AIRLINE METRIC CONCEPTS FOR EVALUATING AIR TRAFFIC SERVICE PERFORMANCE

Report of the

Air Traffic Services Performance Focus Group (ATSP FG)

CNS/ATM Focused Team (C/AFT)

February 1, 1999

Executive Summary

The Communication Navigation Surveillance/Air Traffic Management Focused Team (C/AFT) formed the Focus Group (FG) on Air Traffic Service Performance (ATSP) to facilitate global *airline* consensus on the basis for evaluating the quality of Air Traffic Services (ATS). Within this framework, ATS performance metrics fulfill several important functions. First, they define the elements of value to the scheduled airline business. Second, they form a basis for assessing and monitoring the services provided by the ATM system. Finally, they can become the common criteria for developing economic models needed to predict benefits, and help make decisions when evaluating CNS/ATM alternatives.

Because this report represents the work of the ATSP FG, its basic definition of value is related to how the ATM system impacts the *airlines'* ability to plan and operate their schedules. Each metric concept is described within the context of how well it allows airlines to most effectively use their capital assets and manpower resources to produce their primary product, the flight schedule. This report has categorized metrics into the following basic categories of performance objectives that define air traffic service (ATS) quality.

1. Delay
2. Predictability
3. Flexibility
4. Efficiency
5. Access
6. Cost of Service

Since the term *value* is used to represent the balance between the quality of air traffic services and its cost, all metrics that attempt to evaluate ATS performance within the first five categories must ultimately include the *Cost of Service* metric (ATS charges <u>and</u> airline costs) as their final denominator. This report defines these five categories using high-level, conceptual metric examples, and attempts to describe the fundamental interrelationships between them.[1]

Delay has traditionally been used as the most direct measure of ATS performance. However, measuring delay against scheduled times in a congested system has become much less meaningful over time, because so much expected delay is built into the airlines' block times to maintain operating integrity. Conceptually, delays should be measured by comparing actual flight times against baselined optimum times, not scheduled times, in order to assess overall ATM system performance.

Predictability is a measure of delay variance against a performance dependability target. As the variance of expected delay increases, it becomes a very serious concern for airlines when developing and operating their schedules. Conceptually, predictability metrics should be a comparison of the actual flight time to the scheduled flight time, since the scheduled time includes the amount of expected delay at a targeted dependability performance.

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[1] To determine the true value to airlines, it is necessary to investigate *Cost of Service* to include costs incurred by the ATS provider (i.e. FAA, Eurocontrol, etc.) in delivering the various ATS products and services. Although beyond the scope of this initial report, it is considered an essential focus for follow-on ATSP FG activities.

Flexibility is used by airlines to make tactical “trade-off” decisions in operating their schedule, thereby permitting them to exploit operational opportunities as they occur, such as obtaining more favorable routes, or minimizing customer impact from unplanned capacity-constraining events such as severe weather. Conceptually, flexibility metrics should address how well the ATM system allows airlines to make better operating decisions dynamically.

Efficiency addresses the single-flight perspective. Its value rests in reducing direct operating costs by optimizing flight path trajectory and by eliminating excess flight time, route distance, and fuel usage at non-optimum speeds and altitudes. Since airlines fly millions of single operations per year, small incremental savings of direct operating costs on every flight can add up to significantly improved financial performance. Conceptually, efficiency metrics should compare the planned or actual flight path trajectory to an optimum baseline.

Access to ATS services such as airports or airspace can increase value to all of the above-mentioned performance objectives. As with trajectory efficiency, most of the access value is gaining usage of large blocks of airspace that may be inaccessible to commercial operations due to lack of ATS services or national security requirements. Most of this value would be gained if availability is known when the airline is developing the operating schedule and making resource plans several months in advance. Conceptually, access metrics should take into account the ability to fly through a normally restricted area and how much advance notice of its availability is provided.

From the airline perspective, all ATM service and productivity issues eventually emerge as a *cost of service* to the airline user, whether in the form of ticket taxes, airport landing fees, passenger facility charges, or route charges. Airlines become extremely concerned when ATS costs escalate without a corresponding improvement in service quality or performance. Therefore, the cost of service to airlines must always be considered when evaluating any proposal to improve ATM service quality or performance.

It is also important to understand that the economic value to airlines of decisions based on predicted ATS performance varies with the timeliness of the information, with the greatest value derived from the most advanced notice. The relative value and priority of any performance objective will vary with time and is different for every airline. Typically, airline business planning and operations management are considered separate processes, with business planning decisions driven by yield management (market and price elasticity), and operating decisions driven by schedule integrity and cost. But at a higher-level, the total value of ATS performance metrics is actually driven by its usefulness to both the airline business planning *and* operating decision processes.

In conducting its review, the ATS Performance Focus Group compiled a consolidated list of metrics from those that are now being collected by the various airport and airspace users and ATS providers throughout the world. These metrics included those collected by the Air Transport Association (ATA), International Air Transport Association (IATA), Federal Aviation Administration (FAA), European Organisation for the Safety of Air Navigation (Eurocontrol), and the Civil Air Navigation Services Organization (CANSO). All metrics were collected, evaluated, classified, and mapped into the air traffic service quality and performance objectives, and appended to this report.

Finally, the ATSP FG recommends that the ATS service providers embrace the concepts described by this report, incorporate them into the processes used to evaluate and improve the quality of services delivered, and use these concepts to help support its investment decisions. The ATS service providers should seek airline community involvement to promote the vital dialogue and information exchange needed to achieve a mutual understanding and consensus on these issues.

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Focus Group Lead
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Report of the Air Traffic Services Performance Focus Group
CNS/ATM Focused Team

1. Purpose and Perspective

The Communication Navigation Surveillance/Air Traffic Management Focused Team (C/AFT) was formed in 1996 to facilitate progress on CNS/ATM implementation issues by developing global airline economic consensus. Such consensus is difficult to achieve unless there is also agreement on metrics that describe the basis for assessing the economic benefits driven by newly proposed CNS/ATM technologies. To that end, the C/AFT's Focus Group on Air Traffic Service Performance (ATSP FG) was formed to develop principles for evaluating the performance of the ATM system from the airline perspective, with three main objectives:

- Define what is important to the scheduled airline business.
- Form the conceptual basis for assessing and monitoring ATM services.
- Develop probabilistic economic models for defining predicted benefits of new technologies to help make decisions among CNS/ATM alternatives.

The airline business is characterized by high rates of cash flow and narrow profit margins, with typical returns on revenue averaging only a few percent. These financial results are driven primarily by the high costs associated with a highly capitalized structure (aircraft, airport facilities, and ramp equipment), labor-intensive services (unionized, skilled workforce), perishable inventory (scheduled service), and substantial fuel consumption. When the United States deregulated its airline industry in 1978, competition forced the airlines to reduce their costs to survive. The surviving airlines formed complex, networked route systems through hub-and-spoke design, corporate consolidation, code-sharing, and/or alliances to leverage their costs. They also developed sophisticated revenue management systems to maximize their margins. Today, airlines compete vigorously through optimizing deployment of their capital assets and resources to produce the highest quality product (scheduled available seat-mile) for the lowest cost.

2. The Value of ATS Performance

In general, the value of the Air Traffic Management (ATM) system is manifested in its relationship to the airlines' main product, the flight schedule. Measuring the value of ATS performance should therefore be related to how the ATM system impacts the airlines' ability to plan and operate their schedules. Each metric should be evaluated within the context of how well it allows airlines to manage their tightly networked assets and resources most effectively. Fundamentally, the term *value* represents the balance between service quality and cost. If *value* is being measured, the quality of ATM services cannot be considered separate from the cost to the user.

Depending on economic conditions, market demand for air travel is reasonably elastic, where pricing and demand have a negative exponential relationship. Lower prices can dramatically stimulate market demand, which improve revenue/cost margins primarily through higher load factors. On the other hand, higher prices have an equally dramatic effect in the opposite way.

The delicate equilibrium of cost and efficiency is of critical importance to the airlines' ability to survive in the long term on such narrow returns on revenue. This is the primary reason that airlines become so concerned when ATS charges and related costs increase without a balanced magnitude of efficiency improvement. With the growing effects of airport and airspace congestion, the industry is looking to ATS performance metrics to help assess and monitor how the ATM system can help maintain this equilibrium.

