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Aviation System Performance Metrics: Airport Utilization

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Table of Contents

Section	Page
1. Introduction	1-1
1.1 Scope	1-1
1.2 Background	1-1
2. Airport Utilization Metrics	2-1
2.1 Arrival Utilization	2-1
2.2 Departure Utilization	2-4
2.3 Airport Performance	2-4
3. Data Issues	3-1
3.1 Visual Flight Rules Traffic	3-1
3.2 Target Setting	3-1
3.3 Aggregation	3-1
4. Conclusions	4-1
Glossary	GL-1

List of Figures

Figure	Page
2-1. Example Arrival Utilization Over Time	2-2

Section 1

Introduction

Airport utilization metrics are a subset of Aviation System Performance Metrics (ASPM) which are currently being reported by the Federal Aviation Administration (FAA) on the Internet.¹ These airport utilization metrics were developed by MITRE's Center for Advanced Aviation System Development (CAASD), a Federally Funded Research and Development Center (FFRDC), under the sponsorship and direction of the Air Traffic Control System Command Center (ATCSCC). This paper describes how the metrics are defined and calculated, and provides example results.

1.1 Scope

The intended audience for this document includes providers of air traffic services and the users of those services. Anyone interested in ASPM should find this document useful, since it explains how the airport utilization metrics are calculated.

1.2 Background

The development of airport utilization metrics began under a project, known as the National Airspace System (NAS) Report Card that started at the request of the ATCSCC. One of the goals of the project was to find meaningful measures, beyond delays, to describe system performance. To be meaningful, the measures must incorporate the context: How well did things go considering the constraints, such as adverse weather conditions, that had to be dealt with? Further requirements were that the Report Card was to be available on a next-day basis, with minimum manual workload. The purpose of the Report Card was not to hand out a grade, but rather to flag times at which performance was either exceptional or could possibly have been improved. The Report Card was not intended to provide a complete analysis of why performance was above or below par.

The first set of measures identified for inclusion in the Report Card relates to NAS performance at airports. The aspect of performance being measured is how well an airport's arrival and departure capacity are used whenever there is demand to be met. The metrics that MITRE proposed required estimates of what capacity was available at a given airport at a given time on a given day. At an 18 August 1998 meeting at the ATCSCC with air carriers, the ATCSCC agreed to collect target airport arrival (AAR) and airport departure (ADR) rates

¹ See <http://www.apo.data.faa.gov> under the category ASPM.

from the facilities for ten selected airports² on a daily basis, with updates to the AARs and ADRs being called in when conditions changed. MITRE's airport utilization metrics evaluate actual performance using this target rate information and data collected describing actual demand, as provided by air carriers and by the Enhanced Traffic Management System (ETMS).

² The airports were: William B. Hartsfield Atlanta International Airport (ATL), General Edward Lawrence Logan International Airport (BOS), Newark International Airport (EWR), John F. Kennedy International Airport (JFK), La Guardia Airport (LGA), Chicago O'Hare Airport (ORD), Philadelphia International Airport (PHL), Phoenix Sky Harbor International Airport (PHX), San Francisco International Airport (SFO), Lambert-St. Louis International Airport (STL). The ASPM encompasses an additional eleven airports.

Section 2

Airport Utilization Metrics

System performance at an individual airport is assessed for each 15-minute time period in the day in terms of the number of arrivals and departures handled versus the airport's ability to accommodate that demand. In each 15-minute time period, overall airport performance is evaluated to take into account the need to give priority to arrivals or departures depending on the demand mix.

Arrival Utilization(t)—Assesses how well the Arrival Demand was satisfied for a given time period t , taking into account the airport's target arrival capacity in that time period.

Departure Utilization(t)—Assesses how well the Departure Demand was satisfied for a given time period, taking into account the airport's target departure capacity in that time period.

Airport Utilization(t)—Assesses how well the airport was utilized was for a given time period t , taking into account the mix of Arrival and Departure Demand.

These measurements taken over 15-minute periods are then combined to produce utilization scores for the day: one for arrival performance, one for departure performance, and one for overall airport performance.

Arrival Utilization Performance—Assesses how well the Arrival Demand was satisfied in all time periods, taking into account the airport's target arrival capacity as it varied during the day and arrival demand over the day.

Departure Utilization Performance—Assesses how well the Departure Demand was satisfied in all time periods, taking into account the airport's target departure capacity as it varied during the day and departure demand over the day.

Airport Utilization Performance—Assessment of the use of the airport's capacity over the day, taking into account the relative importance of meeting Arrival and Departure Demand in each time period.

