DOCUMENTATION FOR THE CONSOLIDATED OPERATIONS AND DELAY ANALYSIS SYSTEM

September 1997

Prepared for:

Office of Aviation Policy and Plans
Federal Aviation Administration
Washington, DC 20591

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

1.0 INTRODUCTION

1.1 DELAYS AT U.S. AIRPORTS

Delays at U.S. airports are already a serious problem. Current operations are impeded and future traffic growth is threatened by the prospect of ever-worsening conditions. In 1994 there were 23 airports where aircraft delays exceeded 20,000 hours annually and that number is expected to increase to 33 by the year 2002. But the overall delay picture is worse--the Federal Aviation Administration's (FAA) Office of Aviation Policy and Plans (APO) estimated that delay at all U.S. airports in 1994 totaled approximately 1.7 million hours. Using an average aircraft operating cost of $1,500 per hour, APO estimated the operating cost of flight delays in 1994 to be over $2.5 billion.

Airline passengers on those flights, of course, were also delayed. APO estimated that passengers incurred delays of some 160 million hours in 1994; at a modest $44.00 per hour, the costs of delays to passengers was more than $7 billion.[1] The total estimated cost of flight delays in 1994 was $9.5 billion.

1.2 EXISTING DELAY MEASUREMENT SYSTEMS

The FAA has two delay reporting systems, the Operations Network (OPSNET) and the APO Total Cost for Air Carrier Delay Report. In addition, the Department of Transportation (DOT) publishes the Air Travel Consumer Report (ATCR) and the Air Transport Association (ATA) issues a report based on information it receives from its member airlines. Each system is described below.

OPSNET--Operations Network is the official FAA delay reporting system. Its data come from observations by FAA personnel, who manually record aircraft that are delayed by 15 minutes or more. Aircraft that are delayed by less than 15 minutes are not recorded.

OPSNET also provides information on the cause of delay--weather, terminal volume, center volume, closed runways/taxiways and NAS equipment interruptions. OPSNET reports delays for specific airports, but it reports only

[1]Federal Aviation Administration, APO-130, “Total Cost for Air Carrier Delay Report,” p. 2.

the aggregate number of occurrences and does not report delays by carrier or individual flight.

Total Cost for Air Carrier Delay Report--This report provides estimates of the annual cost of delays for all Form 41 reporting air carriers.[2] The average hours of delay per flight are based upon Airline Service Quality Performance (ASQP) data, while the total number of revenue flights, the cost per operating hour and the estimates of the value of passenger time are based on other APO data sources. The cost report presents delays and costs of delays for the entire system, but not for individual airports. The cost report is issued once a year.

The APO delay estimates use the ASQP data base to estimate average delays by phase of flight (gate-hold, taxi-out, airborne and taxi-in) and to identify airports with over 20,000 hours of annual delay. These data are reported in the annual Aviation Capacity Enhancement Plan published by the FAA's Office of System Capacity and Requirements.

Air Travel Consumer Report (ATCR)--This report, which is issued by the Department of Transportation's Office of Aviation Enforcement and Proceedings, provides information about the on-time performance of the largest U.S. air carriers. It is based on Airline Service Quality Performance (ASQP) operational data filed by major air carriers and on scheduled times from the Official Airline Guide (OAG). A description of the ASQP-reporting carriers is provided in Section 2.

ATCR also defines an "on-time" flight as one that operates within 15 minutes of schedule. However, because ATCR calculates delays for individual flights from actual and scheduled departure, airborne, and arrival times, delays for all flights are available. The ATCR can aggregate delays by individual flight over time, by carrier and by airport.

The ATCR is published monthly, no later than the end of the first week of the second month following the end of the reporting month (e.g., the October 1996 report, which summarized on-time performance for flights in August 1996, was issued before October 5, 1996).

ATA Delay Report--The Air Transport Association is a trade association that represents the scheduled jet air carriers. Its members report the number of flights delayed and the average delay per flight at specific airports, but the

[2]Air carriers report Form 41 data to the Department of Transportation if their annual operating revenues exceed $20 million.

published data do not include data by carrier or aircraft type. The data cover all U.S. commercial domestic flights, international departures but not arrivals and some commuter flights (for those carriers that report Form 41 data to DOT). ATA publishes its delay report monthly; the report provides average delays by airport.

Each of the current delay reporting systems was designed for a specific and different purpose, based on an independent data source or methodology and reports delay differently. As a result, the measures of delay are difficult to compare with each other. No existing delay measurement system provides a comprehensive measure of the performance of the air traffic control (ATC) system. CODAS has been designed to remedy this deficiency.

1.3 THE DEVELOPMENT OF CODAS

The Consolidated Operations and Delay Analysis System (CODAS) was created by the Office of Aviation Policy and Plans to provide estimates of aircraft delay by individual flight. APO's main objective was to develop a clear and well-supported methodology to calculate aircraft delays that will be accepted by both government and industry as valid, accurate and reliable. Because the acceptance of the CODAS delay estimates is the key to its usefulness, APO coordinated the development of CODAS with other FAA organizations and major air carriers and continues to do so.

CODAS combine data from several existing sources to estimate flight delays at U.S. airports. Because CODAS uses existing databases as its inputs, no additional data collection is required. CODAS uses these data to provide more detailed and accurate measures of delay than are available from any of the source databases.

CODAS also calculate delays by phase of flight, enabling analysts to see at what stage of a flight a delay occurred. An individual flight is broken into four sequential segments, each of which may incur some or no delay: gate-delay, taxi-out delay, airborne delay and taxi-in delay. Better measures of delay provide a more complete picture of the performance of the ATC system and will enable analysts to identify problem areas, to evaluate proposed solutions and to track historical trends.

2.0 SOURCES OF CODAS DATA

2.1 INTRODUCTION

CODAS integrate data from two primary sources: the Enhanced Traffic Management System (ETMS) and the Airline Service Quality Performance (ASQP) System. Additional data, primarily as back up for ETMS, come from the Official Airline Guide (OAG) and the carriers' Computerized Reservation Systems (CRS). Specific data on reported gate-hold delay come from reports provided by the Air Transport Association. In addition, APO independently estimates unimpeded taxi times.

It is important to note that each of these data sources was independently created for a specific purpose and that none was designed to provide data to the CODAS delay system. Each source has its own strengths and limitations. CODAS were designed to take advantage of each data source's strengths and to overcome its limitations. Analysts must recognize the limitations of the basic data sources and remember that the CODAS-reported delays are estimates and not actual measures of delay. The reliability of the CODAS data varies from record to record. A record may have estimated values in some cases where some of the data sources are missing. In this case, the record is encoded with flags to indicate these substitutions.

2.2 THE ENHANCED TRAFFIC MANAGEMENT SYSTEM

The Enhanced Traffic Management System, as its name implies, supports the daily management of the ATC system. ETMS data are collected automatically by the Air Route Traffic Control Center (ARTCC) computers for Instrument Flight Rules (IFR) flights. Although ETMS theoretically records all controlled traffic, in practice some flight information may not be recorded. ETMS data are automatically recorded, but this process is not monitored and there are periods of time when data are not recorded because of a computer or communications problem. In addition, when ARTCC computers are particularly busy they may temporarily cease to generate some ETMS messages.

ETMS contains complete flight information for all IFR flights, including air carrier, air taxi/commuter, general aviation and military operations. ETMS also has flight information for cargo flights and for the departures and arrivals of international flights.[3] The ETMS messages include filed flight plans (FZ), departures (DZ), arrivals (AZ), position updates (TZ) and others. However, this flight information is recorded in ETMS as a string of flight messages, not as a complete flight record,[4] so flight records must be constructed from numerous ETMS messages. Air Traffic (AT) uses customized software systems to organize the raw ETMS 5.0 data and to match the messages into flight records.

The ETMS flight records profile actual flight performance, but because ETMS has no data on scheduled flight times, the extent to which actual flight times exceed expected flight times--or delay--cannot be measured. As such, additional data are required.

