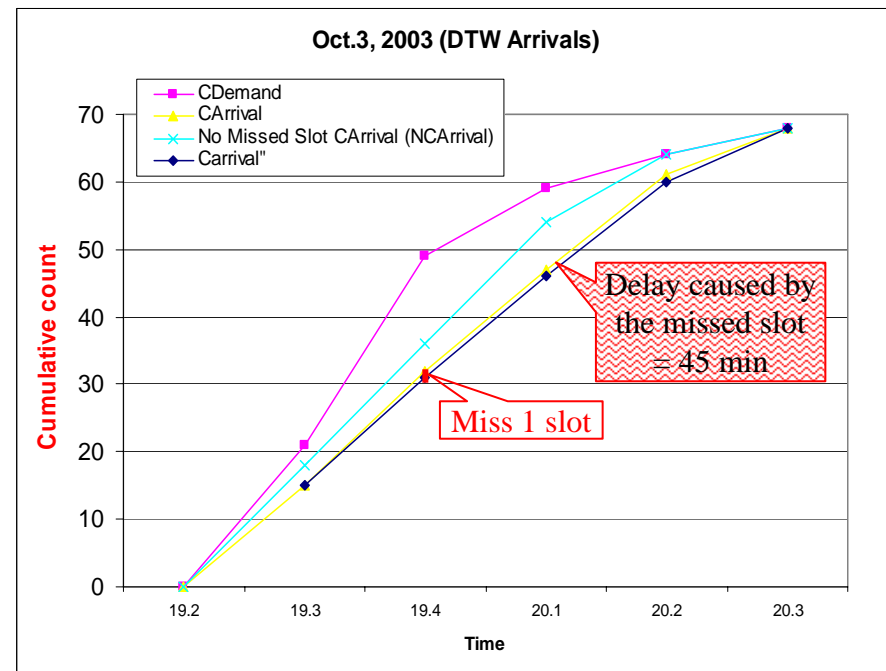
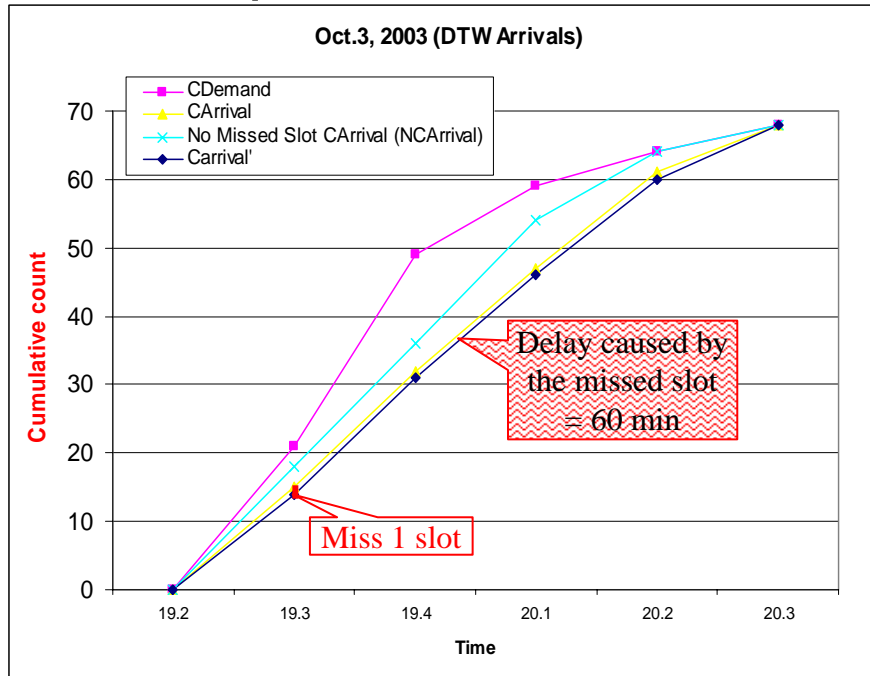
□ Basic Idea

- Keep “Utilization”: account for missed slots
- Find another weighting factor, which better reflects the impacts of missed slots
 - ✓ For each period, consider the delay caused by a missed slot (What is the extra delay if we miss one additional slot?) — the effect may propagate for several periods
 - ✓ Economic explanation: employ the marginal costs (extra delays) as the weights



