Surveillance and Broadcast Services (SBS) Group

Automatic Dependent Surveillance - Broadcast (ADS-B) In Retrofit Spacing (AIRS) Cockpit Display of Traffic Information (CDTI) Assisted Separation on Approach (CAS-A) Operational Evaluation

Year 1 Project Review Report (2023-2024)

December 2024

Version 2.1

Federal Aviation Administration
600 Independence Avenue, SW
Washington, DC 20591

Revision History for

Automatic Dependent Surveillance - Broadcast (ADS-B) In Retrofit Spacing (AIRS) Cockpit Display of Traffic Information (CDTI) Assisted Separation on Approach (CAS-A) Operational Evaluation

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Record of Revisions

Version Number	Modification Description	Version Date (2024)
1.6	First shared draft	Aug 6
1.7	Minor updates from Dan - replaced "Threshold Spacing" with "Interarrival Distance"	Aug 12
1.8	Added monetized benefits data and general editing.	Aug 14
1.9	SBS Team review	Aug 15
2.0	AIRS Team review version (Updated based on SBS Team review and additional benefits material)	Aug 27
2.0.10	Incorporation of AIRS Team Comments for FAA Tech Editor Review	Sept 30
2.1	Final Version	December 2024

Executive Summary

Global demand for air travel is projected to increase over the next 20 years. There is a pressing need for new capabilities and procedures to increase air traffic throughput without compromising safety. Improvements in aircraft communication, navigation, and surveillance systems in the National Airspace System (NAS) have led to the development of multiple concepts to improve efficiency, capacity, and safety. These include the deployment of Automatic Dependent Surveillance-Broadcast (ADS-B). Aircraft that are equipped with ADS-B receivers and with Aircraft Surveillance Applications (ASA) Systems (i.e., an ADS-B In capability) can receive surveillance information about other aircraft in the surrounding airspace and display traffic information. ASAs are a key component of the Next Generation Air Transportation System (NextGen). New operations such as Interval Management (IM), Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS), and CDTI Assisted Separation on Approach (CAS-A), are designed to realize Trajectory Based Operations (TBO) and NextGen objectives. These ADS-B In-enabled operations help mitigate growth in NAS-wide delays and projected airport capacity shortfalls as the number of flights continue to increase.

In 2012, an ADS-B In Aviation Rulemaking Committee (ARC) was tasked with defining "a strategy for incorporating ADS-B In technologies into the [NAS]" (ADS-B In ARC, 2012, cover letter). Two key recommendations were made by the ARC. The first was to prioritize "five key ADS-B In applications with the greatest potential to positively affect the ADS-B In business case." Two of the five concepts were CAVS and a concept termed CDTI Assisted Pilot Procedure (CAPP) from which CAS-A was developed. The ARC also requested "the FAA conduct flight trials for a sufficient number of ADS-B In applications to validate the utility of operational concepts and validate the business case…" (ADS-B In ARC, 2012, p. v).

Both CAVS and CAS-A are ADS-B In-enabled operations that use the same flight deck equipment and extend the use of pilot-applied visual separation. To conduct the operations, the flight crew "designates" a Traffic to Follow (TTF) in the equipment and uses the CDTI to follow the TTF. There are differences between the operations. In CAVS, the flight crew uses the CDTI as a substitute for continuous visual observation of TTF during Visual Meteorological Conditions (VMC). Once the flight crew has visually acquired and designated the TTF and accepted a visual approach clearance behind it, the flight crew can use the CDTI to maintain pilot-applied visual separation when out-the-window visual contact with the TTF is not possible. The CAVS aircraft may not enter Instrument Meteorological Conditions (IMC) while conducting CAVS. The CAVS operation is transparent to the controller since the flight crew uses the equipment during current operations without a unique instruction from the controller to use the CDTI.

CAS-A builds on the CAVS operation. It is initiated by the controller, who provides a traffic designation instruction to the flight crew with the TTF's call sign. The flight crew identifies the TTF on the CDTI using the call sign. After the flight crew reports they have designated the TTF on the CDTI, the controller can issue a CAS-A instruction to follow the TTF in conjunction with, or after, the approach clearance. When the flight crew accepts the CAS-A

instruction, the controller is relieved of the requirement to apply radar separation, and the flight crew follows the TTF using the information available on the CDTI.

The ADS-B In Retrofit Spacing (AIRS) project was established for the purpose of conducting large-scale operational evaluations of ADS-B In technologies during revenue service flights. The primary goal of the AIRS operational evaluation was to demonstrate the operational feasibility and value of ADS-B In capabilities using a retrofit solution. The operational evaluation included three operations: Initial-IM (I-IM), CAVS, and CAS-A. This report mainly covers the CAS-A operations but also includes benefits data associated with traffic designation (including when CAVS operations are expected) and pilot reports of general CDTI use. The designation of traffic and CAVS operations were approved NAS-wide for American Airlines. The CAS-A component of the operational evaluation was conducted with aircraft arriving to Dallas-Fort Worth International Airport (DFW) in partnership with the Allied Pilots Association (APA), American Airlines (AAL), the Dallas-Fort Worth TRACON (D10), DFW Tower, the avionics manufacturer Aviation Communication & Surveillance Systems, LLC (ACSS), the Federal Aviation Administration (FAA) organizations and their support, and the National Air Traffic Controllers Association (NATCA). These partners were on the AIRS team that met and discussed on-going operations, solved any issues, considered improvements, and collected and reviewed data. The data collected included sources needed to assess CAS-A operational feasibility and benefits, as well as CAVS, traffic designation, and general CDTI use benefits. The results are summarized below and covered in detail in this report.