3. ATS Service Quality Performance Objectives

To be more effective in analyzing today's complex operating environment, metrics must define the *outcome* of air traffic services as a *service quality* issue. ATS performance metrics must address airline economic concerns well beyond the single flight perspective, by focusing on higher level outcomes. These outcome metrics can be effectively defined within the following categories of ATS service quality and performance objectives.

1. Delay
2. Predictability
3. Flexibility
4. Efficiency
5. Access
6. Cost of Service

These performance categories are described below, each with a high-level conceptual metric example. The purpose of the metric example included in each category is to serve only as a conceptual starting point when developing future metrics or evaluating current metrics that are listed in the Consolidated Metrics Table appended to this report.

3.1 Delay

Traditionally, delay has been used as the most direct measure of ATS performance. However, measuring delay against the *scheduled* time in a congested system becomes less valid because so much expected delay is built-in to the airlines' block times to maintain operational integrity.

Logistics Management Institute (LMI) used recent data to estimate how airline schedules have changed over a four-year period. Based on the published OAG for April 1993 and April 1997, LMI found that scheduled block time for flights among the 29 hub airports in the U.S. increased by 1.25 minutes over this four year period, as shown in Figure 1 below. If the spacious new Denver airport, which opened in 1995, is excluded from the analysis, the average increase climbs to 1.61 minutes. The large impact of the new Denver airport indicates the significant impact of capacity improvements, and their ripple effects throughout the system.

The aggregate data mask some more significant effects at individual airports. At Atlanta Hartsfield International Airport (ATL), for example, scheduled block times for departures increased 3.28 minutes. The increase at DFW was even greater, at 4.71 minutes. (The numbers for ATL and DFW exclude flights to and from DEN.) The cost to airlines and travelers of such increases is substantial. At DFW, for example, with about 450,000 scheduled departures in 1997, a cost of $40/block minute implies a cost increase of about $85 million over the four years in direct operating costs (DOC) alone.

The potential lost revenue from operational constraints and reduced aircraft and personnel productivity are likely to be at least as large as the direct cost increases. Using the DFW schedule increases as an example, if the airlines operating there could use those 4.71 minutes per flight to generate revenue, the result would be about $160 million.[2] While it is highly unlikely that all of that time could be used productively, at least some percentage could be used to carry passengers and generate revenue.

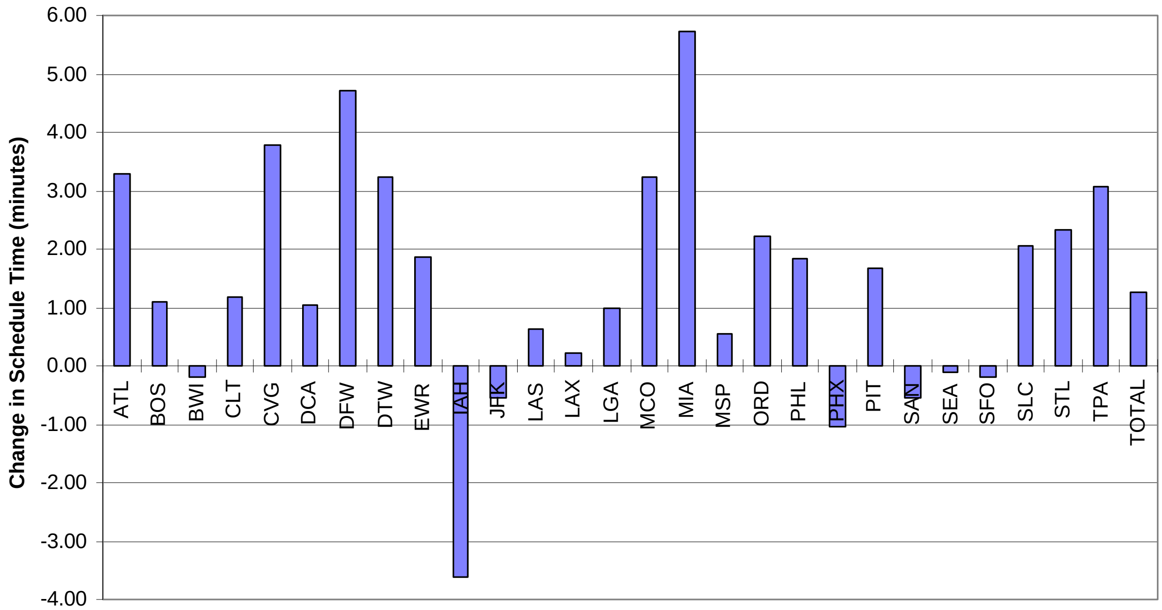

Figure 1. Trends in Scheduled Flight Time (April 1993 to April 1997)

As a result, C/AFT recommends that delays be measured against *optimum time*, not scheduled time, in order to assess overall ATM system performance. C/AFT defines *optimum time* as a time baseline that is *not based on schedule*. Development of a baseline optimum metric must include assumptions of basic performance constraints (i.e. runway occupancy time).

Concept Delay Metric: Actual Flight Time / Optimum (Non-Schedule Baseline) Flight Time

The *value* of delay has traditionally been evaluated using fixed direct operating costs per minute per single event. A more accurate measurement of delay value would include schedule sensitivities, such as impact of how that delay propagates throughout the system, duration, and time-of-day. This assessment could use average multipliers to account for the downline impact beyond the direct operating costs associated with a single delay event. For example, a 60-minute delay at the beginning of the day costs the airlines more than a 60-minute delay at the end of the day. Figure 2 below shows the significance of downline impact of initial delays during different times-of-day.

[2] Based on 450,000 departures per year, an average flight time of 142 minutes, and $10,661 in revenue per flight.

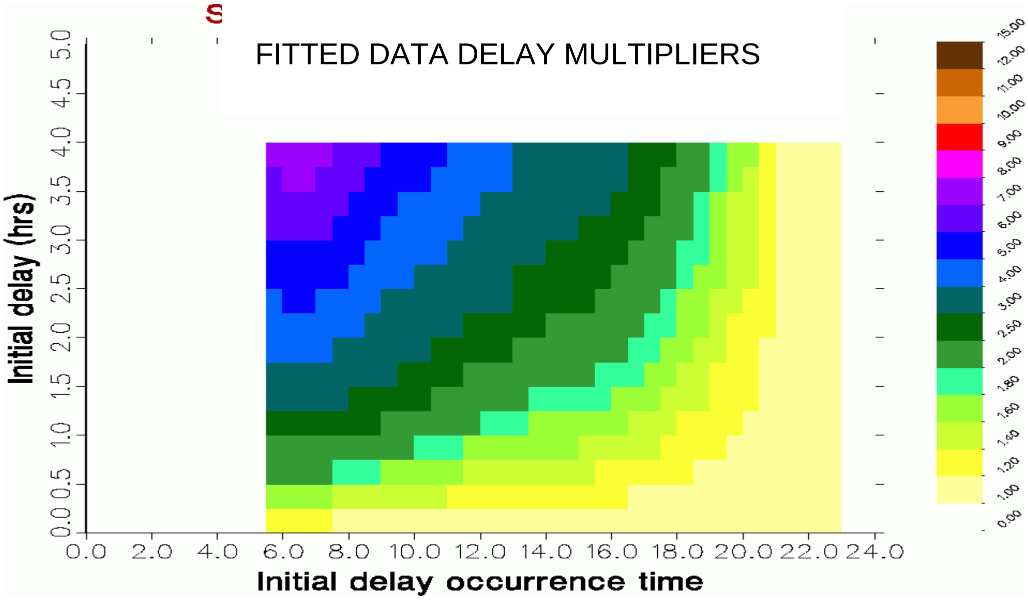

Figure 2. Schedule Sensitivity to Delay Duration and Time-of-Day[3]

3.2 Predictability

Predictability is a measure of delay variance against a performance dependability target. It is a function of the variance in operations as measured across days and weeks and across days and flights and is thus, an across-time measure. As variance against the expected delay increases, it becomes a very serious concern when developing the airline schedule.