2.3 THE AIRLINE SERVICE QUALITY PERFORMANCE SYSTEM

ASQP data are collected by DOT to calculate on-time performance for its monthly Air Travel Consumer Report. Major air carriers are required by regulation to report this information. However, the reporting requirements apply only to air carriers with more than one percent of total domestic scheduled passenger revenues; the 10 carriers that must file include the following:

Alaska Airlines	Northwest Airlines
America West Airlines	Southwest Airlines
American Airlines	Trans World Airlines
Continental Airlines	United Airlines
Delta Air Lines	USAir

[3]ETMS also has flight information for non-scheduled IFR cargo, passenger, general aviation, and military flights.

[4]For most areas, ETMS actually tracks flights only in enroute airspace and not in terminal airspace.

The ASQP carriers are required to report on operations to and from the 27 largest U.S. airports (those with at least one percent of total domestic scheduled passenger enplanements), but all 10 carriers voluntarily provide data for their entire domestic systems and CODAS includes all these airports in its delay reports. However, ASQP does not contain any information on the operations of smaller air carriers, commuters, air taxis, or on general aviation, cargo, military and international flights. The percentage of total operations for which ASQP has data varies depending on the mix of traffic at each airport. At those airports where a significant proportion of operations is not reported, the ground movement and flight times may be biased. In addition, ASQP does not provide any information on the aircraft type used for a flight.

The primary ASQP data elements are the actual ground and flight movement times for each flight: gate departure (gate-out or OUT), takeoff (wheels-off or OFF), landing (wheels-on or ON) and gate arrival (gate-in or IN), collectively known as OOOI times. These data are automatically recorded by aircraft equipped with Aircraft Communication Reporting and Addressing (ACARS) sensors, processed by Aeronautical Radio, Incorporated (ARINC). ASQP-reporting carriers whose aircraft are not equipped with ACARS (e.g., Southwest Airlines) are also required to report these data elements. The ASQP data base also contains scheduled ground and flight movement times for each flight, obtained from the OAG and the carriers' CRS. The availability of these data permits ASQP to calculate performance and delays by phase of flight.

However, there is a significant lag between the time that a flight actually occurs and when the data are assembled and available to CODAS. The ASQP data are submitted to DOT approximately 15 days after the end of the reporting month and DOT takes another 15 days to process the data. Complete ASQP data are usually provided to APO as an input to CODAS 45 days after the end of the reporting month.

2.4 OFFICIAL AIRLINE GUIDE

The Official Airline Guide lists planned flight times for all scheduled air carrier and commuter flights. The OAG contains flight information, including the type of aircraft used, for all domestic flights and for international flights originating or terminating in the U.S. The OAG does not contain information on non-scheduled and cargo flights or for general aviation or military operations.

OAG flight information is incorporated into the ASQP database and input to CODAS with the OOOI data. The OAG planned times are used to calculate delays only when the filed flight plan times from ETMS are not available.

2.5 COMPUTER RESERVATION SYSTEM

The Computer Reservation System is the main outlet used by the major air carriers to distribute tickets. Like the OAG, it contains flight information, including the aircraft type, for all domestic flights and for international flights originating or terminating in the U.S. The CRS records contain any updates from the previously released OAG schedules. CRS flight information is also incorporated into the ASQP database and input to CODAS with the OOOI and OAG data. The CRS planned times are used to calculate delays only when both the ETMS flight plan times from ETMS and the OAG planned times from ASQP are not available.

2.6 AIR TRANSPORT ASSOCIATION DELAY DATA

The Air Transport Association represents all of the carriers that report ASQP data to DOT. ATA compiles information on delays from data submitted by its member carriers and publishes a summary report monthly. CODAS compare the ATA average delays at each airport with actual gate delays and other gate-hold measures.

2.7 UNIMPEDED TAXI TIMES

CODAS cannot calculate taxi delays because it has no data available on taxi times under optimal operating conditions. Therefore, APO developed a procedure to estimate this parameter. It is based on aircraft queue lengths by carrier and airport and uses a statistical function to estimate taxi times when the queues are of a minimal length. These estimates of taxi times are entered into the CODAS database and used to calculate taxi delays (i.e., actual taxi times minus unimpeded taxi times). The procedures used to develop the queues and to estimate the unimpeded taxi times are discussed in detail in Section 5 of this report.

3.0 DESCRIPTION OF THE CODAS DATA BASE

3.1 SUMMARY OF THE CODAS ENVIRONMENT

As noted in the previous section, CODAS data come from two primary and three secondary data sources. Because the data come from independent sources, they are not all available at the same time. ETMS data are available to CODAS from Airspace Analytical Archives (ATA-200) within five days after the day the flight takes place. ATA monthly average delays are taken from the ATA delay report as needed. The ASQP data are received last because the OOOI data are first submitted to DOT. The complete ASQP data, which include OAG, CRS and OOOI data, are received from DOT 45 days after the end of the reporting month.

Because of this delay in receiving data, CODAS cannot be used for day-to-day or weekly planning and response. However, CODAS delay data should provide a Valuable resource for mid- and long-range planning.

3.2 THE CODAS RECORD STRUCTURE

The fields in the CODAS data base have been revised during CODAS's design and may be updated as CODAS is tested and implemented. Figure 3-1 presents the CODAS record structure as of March 1, 1997.

The CODAS data fields can be divided into those that contain primary data from one of the source data bases, or are calculated from primary data, and flags that indicate whether these values are estimates of primary data or are derived from other estimated data. The former is shown in uppercase (ASQP_DEP) and the latter in lowercase (e_asqp_dep).[5]

Certain key fields are common to both primary databases and are used to match records of individual flights. These matching fields include FAA CARRIER, FLTNO, DEP_LOCID, ARR_LOCID and YYDDMM.

---

[5] The exception to this pattern is E_GATE_HOLD, which is the estimated gate-hold and is defined as either GATE_DELAY, EDCT_HOLD or ATA_GATE_HOLD.

Figure 3-1
CODAS Record Structure

		Source(s)			
Field Name	**Type/ Size**	**A**	**E**	**O**	**Description**
FAACARRIER	C 3	x	x		FAA Carrier code from ETMS or ASQP; NA if GA or Military
FLTNO	N 4	x	x		Numeric part of flight number from ETMS or ASQP for Air Carrier only, 0 for other user_classes.
USER_CLASS	C 1	x	x		Air Carrier (C), AirTaxi (T), Military (M), GA (G), Freight (F) and Unknown (?). If from ASQP, always C.
ASQP	C 1	x			ASQP record found flag
ETMS	C 1		x		ETMS record found flag
OAG	C 1			x	OAG record found flag. Note, if both ASQP and ETMS, then OAG is not used
TAILNO	C 6	x	x		Aircraft tail number from ASQP, or, for non-ASQP flights parsed from ETMS carrier/flight number, or? when unknown
SEGMENT_NO	N 2				Flight segment number, -1 if unknown
FLT_TYPE	C 1	x	x		International Departure (D), International Arrival (A) or Domestic (N) - derived by examining length and leading character of airport locids in ETMS RT message
DEP_LOCID	C 4	x	x		FAA Location Identifier
ARR_LOCID	C 4	x	x		FAA Location Identifier
YYMMDD	C 6	x	x		Local day of flight departure
OAG_S_DEP	N 9	x		x	OAG Scheduled gate departure GMT time (in seconds). From ASQP
e_oag_dep	C 1		x		Blank - as defined A - from OAG Match, no ASQP B - from ETMS FILED_P_TIME. Y - missing, no OAG match Z - ASQP present, but missing
OAG_S_ARR	N 9	1		2	OAG Scheduled gate arrival GMT time (in seconds). From ASQP
e_oag_arr	C 1		3		Blank - as defined A - from OAG Match, no ASQP B - computed from ETMS as FILED_P_TIME + NOM_TO (unimpeded TO) +FILED_ETE +NOM_TI.(unimpeded TI) Y - missing, no OAG match Z - ASQP present, but missing

