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

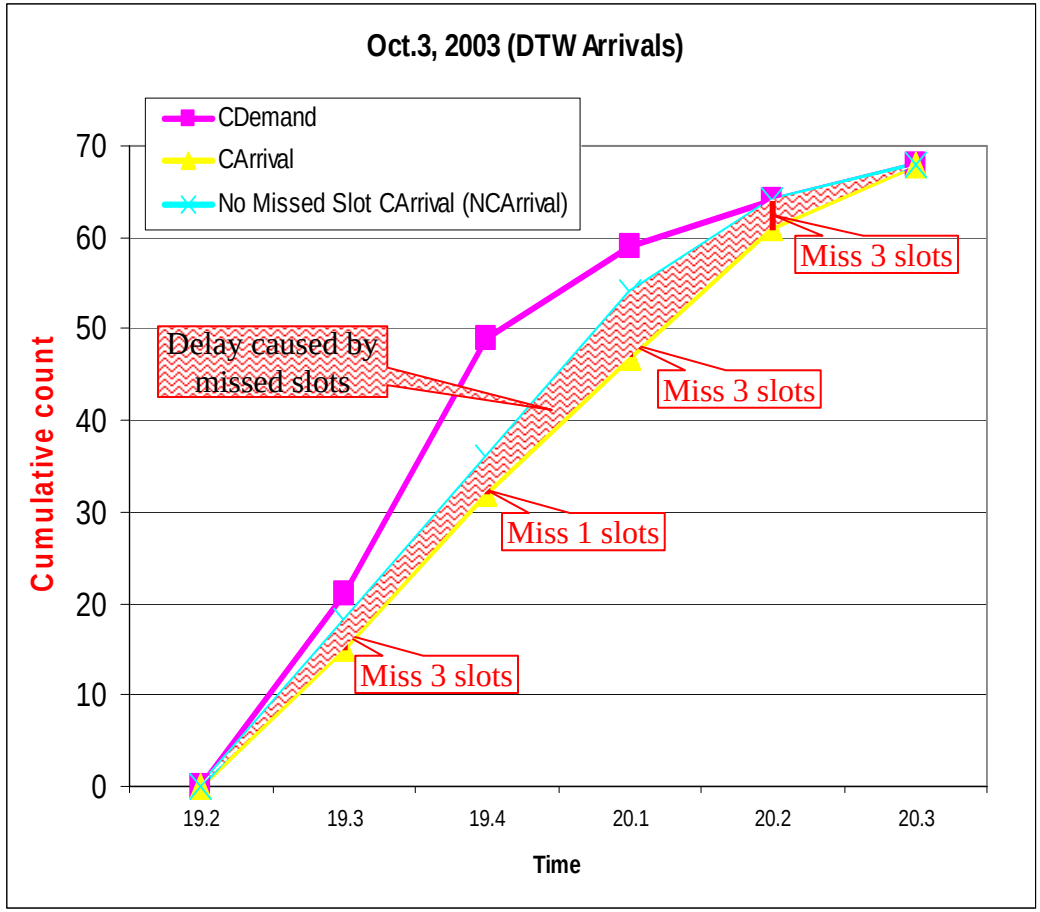
- Arrival Score Formula

$$Arrival\_Score = \frac{\sum_t Arrival\_Utilization_t * Arrival\_Demand_t}{\sum_t Arrival\_Demand_t}$$

  - 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



$$CDemand_t = CDemand_{t-1} + Arrival\_Demand_t - (CDemand_{t-1} - CArrivals_{t-1}) = CArrivals_{t-1} + Arrival\_Demand_t$$

$$CArrivals_t = CArrivals_{t-1} + Actual\_Arrival_t$$

$$NCArrival_t = Min\{CDmand_t, NCArrival_{t-1} + Min(Arrival\_Demand_t, Arrival\_Rate_t)\}$$