The product that an airline offers to its customers is its *flight schedule*. It represents the airline's commitment of nearly all of its capital assets and manpower resources to serve the demand for travel and to generate revenue. This includes not only the aircraft required to fly the schedule, but also the staff and facilities necessary to operate the flights, to maintain the aircraft, and serve its customers. It is therefore critically important for airlines to be able to operate their schedules predictably for a number of reasons:

- Productivity: Schedules incorporate time beyond the minimum required flight times and turn-around times, since unforeseen events occur and flights simply cannot be expected to operate precisely according to schedules, even on the best of days. However, stretching schedules to accommodate this uncertainty to achieve adequate on-time performance lowers productivity -- more aircraft and staff are required to operate the schedule.

- Contingency Requirements: After developing schedules that can be completed reliably on most days, airlines often allocate extra crews, aircraft, and gates, to mitigate the impact of uncertainty -- the lower the predictability, the greater the need for such contingent resources in order to ensure that the schedule can be delivered.

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[3] "Preliminary Evaluation of Flight Delay Propagation Through and Airline Schedule"; Roger Beatty (Americqan Airlines), Rose Hsu (American Airlines), Lee Berry (Oak Ridge National Laboratory), and James Rome (Oak Ridge National Laboratory); Produced for the FAA Collaborative Decision Making Analysis Working Group, 1998.

- Schedule Completion: Airlines operate complex, overlapping networks of interdependent schedules -- flight schedules, crew schedules, maintenance schedules, and passenger/baggage connections, to name but a few. Such schedules can be planned to operate reliably as long as events unfold roughly as expected. However, lower predictability can very quickly destroy the ability to meet these schedules, thus resulting in misplaced aircraft and crews, canceled flights, and missed connections.

These consequences of the variance in delays can be *substantial*. They impact the fundamental ability of the airline to operate its schedule, and thus, to generate revenue. They also impact costs to the airlines in significant ways. Predictability metrics should address how well the ATS system delivers what is expected (in terms of the schedule).

Concept Predictability Metric: Actual Flight Time / Scheduled Flight Time

In this example, predictability is measured by comparing the *actual* flight time to the *scheduled* flight time, since the scheduled time includes the amount of expected delay at a given performance dependability target. Improved predictability can reduce operating costs, such as ramp crew and equipment utilization, and planned block time variance.

The value of predictability is primarily driven by the costs associated with complex networked systems that are highly dependent on size and number of support facilities. Airline operating costs are very sensitive to the utilization of fixed cost assets. Because airline network systems create peaking resource requirements, unpredictability can drive a need for excessive resources.

Because the most value from predictability can be realized during the airline schedule planning process, these metrics are most useful 60-90 days before the scheduled operation. Airlines usually plan aircraft schedules and network interdependencies by including unpredictable delays caused by weather, traffic congestion, and ATS flow control in their block times to assure network integrity. Lower predictability causes increased costs associated with ground facility usage and manpower.

After departure, use of arrival predictability information could continue to have value. For example, if the pilot could depend on the accuracy of a projected landing time, value may be potentially derived by avoiding a number of low-fuel diversions. The results in Figure 3 show the improvement in arrival predictability as a result of using an automated arrival traffic flow management tool, such as the Center TRACON Automation System (CTAS), to help meter traffic into the Terminal Maneuvering Area (TMA) and sequence the traffic for landing.

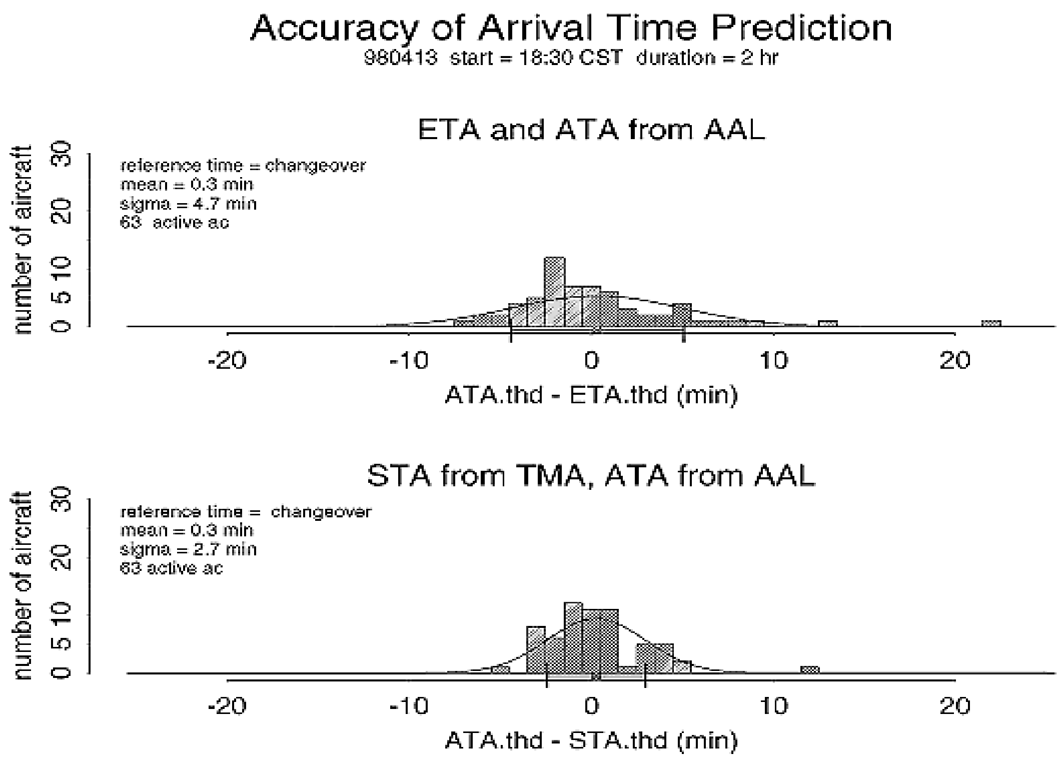

Figure 3. Arrival Time Predictability Improvement

3.3 Flexibility

Flexibility is used by airlines to make tactical "trade-off" decisions, thereby permitting them to exploit operational opportunities as they occur, such as obtaining more favorable routes, or minimizing the impacts of unplanned events on customers and yield. For example, airlines may choose to introduce delay during severe weather events by instituting "company arrival control" to preserve the intricate timing of its connecting network. Or, airlines may selectively cancel flights to mitigate the schedule impact of a severe weather event.

A good example of improving ATM system flexibility is the “Collaborative Decision Making” (CDM) program. CDM allows airlines and central traffic flow management to make better operational decisions by the sharing of flight and schedule information in real time. Since the ATS provider does not know which flights should be delayed when it imposes flow control at an airport, flexibility metrics should address the ATM system’s ability to allow airlines to make dynamic, off-schedule operating decisions.

CDM may be thought of as a broad process that is characterized by information exchange that distributes decision making between ATC service providers and NAS users. Under this structure there are three types of decision making that can be employed:

1) Collaborative - in which both parties must reach consensus before a joint activity can be undertaken.
2) Cooperative - where both parties must contribute information and decision making may be interactive, but by design the decisions can not conflict.
3) Enhanced Independent Decision - where the information contributed by one party enhances the decision making of the other.

Since the introduction of CDM, much of the program effort and expense has been expended on the first type of decision-making, Collaborative. However, the greatest airline value may actually be derived from the last two types of decision-making. For the airline, the benefit derived from the CDM process may be thought of as "yield management" for Airline Operational Control (AOC). Although the CDM process (with few exceptions) does not actually produce any additional system capacity, it gives the airline an opportunity to manage the value of its operations under constrained capacity conditions such as improved landing slot swapping and substitution in the enhanced ground delay program.

Concept Flexibility Metric: ATS Denials / ATS Change Requests

This conceptual example measures how many airline change requests (i.e. for departure time, routing, etc.) are denied by the ATS service provider. The ratio of denials over requests can be further sub-categorized to indicate how well the ATM system can accommodate certain categories of airline flexibility needs.

The value of flexibility becomes more significant as time approaches the planned operation. Up to 30 days in advance, resource flexibility is exercised in crew scheduling, airplane routing, aircraft assignment, and gate control processes. Maximum flexibility in route planning can be used up to 90 minutes before the scheduled departure as airline dispatch processes concentrate on meeting the airline’s schedule commitments. Unplanned delays, such as traffic flow control, changing weather conditions, and mechanical problems drive up the costs associated with maintaining schedule integrity needed for passenger connections, crew pairings, and required aircraft maintenance.