OAG_S_G2G	N 3	1		2	OAG scheduled gate-to-gate time in minutes from ASQP.
e_oag_g2g	C 1				Blank - as defined A - from OAG Match, no ASQP B - as defined, but reflects estimated OAG DEP or ARR X - missing, out of range (0-999) Y - missing, no OAG match Z - ASQP present, but missing
CRS_DEP	N 9	x			From Computer Reservation System (CRS) scheduled departure time from ASQP
e_crs_dep	C 1			x	Blank - as defined A - equals OAG_DEP if missing
CRS_ARR	N 9	x			CRS scheduled arrival time from ASQP
e_crs_arr	C 1			x	Blank - as defined A - from OAG_ARR
CRS_G2G	N 3	x			CRS_ARR - CRS_DEP from ASQP
e_crs_g2g	C 1			x	Blank - as defined A - as defined, but reflects estimated CRS DEP or ARR
ASQP_DEP	N 9	x			ASQP actual GMT gate departure time; based on sensor in aircraft transmitting using ARINC's ACARS
e_asqp_dep	C 1		x		Blank - as defined A - no ASQP = WHEELS_OFF - estimated TAXI_OUT
ASQP_ARR	N 9	x			ASQP actual GMT gate arrival time; based on sensor in aircraft transmitting using ARINC's ACARS
e_asqp_arr	C 1		x		Blank - as defined A - no ASQP = WHEELS_ON + TAXI_IN*60
ASQP_G2G	N 3	x			ASQP actual GMT gate-to-gate time in minutes
e_asqp_g2g	C 1		x		Blank - as defined A - as defined, but reflects estimated ASQP DEP or ARR
ETMS_EQPT	C 4		x		FAA equipment type from ETMS flight plan (FZ) message (???? if not determined).
EQPT_LS	C 1		x		Coded Large (L) or Small (S) from ETMS, else "?" if not known
FILED_ETE	N 3		x		Carrier filed Estimated Time Enroute in Minutes from ETMS FZ message.
e_filed_et	C 1				Blank - as defined A - CRS_G2G - median NOM_TO - median NOM_TI B - PLAN_ETE
FILED_PTIM	N 9		x		Carrier filed "P Time" or planned gate departure time from ETMS FZ message.
e_filed_pt	C 1				Blank - as defined. A - Equals CRS_DEP if ETMS missing. B - No ETMS ptime & no ASQP; use ETMS plan_off -

					nom. taxi out. Y - No ETMS. Value is ASQP. Z - No ETMS; no replacement.
PLAN_OFF	N 9		x		FAA planned wheels off GMT time from ETMS FZ or RT
e_plan_off	C 1				Blank - as defined A - Equals CRS_DEP +median NOM_TO
PLAN_ON	N 9		x		FAA planned wheels on GMT time from ETMS FZ or RT
e_plan_on	C 1				Blank - as defined A - FILED_ETE + PLAN_OFF
PLAN_ETE	N 3				FAA planned flight time in minutes = ON - OFF
e_plan_ete	C 1				Blank - as defined A - reflects estimated ON or OFF
EDCT_OFF	N 9		x		Controlled wheels off time from ETMS CDT EDCT RT
ACT_DZ	N 9		x		Departure time from ETMS DZ message (usually 1 minute after wheels off)
e_act_dz	C 1				Blank - as defined A - No ETMS estimate = WHEELS_OFF + GAP_DZ Y - No ETMS Found Z - ETMS Found, but no DZ Record
ACT_AZ	N 9		x		Arrival time from ETMS AZ message timestamp rather than the time in the message (usually 1 to 3 minutes after wheels on).
e_act_az	C 1				Blank - as defined A - Equals WHEELS_ON - GAP_AZ Y - No ETMS Found Z - ETMS Found, but no AZ Record
ACT_DZ2AZ	N 3		x		DZ to AZ time in minutes
e_act_dz2a	C 1				Blank - as defined A - reflects estimated DZ or AZ Y - No ETMS Found
WHEELS_OFF	N 9	x			ASQP actual wheels off time
e_whls_off	C 1		x		Blank - as defined A - if no departure ASQP, estimate = ACT_DZ - GAP_DZ
WHEELS_ON	N 9	x			ASQP actual wheels on time
e_whls_on			x		Blank - as defined A - if no arrival ASQP, estimate = ACT_AZ + GAP_AZ
GAP_DZ	N 4.1	x	x		Time in minutes between wheels off (ASQP) and DZ message (ETMS).
e_gap_dz	C 1				Blank - as defined A - DZ message time estimated due to missing DZ B - GAP_DZ is estimated for non-ASQP flights using median ASQP gaps by airport and time of day.

					C - Estimated average for overseas locations (Canada, England).
GAP_AZ	N 5.1	x	x		Time in minutes between AZ message timestamp (ETMS) and wheels on (ASQP).
e_gap_az	C 1				Blank - as defined A - AZ message time estimated due to missing AZ B - GAP_AZ is estimated for non-ASQP flights using median ASQP gaps by airport and time of day. C - Estimated average for overseas locations (Canada, England).
TAXI_OUT	N 4.1	x			Gate Out to Wheels Off from ASQP
e_taxi_out	C 1				Blank - as defined A - estimated for non-ASQP flights from median taxi out by airport and time of day. X - Median value not available.
AIRBORNE	N 5.1	x			Wheels off to wheels on from ASQP
e_airborne	C 1				Blank - as defined A - estimated using ACT_DZ and ACT_AZ and GAP_DZ and GAP_AZ for non ASQP flights Y - less than filed flight plan value (FILED_ETE).
TAXI_IN	N 4.1	x			Wheels on to Gate In
e_taxi_in	C 1				Blank - as defined A - estimated for non-ASQP flights from median taxi in by airport and time of day. X - Median value not available.
GATE_DELAY	N 5.1	x	x		Minutes of gate delay = ASQP_DEP - FILED_P_TIME if > 0
e_gate_del	C 1				Blank - as defined A - if OAG, ASQP_DEP - OAG_DEP Y - out of range (negative) Z - missing
ATA_GATE_H	N 5.1				Average minutes of ATC caused gate hold for the airport this month as reported to ATA by airlines.
E_GATE_HLD	N 5.1				Estimated gate hold using gate delay, EDCT_HOLD and ATA reported averages.(EDCT_HOLD or GATE_HOLD or ATA_GATE_HODE)
EDCT_HOLD	N 5.1		x		Calculated ground delay based on planned vs. controlled time of departure. (EDCT_OFF - PLAN_OFF).
e_edct_hld	C 1				Blank - as defined Y - ETMS present, but out of range (< 0) Z - No EDCT_OFF
DELAY_TO	N 5.1	x			Taxi out delay based on NOM_TO
e_delay_to	C 1				Blank - as defined
DELAY_AIR	N 5.1	x	x		Airborne delay based on AIRBORNE - FILED_ETE.
e_delay_a	C 1				Blank - as defined