Proposed metrics

□ example:



Miss Slot Period	3 rd qrt, 7p.m.	4 th qrt, 7p.m.
Arrival Demand t	21	< 34
Delay per missed slot t	60	> 45



Proposed metrics

□ New Arrival Score Formula

$$New_Arrival_Score = \frac{\sum_t Arrival_Utilization_t * Marginal_Delay_t}{\sum_t Marginal_Delay_t}$$

- **Utilization** to capture the **missed slots** of each period
- **Marginal Delay** to represent the **relative importance (missed slot effects)** of each period: It is the area between original and hypothetical (assuming one additional missed slot) cumulative arrival curves



Comparisons: existing vs. proposed scores

Data

- ASPM Airport Quart Hour Data
- 32 DOT Airports, from 1/1/00 to 11/17/03, except some days in which their data with “daylight saving changes” problem

Comparisons

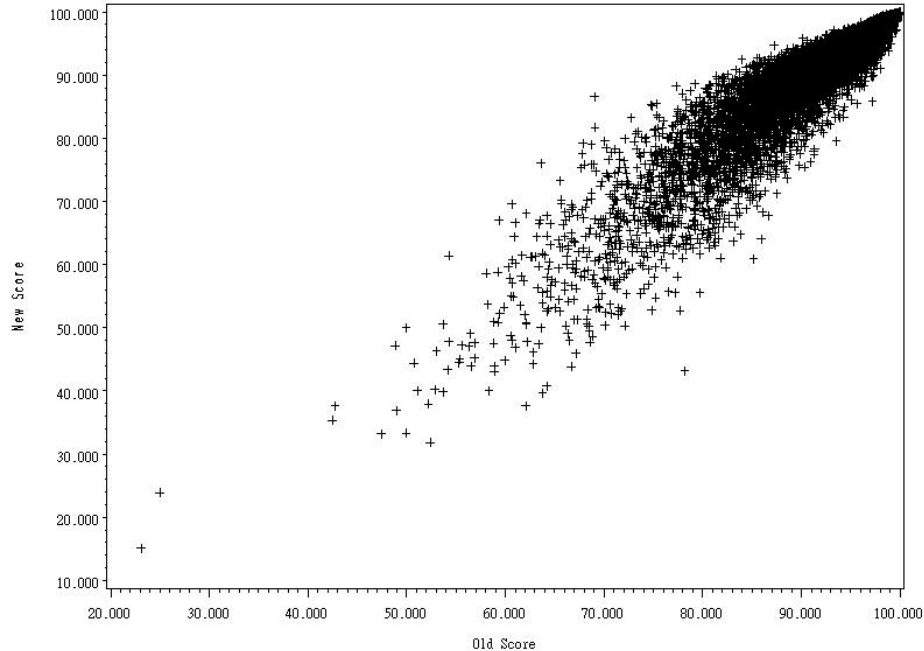
- Different length of time: daily and monthly scores
- Given airports, investigate the time trends
- Given time periods, examine the differences between airports