Predictability and flexibility are not independent. Predictability is used to plan revenue, while flexibility is used to reduce the losses against the planned revenue. For example, CDM on a bad weather day does not generate revenue for the airline. It does, however, help reduce the risk of not achieving that planned revenue.

3.4 Efficiency

Efficiency addresses the single-flight perspective most readily. Its value rests in reducing direct operating costs (DOC) by optimizing flight path trajectory and by eliminating excess flight time, route distance, and fuel usage at non-optimum speeds and altitudes. Because airlines fly millions of single operations per year, small incremental DOC savings on every flight can add up to significantly improved financial performance. In non-congested traffic environments such as long-haul oceanic routes, flexibility in trajectories before and during the planned operation can yield important DOC savings. However, its most significant value would only be realized when such reductions can be used to develop the operating schedule and resource plans that are made several months in advance.

Concept Efficiency Metric: Planned Flight Time / Optimum (Non-Schedule Baseline) Flight Time

This high-level Concept Efficiency Metric would be the ratio between the *planned time to fly the clearance granted* (to the flight) over the *optimum flight time*, where optimum is the non-schedule baseline described in Section 3.1. Another example of a Concept Efficiency Metric could be the *actual flight time* over the *optimum flight time*.

3.5 Access

Access is a yes/no function which answers the question, “Does an airline have the ability to use a resource?” Thus, access can be considered the measure of CAT I or near CAT I approaches in the NAS, or a class of airports, or a geographic area. This metric can also be applied to other NAS resources such as airfields, runways, and routes. Examples of increase in access can be increasing the capacity of airports in low visibility operations or the use of Special Use Airspace when not busy.

Access to ATS services can increase value to all of the above categories. Since large blocks of airspace may be inaccessible to commercial operations due to a lack of ATS services or national security requirements (i.e., military restricted areas), traffic bottlenecks may develop from circumnavigating these areas. As with trajectory efficiency, most of the value in gaining access to these restricted areas would be realized if their availability were known when developing the operating schedule and resource plans made several months in advance.

Concept Access Metric: (Restricted Airspace Availability Days / Month) x (Weeks of Advanced Notice)

This example would have to include certain assumptions such as useful time of availability. An important factor to this metric is how much in advance a notice on its availability is provided.

3.6 Cost of Service

From the airline perspective, all ATS productivity and cost issues eventually emerge as a cost to the airline user. This may take several forms, such as ticket taxes, airport landing fees, passenger facility charges, route charges, and special aircraft equipage requirements. Airlines become extremely concerned when ATS charges and related costs escalate without a concomitant improvement in one or more of the ATS service quality performance objectives, since this signals the onset of higher ticket prices which, in turn, depresses demand, profitability, and return on revenue. The *cost of service* to airlines should be considered whenever considering any proposal to improve ATS performance on any of the ATS service quality performance objectives. Conceptually, the *cost of service* should be included as the denominator when computing the *value* of the proposal.

Concept Value Metric: Delay Reduction / ATS Cost Increase

In this example, an ATS program proposal to reduce delay (e.g., through the implementation of a new ATC system or technology) should be considered against expected increases in ATS charges associated with its implementation.[4]

It is critically important in managing CNS/ATM services that service providers, like their counterparts in the aviation industry, have modern cost accounting systems that permit them to understand the true costs of providing services. Without such information, it is impossible for service providers to manage their own operations effectively, to assess their efficiency, and to set priorities and pricing for improvements to the NAS. To be effective, a cost accounting system must be able to clearly identify the cost components associated with providing specific CNS/ATM services at a detailed level that is tied to the services they provide and the opportunities to improve those services.

4. Performance Measurement in Airline Decision Processes

The significance of each performance objective varies with the timeliness of receiving the information. The greatest value to the airline is derived from the most advanced notice. The following table summarizes each performance objective against the airline process where its value is derived.

Time Frame	Performance Objective Categories	Airline Decision Processes
2-5 years	Delay, Predictability, Efficiency, Access	Capital planning decisions (fleets, facilities)
1-2 years	Delay, Predictability	Schedule Planning, Resource Planning (manpower, training), Operations Analysis
2-3 months	Delay, Predictability	Schedule Planning, Capacity Management, Operations Analysis
30 days	Delay, Predictability, Efficiency, Access	Schedule Adjustment, Resource Adjustment, Operations Analysis
18 hours	Flexibility	Schedule Integrity, Company Delay/Cancellations Programs
4 hours	Flexibility, Efficiency, Access	Optimize Flight Planning, Load Planning, Gate Usage
90 minutes	Flexibility, Efficiency, Access	Commit Flight Planning, Load Planning, Gate Usage
30 minutes	Flexibility	Systems Control (dispatch)
Departure	Flexibility, Predictability	Flight Operations (aircraft management)
En Route	Flexibility, Efficiency, Access	Flight Operations, Systems Control

[4] An understanding of the true costs of providing ATS products and services is beyond the scope of this initial report, and would be the objective for a follow-on ATSP FG investigation.

Arrival	Flexibility, Predictability	Flight and Airport Operations (passenger, ramp)
Post Flight	Delay, Predictability, Flexibility	Operations Analysis (cost, block performance)
Ongoing	Cost of Service (ATS charges and airline costs)	Financial Analysis (profitability, cost)

Table 1. Relationship of Time, Performance Objectives, and Airline Processes

These relationships show how the economic value of any operational ATS objective varies with the timeliness of the information, with the greatest value to the airline derived from the most advanced notice. The relative value and priority of any performance objective will vary with time and is different for every airline. Typically, airline business planning and operations management are considered separate processes, with business planning decisions driven by yield management (market and price elasticity), and operating decisions driven by schedule integrity and cost. But at a higher-level, the total value of ATS performance metrics is actually driven by its usefulness to both the airline business planning *and* operating decision processes.

5. Metrics Assessment

The first task of the ATSP FG was to collect and review the metrics that were being collected by the various airport and airspace users and ATS providers throughout the world. Data was obtained from ATS providers and Airline Associations. This included the Federal Aviation Administration (FAA), the European Organisation for the Safety of Air Navigation (Eurocontrol), the Civil Air Navigation Services Organization (CANSO), the Air Transport Association (ATA) and the International Air Transport Association (IATA). This comprehensive list of metrics was then evaluated by the airline members of the Focus Group as to whether each metric provided a direct, indirect, on non-value to the airline. After reviewing the comments offered by the airline members of the Focus Group, it was possible to establish a relationship diagram between the metrics valued by the airlines and those valued by the ATS service providers. Such a relationship diagram is presented in Figure 4.

The top of the diagram shows the resources controlled by the service providers: airspace, airports, equipment, and people. The service providers need capital to develop, operate, and maintain those resources. Metrics that are important to the service providers in evaluating their resources are: Traffic, Capacity, Coverage/Availability, Productivity, and Safety. These service provider valued metrics are directly related to those airline valued metrics presented in Section 3 above: Delay, Predictability, Flexibility, Efficiency, Access, and Cost of Service to users. The relationship among these metrics is presented in Figure 4. Those metrics above the dotted line represent service provider valued metrics; those below the dotted line represent airline valued metrics. Relationships among the metrics are shown by solid or dashed lines. Safety is an important metric. However, the Focus Group agreed that safety was outside the scope of C/AFT.

The airline members of the Focus Group were then asked to evaluate which metrics were considered primary or secondary to their operations. This is presented in Figure 5, with each organization represented by a different symbol. These primary and secondary metrics will be further described in Section 8.