					Y - out of range (negative) Z - missing
DELAY_TI	N 5.1	x			Taxi in delay based on NOM_TI
e_delay_ti	C 1				Blank - as defined
NOM_TO	N 4.1	x			Un-impeded taxi-out in minutes statistically estimated for airport, carrier and equipment.
NOM_TI	N 4.1	x			Un-impeded taxi-in in minutes statistically estimated for airport, carrier and equipment.
FLIGHT_IND	N 10		x		ETMS 5.0 flight index for tracking ETMS messages
D_WSTN	C 4				Weather report station LOCID
D_DISTANCE	N 3				Distance from airport to weatherstation
D_TIMELAG	N 3				Time between weather report and scheduled departure
D_CEILING	N 4				Ceiling height in meters
D_VISIBILE	N 6.2				Visibility in miles
D_TEMP	N 3				Temperature Fahrenheit
D_WND_ANGL	N 3				Wind direction: North = 0
D_WND_SPED	N 3				Wind speed knotts
D_CONDNS	C 10				Weather conditions; coded string
AD_TIMELAG	N 3				Time between arrival stn. report and sched. departure
AD_CEILING	N 4				Ceiling height at arrival airport on departure
AD_VISIBIL	N 6.2				Visibility at arrival airport on departure
AD_TEMP	N 3				Temperature at arrival airport on departure
AD_WND_ANG	N 3				Wind direction at arrival airport on departure
AD_WND_SPE	N 3				Wind speed at arrival airport on departure
AD_CONDNS	C 10				Weather conditions at arrival airport on departure
A_WSTN	C 4				Arrival airport station LOCID
A_DISTANCE	N 3				Distance between weatherstation and arrival airport
A_TIMELAG	N 3				Time between weather report and scheduled arrival
A_CEILING	N 4				Ceiling height in meters
A_VISIBLE	N 6.2				Visibility in miles
A_TEMP	N 3				Temperature Fahrenheit
A_WND_ANGL	N 3				Wind direction: North = 0
A_WND_SPED	N 3				Wind speed knotts
A_CONDNS	C 10				Weather conditions; coded string

Notes: All points in time are GMT times in seconds since midnight 01-01-1980.
All duration times are in minutes.

Many fields have ‘flag fields’ that indicate when a field is estimated or computed from other fields that were estimated. Further, these flag fields often have more than one code to indicate which of several possible estimates was used. The first estimate (coded A) would be preferred over the second (coded B), and so on. Several of these flag fields also have values that show why a number is missing in the final CODAS record. This is generally true of values X, Y, and Z. Missing values are usually indicated as -1, unless a negative value is normally legal for the field, in addition to the flag field (X, Y, and Z). **It is important to omit -1 values and/or check the flag fields when calculating sums, averages, etc.**

The following weather phenomena are coded into the D_CONDNS, AD_CONDNS, and A_CONDNS fields using these codes.

FIELD VALUE:	DESCRIPTION:
WV	Variable winds
SC:999	Scattered clouds (<50% coverage)
BK:999	Broken clouds (50-67% coverage)
OV:999	Overcast clouds (67-100% coverage)
RV:[99R|L]:999	Runway visual range
VM:999	Runway Vis Range max if varies
VI:[AAA]	VIRGA direction
TT:[F|T|W]	Tornadic Type
CT:[CB|TCU]	Cloud type
PA:99	Precipitation amount 3-6 hour (inches)
SD:999	Snow depth
WE:999	Water Equivalent depth of snow
PW:999:99:9999	Peak wind dir:speed:hour+minute
WS:9999	Wind shift time in hour+minute
LD:[AA]	Lightning Direction
LQ	Lightning Frequent
LO	Lightning Occasional
LC	Lightning Constant
LL:[AAA]	Lightning location
RW:[AAAA]:999:999	Recent weather phenomenon
PD:999	24 hour precip. amount
PR	pressure rising rapidly
PF	pressure falling rapidly
NO:CIG	Sensor out
MA	Maintenance needed
WV:999:999	Variable wind dir variation
CO	Correction report

The fields that are used to calculate the four delay components come from both ETMS and ASQP and some require data from both data sources; if these are not available; the OAG and CRS data are used to estimate the missing values. These key fields and their components are listed below:

AIRBORNE DELAY	WHEELS_OFF	from ASQP
	WHEELS_ON	from ASQP
	FILED_ETE	from ETMS
GATE DELAY	ASQP_DEP	from ASQP
	FILED_PTIME	from ETMS
GATE-HOLD	EDCT_HOLD	from ETMS
	ATA_GATE_HOLD	from ATA
TAXI-OUT DELAY	WHEELS_OFF	from ASQP
	ASQP_DEP	from ASQP
	NOM_TO	from ASQP[6]
TAXI-IN DELAY	WHEELS_ON	from ASQP
	ASQP_ARR	from ASQP
	NOM_TI	from ASQP[6]

Figure 3-1 also shows 25 fields for weather information: conditions at the departure airport at FILED_PTIME; conditions at the arrival airport at FILED_PTIME; and conditions at the arrival airport at FILED_PTIME + FILED_ETE + NOM_TO. Weather observations will be limited to readings taken within two hours of the departure or arrival time.

The CODAS record structure also will be expanded to include information on ATC equipment outages. Because the ARTCC computers are the source of ETMS data, that database does not have any information on ATC equipment outages.

[6]NOM_TO and NOM_TI, the unimpeded taxi times, are estimated from ASQP data.

4.0 MEASURES OF DELAY

4.1 DEFINITION OF DELAY COMPONENTS

Although total aircraft delay is an important measure of on-time performance, it is difficult to analyze patterns of delay without more detailed information. In a major improvement from previous FAA and DOT delay reporting systems, CODAS provides delay data for both individual flights and for separate phases of each flight: gate-delay, taxi-out delay, airborne delay and taxi-in delay. Each of these delay components can also be correlated to other flight characteristics, such as airport, carrier, season and so forth. The CODAS definitions of the delay components are as follows:

Airborne Delay--The difference between the actual flight time reported in ASQP and the planned flight time in the flight plan filed with FAA and reported in ETMS.

Gate Delay and Gate-Hold Delay--Gate delay is the difference between the actual gate departure time reported in ASQP and the scheduled gate departure time reported in ETMS. However, the actual delay measurement of interest is gate-hold delay. Gate-hold is defined as one of three independent measures of delay: Expected Departure Clearance Time hold (EDCT-hold), which is a delay in the scheduled gate departure imposed by FAA's ATC System Command Center; or Air Transport Association (ATA gate-hold), which is a delay in the actual gate departure after a clearance departure time has been issued; or gate delay.

Taxi-out Delay--The difference between actual taxi-out time and unimpeded taxi-out time by airport, carrier and season. The unimpeded taxi-out time is the estimated average taxi-out time for an aircraft under optimal operating conditions when neither congestion, weather nor other factors delay it during its movement from gate to takeoff.

Taxi-in Delay--The difference between actual taxi-in time and unimpeded taxi-in time by airport, carrier and season. The unimpeded taxi-in time is the estimated average taxi-in time for an aircraft under optimal operating conditions, when neither congestion, weather nor other factors delay it during its movement from landing to gate.

4.2 METHODOLOGY USED TO CALCULATE DELAYS

Only one of the four delay components--airborne delay--is calculated directly from CODAS flight records. A two-step process is used to calculate taxi-out delay and taxi-in delay. CODAS provide taxi-out and taxi-in times, but these are measures of performance rather than delay. Taxi delay is the difference between the actual and scheduled taxi times. Because scheduled taxi times are not available; they must be estimated from other data. Finally, gate delay is adjusted to remove the effect of ATC-imposed gate holds. The methods used to calculate the CODAS delay components are described below:

Airborne Delay (DELAY_AIR)--Actual Flight Time Minus Planned Flight Time

Actual flight time is WHEELS_ON minus WHEELS-OFF, both from ASQP. Planned flight time is FILED_ETE, the estimated time enroute (ETE) filed by the carrier and reported in the ETMS flight plan (FZ) message.

DELAY_AIR = (WHEELS_ON - WHEELS_OFF) - FILED_ETE

Flight records from both ASQP and ETMS are required to calculate airborne delay. If the ASQP data are missing, they can be estimated from other CODAS data. WHEELS_OFF can be estimated as ACT_DZ minus GAP_DZ, i.e., the aircraft departure time from the ETMS departure (DZ) message minus the median time between WHEELS_OFF and ACT_DZ for all ASQP flights at that airport on that day. WHEELS-ON can be estimated through a parallel process.