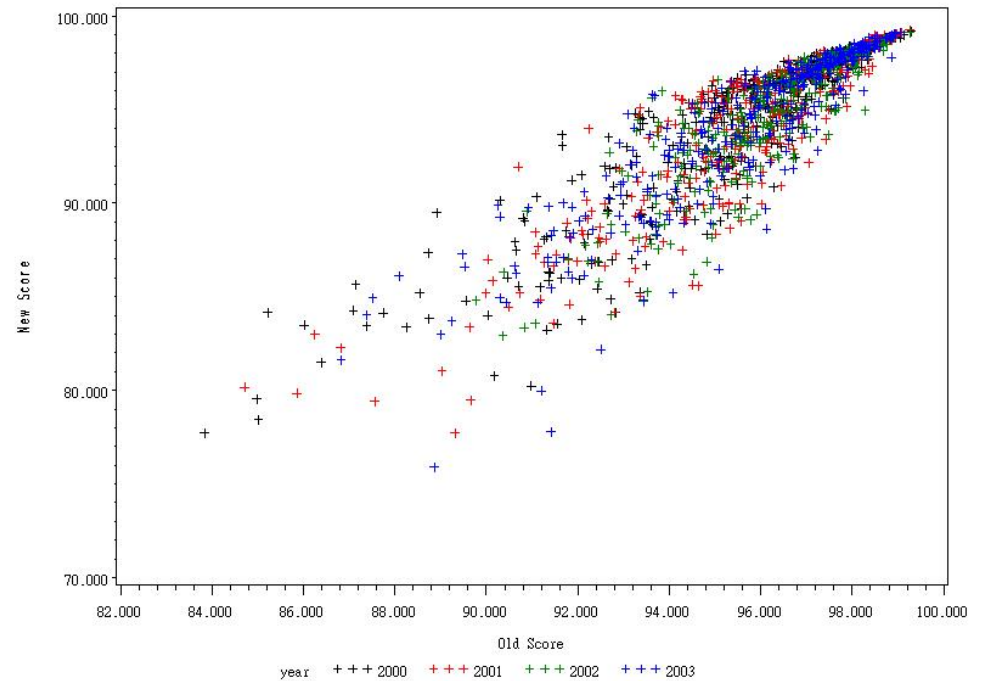
Comparisons: *existing vs. proposed scores*

- All Data:
 - Highly (positively) correlated
 - Correlation is less for low scores
 - Daily scores have higher correlation than monthly scores

All Airport Daily Score (corr. coeff=0.95)



All Airport Monthly Score (corr. coeff=0.89)