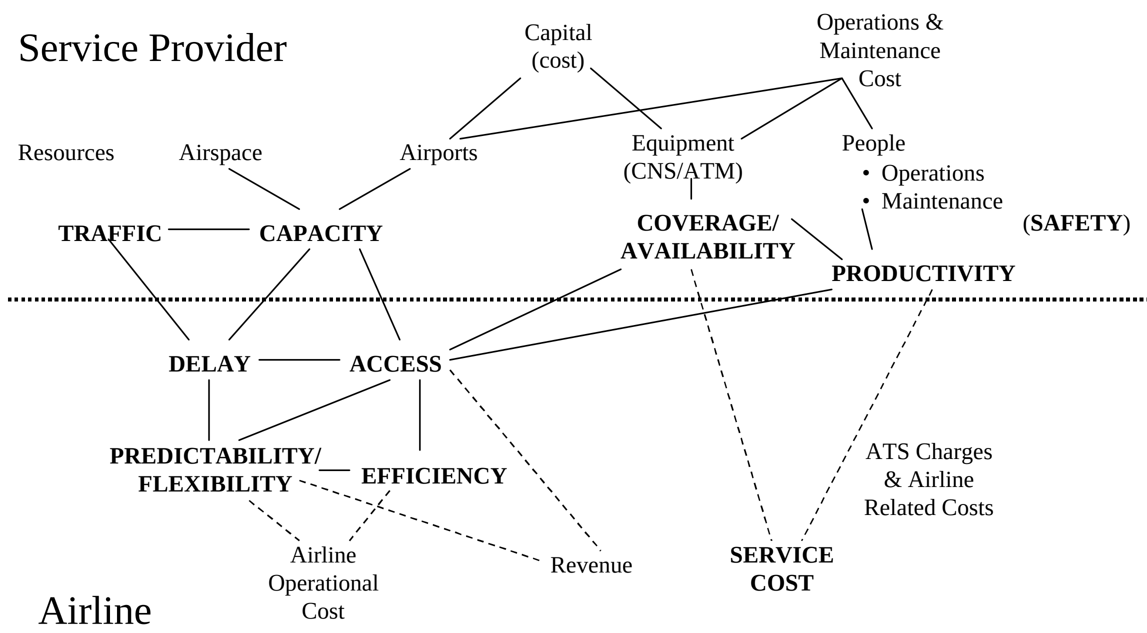

Figure 4. Relationship Between Airline Valued Metrics and Service Provider Valued Metrics

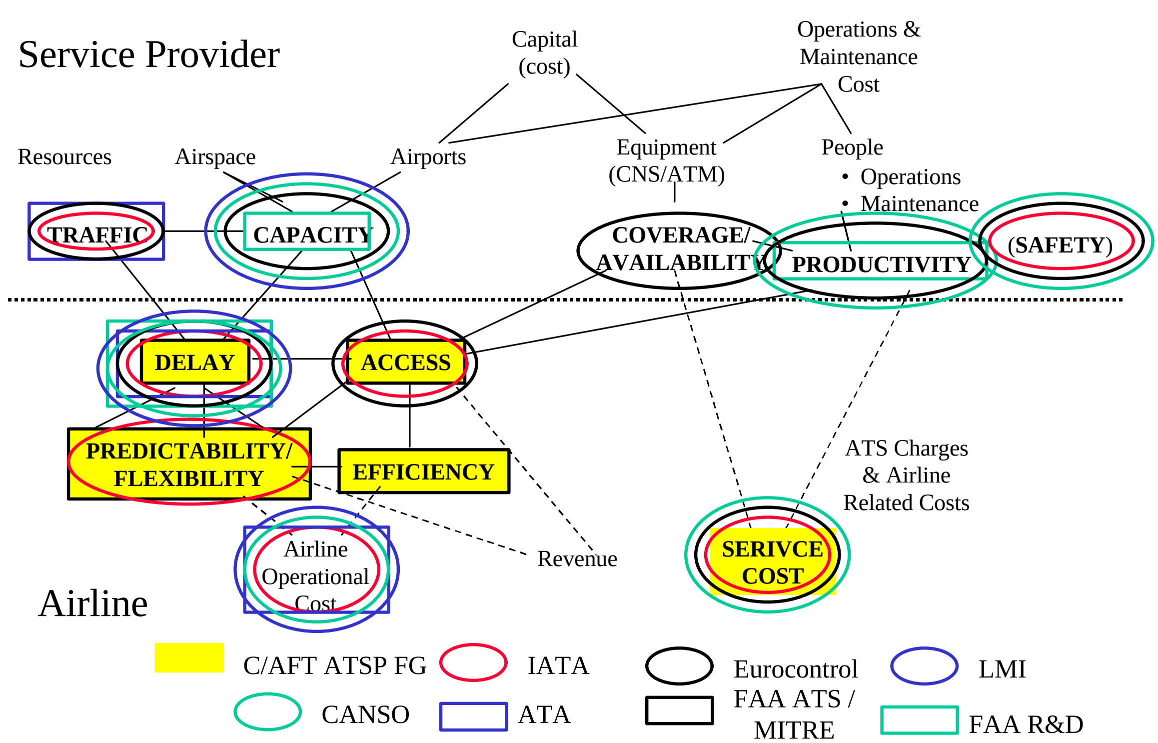

Figure 5. Evaluation of Primary Metrics According to Organization

6. Literature Summary

The list of performance metrics collected here have been compiled from a variety of sources.

6.1 Airline Association Sources

- Data collected by the Air Transport Association (ATA).
- Data collected by the International Air Transport Association (IATA).

6.2 Air Traffic Provider Sources

- Federal Aviation Administration (FAA) report on the development and application of performance metrics to evaluate the FAA's National Airspace System (NAS) Version 3.0 Architecture from a capacity, efficiency, and productivity perspective.
- Data collected by Eurocontrol.
- Information gathered by the Civil Air Navigation Services Organization (CANSO) from International Air Transport Association (IATA) representatives.

6.3 Research Organization Sources

- Logistics Management Institute, Inc (LMI) presentations to the industry on ATM performance metrics based on the development of models for NASA's Aviation System Analysis Capability (ASAC) Program.
- The Center for Advanced Aviation System Development of the MITRE Corporation (MITRE/CAASD) report for the FAA on the development, consensus, and measurement of a new set of metrics from the user (air carrier, general aviation, military) perspective that include flexibility, predictability, access, and delay.

7. Applying Principles of the Performance Objectives

The following are examples of how these basic metric concepts and targeted performance objectives might be used to assess the value of current ATM programs.

Example 1: <u>National Route Program</u> - Allows for user preferred routing, given altitude and radius constraints.

Flexibility
- Distance savings from user-preferred routing (time, fuel, operations costs savings)
- Increase in percentage of flights operating off ATC-preferred routes

Predictability
- Possible increase in variability of en route times

Example 2: <u>Conflict Probe</u> - Allows for increased user-preferred routing by enabling reduced en route restrictions.

Flexibility
- Reduction in number of restrictions in the system
- Distance savings from preferred routing (time, fuel, operations costs savings)

Predictability
- Reduction in uncertainty in en route times

Access
- Possible increase in civilian usage of Special Use Airspace (dependent on airspace probe capabilities)

Delay
- Reduced en route delays

Example 3: Data Link - Reduces controller time in air-ground communications (enables additional throughput) and increases potential opportunity for access to information services.

Flexibility
- Distance savings from increased user-preferred routing - controllers have more time to review and assess user preferences

Predictability
- Reduction in variability of en route times

Access
- Increase in availability of flight services to system users

Example 4: Collaborative Decision Making - Allows for user input to development and implementation of TFM strategies, provides users information on system status and constraints.

Flexibility
- Increased utilization of acceptance rates

Predictability
- Reduction in variability of taxi-out times
- Increase in number of decisions with direct user inputs

Delay
- Reduction in impact of ground delay programs

Example 5: Modernization (Free Flight Phase 1) - Provides new Decision Support System capabilities to users and controllers for increased flexibility and predictability of operations.

Flexibility
- Variation in route/time planned for an individual flight number over similar days (e.g., flight XXX every Thursday)

Predictability
- Variation in flight time experienced for all flights between city pairs
- Reduction in variability of taxi-out times
- Variance in peak arrival throughput per runway

Delay
- Reduction in impact of ground delay programs

Access
- Number of CAT I arrivals

8. The Consolidated Metrics Table

Air traffic service providers and airspace users have focused increasing attention in recent years on understanding how to measure the performance of the air traffic management system most meaningfully. This attention has occurred concurrently with an increasing focus on viewing government functions in terms of *providing services* to *customers*. As part of this discussion, the various performance measurement approaches used in the past have been reviewed and found to reflect a hierarchy of measurement concepts:

- Outcomes: Result for customers
- Outputs: Products, services, and processes provided to achieve *outcomes*
- Activities: Actions undertaken to produce *outputs*
- Inputs: Resources (funding, staff, material) committed to perform *activities*

Measurement of ATM system performance is difficult, especially recognizing the diverse interests of airspace users and the circumstances they face. Consequently, ATM service providers have relied on all of these types of measures at various times. However, it is important to recognize that the connection to providing *results for customers* becomes more and more removed as one moves down this hierarchy. Consequently, the ATSP Focus Group has paid greatest attention to metrics that reflect ATS performance in *outcome* terms and also, but to a somewhat lesser extent, in *output* terms where outcome measures are difficult to quantify. Recognizing their importance, outcome and output measures warrant some elaboration.