If the ETMS time is missing, it also can be estimated from other CODAS records. FILED_ETE can be estimated in one of two ways. The first and preferred method is to estimate planned flight time as CRS_G2G minus median NOM_TO minus median NOM_TI, i.e., the gate-to-gate time from the CRS, minus the median unimpeded taxi-out time for all ASQP flights for that airport and that hour minus the median unimpeded taxi-in time for all ASQP flights for that airport and that hour. If these fields are not available, planned flight time can be estimated as PLAN_ETE, the FAA-planned flight time.

Airborne delay is the only delay component that can have a negative value; that is, the flight will be early if the actual flight time is less than the planned flight time. This can occur because the planned flight time is always an estimate but does not change once it is submitted, while the actual flight time will be reduced if the flight is permitted to follow a more direct route, if the speed of the aircraft is increased or if high altitude winds increase (tailwind) or decrease (headwind). If the airborne delay is negative, however, CODAS assigns a value of zero for that flight, i.e., zero delay.

Gate Delay (GATE_DELAY)--Actual Gate Departure Time Minus Scheduled Gate Departure Time

The actual gate departure time (ASQP_DEP) is reported directly from ASQP. The scheduled gate departure time (FILED_PTIM) is reported from the carrier-filed planned departure time in the ETMS flight plan (FZ) message.
Flight records from both ASQP and ETMS are required to calculate gate delay.

GATE_DELAY = ASQP_DEP - FILED_PTIM

ASQP_DEP can be estimated as WHEELS_OFF (ACT_DZ minus GAP_DZ) minus TAXI_OUT, which is the median taxi-out time by airport and hour for all ASQP flights. FILED_PTIM can be estimated as CRS_DEP, the scheduled departure time from the computer reservation system (CRS).

Gate-Hold Delay (E_GATE_HOLD)--Select One of Three Independent Measures of Delay

Gate-hold delay (E_GATE_HOLD) requires the calculation of the three independent measures of delay--EDCT_HOLD, ATA_GATE_H and GATE_DELAY--and the selection of one of those measures according to specified decision rules.

EDCT_HOLD is the calculated ground delay based on the controlled wheels-off time minus the FAA-planned wheels-off time from the ETMS flight plan message (FZ). EDCT_HOLD cannot be estimated from any other CODAS data. ATA_GATE_H is the average ATC-caused gate hold for that airport for that month. These data are supplied to CODAS by the Air Transport Association, which receives the data from the individual carriers. ATA_GATE_H cannot be estimated from any other CODAS data. GATE_DELAY is described above.

The decision rules for selecting one of these three measures as the estimated gate-hold delay (E_GATE_HOLD) are based on the comparative magnitude of each, as follows:

E_GATE_HOLD = 0	if GATE_DELAY	= 0
E_GATE_HOLD = EDCT_HOLD	if EDCT_HOLD	> 0
	and EDCT_HOLD	<= GATE_DELAY
E_GATE_HOLD = ATA_GATE_HOLD	if EDCT_HOLD	= 0
	and ATA_GATE_HOLD	< GATE_DELAY
E_GATE_HOLD = GATE_DELAY	if EDCT_HOLD	= 0
	and ATA_GATE_HOLD	> GATE_DELAY
E_GATE_HOLD = GATE_DELAY	if EDCT_HOLD	> 0
	and EDCT_HOLD	> GATE_DELAY

Taxi-Out Delay (DELAY_TO)--Actual Taxi-out Time Minus Unimpeded Taxi-out Time

Actual taxi-out time is WHEELS_OFF minus ASQP_DEP, both from ASQP. ASQP_DEP is the actual gate departure time, also known as gate-out time. Unimpeded taxi-out time (NOM_TO) is statistically estimated for airport, carrier and season. The methodology used to estimate unimpeded taxi-out time is described in the next section of this report.

DELAY_TO = (WHEELS_OFF - ASQP_DEP) - NOM_TO

All of the data required to estimate taxi-out delay are from ASQP records. WHEELS_OFF can be estimated as ACT_DZ minus GAP_DZ, i.e., the aircraft departure time from the ETMS departure (DZ) message minus the median time between WHEELS_OFF and ACT_DZ for all ASQP flights at that airport on that day. ASQP_DEP can be estimated as WHEELS_OFF minus the median taxi-out time by airport and hour for all ASQP flights. NOM_TO is separately estimated from ASQP data and cannot be estimated from any other CODAS data.

Taxi-In Delay (DELAY_TI)--Actual Taxi-in Time Minus Unimpeded Taxi-in Time

Actual taxi-in time is ASQP_ARR minus WHEELS_ON, both from ASQP. ASQP_ARR is the actual gate arrival time, also known as gate-in time. Unimpeded taxi-in time (NOM_TI) is statistically estimated for airport, carrier and season. The methodology used to estimate unimpeded taxi-in time is the same as that used to estimate unimpeded taxi-out time.

DELAY_TI = (ASQP_ARR - WHEELS_ON) - NOM_TI

All of the data required to estimate taxi-in delay are from ASQP records. WHEELS_ON can be estimated as ACT_AZ minus GAP_AZ, i.e., the aircraft arrival time from the ETMS arrival (AZ) message minus the median time between WHEELS_ON and ACT_AZ for all ASQP flights at that airport on that day. ASQP_ARR can be estimated as WHEELS_ON plus TAXI_IN, the median taxi-in time by airport and hour for all ASQP flights. NOM_TI is estimated from other ASQP records, as described in Section 5.

4.3 OTHER FLIGHT CHARACTERISTICS OF DELAY COMPONENTS

A major analytical advantage of CODAS is that the delays for each individual flight can be correlated to other flight characteristics; these include the following:

Season--CODAS data are reported on a monthly basis and assembled into four seasonal blocks, representing winter, spring, summer, and fall.

Airport--CODAS provides delay information for flights at 181 U.S. airports. These airports account for almost all domestic passenger flights.

Air Carrier--CODAS provides delay information for all air carrier flights.

Day of Month and Time of Day--CODAS provides delay data by the day of the month and each flight is identified by time of departure and time of arrival.

Weather Conditions--The CODAS record structure contains fields for 25 different measures of weather conditions, including ceiling, visibility, temperature, wind angle and wind speed at both departure and arrival airports. Each set of weather observations will be the actual observations from within two hours of the actual flight departure or arrival time.

In the future, CODAS will collect additional information that will enable analysts to compare delays under the following operating conditions:

Runway Configuration[7]--The particular combination of runways that is in use at an airport affects both capacity and patterns of operations. Runway configuration will be particularly useful in calculating unimpeded taxi times, since changes in the distance and orientation between a particular carrier's gates and the runways in use for takeoffs and landings will vary. Data on the runway configuration in use at the time of takeoff and landing for each flight will be incorporated into the CODAS database when such data are available.

---

[7]Runway configuration is the number, location, and orientation of the active runway(s), the type and direction of operations, and the flight rules in effect at a particular time.

ATC Equipment Status--Outages of ATC equipment at the time of each phase of flight will be incorporated into the CODAS database when such data are available.

4.4 ELIMINATING OUTLIERS

Outliers are defined as observations that are so far away from the rest of the data that they should be discarded or modified. Often outliers are the result of an error in data reporting or calculation. For example, an airborne time of 1528 minutes--or 24 hours and 88 minutes--would suggest that the date field of either the departure or arrival was in error. CODAS assume that outliers are the result of some error or atypical observation rather than a representative flight delay. Since every record among millions cannot be inspected manually, CODAS uses specified tolerance limits for the values of the key data fields to exclude outliers. The limits for each delay component and the key fields used to calculate those components are described below.

Airborne Delay--The value of actual flight time must be less than or equal to 999 minutes (16 hours and 39 minutes) or the record is dropped. The value of airborne delay (actual flight time minus planned flight time) must be less than or equal to 999 or the value is set to -1. Records with a value of -1 are flagged and the values are not used in any further calculations. As noted above, airborne delay can be less than zero, but in that case the delay is set to zero.