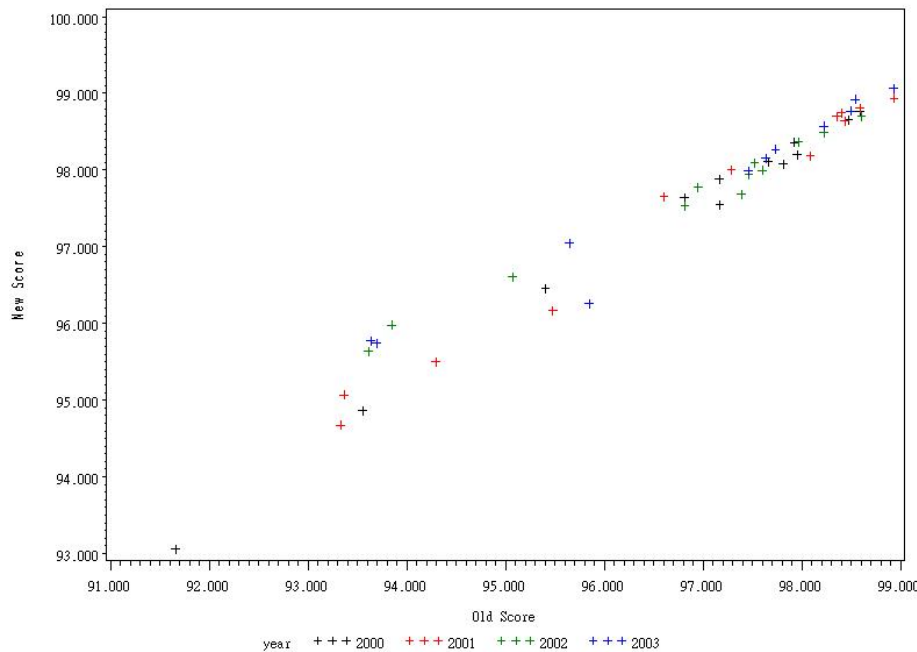




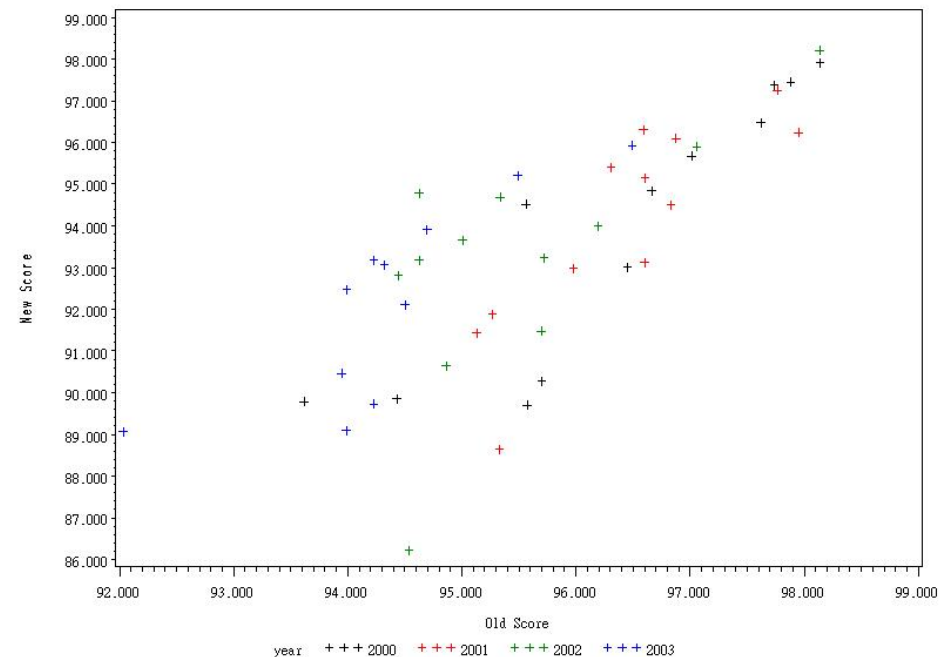
Comparisons: *existing vs. proposed scores*

- Given Airport (each point is a monthly score):
 - Positively correlated, but differences among airports