- An ***outcome*** metric is used to measure the extent to which an organization's service-related role is being achieved. The focus of outcome measurement is not on the work being done, but on the results achieved by those for whom the work was undertaken. For the air traffic service providers, outcomes represent the *externally focused* results of the delivery of ATM services to airspace users *in terms valued by users*. Thus, they are user-oriented measures of ATM system performance, such as delay or predictability, among others.

- An ***output*** metric is used to measure the results of an organization's activities. Outputs are measures of ATM system performance, usually from the *internally focused* view of the *service provider*. Output measures may include, for example, CNS service outages, runway utilization, or traffic handled.

Table 2 presents a consolidated list of the metrics that have been proposed or are currently being collected by various airline and service provider organizations. It is important to note that those metrics included in the table may not ultimately reflect the airline valued performance metrics presented in Section 3.

The Consolidated Metrics Table organizes metrics along the definitions of the Airline Performance Objectives in terms of primary and secondary metrics.

Primary Metrics – Airline Performance Objectives (Outcomes)

These categories of metrics generally reflect performance *outcomes* as discussed earlier; that is, performance results achieved by airlines as they would define them.[5]

Delay - Measures the amount of time beyond optimum to complete an operation.
Predictability - Measures the variation in the ATM system expected by the user.
Flexibility - Measures the ability of the system to meet users' changing needs.
Efficiency - Measures aircraft trajectory path circuity, including route and altitude.
Access – Measures ability to enter the ATC system and obtain services on demand.
Cost of Service- ATS charges and airline costs. Uses standard industry cost concepts.

Secondary Metrics

These categories of metrics generally reflect ATS performance in *output* terms: what service providers produce. Safety is, however, clearly an outcome measure, but has been included in the list of secondary metrics since it was agreed that safety must not be degraded by any changes introduced. However, it was considered out of scope of C/AFT and thus was not specifically addressed by the C/AFT ATSP Focus Group.

Productivity - Measure of an output over the cost to produce it.
Capacity - Number of operations using a resource in a specified period of time.
Traffic - Number of total operations (flights, passengers).
Safety - Measures exposure of certain incidents.

During early discussions among ATSP Focus Group members, the metrics were classified into two major categories (ATM system performance monitoring and specific studies), depending on the perspective of the user analyzing or collecting the metric. These are further described as:

ATM System Performance Monitoring:
- Clear replicable measures showing trends and service levels of ATM system performance
- Identify areas for improvement

Specific Studies:
- To identify specific areas that need improvement, provide set of metrics to evaluate potential benefits of changes and its costs
- A concise set of measures that quickly inform senior management of the areas requiring attention or investment

With recognition that there are limitations to current data sources and collection processes, C/AFT does not recommend that ATS performance assessments or monitoring be delayed for lack of "perfect" data elements or sources. However, difficulty in securing better data sources

[5] Some of the metrics (indicators) in Table 2 in the primary metrics categories are, however, more output-like measures. In these cases, where outcome-like measures are unavailable, such metrics are being used to try to capture or reflect the performance outcome implications.

should not be used as a reason for not pursuing better data processes as methods of assessing and monitoring ATS performance matures.

The information for each metric in Table 2 is presented in the following format:

- The 1st column presents the metric category and the organization(s) that proposed or provided that particular metric. The original classification categories were: Access, ATFM, Capacity, Cost, Delay, Efficiency, Flexibility, Predictability, Productivity, and Safety. To make the table easier to read, the organizations listed in the 1st column have been abbreviated as follows:

  ATA = Air Transport Association
  CAASD = MITRE Center for Advanced Aviation System Development
  CANSO = Civil Air Navigation Service Organization
  ECAC = European Civil Aviation Conference
  EEC = Eurocontrol Experimental Centre/Performance and Economy Research
  EPRU = Eurocontrol Performance Review Unit
  FAA = Federal Aviation Administration
  IATA = International Air Transport Association
  LMI = Logistics Management Institute

  Other abbreviations include:
  ATFM = Air Traffic Flow Management
  CFMU = Central Flow Management Unit
  CODA = Central Office for Delay Analysis

- The 2nd column presents a numbering scheme, or reference number, for the reader to keep track of the metric as it was originally proposed. In the original table, the number of metrics collected for each of these classification categories were: Access - 7; ATFM - 7; Capacity - 11; Cost - 11; Delay - 12; Efficiency - 10; Flexibility - 6; Predictability - 5; Productivity - 8; and Safety - 1. In subsequent versions of the table, several of the metrics were grouped together as shown in Table 2.
- The 3rd column provides the specific metric or indicator.
- The 4th column provides a description or explanation of that metric or indicator.
- The 5th column gives an example of the data that would be collected to measure that metric.
- The 6th and 7th columns provide the reader with a sense of how the Focus Group members classified this metric, e.g. whether that metric would be collected for ATM system performance monitoring purposes or for use in specific studies.
- The 8th column provides the reader information on the airline value of that metric (D = direct value, I = indirect value, N = not applicable).
- The 9th column provides airline concerns regarding that metric. These concerns were wide-ranging. Airline comments were coded as follows:

  A. This metric should be considered from an airline perspective.
  B. This metric does not appear to be applicable globally and needs to be reviewed and redefined.

C. This metric does not appear to be relevant to airlines.
D. This metric does not appear to assess performance directly.
E. Is this a performance metric?
F. Is this metric stable?
G. This metric should be easy to quantify.
H. This metric is difficult to quantify.
I. This metric needs to be better defined.
J. The definition for this metric is too broad.
K. Is this metric the right level of detail?
L. The specific meaning of this metric is unclear.
M. This metric may overlap with other metrics.
N. Is a high number for this metric good or bad?
O. This metric needs a high and low value.
P. This metric is relevant for current and future years.
Q. This metric is the same as (__).
R. This metric should be related to (__).
S. This metric should not be restricted to weather.
T. This metric should be stratified by cause.
U. Comparisons of this metric may be difficult.
V. Some of these metrics may reflect airline decisions that result from system performance problems.
W. This metric provides better information which helps airspace users anticipate conditions, control actions, and expected performance.
X. This metric reflects the ability of airspace users to obtain the routes and altitude profiles they want.
Y. This metric describes the amount of service but not the quality or productivity of service provided
Z. This metric is considered to be out of scope of C/AFT ATSP Focus Group.

Table 2. Primary Metric: Delay

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type: Monitor Perf	Metric Type: Specific Studies	Airline Value D / I / N	Comments

Delay (ATA) (CAASD) (EPRU) (as revised)	D4 D5.1 D3 D11 (revised)	• airborne delay	• difference between actual flight time and minimum projected flight time (e.g., either computer-projected flight time or estimated time en route filed in flight plan)	• airborne delay
				• percentage of flights delayed
				• average delay per flight
				  • listed by location (en route or terminal facility)
				  • stratified by cause (e.g., wx, TBD)
					X	X	D	

Delay (ATA) (EPRU) (as revised)	D5.2 D3 D11 (revised)	• gate delay	• difference between OAG-scheduled "out time" and actual "out time" (due to ATC delays)	• gate delay
				• percentage of flights delayed
				• average delay per flight
				  • listed by location (airport)
				  • stratified by cause (?) (e.g., wx, TBD)
					X	X	D	

Delay (ATA) (CAASD) (EPRU) (as revised)	D6 D7 D3 D11 (revised)	• taxi-in delay • taxi-out delay	• difference between actual taxi-in time and minimum taxi-in time filed in flight plan • difference between actual taxi-out time and minimum taxi-out time	• taxi-in delay • taxi-out delay • percentage of flights delayed • average delay per flight • listed by location (airport) • stratified by cause (?) (e.g., wx, ... TBD)	X	X	D	
Delay (CAASD) (EPRU)	D8 D9 D10 D11	• ground delay	• a measure of the amount of time beyond expectations that it takes to complete an operation	• number, deviation, and impact of ground delays imposed by the air traffic control system	X	X	D	R (D5.2, D3, D11)
Delay (CANSO)	D1	• delay		• total delay • number of flights delayed	X	X	D	I, J
Delay (LMI)	D2	• delay	• versus nominal times or through queuing methods		X	X	D	I, J
Delay (EPRU)	D9	• ATFM delay	• ATFM delay • average ATFM delay per all traffic • average ATFM delay per delayed traffic • average ATFM delay per regulated traffic	• delays caused by ATFM regulations (minutes) • ATFM delay/traffic demand (minutes) • ATFM delay/delayed traffic (minutes) • ATFM delay/regulated traffic (minutes)	X	X	D	L, M
Delay (EPRU)	D10	• CFMU delay	• CFMU overall delay • CFMU peak delay	• overall delay computed by CFMU • highest daily delay in a given period	X	X	D	L, M