2.1 Arrival Utilization

Arrival Utilization compares what an airport did to what it could have done. Arrival Utilization will be 100 percent when either:

- The target arrival rate is met or
- All the arrival demand is met

Since both demand and capacity may vary over time, the day is divided into 15-minute time periods and the metric is calculated for each time period. Arrival Utilization for a time period is determined by comparing the actual arrivals to the target AAR for that period, or the demand, whichever is less. If the number of actual arrivals exceeds the target, utilization is capped at 100 percent. For the utilization metrics to be meaningful, it is important to have realistic airport target rates. Giving no more than 100 percent credit represents an effort to avoid providing an incentive to set target rates too low, thus “gaming” the system.

$$\text{Arrival Utilization}_t = \min(100\%, \text{Arrivals}_t / \min(\text{Arrival Demand}_t, \text{AAR}_t))$$

Figure 2-1 shows an example chart for this metric. The three components for measuring Arrival Utilization (Demand, Actual Arrivals, Airport Arrival Rate) are shown in 15-minute intervals.

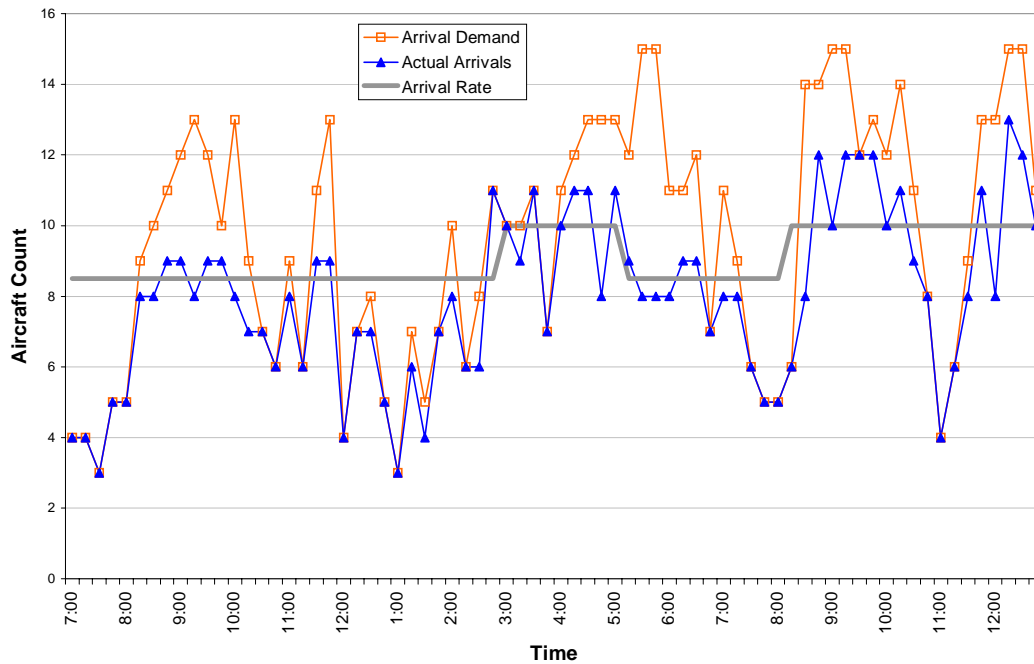


Figure 2-1. Example Arrival Utilization Over Time

Arrivals_t is defined as the number of aircraft that landed during a specified time period. ETMS data are used to calculate the number of actual arrivals. An aircraft's landing time is based on the airline-supplied "on" time, if available, otherwise the landing time is determined from the ETMS arrival (AZ) message.

Arrival Demand_t is defined as the number of aircraft that want to land within that time period. For the purposes of this calculation an aircraft is presumed to want to land starting at the estimated time of arrival (ETA) specified in its ETMS departure (DZ) message, or at its actual arrival time, whichever is earlier. That is, an aircraft's Arrival Demand period lasts from its ETA to its arrival time, except if the ETA is later than the arrival time then the demand period coincides with the arrival time. When an ETA is not available for an arrival, its actual arrival time is used to identify the time period it contributes to the Arrival Demand. Demand is generated solely by aircraft that have actually departed, not those that have merely filed flight plans.

An aircraft may contribute to Arrival Demand during more than one time period. If the ETA is 20:10 and the aircraft actually lands at 20:35, the aircraft contributes to the demand count in each of three time periods: 20:00–20:14, 20:15–20:29 and 20:30–20:44. This definition of demand means that demand is always greater than or equal to the actual number of aircraft that land in any time period. Over the day, the total of actual demand in each time period **will not** be equal to the number of actual landings, although the two curves, demand and actual, will meet when the last aircraft of the day lands.