Gate Delay and Gate-Hold--The value of gate delay must be greater or equal to zero, but there is no upper limit. The value of E_GATE_HOLD must be less than or equal to 999 minutes or the value is set to -1; the same limits apply to EDCT_HOLD and ATA_GATE_HOLD.

Taxi-Out Delay--The value of actual taxi-out time must be less than 99 minutes or the record is dropped; the value must be greater than or equal to zero or the value is set to -1. The value of unimpeded taxi-out time as estimated statistically must also be greater than or equal to zero or the value is set to -1. Taxi-out delay must be less than or equal to 999 minutes or the value is set to -1.

Taxi-In Delay--The value of actual taxi-in time must be less than 99 minutes or the record is dropped; the value must be greater than or equal to zero or the record is set to -1. The value of unimpeded taxi-in time as estimated statistically must also be greater than or equal to zero or the value is set to -1. Taxi-in delay must be less than or equal to 999 minutes or the value is set to -1.

5.0 ESTIMATION OF ACTUAL TIMES FOR NON AIRLINE SERVICE QUALITY PERFORMANCE REPORTING CARRIERS

5.1 ESTIMATION OF ACTUAL TIMES

For carriers that do not report to the Department of Transportation under the Airline Service Quality Performance program, no information is currently available for actual times except for the DZ message and the AZ message time (these times are discussed in section 2.2). The following sections discuss the techniques for estimating actual times.

5.2 ESTIMATION OF WHEELS_OFF AND WHEELS_ON TIME

Using all ASQP flights, the median difference between the DZ message and wheels_off is computed by airport and day. This value is designated as the departure gap. The departure gap is then subtracted from the DZ time for all non-ASQP flights to obtain wheels_off. The departure gap is generally about 1 minute and is a fairly stable value.

In a similar manner, the median difference between wheels_on and the message time of the AZ message is computed by airport and day. This value is designated the arrival gap. The arrival gap is then added to the AZ message time for all non ASQP flights to obtain wheels_on. There is more variability in the arrival gap then the departure gap. The arrival gap varies from a minus 5 to a plus 6.

5.3 ESTIMATION OF TAXI TIMES

Using all ASQP flights, the median taxi-out and median taxi-in time is computed by airport, day, and hour. The median taxi times by airport and day are also computed. In addition, a default value by day for taxi time is computed by excluding the top 50 airports and computing the median value of taxi times for all other ASQP flights. The order for estimating taxi times for non-ASQP flights is as follows:

1. Use median by airport, day, and hour
2. Use median by airport and day
3. Use national default value by day

5.4 ESTIMATION OF GATE TIMES

For non-ASQP flights, the gate-out time is computed by subtracting the taxi-out time from the wheels_off time. In a like manner, the gate-in time is computed by adding the taxi-in time to the wheels_on time.

6.0 ESTIMATION OF UNIMPEDED TAXI TIME

6.1 DEFINITION OF UNIMPEDED TAXI TIME

As noted in the previous section, taxi-out delays are calculated in a two-step process.[8] First the actual taxi-out time for a given flight is determined by subtracting the wheels-off time from the gate-out time, both of which are available directly from ASQP. Then taxi-out delay is calculated by subtracting an expected taxi-out time from the actual taxi-out time.

This two-step process is necessary because actual taxi-out time is the sum of two elements: expected (minimum) taxi-out time and delay. All flights have a certain minimum taxi-out time, which is the time it takes for the aircraft to go from the gate to the runway and then take off. A taxi-out delay occurs only when the taxi-out time exceeds an expected time for completing this aircraft movement. Therefore, to measure taxi-out delay some measure of that expected time is required. CODAS calls that measure the unimpeded taxi-out time.

Unimpeded taxi-out time is defined as the taxi-out time under optimal operating conditions, when neither congestion, weather nor other factors delay the aircraft during its movement from gate to takeoff. Unimpeded taxi-out time varies by airport, depending on the combination of gates and runways at that airport; by carrier at an airport, depending on the location of that carrier's gates relative to the runways being used for takeoffs; and by season, depending on the changes in normal operating procedures during each period.

6.2 ESTIMATION OF UNIMPEDED TAXI TIMES

Because CODAS has no data for expected taxi-out times under optimal operating conditions, unimpeded taxi-out times are estimated from data that are available. Unimpeded taxi-out time is defined as the taxi-out time under two simultaneous

[8]CODAS calculate taxi-in time, unimpeded taxi-in time and taxi-in delay in a similar manner, beginning with wheels-on and gate-in times from ASQP.

conditions--when the departure queue is equal to 1 and the arrival queue is equal to 0.[9] The departure queue is the number of aircraft at each minute of the day that have pushed back from the gate (gate-out) but have not yet taken off (wheels-off). The departure queue is equal to 1 if a departing aircraft is the only one in motion when it pushes back from the gate. When another aircraft pushes back from its gate, the departure queue increases to Q=2 and so on until the first aircraft leaves the runway (wheels-off). The arrival queue is the number of aircraft that have landed (wheels-on) but have not yet reached the gate (gate-in). The arrival queue is equal to 0 if there are no aircraft landing (wheels-on) when the departing aircraft pushes back from the gate. The arrival queue increases in the same way as the departure queue until the first arriving aircraft leaves the runway.

The first step in the estimation of unimpeded taxi times is to determine the length of the departure and arrival queues for each minute. The departure and arrival queues are derived through a minute-by-minute analysis of actual flights in the ASQP database. There is one observation for each flight, for the length of the queues in the minute after it pushes back from the gate. Three values are identified for each flight: taxi-out time, number of aircraft in the departure queue and number of aircraft in the arrival queue.

CODAS uses a statistical function to estimate unimpeded taxi-out times by airport, carrier and season. The function is in the form of a multiple regression of two variables, with taxi-out time as the dependent variable and the queue lengths as independent variables. The regression equation is as follows:

$$TO_{a,c,s} = b_1 TOQ_{a,c,s} + b_2\, TIQ_{a,c,s} + c$$

Where

- TO = taxi-out time
- TOQ = number of aircraft in taxi-out Queue
- TIQ = number of aircraft in taxi-in Queue
- *a* = airport
- *c* = carrier
- *s* = season
- b_1 = coefficient for TOQ
- b_2 = coefficient for TIQ
- c = constant

---

[9]Although it may seem unlikely that these conditions will be met at a busy airport, an analysis of actual flight operations at the CODAS airports demonstrated that there are a number of such occurrences at each airport and that at some airports most of the flights meet these conditions.

Once the coefficients for the dependent variables are estimated from the regression, the unimpeded taxi-out time is estimated by setting the departure queue DQ=1 and the arrival queue AQ=0.

In estimating the unimpeded taxi-out times, the highest 25 percent of the values of actual taxi time were excluded from the regression. This step was taken to remove the influence of extremely large taxi-out times from the estimation of expected taxi time under optimal operating conditions.

The estimation of unimpeded taxi-out times has two important limitations. First, the impact of the use of different runway configurations on both actual taxi-out times and unimpeded taxi-out times could not be measured because no data are available on the runway configurations used for each flight. The addition of this information to the CODAS database would be valuable and will be a priority in subsequent enhancements of CODAS.

Second, the length of the departure and arrival queues is determined by an analysis of the flights for which OOOI data were available. These flights are a subset of the total activity at each airport. Because CODAS does not have data on all of the flight activity, it must be assumed that the queue lengths are minimum queue lengths and that the actual queues may be longer. Since the estimates of unimpeded taxi-out times are based on the value of the function when DQ=1 and AQ=0, but in reality DQ may be greater than 1 and AQ greater than 0, the estimated taxi-out times are not really unimpeded taxi-out times. However, when this is the case, the CODAS estimates would tend to be greater than the actual unimpeded taxi-out times.