 - The proposed metrics may get lower (MSP) or higher (MCO) scores

MCO (Highest Correlation, corr. coeff=0.98)



MSP (Lowest Correlation, corr. coeff=0.78)



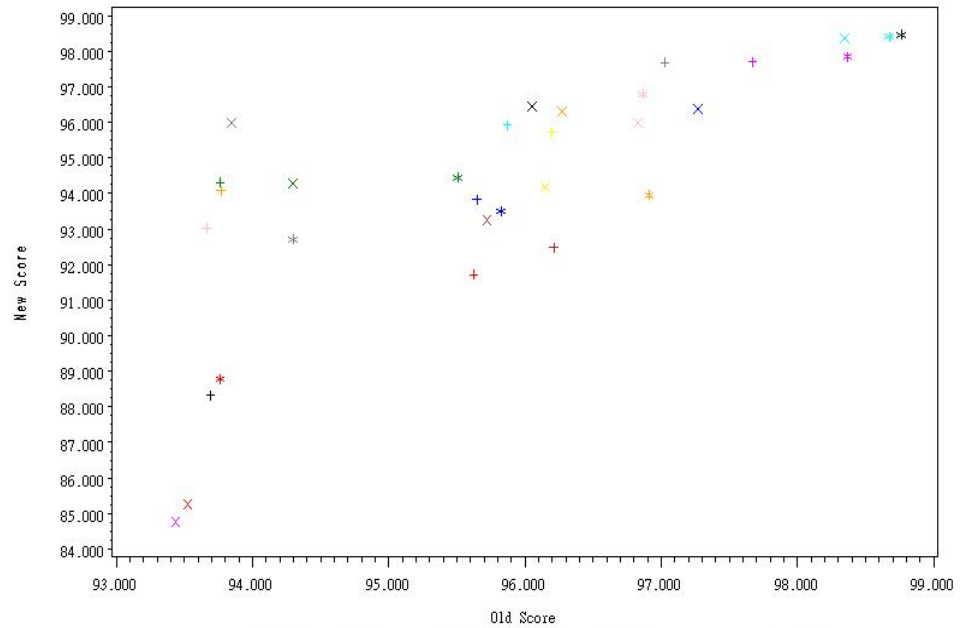
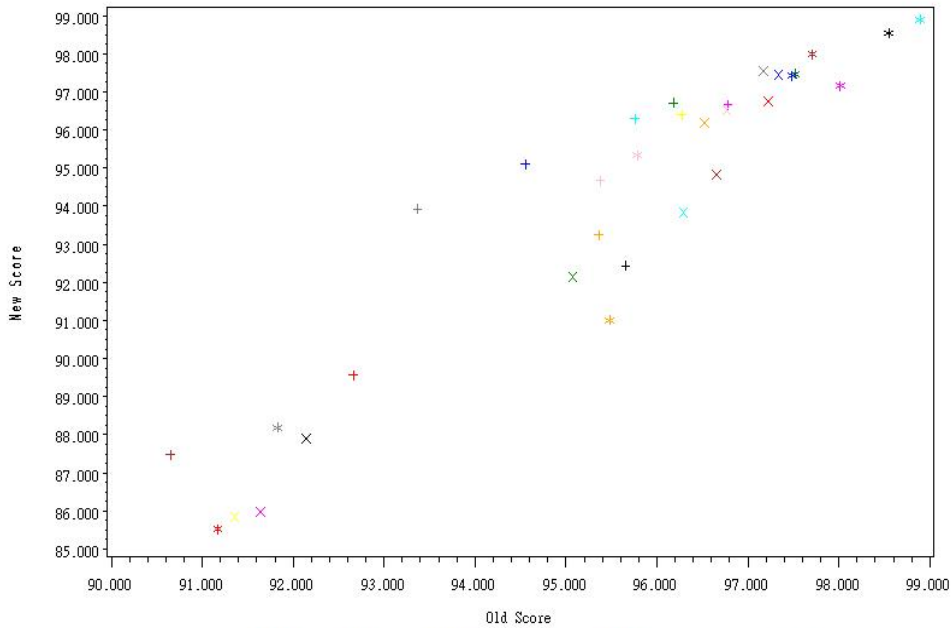