Table 2. Primary Metric: Delay (continued)

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type Monitor Perf	Metric Type Specific Studies	Airline Value D / I / N	Comments
Delay (EPRU) (IATA)	D11	• CODA delay	• CODA overall delay • most affected traffic flows	• total delay • number of flights delayed • sum of delays (weather, passenger, equipment, airport, etc) (minutes) • average delay per operation (minutes)	X	X	D	L, M, T Central Office for Delay Analysis produces data based on ATS delay information provided by 16 IATA carriers.
Delay (FAA)	D12	• system delays	to determine the effectiveness of the V3.0 architecture designed to reduce system delays and enable evolution to free flight	• passenger delay (as measured by NASPAC) • operational delay (as measured by NASPAC)		X	D	M

Table 2. Primary Metric: Predictability

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type: Monitor Perf	Metric Type: Specific Studies	Airline Value D / I / N	Comments
Predictability (ATA)	Pre1	• weather	diversions, cancellations, and misconnects due to weather	• number of diversions (segments) recorded due to weather • number of cancellations recorded due to weather • number of passenger misconnects recorded due to weather	X	X	D	S, T, V (Should cancellations and misconnects be included?)
Predictability (CAASD) (as revised)	Pre2 (revised)	• variation in system performance associated with changes in weather	to measure the variation in the ATM system as experienced by the user	• difference between highest EPS VFR capacity and smallest CAT I IFR capacity • dispersion in daily average taxi-in times and taxi-out times (i.e., mean vs. 75th percentile) • dispersion in expected arrival time vs.actual arrival times (i.e., mean arrival delay vs. 75th percentile arrival delay)	X	X	D/I	S, T
Predictability (CAASD)	Pre3	• timeliness and quality of data provided to the user on weather, traffic, and system status	A measure of the variation in the ATM system as experienced by the user		X	X	D	H, W
Predictability (CAASD)	Pre4	• number of delay allocation decisions made with direct user input	A measure of the variation in the ATM system as experienced by the user		X	X	D	H, W
Predictability (CAASD) (as revised)	Pre5 (revised)	• impact of system outages	A measure the variation in the ATM system as experienced by the user	• number of cancellations and diversions at major airports within the affected area • total delay of departures • total difference between scheduled and actual arrival times	X	X	D	R (Pre1), S, T, V

Table 2. Primary Metric: Flexibility

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type Monitor Perf	Metric Type Specific Studies	Airline Value D / I / N	Comments
Flexibility (LMI) (EEC) (EPRU) (CAASD) (as revised)	Cap6 Cap7 Cap8 F1 (revised)	• airport capacity		• airport capacity per period of time under different runway configurations, weather conditions, and procedures	X	X	D	Q (Cap6, Cap7, Cap8, F1)
Flexibility (LMI) (CAASD)	Cap11 F1	• sector capacity		• sector capacity per period of time under different weather conditions and procedures	X	X	D	Q (Cap11, F1)
Flexibility (CAASD) (as revised)	F2 (revised)	• restrictions	A measure of the ability of the system to meet users' changing needs and to permit users to adapt their operations to changing conditions	• number of procedural restrictions (e.g., flow, route, altitude, and speed constraints) • number of flights subject to these restrictions • amount of aviation activity not constrained by these restrictions • severity of impact of each restriction	X	X	D	
Flexibility (CAASD) (as revised)	F3 (revised)	• number of user preferred route requests granted	A measure of the ability of the system to meet users' changing needs and to permit users to adapt their operations to changing conditions	• number of ATC preferred routes • percentage of number of flights subject to ATC preferred route • amount of aviation activity not on ATC preferred route, among flights subject to ATC preferred routes • lateral deviation between ATC preferred route and flight plan route, among flights subject to ATC preferred routes	X	X	D	B (Reflects the number and severity of routing constraints.)
Flexibility (CAASD)	F4	• deviation between published preferred route distance and direct routing distance between city pairs	A measure of the ability of the system to meet users' changing needs and to permit users to adapt their operations to changing conditions	• distance between preferred routes and great circle distance by origin-destination pair, weighted by level of traffic	X	X	D	B
Flexibility (CAASD)	F5	• deviation between the route requested and route flown	A measure of the ability of the system to meet users' changing needs and to permit users to adapt their operations to changing conditions	• number of flights whose max altitude equaled the requested altitude in flight plan • excess time from top of descent to wheels down • mean lateral deviation between flight plan route and actual flown route	X	X	D	X
Flexibility (CAASD)	F6	• decisions	to measure of the ability of the system to meet users' changing needs and to permit users to adapt their operations to changing conditions	• number of decisions involving pilot controller collaboration	X	X	D	H (Users involvement in ATM decision making can aid in meeting ATC/TFM needs while minimizing dynamic airspace user needs.)

Table 2. Primary Metric: Efficiency

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type Monitor Perf	 Specific Studies	Airline Value D / I / N	Comments
Efficiency (EPRU)	E1	• airspace complexity	• sector complexity • sector horizontal traffic complexity • sector vertical traffic complexity	• function of vertical and horizontal complexity and conflict probability • function of entry/exit points, crossing points • function of cruising, climbing, and descending traffic			I	D, E
Efficiency (EPRU)	E2	• ATM configuration	• ACC classification	• function of airspace complexity and equipment		X	I	D, E
Efficiency (ECAC)	E3	• procedures		• list of procedures or techniques implemented in each ACC (EATCHIP CIP data)	X		I/N	D, E (unless this includes route, altitude, or speed restrictions)
Efficiency (EEC)	E4	• procedures		• list of ATC mature procedures implemented	X		D/I	D, E (unless this includes route, altitude, or speed restrictions)
Efficiency (EPRU)	E8	• equipment	• system MTBF • system MTTR	• reliability of the center equipment (hours) • recovery of the center equipment (hours) • FDPS functional level using CIP data	X	X	D/I	D, E
Efficiency (EPRU)	E9	• IFPS operations	• IFPUs load • IFPUs transit time	• number of messages processed by IFPU per day (messages/day) • time to process a message through IFPUs (minutes)	X	X	I	D, E (The time to process a request is a system performance metric, but it does not appear to be a significant performance concern globally).
Efficiency (FAA)	E10	• system outages	to estimate the potential effects of system disruption as a function of the reliability of major components of the NAS at ARTCCs and terminals	• outage-induced reduction in capacity • duration of the outage • demand at the affected facilities	X	X	I	D, E

Table 2. Primary Metric: Access

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type: Monitor Perf	Metric Type: Specific Studies	Airline Value D / I / N	Comments
Access (CAASD)	A2	Number of • airports with approved approaches • airports with precision approach capability • operations provided with VFR tower services	A measure of the ability of users to enter the ATC system and obtain services on demand	• number of airports that have at least one approach record in Jeppesen Navigation Database • number of airports that have at least one precision approach record in Jeppesen Navigation Database • number of operations using VFR tower services	X	X	D	A (Should this be limited to airports that currently have some type of commercial service?)
Access (CAASD)	A3	• civilian utilization of special use airspace	A measure of the ability of users to enter the ATC system and obtain services on demand	• percentage of air carrier flights that penetrate Special Use Airspace, for those origin-destination pairs in which at least one flight penetrated Special Use Airspace	X	X	D	
Access (CAASD) (EPRU) (as revised)	A4 A5 A6 A7 (revised)	• CNS coverage	A measure of the ability of users to enter the ATC system and obtain services on demand	• coverage by various CNS capabilities at various altitudes	X	X	D	A
Capacity (FAA) (EPRU)	Cap5 Cap8	• airport capacity utilization	Airport capacity relative to air traffic operations	• average demand to capacity ratio • peak demand to capacity ratio	X	X	D	E, N, O, P
Capacity (LMI) (EEC) (EPRU) (CAASD) (as revised)	Cap6 Cap7 Cap8 F1 (revised)	• airport capacity		• airport capacity per period of time under different runway configurations, weather conditions, and procedures	X	X	D	Q (Cap6, Cap7, Cap8, F1)
Capacity (LMI) (CAASD)	Cap11 F1	• sector capacity		• sector capacity per period of time under different weather conditions (?) and procedures (?)	X	X	D	F, K, Q (Cap11, F1), U
Access (EPRU)	A8 (renamed E7)	• ATM data processing functionality	• conflict alert • correlation • processing	• areas with conflict alert and proximity warning • areas with flight plan/track correlation • areas with flight plan/routes/airspace/meteorological data processing	X	X	I/N	Q (A4, A5, A6, A7)
Access (CAASD)	A1	Availability and quality of • VFR in flight services • flight services to the system user	A measure of the ability of users to enter the ATC system and obtain services on demand		X		I/N	C