6.3 INTERPRETATION OF RESULTS

Figure 6-1 shows the results of the estimation of unimpeded taxi-out times for all carriers at Atlanta Hartsfield International Airport during 1995. The seasonal groupings are for three months each, representing winter (1=December-February); spring (2=March-May); summer (3=June-August) and fall (4=September-November). The CODAS data in this example are for calendar year 1995 except for the first month in the first seasonal quarter, which uses flights from December 1994.

The regression flag indicates whether a linear or linear multiple regression equation with constraints was used to estimate the unimpeded taxi-out time. With the linear regression both coefficients should be greater than zero; that is, for both taxi-out and taxi-in queues, unimpeded taxi-out time would be expected to increase as they increased. However, in some cases an estimated coefficient was negative. When this occurred, the coefficients were re-estimated using a non-linear regression that was constrained so that both coefficients were greater than zero.

Figure 6-1
TAXI-OUT QUEUE STATISTICS: ATLANTA

Year	Season	Regression Flag	Number of Observations	Mean*	Median*	Mode*	Standard Deviation*	5th Percentile*	10th Percentile*	Low Quartile*	High Quartile*	Departure Count DQ = 1 AQ = 0	Avg. Taxi Out* DQ = 1 AQ - 0	Estimated Unimpeded Taxi-Out Time*
95	1	0	55,739	17.8	16	11	8.4	8	9	12	22	413	11.6	10.4
95	2	0	56,874	17.9	16	10	9.3	8	9	11	22	473	10.9	10.2
95	3	0	57,967	19.0	16	10	11.4	8	9	12	23	358	10.8	10.1
95	4	0	56,683	17.7	16	10	8.6	8	9	11	22	414	11.0	10.0

The number of observations is the number of flights by all ASQP carriers at Atlanta by season. As noted above, these do not include all the flight activity at Atlanta. Summary statistics that are calculated for these flights include the mean, median, mode, standard deviation, 5th percentile, 10th percentile, lower quartile and higher quartile.

The departure count is the number of flights by all ASQP carriers by season at Atlanta where the departure queue was equal to 1 and the arrival queue was equal to 0 (the definition of unimpeded taxi-out time). The average taxi-out time for these flights is greater, in all seasons, than the estimated unimpeded taxi-out time, as expected.

The analysis of unimpeded taxi-out times will eventually include data from air carriers on the taxi-out times that they use as expected taxi-out times when they construct their schedules. These will be compared with the estimated unimpeded taxi-out times and the differences between the regression and the carrier times will be used to improve the estimation.

7.0 IMPLEMENTATION OF CODAS

7.1 NEW MEASURES PROVIDED BY CODAS

CODAS provides estimates of flight delays, based on actual performance data, that are more accurate and comprehensive than any previously available. In addition, using OOOI data, CODAS provides estimates by phase of flight, enabling researchers to identify where and under what conditions flight delays occur. By combining phase of flight information with other data elements, delays by flight can be aggregated by airport and carrier, by time of day and season, and by city pair.

Because CODAS delay estimates are not available until a month or more after the actual flights, they cannot be used for daily management analysis. However, the CODAS estimates are an invaluable resource for conducting mid- to long-range ATC and airport capacity studies.

7.2 ANALYTICAL USES OF CODAS DELAY ESTIMATES

With the more detailed delay information available from CODAS, analysts will be able to undertake studies that they have not been able to even contemplate in the past because of the lack of any disaggregated data on airport performance. These include the analysis of the following:

Delays by time of day and by season;
Delay patterns associated with weather conditions and forecasts;
National delay trends over time;
The effects of changes in demand and capacity on delays; and
How delays vary by airport, carrier and city pair.

The availability of delay estimates based on actual operational data rather than scheduled should improve many types of research. For example, FAA now performs studies at individual airports of the impact of ATC and other improvements. Private architectural and engineering firms conduct similar analyses as part of airport master planning studies. Both government and industry analysts rely upon OAG schedules (or comparable data) to estimate capacity and demand, without any measure of the actual demand for air traffic services by time of day and how individual airports met that demand. CODAS will provide a base of information for airport planners and ATC capacity planners using actual activity and service times at airports.

Airlines may find CODAS data equally useful in understanding how their own activities affect the delays at a given airport and how their operations may be affected by other carriers' actions. Having an unambiguous data set of performance measures such as taxi times, airborne times and patterns of delays can greatly improve the understanding of how complex hubs operate and what affects airport service levels. Such studies are now often performed with OAG data or incomplete data such as that provided by hourly tower logs. CODAS delay estimates are likely to materially improve the understanding of how the air transport system actually functions and where bottlenecks and delays occur.

CODAS data will also provide information on the performance of the enroute system, something that heretofore has only been broached through large simulation studies based on small samples of schedule data, rather than on actual performance data. For example, CODAS airborne delay estimates might be extremely useful in determining the ultimate benefits of free flight.

However, as with any other new data or system, the ultimate range of applications of CODAS delay estimates rests with the imaginations of researchers in the aviation community. As the CODAS database is improved and as a historical record of delays accumulates, additional analyses will be possible.

7.3 INCORPORATION OF WEATHER DATA

Historically, most aircraft delays have been attributed to weather. Information on weather conditions at the departure airport, enroute and at the arrival airport will make it possible to estimate the impact of weather on delays and to evaluate strategies to improve performance under varying weather conditions.

In addition, having delay estimates by airport and carrier will enable analysts to track delays and weather patterns together. When weather patterns can be associated with flight delays and cancellations, airports may be better able to predict how operations will be affected by weather systems and schedule the restoration of capacity after weather systems pass. As noted in section 3, the CODAS record structure already includes fields for weather information.

7.4 CONTINUED INVOLVEMENT OF INDUSTRY

One of the key objectives in the development of CODAS was to produce delay estimates that are accepted by both government and industry. APO and other FAA personnel have conducted a number of meetings with major air carriers as part of the development of the CODAS methodology. This industry involvement has been extremely helpful in producing a better product.

The CODAS database is not a completed system--it will be refined and expanded in the future. A key part of its continuing development will be input from analysts from both government and industry. In particular, as researchers become familiar with CODAS data and use them to support their studies, they will be able to identify its strengths and weaknesses. CODAS's developers will seek to capitalize on the former and to eliminate the latter.

7.5 REPORTING CODAS ESTIMATES OF FLIGHT DELAYS

FAA will issue monthly reports of CODAS estimates of flight delays. Consolidated data from all primary and secondary sources will be available about 30 days after the end of the reporting month. FAA will issue the CODAS reports in another 15 days or approximately six weeks after the end of the reporting month; i.e., January data will be published on or about the 15^{th} of March.

The CODAS report will provide average delay by phase of flight for approximately 181 airports. The CODAS report will be available via the Aviation Policy and Plans (APO) home page.

8.0 GLOSSARY OF TERMS

Actual Airborne—Time from Wheels off to Wheels on. Actual for ASQP carriers. Estimated for non-ASQP carriers.

Actual DZ2AZ—Time from departure message (DZ) to arrival message (AZ)

Adjusted Gate Delay—Gate delay which is adjusted depending on the value of Estimated Departure Clearance Time (EDCT) and Air Transport Association (ATA) Gate Delay.

Airborne Delay—The difference between actual flight time and planned flight time as reported in the flight plan filed with FAA. The difference between actual flight time and planned flight time can be a negative value (i.e., the actual flight time is less than the planned flight time), but is reported as zero minutes of delay when this occurs.

Airline Service Quality Performance (ASQP)—Data collected by the Department of Transportation to calculate on-time performance for the monthly Air Travel Consumer Report. Major air carriers are required by regulation to report this information. However, the reporting requirements apply only to air carriers with more than one percent of total domestic scheduled passenger revenues; the 10 carriers that must file include the following:

Alaska Airlines	Northwest Airlines
America West Airlines	Southwest Airlines
American Airlines	Trans World Airlines
Continental Airlines	United Airlines
Delta Air Lines	USAir

ASQP does not contain any information on the operations of smaller air carriers, commuters, air taxis, or on general aviation, cargo, military and international flights.