Existing metrics examination

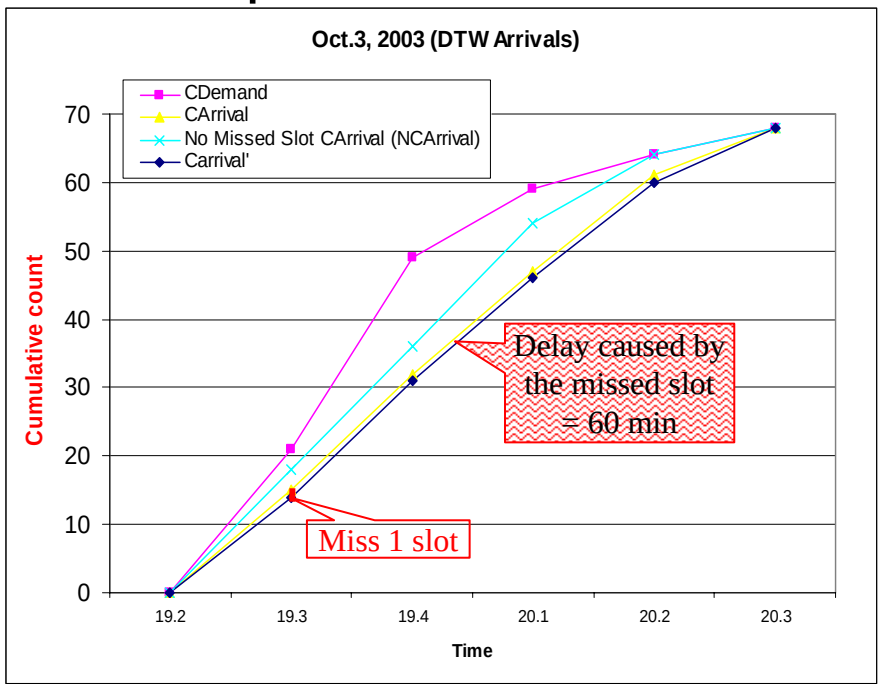
- Major Drawback: Arrival Demand may not appropriately reflect the relative importance (missed slot effects) of each period
  - Some periods, although their demands are low, are important because if we miss slots in these period there will be huge delays
  - In contrast, some high demand periods are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

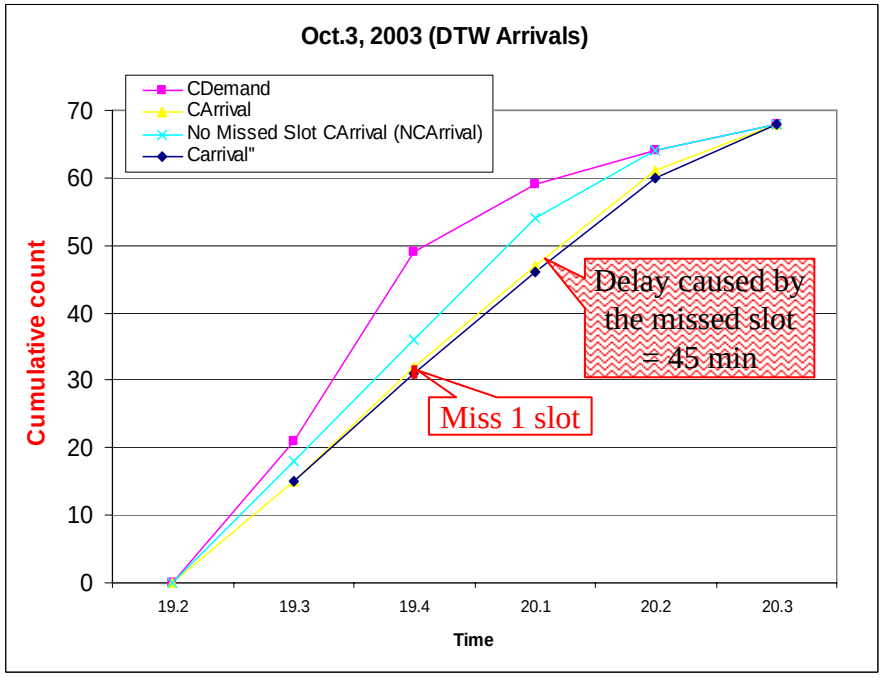
Proposed metrics

- 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	3rd qrt, 7p.m.		4th qrt, 7p.m.
Arrival Demand $_t$	21	<	34
Delay per missed slot $_t$	60	>	45