Comparisons: *existing vs. proposed scores*

- Given Time (each point is an airport monthly score):
 - Positively correlated, but differences among time periods
 - More airports get lower scores in this two periods by the proposed metrics

April 2000 (Highest Correlation, corr. coeff=0.94)

July 2002 (Lowest Correlation, corr. coeff=0.76)



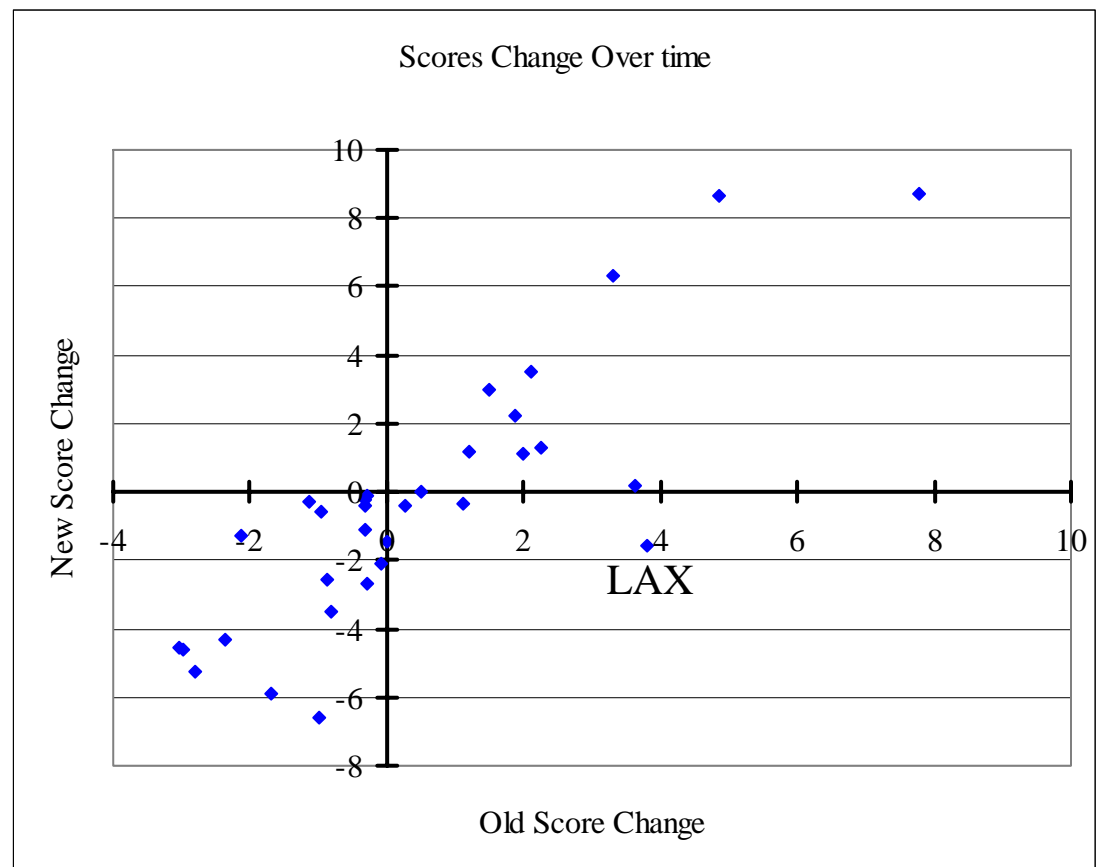
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	+++ DTW	+++ EWR	+++ FLL	+++ IAD	+++ IAH	+++ JFK	+++ LAS	+++ LAX
	+++ LGA	+++ MCO	+++ MDW	+++ MIA	+++ MSP	+++ ORD	+++ PDK	+++ PHL
	+++ PHX	+++ PIT	+++ SAN	+++ SEA	+++ SFO	+++ SLC	+++ STL	+++ TPA