American Airlines retrofitted their entire Airbus A321 fleet of 298 aircraft with the commercially available ACSS SafeRoute+ ADS-B In avionics suite for the operational evaluation. Flight crews were found to use traffic designation in all phases of flight once equipage began. Between September 2020 (before CAVS or CAS-A approval) and December 2023, American Airlines A321s had logged 168,000 traffic designations totaling over 48,000 hours of use. When further examining designation within 25 nautical miles (NMs) of six American Airlines hubs, the number of designations generally increased over time. When examining the 25 NM radius around DFW, approximately 25% of the flight crews designated another aircraft.

When examining the time and distance spacing within aircraft pairs (i.e., Inter-Arrival Time (IAT) and Inter-Arrival Distance (IAD), respectively) at six American Airlines hubs, flight crews designating an aircraft (including for CAS-A) were consistently closer on average than aircraft not designating. This effect was shown to be driven not simply by demand loads but by different behavior from flight crews. Across the six hubs, the mean IAT was 11-13 seconds, and 0.5-0.6 NM, less for aircraft designating compared to aircraft that were not. DFW had a 13-second reduction. If that reduction at DFW could be sustained for an hour, the runway throughput could be increased by 4-5 aircraft per hour for each arrival runway.

When examining flight time and distance flown in the terminal area within a 25 NM radius around DFW, the following benefits were realized.

- Aircraft conducting CAS-A flying a downwind segment had a reduced distance flown of 0.6 NM and 20 seconds when compared to other traffic.
- Other aircraft arriving within 15 minutes after a CAS-A operation had a reduced distance and time flown (for each CAS-A aircraft present in that 15-minute window) when compared to aircraft arriving without a CAS-A operation in the timeframe. The results were:
    - 0.3 NM and 9 seconds in conditions above the IMC ceiling and visibility thresholds
    - 0.6 NM and 14 seconds in conditions less than a 6000-ft ceiling or less than or equal to 8 miles visibility

The benefits for any arrival aircraft increases by the same value shown above if more CAS-A aircraft are in that same 15-minute window. As an example, if there are two CAS-A aircraft in front of an arrival in weather conditions less than a 6000-foot ceiling or less than or equal to 8 miles visibility, that arriving aircraft would experience a reduction in distance of 1.2 NM.

When considering the flight time and distance flown savings for aircraft conducting CAS-A and all other aircraft arriving at DFW within 15 minutes after a CAS-A operation, a total savings of 10,819 NM in flight distance or 5,350 minutes of flight time is realized. Assuming an airline cost of approximately $60 per minute, the total result sums to $321,016 over the period. Transforming the measured time benefit into fuel and emissions benefits results in a savings of approximately 490,000 pounds of fuel and 700 metric tons of carbon dioxide. If all American Airlines A321 arrivals into DFW had conducted CAS-A, the total benefit for all aircraft arriving at DFW within 15 minutes after a CAS-A operation would be closer to 162,000 minutes of flight time savings with a value of $9.7 million, as well as a savings of 15 million pounds of fuel and 21,000 metric tons of carbon dioxide. To realize these benefits and take full advantage of the unused slots created in the traffic flow when CAS-A operations are used, aircraft would have to be scheduled to the airport in metering automation based on the anticipated use of CAS-A.

For CAS-A operational data, the results indicate the CAS-A defined procedures, phraseology, and flight-deck interface were acceptable for CAS-A operations. Operational data indicates CAS-A works equally well during visual and instrument approaches. The use of a speed at the discretion of the controller to manage the spacing between the CAS-A and the TTF appears to work as well with CAS-A operations as it does with current pilot-applied visual separation operations. The percentage of flight crews that declined or were unable to conduct CAS-A was generally low and no go-arounds were determined to be caused by CAS-A.

Most of the challenges during CAS-A operations occurred in the flight crew designation communications and were often related to the use of call signs. For example, CAS-A aircraft flight crews sometimes mixed the TTF's call sign numbers with their own. Some TTF flight crews asked if a communication was for them when they heard their own call sign in the designation instruction. While some issues occurred, they were resolved quickly either by the flight crew or the controller. No events led to the following of an incorrect TTF. Any confusion will likely be reduced when flight crews are conducting CAS-A operations, and hearing the communications, on a regular basis. Additionally, there are potential solutions to help. In this operational evaluation, some controllers used different methods of saying the TTF call sign to avoid potential confusion (e.g., saying “N K S” instead of “Spirit Airlines” so the CAS-A aircraft flight crew would know the three-letter identifier displayed on the CDTI and the TTF aircraft flight crew would not hear their own call sign). Issues after designation were infrequent. For example, communication issues for both flight crews, and controllers, were infrequent during the CAS-A “follow traffic” instruction.