Proposed metrics

- New Arrival Score Formula

$$New\_Arrival\_Score = \frac{\sum_t Arrival\_Utilization_t * Marginal\_Delay_t}{\sum_t Marginal\_Delay_t}$$

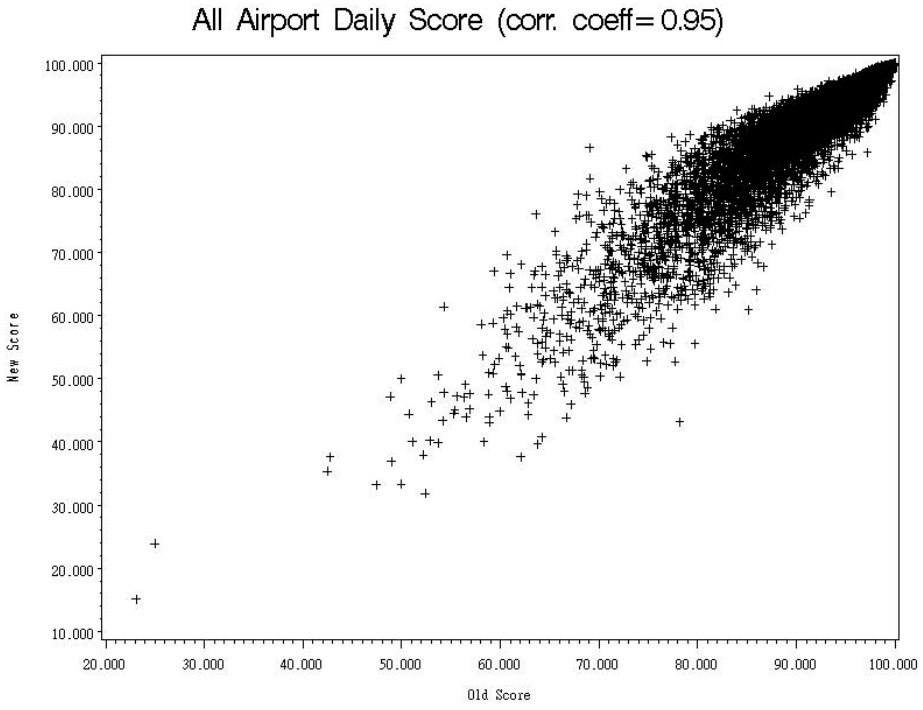
  - Utilization to capture the missed slots of each period
  - Marginal Delay to represent the relative importance (missed slot effects) of each period: It is the area between original and hypothetical (assuming one additional missed slot) cumulative arrival curves