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	+++ LGA	+++ MCO	+++ MDW	+++ MIA	+++ MSP	+++ ORD	+++ PDK	+++ PHL
	+++ PHX	+++ PIT	+++ SAN	+++ SEA	+++ SFO	+++ SLC	+++ STL	+++ TPA



Comparisons: *existing vs. proposed scores*

- Airports change over times (each point is an airport monthly score):
 - Scores differences between 10/2000 and 10/2003
 - For most airports the measures are consistent: (+,+) or (-,-) --better or worse
 - 4 airports inconsistent: (+,-)

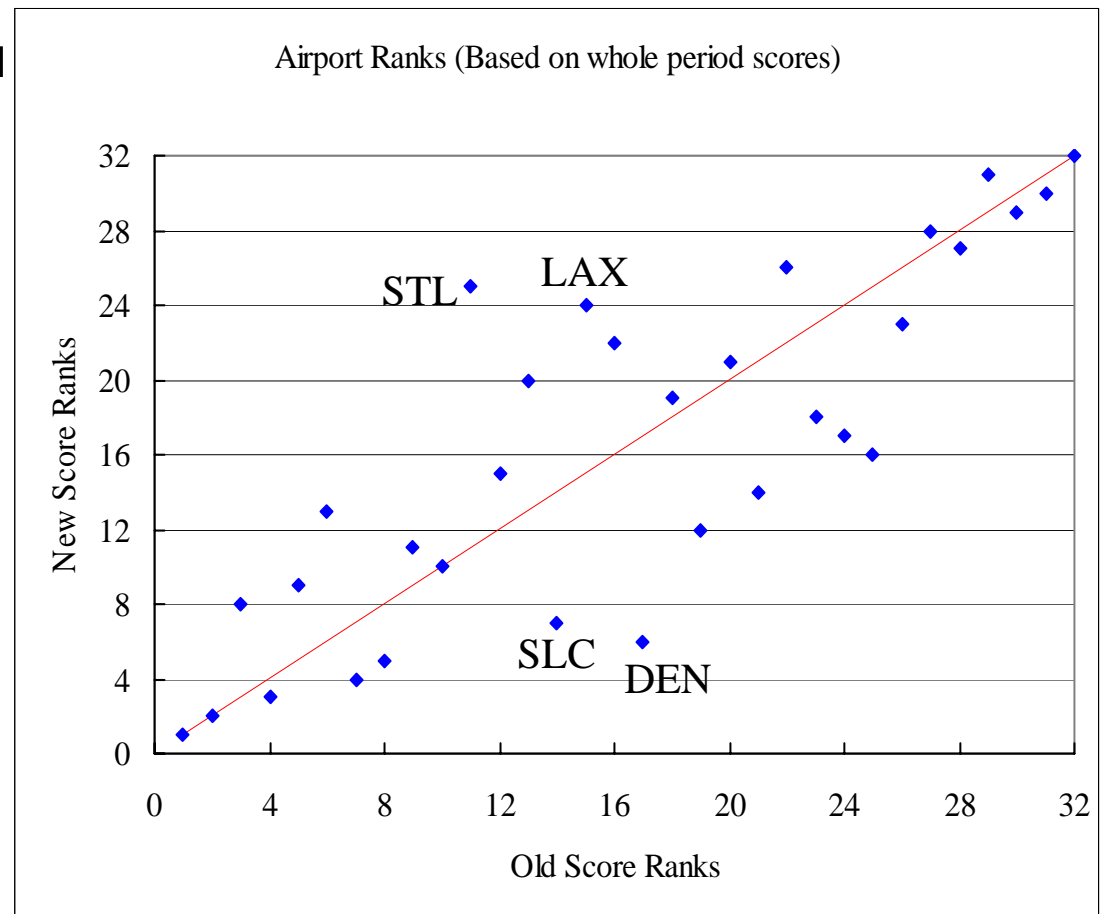




Comparisons: *existing vs. proposed scores*

☐ **Airport Ranks:** (Based on whole period scores)

- For top and bottom ranking airports, ranks are similar
- For medium ranking airports, ranks may change more





Comparisons: existing vs. proposed scores

- ❑ Correlation between Airport Traffic and Scores (All Data)
 - For the both metrics, an airport with high traffic has a little higher possibility get lower score
 - If we consider specific airport, the correlation may change to positive

Corr. Coeff.	Daily Traffic	Monthly Traffic
Old Score	-0.02	-0.17
New Score	-0.03	-0.24



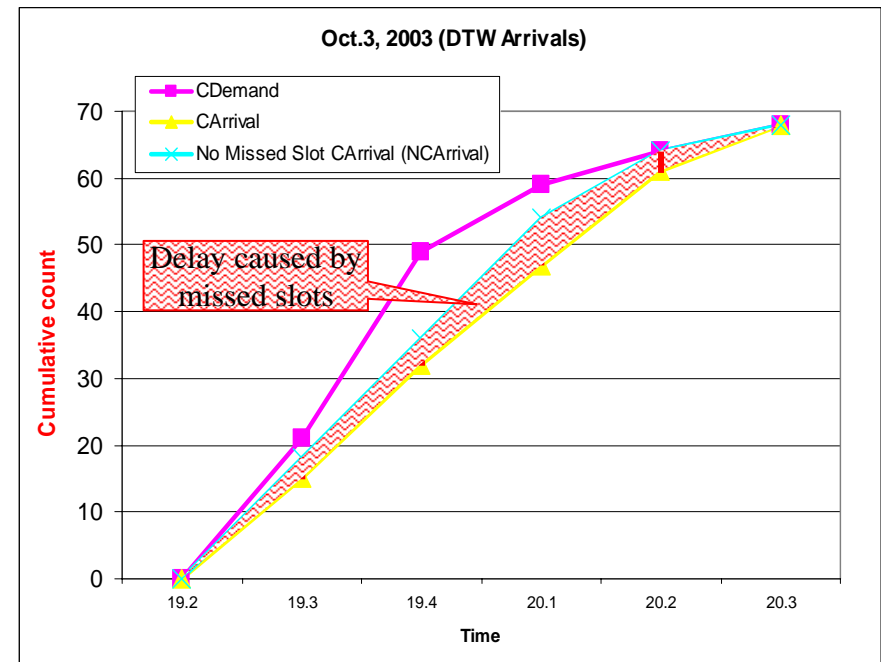
Remarks

- ❑ Alternative ways of determining marginal delay
 - One less missed slot instead of one more
 - Cases when $\text{demand} < \text{AAR}$ —missed slot may be filled or unfilled
- ❑ Utilization compensation:
 - Both metrics set utilization ≤ 1 : no credit for exceeding AAR
 - Modest proposal: don't truncate!



Remarks

- Other meaningful metrics:
 - Total Delay caused by missed slots
 - Average delay per missed slot





Questions?