Most pilots reported a positive to neutral experience with CAS-A operations. The most noted issues were challenges related to getting the designation instruction late in the traffic pattern, conducting CAS-A with flight crew members new to the aircraft or recently hired, being surprised by the designation instruction, and having difficulty finding the TTF in the CDTI traffic list. For the benefits of CAS-A, pilots reported added traffic awareness for avoiding overtakes, go-arounds, and slowing earlier than necessary. Another benefit mentioned was discussions between both crew members about closure on and proximity to the TTF that do not occur without the CDTI when only looking out the window. Some unique non-CAS-A benefits of the CDTI were also mentioned (e.g., monitoring other aircraft’s paths to assist in weather avoidance). Most pilots said the CAS-A phraseology was explicit and understandable. Pilots did not report issues with decoding lead airline name (e.g., Envoy) to the three letters shown on the CDTI (e.g., ENY). Pilots generally found the CDTI acceptable but did express a desire to have the information displayed on the Navigation Display (ND). Several pilots reported the need for improved training beyond the initial training bulletin. American Airlines addressed the requests with training aids and special briefings during recurrent ground school and simulator training.

Controller feedback was limited. However, the feedback from the D10 facility was that recent waivers (e.g., the approval of widely spaced operations on the outboard runways) have reduced the benefits of CAS-A at D10, but they did see some benefits during certain operations and would like to continue using it. They also said they believe CAS-A has benefits for other airports. They reported the current challenge is knowing which aircraft are equipped and the limited number of equipped aircraft. They said equipage indicators on their Standard Terminal Automation Replacement System (STARS) display and more equipped aircraft are necessary before a larger number of operations can be expected.

Overall, the AIRS Evaluation demonstrated the operational feasibility and benefits of ADS-B In, traffic designation (including when CAVS operations are expected), and CAS-A operations. Benefits data and controller and flight crew feedback support continued development and integration of CAS-A operations into the NAS to meet the growing demands of air traffic. Considerations for that integration are provided in the Conclusions and Recommendations section of this report.

Acknowledgements

This report includes contributions from several members of the AIRS CAS-A team. Contributing organizations include the following.

- Allied Pilots Association (APA)
- American Airlines (AAL)
- Aviation Communication & Surveillance Systems, LLC (ACSS)
- National Air Traffic Controllers Association (NATCA)
- Dallas-Fort Worth TRACON (D10)
- Federal Aviation Administration (FAA) employees and their support
    - The Belmont Group, Inc.
    - Blue Mountain Aero, LLC
    - The MITRE Corporation
    - The Regulus Group

Contents

1 Introduction

1.1 AIRS Project Overview

Global air traffic demand continues to rise with predicted year-over-year increases of 3.8% (International Air Transport Association [IATA], 2024). To address this increased demand, new capabilities and procedures are needed to increase air traffic throughput without compromising safety. Improvements in aircraft communication, navigation, and surveillance systems in the National Airspace System (NAS) have led to the development of multiple concepts to improve efficiency, capacity, and enhance safety. These include the deployment of Automatic Dependent Surveillance-Broadcast (ADS-B) and expanded use of Trajectory-Based Operations (TBO). Aircraft that are equipped with ADS-B receivers and Aircraft Surveillance Applications (ASA) Systems can receive surveillance information about other aircraft in the surrounding airspace and display this information as well as application specific information (known as ADS-B In). ADS-B, and the operations that it enables, are key components of the Next Generation Air Transportation System (NextGen), will enhance TBO, and help mitigate the growth in NAS-wide delays and projected airport capacity shortfalls. New operations such as Initial-Interval Management (I-IM), Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS) and CDTI Assisted Separation on Approach (CAS-A), leverage ASA systems and are designed to help improve capacity and realize NextGen TBO objectives.

In 2012, an ADS-B In ADS-B In Aviation Rulemaking Committee (ARC) was tasked with defining "a strategy for incorporating ADS-B In technologies into the NAS" (ADS-B In ARC, 2012, cover letter). Two key recommendations were made by the ARC. The first was to prioritize "five key ADS-B In applications with the greatest potential to positively affect the ADS-B In business case." Two of the five concepts were CAVS and a concept termed CDTI Assisted Pilot Procedure (CAPP) from which CAS-A was developed. The ARC also requested "the FAA conducts flight trials for a sufficient number of ADS-B In applications to validate the utility of operational concepts and validate the business case…" (ADS-B In ARC, 2012, p. v).