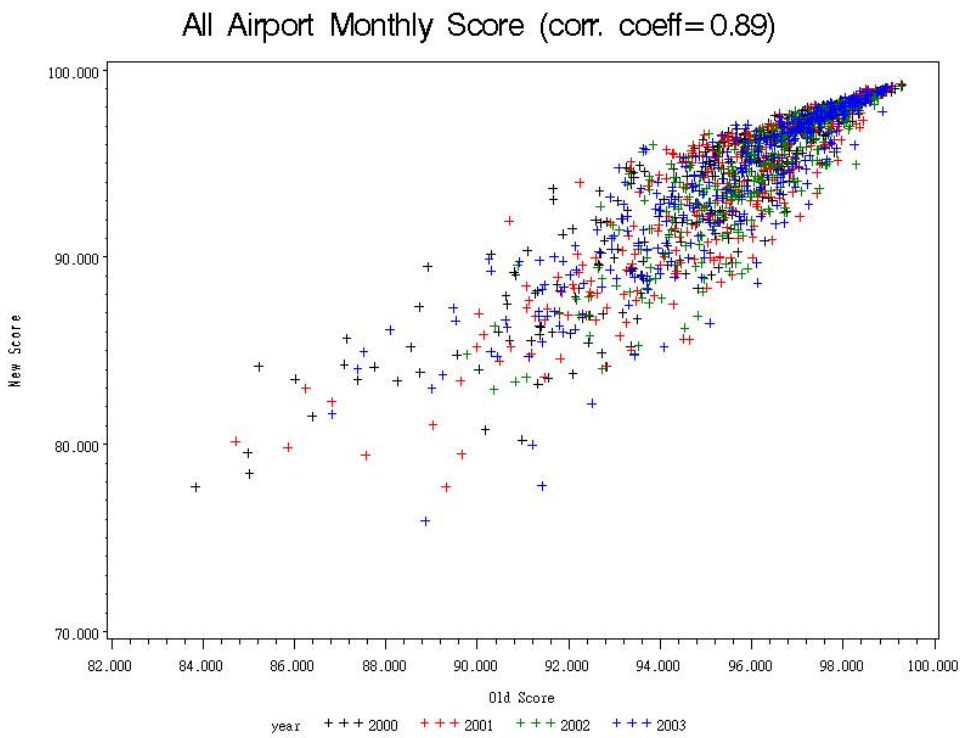
Comparisons: existing vs. proposed scores

- 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

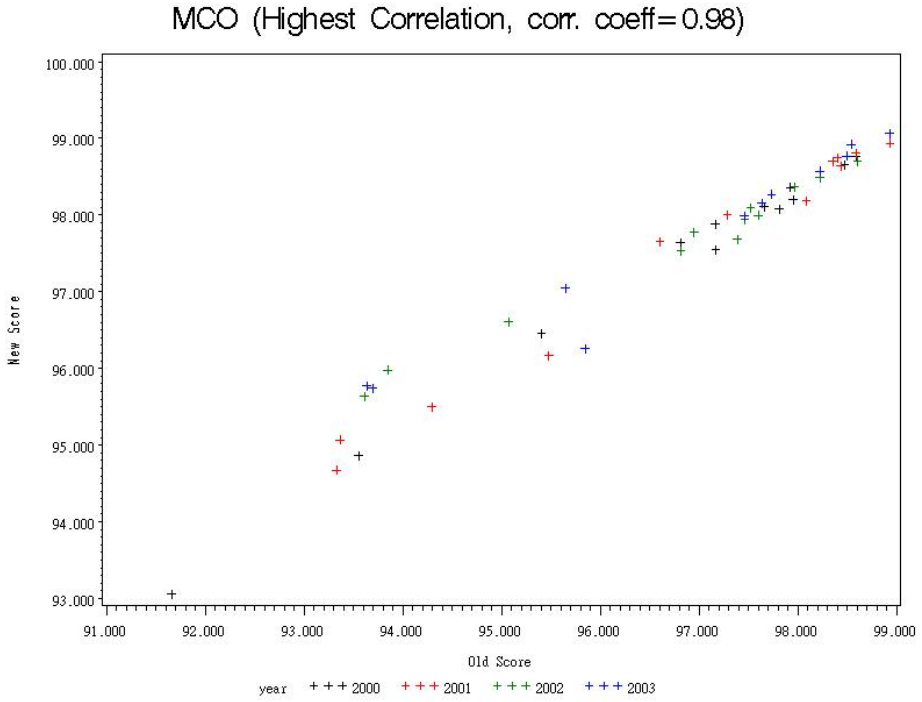
- All Data:
  - Highly (positively) correlated
  - Correlation is less for low scores
  - Daily scores have higher correlation than monthly scores