Note the period, in Figure 2-1, from about 4:00–6:00 PM local, where demand greatly exceeds both the actual arrivals and the target rate. Such results from the utilization computations have been compared with operational data, and it has been found that periods of high-unmet demand correlate with reported airborne holding or departure delays.

The target airport arrival rate, *AAR_t* is called in by the facility to the ATCSCC at the beginning of the operational day. If conditions change, the ATCSCC is to be notified of the modified rate (if workload permits). Planned target rates can be specified for each 15-minute interval of the day. For example an airport expecting an arrival push at 5:15 PM local can specify changes in the AAR and ADR starting at that time, and then change the rates again later to reflect the need to accommodate a departure push. Planned target rates over the day do not have to be called in on a real time basis but can be specified in the initial daily coordination with the ATCSCC.

The 15-minute arrival utilization scores are combined in order to provide an overall daily arrival score. The formula used to do so is provided below.

$$\text{Arrival Utilization Performance} = \frac{\sum_t [\text{Arrival Utilization}_t * \text{Arrival Demand}_t]}{\sum_t (\text{Arrival Demand}_t)}$$

That is, Arrival Utilization in each time period is weighted by the proportion of the Arrival Demand in that time period. This weighting scheme gives emphasis to periods of high demand, making it particularly important to perform well in those periods.

2.2 Departure Utilization

The computation for Departure Utilization is similar to that of Arrival Utilization and is defined as:

$$\text{Departure Utilization}_t = \min (100\%, \text{Departures}_t / \min (\text{Departure Demand}_t, \text{ADR}_t))$$

Departure Demand_t is defined as the number of aircraft that “want to depart” in that time period. If a flight has an Estimated Departure Clearance Time (EDCT), the EDCT defines the start of the demand period. Otherwise, the start of a flight’s departure time demand period is estimated as the airline-supplied pushback (“out”) time plus an airport-dependent unimpeded taxi time. If the “out” time is not available, the proposed time (PTIME) from the Flight Plan (FZ) message plus an airport-dependent unimpeded taxi-out time is used as the start of the Departure Demand period. Finally, if the PTIME is not available, or it is later than the actual departure time, the demand period is assumed to be the actual departure time. When available, the airline-supplied “off” time is used as the actual departure time, otherwise the actual departure time is taken to be the time in the (DZ) message.

Again, individual utilization scores are combined in order to provide an overall daily departure score. The formula used to do so is provided below.

$$\text{Departure Utilization Performance} = \frac{\sum_t [\text{Departure Utilization}_t * \text{Departure Demand}_t]}{\sum_t (\text{Departure Demand}_t)}$$

As with arrivals, Departure Utilization in each period is weighted by the proportion of the Departure Demand in that time period, which emphasizes good performance at times of high demand.

2.3 Airport Performance

Both arrival and departure measures are combined to give an overall indicator of airport performance in the time period. At some airports there is an explicit tradeoff between accommodating arrivals and departures. The airport performance metric recognizes the need to give priority to arrivals during arrival pushes and departures during departure pushes. In the present formulation, the airport performance score is weighted according to the relative amount of Arrival Demand as compared to Departure Demand.

$$\text{Airport Utilization}_t = \text{Arrival Importance}_t * \text{Arrival Utilization}_t + \text{Departure Importance}_t * \text{Departure Utilization}_t$$

The relative importance, or weighting, of meeting Arrival Demand, as opposed to Departure Demand, in time period t, is calculated as:

$$\text{Arrival Importance}_t = \text{Arrival Demand}_t / (\text{Arrival Demand}_t + \text{Departure Demand}_t)$$

Similarly,

$$\text{Departure Importance}_t = \text{Departure Demand}_t / (\text{Arrival Demand}_t + \text{Departure Demand}_t).$$

Note that the sum of Arrival Importance_t and Departure Importance_t equals 1. Therefore, airport performance always lies between arrival performance and departure performance.

The airport performance score is calculated by weighting the time periods according to percentage of total demand.

$$\begin{aligned} \text{Airport Utilization Performance} = & \sum_t [\text{Airport Performance}_t * (\text{Arrival Demand}_t \\ & + \text{Departure Demand}_t)] \\ & / \sum_t (\text{Arrival Demand}_t + \text{Departure Demand}_t) \end{aligned}$$

This weighting scheme has the effect of placing the most emphasis on performance in time periods when demand is high; so that meeting the target rate in those time periods is essential for a high performance score.

Section 3

Data Issues

This section discusses some of the data issues that arise in connection with calculating the airport utilization metrics.