The ADS-B In Retrofit Spacing (AIRS) project was established for the purpose of conducting large-scale operational evaluations of ADS-B In technologies during revenue service flights. This public-private partnership, covered under a Memorandum of Agreement (MOA), included a collaboration between the Federal Aviation Administration (FAA), American Airlines, and the avionics manufacturer Aviation Communication & Surveillance Systems, LLC (ACSS). Other partners include representatives from the National Air Traffic Controllers Association (NATCA) and the Allied Pilots Association (APA).

The primary goal of the AIRS operational evaluation was to demonstrate the operational feasibility and value of ADS-B In capabilities via a retrofit solution.

The AIRS operational evaluation enables the FAA and the airline industry to:

- Evaluate and confirm operational benefit assumptions
- Evaluate the use of an ADS-B Guidance Display as a retrofit solution for displaying traffic information in the flight deck forward field of view
- Validate ADS-B In avionics performance in real-world conditions
- Gather real-world experience to validate future Air Traffic Control (ATC) automation requirements and costs
- Evaluate flight crew and controller acceptance
- Determine guidance on phraseology and procedures for future NAS-wide implementation
- Accelerate the development and deployment of ADS-B In technology

1.2 AIRS Project Operational Evaluation Approach

The AIRS operational evaluation involves a unique approach to managing the risks associated with introducing new technologies and operations into the NAS. The operational evaluation is being conducted using certified aircraft operating in revenue service but limited to specified airspace regions for a period of two years. The AIRS operational evaluation did not include any updates to ATC automation. While the automation would need to be updated to enable NAS-wide adoption, manual workarounds were used during the trial instead of automation updates. Operational evaluations are not flight tests involving experimental aircraft nor are they NAS-wide implementations. The operations and certified avionics are intended to be representative of potential solutions that could be deployed NAS-wide.

The operational evaluation approach allows the FAA and industry to make modifications based on data obtained. For example, based on feedback obtained during the trial, it was determined that modifications to the initially proposed phraseology would improve the clarity and overall flow of the operations. Similarly, it was determined that changes to the avionics display would improve flight crew understanding and conduct of the operations. The initial solutions were acceptable, but the operational evaluation approach allowed the proposed implementations to be improved prior to potential NAS-wide deployment.

To support the operational evaluation, AAL retrofitted their entire Airbus A321 fleet, comprising A321ceo (Current Engine Option) and A321neo (New Engine Option) aircraft, with the commercially available ACSS SafeRoute+ ADS-B In avionics suite. This flight deck system and applications enable CAVS, CAS-A, and I-IM operations. In total, 298 aircraft were equipped, of which 218 were A321ceos and 80 were A321neos.

A team with the partners noted in Section 1.1 was set up to meet and discuss on-going operations, solve any issues, consider improvements, and collect and review data. The data collected included CAS-A operational feasibility and benefits, CAVS benefits, traffic designation use, and general CDTI use.

1.3 Document Scope

The Year 1 AIRS CAS-A operational evaluation was conducted in partnership with the Dallas-Fort Worth Terminal Radar Approach Control (TRACON) (D10) between March 1, 2023 and February 29, 2024. The purpose of this report is to document the results from the operational evaluation. It reviews the operational evaluation, the CAS-A concept, data collection methods, results, and provides conclusions and recommendations. A second year of the operational evaluation is still underway and data from that year will be provided at a later point. Benefits data from CAVS, traffic designation use, and general CDTI are also included.

2 CAS-A

2.1 CAS-A Development

Runway capacity can be increased by relieving the controller of the requirements to apply radar separation during approaches using visual separation from Traffic-To-Follow (TTF). Concepts have been developed to maintain visual-like separation more safely and efficiently from a TTF via the CDTI during approach procedures. They are expected to recapture some of the runway capacity benefits of pilot-applied visual separation operations during weather conditions that do not support visual operations, such as when identification of the TTF out-the-window may be delayed or challenging.

A concept called Enhanced Visual Separation on Approach (VSA) was developed and implemented to support pilot traffic situation awareness when conducting visual separation. The CDTI can only be used for traffic awareness, and if the TTF is lost out the window, the flight crew must inform the controller. VSA is available in Airbus aircraft and was found to be beneficial by United Parcel Service (UPS) in its Boeing implementation (FAA, 2005). It is defined in DO-317C (RTCA and European Organisation for Civil Aviation Equipment [EUROCAE], 2024).

A body of simulation work and standards development was conducted to develop ASAs to build upon VSA and maintain pilot-applied visual-like separation more safely and efficiently from TTF via the CDTI during weather conditions that make the continuation of pilot-applied visual separation operations challenging. The concept was explored for single runways in several simulations (e.g., Bone, Domino, et al., 2003; Bone, Helleberg, Domino, and Johnson, 2003; Mundra, Domino, Helleberg, and Smith, 2009; Domino, Tuomey, Mundra, and Smith, 2010). Some simulations also explored the concept during departure (e.g., Domino, Tuomey, Mundra, and Smith, 2010).