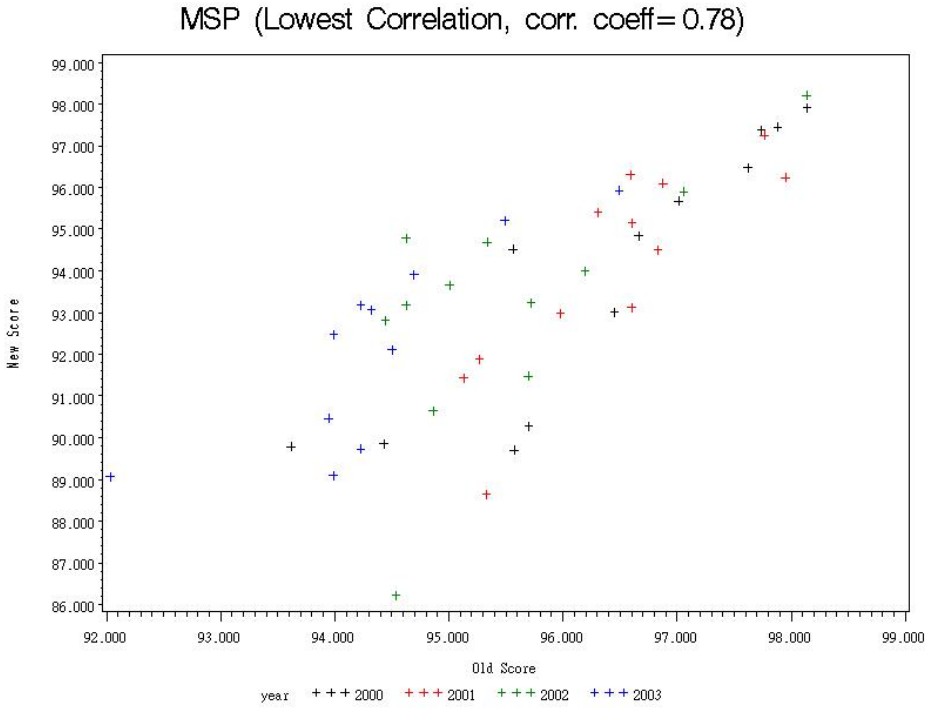




Comparisons: existing vs. proposed scores

- 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