If it appears as a 'Y' on report, it means that flight had ASQP data available.

Air Transport Association (ATA)—A trade association that represents all of the carriers that report Airline Service Quality Performance (ASOP) data to the Department of Transportation. ATA compiles information on delays from data submitted by its member carriers and publishes a summary report monthly.

Air Travel Consumer Report (ATCR)—A monthly report, which is issued by the Department of Transportation's Office of Aviation Enforcement and Proceedings, that provides information about the on-time performance of the largest U.S. air carriers. It is based on Airline Service Quality Performance (ASQP) operational data filed by major air carriers and on scheduled times from the Official Airline Guide (OAG).

Arrivals—Number of arrivals for which data is available to compute all components of delay.

Arr. Apt. —Arrival Airport

Arrival Delay— Actual arrival time minus CRS scheduled arrival time.

ASQP Gate In—OAG scheduled arrival time

ASQP Gate Out—Actual gate departure time for ASQP carriers. Estimate gate departure time for non-ASQP carriers.

ASQP G2G Min. —Actual gate to gate time for ASQP carriers. Estimated gate to gate time for non-ASQP carriers

ATA Delay Report—A monthly report based on data provided by members of the Air Transport Association. The report includes the number of flights delayed and the average delay per flight at specific airports, but data by carrier or aircraft type is not available in this report. The data cover all U.S. commercial domestic flights, international departures but not arrivals and some commuter flights (for those carriers that report Form 41 data to the Department of Transportation).

ATA Gate Delay—The airport average Air Traffic Control caused gate delay. These data are supplied by the Air Transport Association, which receives the data from the individual air carriers.

AZ—Enhanced Traffic Management System (ETMS) arrival message.

CARR—Carrier Operating Flight

CODAS—The Consolidated Operations and Delay Analysis System. This system was created by the Office of Aviation Policy and Plans (APO) to provide estimates of aircraft delay by individual flight.

Computer Reservation System (CRS)—The main outlet used by the major air carriers to distribute tickets. The system contains flight information, including aircraft type, for all domestic flights and for international flights originating or terminating in the U.S. The CRS records contain any updates from the previously released OAG schedules.

CRS Gate In—Computer Reservation System scheduled arrival time.

CRS Gate Out—Computer reservation system scheduled departure time.

CRS G2G Min. —Computer reservation system scheduled gate to gate time.

Date—Departure date of flight.

Departures—Number of departures for which data is available to compute all components of delay.
Dep. Apt. —Departure Airport

DZ—Enhanced Traffic Management System (ETMS) departure message.

EDCT—Estimated Departure Clearance Time.

EDCT Delay—Calculated ground delay. It is computed as the difference between the controlled wheels-off time and the FAA-planned wheels-off time, which can be obtained from the Enhanced Traffic Management System (ETMS) flight plan message (FZ).

EDCT Wheels Off—Controlled wheels off time as generated in ETMS. A flow control hold.

EDCT Where Caused—Flow Control Delay caused by arrival restrictions (assigned to arrival airport).

EDCT Where Taken—Flow Control Delay taken at departure airport due to arrival restrictions.

Enhanced Traffic Management System (ETMS) —A system supporting the daily management of the ATC system. ETMS data are collected automatically by the Air Route Traffic Control Center (ARTCC) computers for Instrument Flight Rules (IFR) flights. ETMS contains flight information for all IFR flights, including air carrier, air taxi/commuter, general aviation and military operations. ETMS also has flight information for cargo flights and for the departures and arrivals of international flights. Additionally, flight information for non-scheduled IFR cargo, passenger, general aviation, and military flights is also included.

If it appears as a 'Y' on report it means that flight had an ETMS record.

Est. Time Enroute—Carrier submitted flight plan time from wheels off to wheels on.

Estimated Time En Route (ETE) —En route time in minutes filed by air carriers and reported in the Enhanced Traffic Management System (ETMS) flight plan (FZ) message.

Equip Code—Type of Aircraft.

FAA Flight Plan—Specified information relating to the intended flight of an aircraft that is filed orally or in writing with a flight service station or air traffic control facility.

Flight Plan Gate Out—Carrier submitted scheduled departure time obtained from ETMS.

Flight Type—All flight types in CODAS are coded as "N" (both arrival and departure in US).

FZ—Enhanced Traffic Management System (ETMS) filed flight plan message.

Gap DZ—Time in minutes between the Airline Service Quality Performance (ASQP) wheels-off and the Enhanced Traffic Management System (ETMS) departure (DZ).

Gap AZ—Time in minutes between the Enhanced Traffic Management System (ETMS) arrival (AZ) time stamp and the Airline Service Quality Performance (ASQP) wheels on.

OAG Gate In—OAG scheduled arrive time.

OAG Gate Out—OAG scheduled departure time.

OAG G2G Min. —OAG scheduled gate to gate time.

Official Airline Guide (OAG) —The OAG contains flight information, including the type of aircraft used, for all domestic flights and for international flights originating or terminating in the U.S. It lists planned flight times for all scheduled air carrier and commuter flights, but does not contain information on non-scheduled and cargo flights or for general aviation or military operations.

OPSNET—Operations Network is the official FAA delay reporting system. Its data come from observations by FAA personnel, who manually record aircraft that are delayed by 15 minutes or more. Aircraft that are delayed by less than 15 minutes are not recorded. OPSNET also provides information on the cause of delay--weather, terminal volume, center volume, closed runways/taxiways and NAS equipment interruptions. OPSNET reports delays for specific airports, but it reports only the aggregate number of occurrences and does not report delays by carrier or individual flight.

Phase of Flight—Each flight can be decomposed into phases. CODAS phases of flight are gate, taxi-out, airborne, and taxi-in.

Ranking Factor—Factor used to determine sort order of report.

Season—
Dec to Feb is 1
Mar to May is 2
Jun to Aug is 3
Sep to Nov is 4

Tail No. —Tail number of aircraft used for the flight. Only available for ASQP reporting carriers.

Taxi-in Delay—The difference between actual taxi-in time and unimpeded taxi-in time by airport, carrier and season.

Taxi-in Time—Time from wheels on to gate arrival.

Taxi-out Delay—The difference between actual taxi-out time and unimpeded taxi-out time by airport, carrier and season.

Taxi-out Time—Time from gate departure to wheels off

Total All Phases—Sum of average delay for all phases.

Total Cost for Air Carrier Delay Report—A report that provides estimates of the annual cost of delays for all Form 41 reporting air carriers. The average hours of delay per flight are based upon Airline Service Quality Performance (ASQP) data, while the total number of revenue flights, the cost per operating hour and the estimates of the value of passenger time are based on other FAA data sources. The cost report presents delays and costs of delays for the entire system, but not for individual airports.

Total Gate Delay—The difference between actual gate departure time and scheduled gate departure time.

Total Inbound—Sum of airborne delay and taxi in delay.

Total Outbound—Sum of adjusted gate delay and taxi out delay

Total Per Operation—Sum of delay for all phases divided by sum of number of departures and number of arrivals.

Unimpeded Taxi-In—The estimated average taxi-in time for an aircraft under optimal operating conditions, when neither congested weather nor other factors delay it during its movement from landing to gate. CODAS use a statistical function to estimate unimpeded taxi-in time.

Unimpeded Taxi-Out—The estimated average taxi-out time for an aircraft under optimal operating conditions when neither congested weather nor other factors delay it during its movement from gate to takeoff. CODAS use a statistical function to estimate unimpeded taxi-out time.

User Class—C--Commercial, F--Freight, T--Air Taxi

Wheels-off—Actual wheels-off time as reported in the Airline Service Quality Performance (ASQP) data. Estimated for non-ASQP carriers.

Wheels-on—Actual wheels-on time as reported in the Airline Service Quality Performance (ASQP) data. Estimated for non-ASQP carriers.