Some of this simulation work led to and supported the development of Minimum Operational Performance Standards (MOPS) (DO-317C, RTCA and EUROCAE, 2024) and an FAA Advisory Circular (AC) (FAA, 2019) for a concept called CAVS. CAVS allows flight crews to “designate” traffic and use information on the CDTI as a substitute for continuous visual observation of the TTF during Visual Meteorological Conditions (VMC). Once the flight crew has visually acquired the TTF and accepted a visual approach clearance behind it, the flight crew can use the information on the CDTI as a means for maintaining pilot-applied visual separation from at TTF when out-the-window visual contact with the TTF cannot be maintained. The CAVS aircraft may not enter Instrument Meteorological Conditions (IMC) while conducting CAVS. The CAVS operation is transparent to the controller since the flight crew uses the equipment during current approach operations without a unique instruction from the controller to use the CDTI. Figure 1 provides a sample and overview of CAVS.

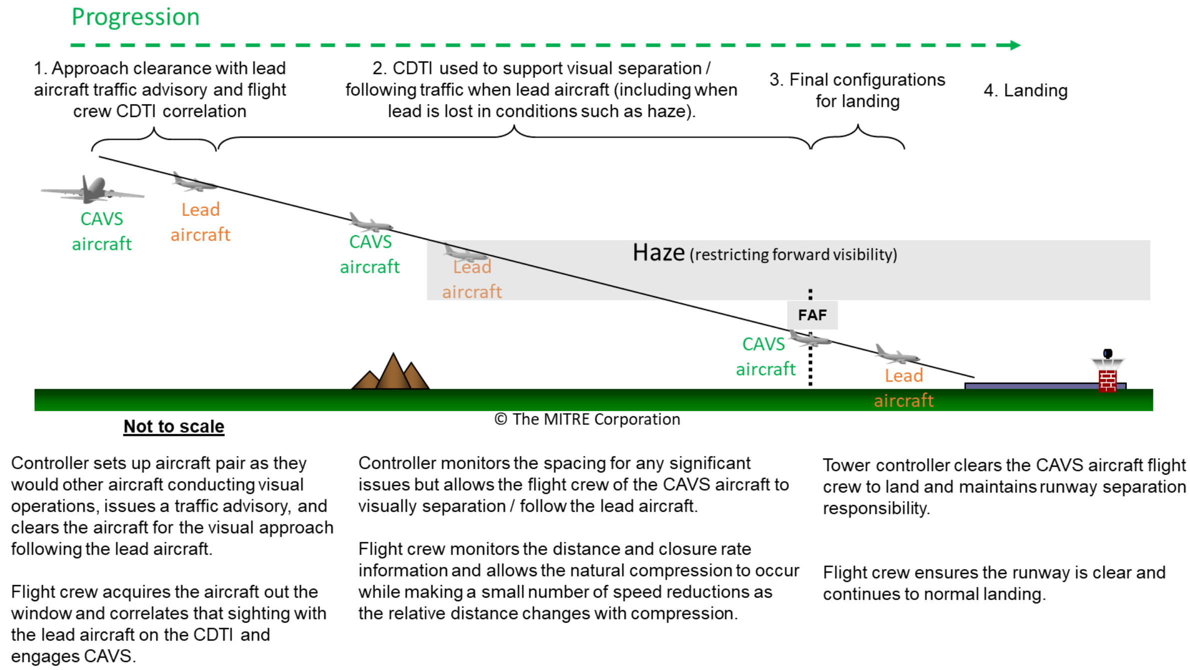


Figure 1 – Sample CAVS Operation

CAVS is part of the AIRS operational evaluation and was approved by the FAA for NAS-wide use by American Airline in May 2021. CAVS benefits data is included in this report since the operation is similar to CAS-A, has similar benefits mechanisms, and uses the same equipment.

CAS-A builds on the CAVS operation and uses the same flight deck equipment as described in the FAA AC (FAA, 2019) and DO-317C (RTCA and EUROCAE, 2024). The concept for CAS-A was also explored in the same simulations that supported the development of CAVS.

2.2 CAS-A Overview

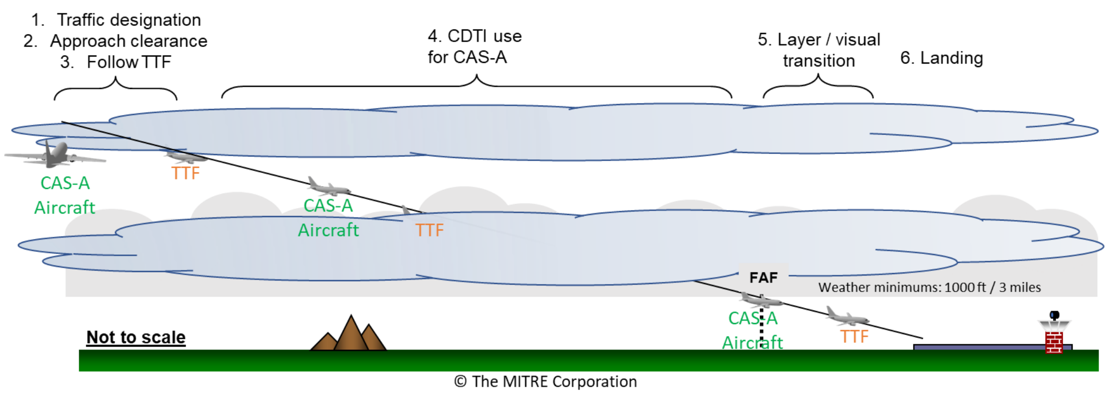
The CAS-A operation is initiated by the controller, who provides a designation instruction to the flight crew with the TTF's call sign. The flight crew identifies the TTF on the CDTI using the call sign provided by the controller. Visual acquisition of the TTF out-the-window is not required. After traffic is identified and designated, the controller can issue a CAS-A instruction to follow the TTF in conjunction with or after the approach clearance is issued. When the flight crew accepts the CAS-A instruction, the controller is relieved of the requirement to apply radar separation, and the flight crew follows the TTF using the information available on the CDTI.