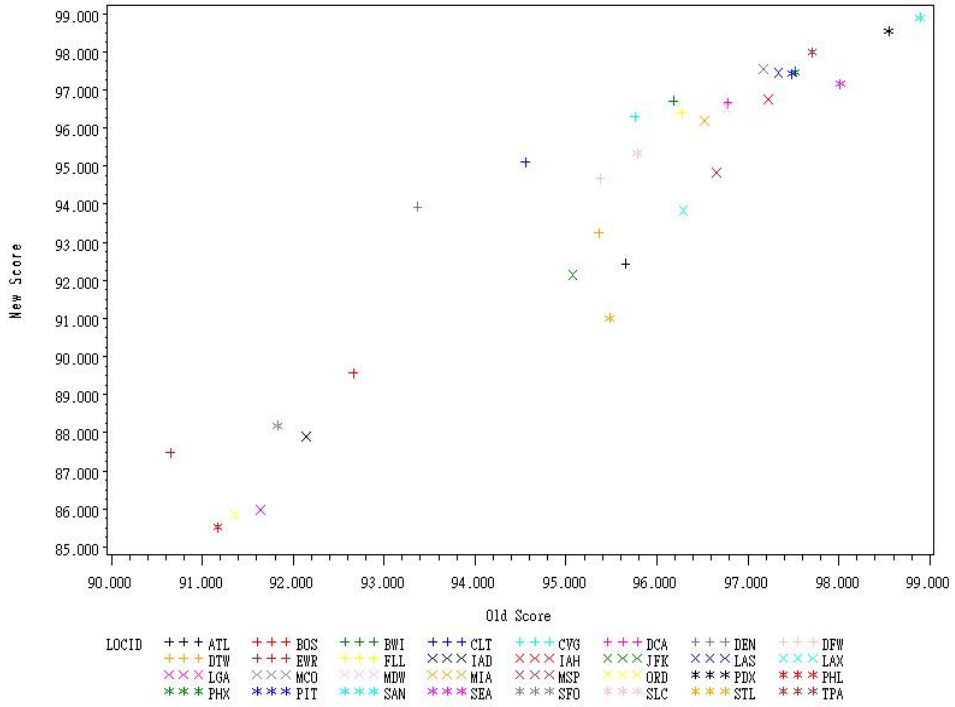




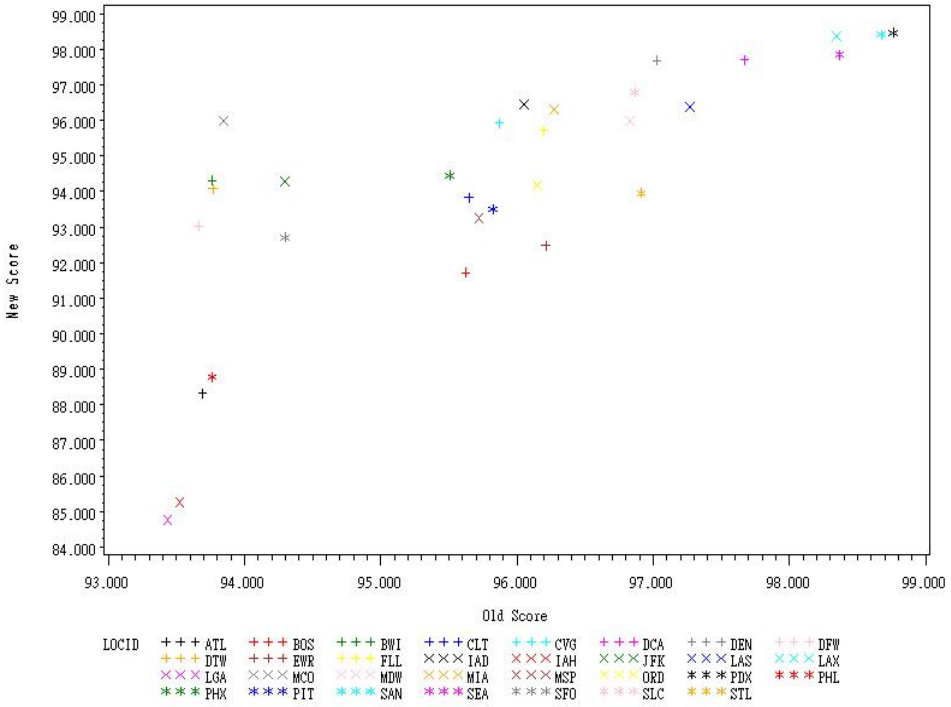
Comparisons: existing vs. proposed scores

- 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)