Table 2. Primary Metric: Cost of Service

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type Monitor Perf	Specific Studies	Airline Value D / I / N	Comments

Cost Efficiency (ATA) (CANSO) (LMI) (as revised)	Cost1 Cost2 E5 E6 (revised)	• aircraft operating costs		• crew costs (block time)
				• fuel costs (block fuel)
				• other costs
				  • expressed in units to permit comparisons (e.g., per dep, per GC route mile)
				  • expressed relative to the minimum cost necessary (e.g., as compared optimum route and profile)
				  • stratified by phase of flight
					X	X	D	

Cost (EEC)	Cost3	• airport costs		• airport aviation income • airport commercial income • airport depreciation costs • airport goods and services costs • airport investments • airport number of employees • airport staff cost	X	X	N	D
Cost (CANSO)	Cost4	• ATS costs		• annual expenses per fixed assets • liabilities per assets • average salary	X	X	N	D, E
Cost (ECAC)	Cost5	• ATS costs		• ATS • AIS • MET • Studies and Tests • Training	X	X	D/I/N	D, E
Cost (EPRU)	Cost7	• ATS costs per country		• total payment deposited to the countries (ecu) • total payment invoiced by the CRCO (ecu) • ATM costs per country (ecu)	X	X	D/I	D, E
Cost (EPRU)	Cost8	• Eurocontrol costs		• agency costs per country (ecu)	X	X	I	D, E
Cost (EPRU)	Cost9	• route charges		• sum (service units * unit rates) for all flights (ecu) • ATC (en route) costs	X	X	D	B, D
Cost (EPRU)	Cost10	• service unit		• Number of Service unit provided, measured from aircraft weight and distance flown		X	D/I	Y
Cost (EPRU)	Cost11	• unit rate		• charge per service unit (ecu/service unit)	X	X	D	B

Table 2. Secondary Metric: Service Provider Productivity

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type		Airline Value D / I / N	Comments
					Monitor Perf	Specific Studies		
Cost (EPRU) (as revised)	Cost6 (revised)	• ATS costs	• en route costs • terminal costs • airport costs	• ATM costs per unit of service (TBD: flight, aircraft-hr, aircraft-mile, weight-distance flown)	X	X	D	
Productivity (CANSO) (FAA) (EPRU)	Pro1 Pro4 Pro8	• air traffic controller productivity	A quantitative and qualitative measure of controller productivity	• number of aircraft operations handled per controller over a specified time period • capacity based on heavy workload threshold (flights/hr)	X	X	I	I, R (F1) (What period of time, what number of controllers?)
Productivity (FAA)	Pro7	• maintenance technician productivity	to highlight the program that has the biggest impact on technician productivity in the V3.0 architecture	• annual number of facilities per technician multiplied by availability (fraction of time that NAS services are available)	X	X	I	
Productivity (EEC)	Pro2	• air traffic controller productivity		• annual number of controllers		X	N	D, E
Productivity (EPRU)	Pro3	• air traffic controller productivity	• staff • staff under training	• number of controllers affected to the center • number of controllers under training in the center		X	N	D, E
Productivity (CANSO)	Pro5	• air traffic controller/staff productivity		• average salary ATC • controller/other staff FTE • controller/tech and systems staff FTE • controller/admin staff FTE • tech and systems/admin staff FTE	X	X	I	D, E
Productivity (FAA)	Pro6	• flight service station productivity	to determine flight service station productivity	• number of pilot briefings given by flight service specialist to NAS users • duration of pilot briefings given by flight service specialist to NAS users • number of flight plans handled by flight service specialist • amount of time to process flight plans handled by flight service specialist	X		D/I/N	C

Table 2. Secondary Metric: Traffic (Demand)

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type: Monitor Perf	Metric Type: Specific Studies	Airline Value D / I / N	Comments
Traffic (Demand) (EPRU)	AT1	• ATFM equity		• deviation from standard equity rule (slots)	X	X	D	B, E, L
Traffic (Demand) (EPRU)	AT2	• ATFM exempted traffic		• traffic exempted from ATFM regulations (flights)	X	X	D/I/N	B, E, L, N
Traffic (Demand) (EPRU)	AT3	• ATFM overloads		• number of flights exceeding the capacity, per sector per hour (flights/sector * hrs)	X		D	D, N .
Traffic (Demand) (EPRU)	AT4	• ATFM under-deliveries		• number of lost slots, per regulation per hour (slot/regulation * hr)	X	X	D	D, E
Traffic (Demand) (EPRU)	AT5	• flights not adhering to ATFM slots		• regulated flights departing outside slot window (flights)	X		D	B, D, E, N
Traffic (Demand) (EPRU)	AT6	• flights with delay compensation		• departure time earlier to compensate for delay (flights)	X	X	D	B, D, E, N
Traffic (Demand) (EPRU)	AT7	• ghost flights • multiple flights		• flight plans not canceled and non-activated (flights) • canceled flight plans with similar parameters (flights)	X	X	D	D, E
Traffic (Demand) (EEC)	Cap1	• passenger statistics		• number of passengers	X	X	N	D
Traffic (Demand) (ATA) (IATA) (EEC)	Cap2	• air traffic statistics		• total number of flights • RPMs for domestic and international, by aircraft type • ASMs for domestic and international, by aircraft type	X		N same as Cap1	D
Traffic (Demand) (EPRU)	Cap3	• air traffic statistics	• peak traffic • regulated traffic • traffic demand • traffic duration • exempted traffic • traffic statistics • traffic distance • actual IFR traffic • forecasted IFR traffic	• highest daily number of flights in a given period (flights) • number of regulated flight plans (flights) • number of activated flight plans (flights) • total duration of overflights over an airspace during the period (minutes) • number of exempted flights (flights) • number of actual flights (flights) • total distance flown over an airspace during the period (km) • historical number of IFR flights (flights) • forecast number of IFR flights (flights)	X	X	I	D

Table 2. Secondary Metric: Capacity

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type		Airline Value D / I / N	Comments
					Monitor Perf	Specific Studies		
Capacity (CANSO) (EEC)	Cap4	• runway statistics		• number of runways • number of stands • operations per 1,000 km • average runway load factor • peak runway load factor • runway utilization vs. theoretical capacity • average separation used	X	X	D	D, L
Capacity (ECAC)	Cap9	• airspace and route structure, sectorization, routes, CFMU data			X	X	I	E, I
Capacity (EPRU)	Cap10	• overall capacity • sector capacity • traffic distribution		• traffic variation at constant ATFM delay (%) • cumulated declared sector capacity (flights/hr) • ratio between overloaded and underutilized sectors (lb?/flight)	X	X	D/I	M

Table 2. Secondary Metric: Safety

Metric Classification (Org.)	Metric Ref No.	Metric/Indicator	Description or Explanation of Metric	Data Collected or Proposed to be Collected	Metric Type		Airline Value D / I / N	Comments
					Monitor Perf	Specific Studies		
Safety (CANSO) (EPRU)	S1	• incidents	• air-misses • procedural incidents • separation infringements • TCAS incidents • accidents	• critical incidents per 100,000 operations • near-critical incidents per 100,000 operations • number of air misses per period • number of procedural incidents per period • number of separation infringements per period • number of TCAS incidents per period • number of accidents per period	X	X	D	Z

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