CAS-A can only be used when both aircraft are on approach to the same runway. CAS-A can be conducted when the airport of intended landing is VMC (i.e., a reported ceiling of 1000 feet or greater and visibility of 3 Statute Miles (SM) or greater). The CAS-A aircraft may enter IMC conditions when flying an instrument approach procedure but must remain clear of clouds if flying a visual approach.

CAS-A applies when the CAS-A Aircraft and TTF are flying an approach. CAS-A does not change any requirements for instrument or visual approach procedures (e.g., accepting or flying that approach procedure) and it is not used to fly the approach procedure. It relieves the controller of the requirement to apply radar separation from the preceding TTF on approach when out-the-window visual contact by the flight crew would not otherwise be possible. If visual out-the-window contact of the TTF is achieved at any point, the flight crew can use the information for traffic awareness, but cannot rely solely on out-the-window contact to conduct CAS-A.

While the application was developed for air transport aircraft arriving at capacity-limited airports, it could be used by all capable aircraft during approach to any airport where instructions for maintaining pilot-applied visual separation from the TTF are used. CAS-A does not change any current pilot procedures or responsibilities related to wake turbulence.

Figure 2 provides a sample and overview of CAS-A.



Controller sets up aircraft pair closer than aircraft not able to conduct CAS-A and clears them for the instrument approach and CAS-A (possibly with a speed instruction).

Flight crew identifies the TTF on CDTI and engages CAS-A.

Controller monitors the spacing for any significant issues but allows the flight crew of the CAS-A Aircraft to apply CAS-A from the TTF.

Flight crew monitors the distance and closure information and allows the natural compression to occur and potentially makes a small number of speed reductions as the relative distance changes with compression.

Tower controller clears the CAS-A aircraft flight crew to land and maintains runway separation responsibility.

Flight crew ensures the runway is clear and continues to normal landing.

Figure 2 – Sample CAS-A Operation

2.3 Context of CAS-A Operation

In current operations, there is expected to be an increase in landing capacity and/or increase in the number of movements when controllers can precondition aircraft so flight crews can use pilot-applied visual separation against TTF during approach. In the United States, this often occurs during visual approach operations. Arrival rates at airports in the U.S. are significantly higher when controllers can count on visual separation provided by the flight crew.

Two factors contribute to this:

1. When the controllers know that flight crews can conduct pilot-applied visual separation, they are able to provide closer spacings over the threshold, delivering aircraft at appropriately closer distances on a long final approach to take advantage of this tighter eventual spacing. After this controller set-up, flight crews manage their speed to maintain a safe landing interval.

2. When flight crews can conduct visual separation, controllers deliver spacings over the runway threshold that are consistently closer than when the controller must apply standard separation.
    - For example, the minimum spacing achieved over the threshold with pilot-applied visual separation behind Large category aircraft is generally between 2.5 and 3.0 Nautical Miles (NMs) compared to the minimum spacing provided by the controller who must include some additional spacing above the minimum separation requirement of either 2.5 or 3.0 NMs to avoid separation issues during a non-visual operation. This additional spacing results in gaps between successive arrivals of 3 to 4 NM.

During visual approach operations, the primary influence on spacing is runway separation where only one aircraft may occupy the runway at a time, as defined in FAA JO 7110.65 Para. 3-10-3 (FAA, 2024). During instrument approach operations, the primary influence is radar separation as defined in FAA JO 7110.65 Para. 5-5-4. Since approach controllers are responsible for separation to the runway threshold, they apply a buffer in excess of separation minima, due to the uncertainty of arrival aircraft final approach speed.

In the current system, the higher capacity rates are lost, not at basic VMC minima, but at visual approach minima which are considerably higher than the basic VMC minima at airports, as shown in Figure 3.

Since visual separation is mainly used during visual approach operations in the U.S., the remaining material in this section will review visual approach operations and the associated benefits.