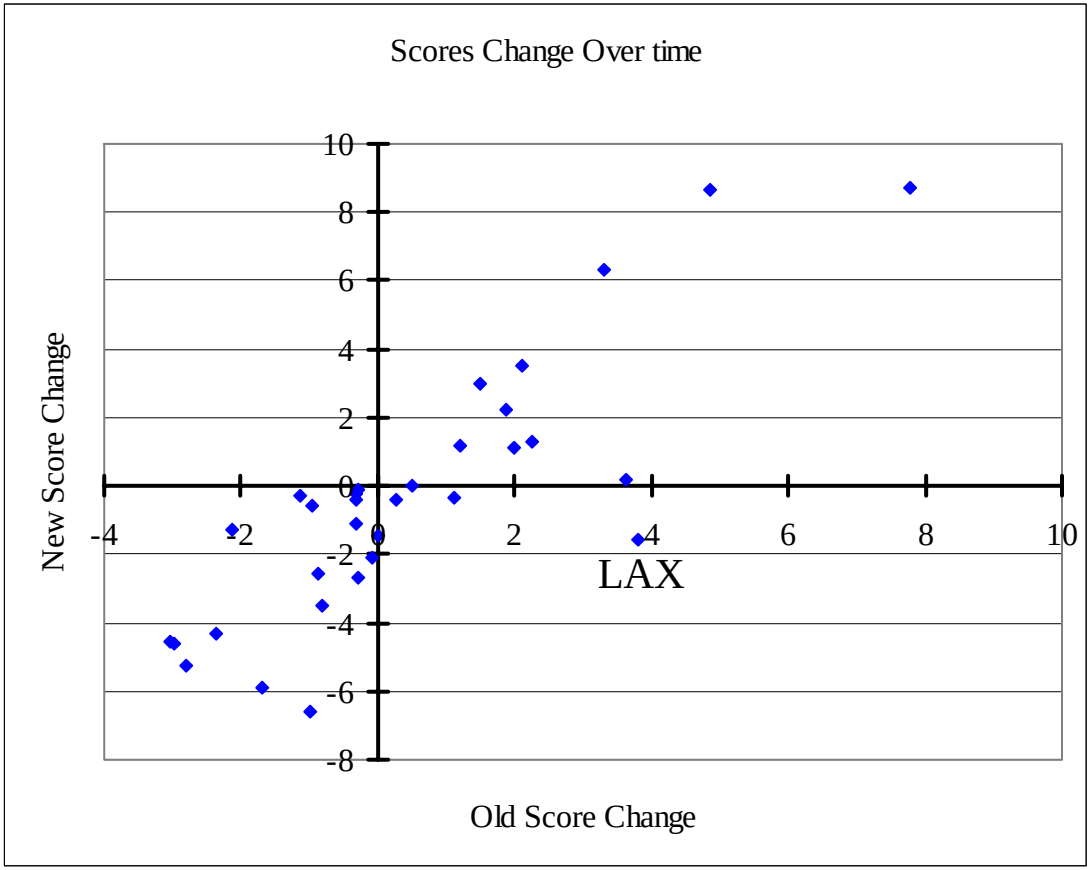


July 2002 (Lowest Correlation, corr. coeff= 0.76)