3.1 Visual Flight Rules Traffic

Actual and demand information is not available for some Visual Flight Rules (VFR) traffic in either ETMS or the air carrier provided data. Therefore, they will not be represented in either the demand and actual counts used to calculate utilization. If such information were made available on a next day basis, the counts of VFR traffic could be incorporated into the calculation as follows. The counts would be assigned uniformly to each of the four 15-minute periods in the hour, with the start of arrival demand coincident with the assumed arrival time, similarly the start of departure demand would coincide with the assumed departure time. This is equivalent to treating the arrivals in the same way as other arrivals that do not have an ETA and treating the departures in the same way as departures having neither a PTIME nor pushback time.

3.2 Target Setting

A question that naturally arises when looking at arrival and departure performance metrics is, since the measurement is relative to a target rate (AARs and ADRs), how realistic was the target? If the target is set too low it will be easy to reach, but the high utilization score will be less meaningful than if the rate was more representative of what the airport could actually do. On the other hand if the target rate was never met, it may have been set too high. Looking into how well the rates were set is a way of trying to assess how meaningful the performance metrics are.

A number of metrics were developed to try to flag unrealistic target rates, however none of the grading schemes has found universal acceptance. The current solution is to report each 15-minute time period in which actual arrivals or departures exceed the target rate, and by how much. This is an indicator of sustained performance in excess of the target rate, which would seem to indicate that the target has been set too low.

3.3 Aggregation

System performance is assessed over each 15-minute time period by comparing demand, capacity and operations in that time period. This time frame enables evaluation of system behavior during periods of peak demand: arrival and departure pushes typically last for no more than half an hour. The drawback to the 15-minute time period is that small inaccuracies in the data may cause the utilization to appear to be less than 100 percent when

in fact all available capacity was used. For example, suppose the arrival message is in error by 3 minutes, indicating a landing time of 11:31 instead of the true landing time of 11:28. This puts the flight into the 11:30–11:44 time bin. The Arrival Utilization chart could show a missed slot during the 11:15–11:29 time bin, when in fact since the aircraft landed at 11:28, no slots were missed. It is quite possible for this to happen when ETMS data must be used for a flight, since it is well known that AZ messages are inaccurate with respect to true landing times. This is one of the reasons why the data supplied by the air carriers plays a crucial role in enhancing the accuracy of the utilization metrics.

Section 4

Conclusions

In summary the metrics explored facilitate characterizing NAS performance on a next day basis. They are more meaningful than delay counts since they take into account the context: how well did things go considering the constraints, such as adverse weather conditions, that had to be dealt with and that affected airport capacity. These metrics can help to distinguish between satisfactory or excellent performance (high airport utilization regardless of delays) and performance that could be improved (delays occurring when the target airport arrival or departure rates are not being met).

The metrics examined have tracked well with both the ATCSCC daily logs and operations network (OPSNET) reports. That is, periods in which there were FAA-reported departure or arrival delays typically corresponded to periods in which the utilization measures showed high unmet demand. In moving towards measures such as these, rather than counting delays without considering the context, it will be important for the facilities to set realistic target rates, so that the resulting performance scores will be more meaningful. It is expected that a NAS Report Card should facilitate discussions between the ATCSCC and other FAA facilities or users when assessing system performance by providing objective measures.

The utilization metrics developed for the NAS Report Card represent an important first step towards evaluating the performance of the NAS in the context of what was possible given the constraints. It is anticipated that additional metrics will be defined and quantified to aid in the FAA's on-going process of seeking to improve NAS performance.

Glossary

AAR	Airport Arrival Rate
ADR	Airport Departure Rate
ASPM	Aviation System Performance Metrics
ATCSCC	Air Traffic Control System Command Center
ATL	William B. Hartsfield Atlanta International Airport
AZ	Arrival Message
BOS	General Edward Lawrence Logan International Airport
CAASD	The MITRE's Center for Advanced Aviation System Development
DZ	Departure Message
EDCT	Estimated Departure Clearance Time
ETA	Estimated Time of Arrival
ETMS	Enhanced Traffic Management System
EWR	Newark International Airport
FAA	Federal Aviation Administration
FFRDC	Federally Funded Research and Development Center
FZ	Flight Plan Message
JFK	John F. Kennedy International Airport
LGA	La Guardia Airport
NAS	National Airspace System
OPSNET	Operations Network
ORD	Chicago O'Hare Airport
PHL	Philadelphia International Airport
PHX	Phoenix Sky Harbor International Airport
PTIME	Proposed Time
SFO	San Francisco International Airport
STL	Lambert-St. Louis International Airport

VFR

Visual Flight Rules