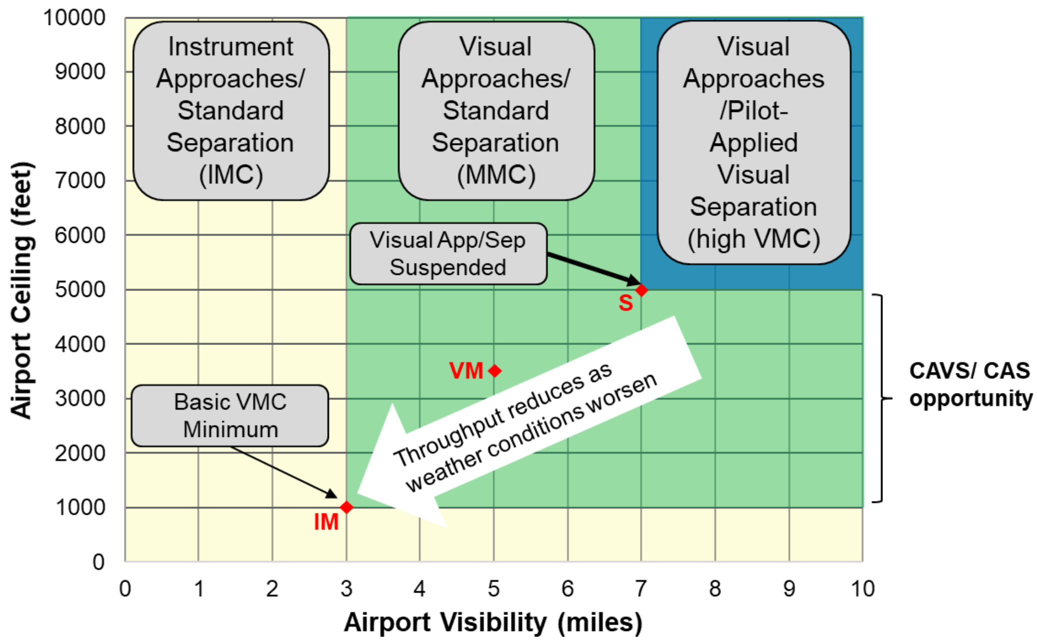


Figure 3 – Weather Conditions for Visual Approach Operations in the United States[1]

[1] Figure 3 is a general representation of airports in the NAS.

The airport's acceptance rates are highest when they conduct visual approach operations. Visual approaches can be conducted when conditions are at least 500 feet above Minimum Vectoring Altitude (MVA). This is shown by point VM in Figure 3. This is a theoretical number. The actual minima below which a facility cannot reliably conduct and therefore suspends visual approach operations depends on when flight crews cannot dependably visually navigate for the approach or visually acquire other aircraft. Since combining instrument and visual approaches presents challenges for the controller, a relatively small percentage of arrivals not being able to visually acquire the airport, or the TTF, can result in suspension of visual approach operations and the correspondingly higher arrival rate.

That point below which a facility suspends visual operations is usually considerably higher than this theoretical minimum of MVA plus 500 feet. This is shown by the point S in Figure 3. Thus, in actual operations, the facility generally must conduct an instrument operation with lower arrival rates when below point S. This point is often considerably higher than the basic VMC minima of 1000 feet and 3 miles (see point IM in Figure 3).

For example, when Dallas-Fort Worth International Airport (DFW) operates on runways 13R|18R|17C|17L in "good visual" conditions for visual approaches (i.e., at least above 3500 feet and 5 miles), the rate, known as the Airport Acceptance Rate (AAR), is 114. This reduces to an AAR of 102 in IMC.

CAVS is expected to help close the gap somewhere between points S and point VM in Figure 3. However, since controllers may not know whether an aircraft is capable of CAVS, it will likely be difficult for the controller to expect CAVS operations without knowing which aircraft are capable of CAVS operations when all other aircraft have switched to an instrument operation. Furthermore, controllers generally do not simultaneously conduct visual approach and instrument approach operations. Once a small percentage of arrivals indicate they are unable to visually acquire the TTF, all arrival traffic is transitioned to instrument approach operations.

Additionally, CAVS probably cannot bring the higher capacity point all the way down to point IM in Figure 3, since the suspension of visual operations may occur either because the CAVS aircraft may lose VMC or is not able to initially acquire the traffic out-the-window. CAS-A will overcome these limitations by relieving the controller of the requirement to apply radar separation during these conditions. CAS-A will enable the facility to approximate the visual operation rates to 1000 feet cloud base and 3 SM of visibility.

Results documented by (Lunsford, et al., 2005) and (Coates, et al., 2018) indicate that the capacity gains from CAS-A would be of the order of 4 to 12% higher (depending on the airport) than the rates now seen in conditions where visual operations cannot be conducted. In addition to the capacity gain, the information provided on the CDTI (e.g., call sign, differential ground speed, and distance to TTF) greatly enhances the flight crew's ability to identify, acquire, track, and space from the TTF. CAS-A will enhance traffic awareness and the positive identification of the TTF.

The realization of the capacity gain benefits will be a function of the percentage of the traffic that is equipped with CAVS equipment and able to conduct CAS-A operations. As equipage increases, the benefits will increase, as a facility's Traffic Management Unit is expected to increase the AAR. Early adopters could experience CAS-A benefits at hub airports where the operator has a high percentage of the traffic.