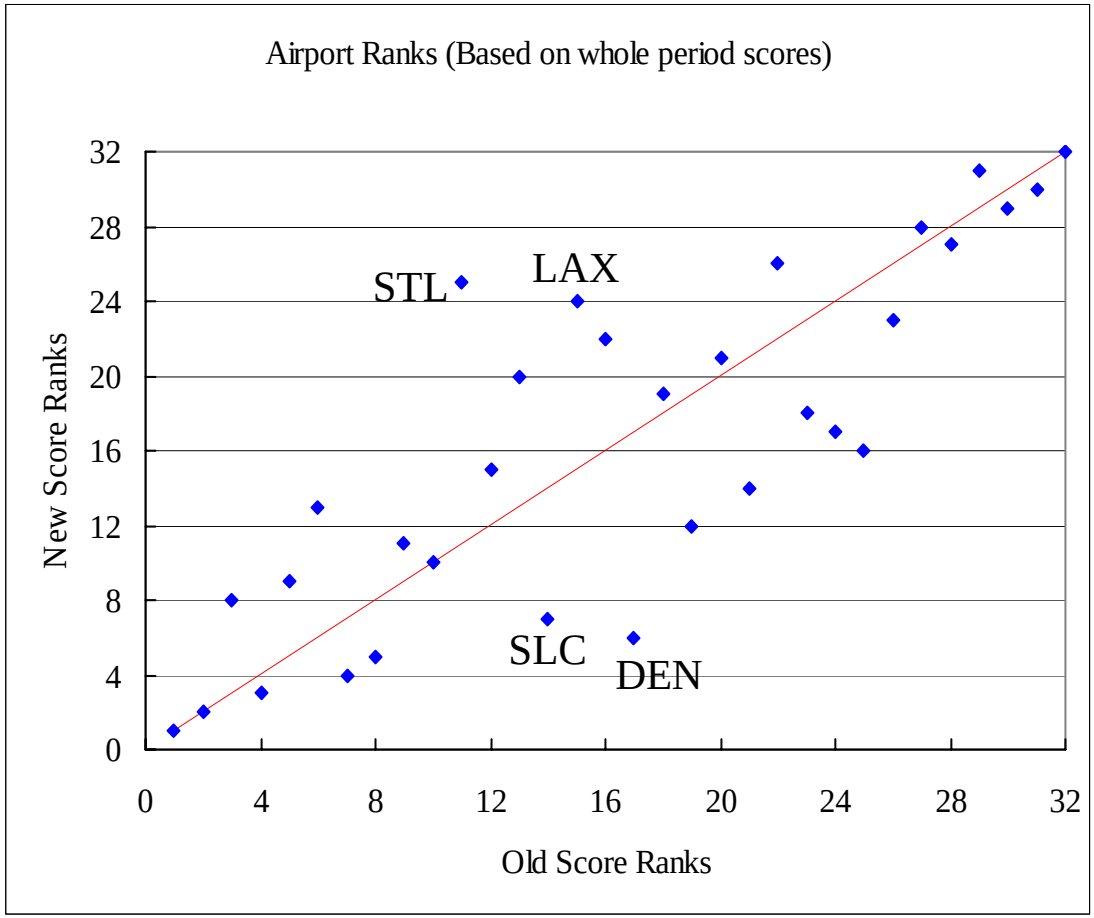
Comparisons: existing vs. proposed scores

- 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

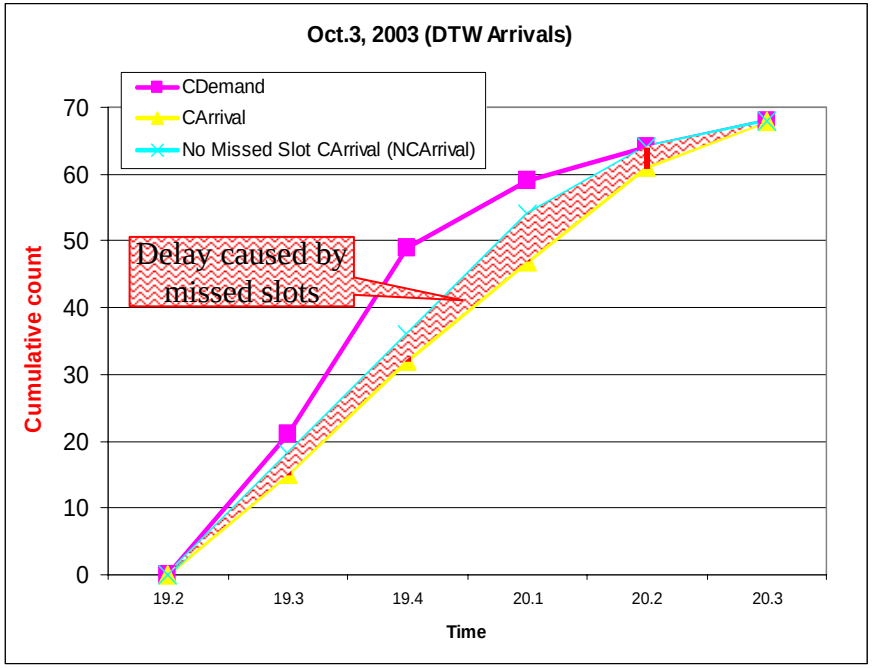
Corr. Coeff.	Daily Traffic	Monthly Traffic
Old Score	-0.02	-0.17
New Score	-0.03	-0.24

Remarks

- Alternative ways of determining marginal delay
  - One less missed slot instead of one more
  - Cases when demand<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?