2.4 AIRS CAS-A Trial Location

In early 2020, an effort was undertaken to identify an operational evaluation site for CAS-A operations. A set of criteria was developed to maximize the opportunity for CAS-A use. The following criteria were considered.

- American Airlines hubs
- Enough equipped aircraft
- Sufficient weather-related opportunities (e.g., the airport has many hours in VMC, but operations are not conducive to visual approach operations)
- Facility receptiveness
- Different types of runway operations
    - Arrivals
    - Departures
    - Parallel arrivals
- Lack of operational constraints that would limit or prevent the use of CAS-A
    - Crossing runways
    - Taxiway configuration
    - Arrival/departure runways
- Lack of competing FAA programs

After initial analysis of American Airlines hubs, several airports were excluded from additional analysis due to operational factors (e.g., lack of dedicated arrival runways) or competing FAA programs.

Using Aviation System Performance Metrics (ASPM) data for the remaining candidate sites, the AIRS team examined the number of equipped aircraft and weather conditions that would support CAS-A usage. The number of equipped aircraft was assumed equal to the historic number of American Airlines A321 aircraft operating at each site.

Traditional visual approach and pilot-applied visual separation operation can be conducted in periods of high VMC. As noted in Section 2.3, CAS-A is expected to recapture some of the runway capacity benefits of pilot-applied visual separation operations during weather conditions that do not support visual operations. These conditions are known as Marginal Meteorological Conditions (MMC). ASPM lists ceiling and visibility conditions for MMC. However, the AIRS team Subject Matter Experts (SMEs) believed some of the visibility values included in the ASPM data were lower than operational reality, so higher visibilities (i.e., 6 and 10 NM) were also examined. This analysis produced metrics indicating how many arrival aircraft could potentially be issued a CAS-A instruction. The results are contained in Table 1.

Table 1 – CAS-A Opportunity Analysis

CAS Opportunities									
MMC Weather & American Airlines A321/A21N									AAL Hub
Facility	ASPM Wx Weighted	Frequency	Facility	CAS Wx Weighted 6 NM	Frequency		Facility	CAS Wx Weighted 10 NM	Frequency
CLT	1.69%	1 Out of 59	CLT	2.39%	1 Out of 42	1	CLT	4.39%	1 Out of 23
DFW	1.55%	1 Out of 64	PHL	1.99%	1 Out of 50	2	PHL	4.21%	1 Out of 24
PHL	1.03%	1 Out of 97	LAX	1.90%	1 Out of 53	3	MIA	3.41%	1 Out of 29
LAX	0.96%	1 Out of 104	DFW	1.66%	1 Out of 60	4	LAX	3.14%	1 Out of 32
SFO	0.87%	1 Out of 115	SAN	1.06%	1 Out of 94	5	DFW	2.38%	1 Out of 42
SAN	0.79%	1 Out of 126	SFO	0.87%	1 Out of 115	6	MCO	2.11%	1 Out of 47
SEA	0.57%	1 Out of 175	SEA	0.62%	1 Out of 161	7	SAN	2.02%	1 Out of 49
LGA	0.33%	1 Out of 307	LGA	0.61%	1 Out of 165	8	SFO	1.41%	1 Out of 71
MIA	0.28%	1 Out of 361	MCO	0.49%	1 Out of 204	9	LGA	1.15%	1 Out of 87
FLL	0.26%	1 Out of 387	JFK	0.48%	1 Out of 207	10	JFK	1.12%	1 Out of 89
BOS	0.24%	1 Out of 419	BOS	0.46%	1 Out of 219	11	ORD	0.91%	1 Out of 110
MCO	0.23%	1 Out of 429	ORD	0.44%	1 Out of 229	12	TPA	0.91%	1 Out of 110
DCA	0.23%	1 Out of 430	DCA	0.38%	1 Out of 260	13	BOS	0.84%	1 Out of 119
JFK	0.23%	1 Out of 433	MIA	0.36%	1 Out of 274	14	DCA	0.82%	1 Out of 121
ORD	0.21%	1 Out of 466	TPA	0.31%	1 Out of 324	15	SEA	0.72%	1 Out of 138
PHX	0.12%	1 Out of 832	FLL	0.27%	1 Out of 376	16	BWI	0.33%	1 Out of 302

Additional input was provided on the site selection for the airports highlighted in yellow in Table 1 and Orlando International Airport (MCO). Fast-time modeling and analyzed real-world operational data were used to predict the throughput benefits possible from CAS-A operations. The fast-time modeling used MITRE's "runwaySimulator" tool, which compared arrival throughput results (i.e., no departures) across the airports in VMC and IMC. The operational data analysis examined inter-arrival spacing between aircraft in visual and instrument approach operations to independent dedicated arrival runways to estimate the expected benefits of CAS-A.

During the data analysis, several FAA and AIRS team discussions led to down-selecting some airports from the original set of American Airlines hubs. The AIRS team determined that Charlotte Douglas International Airport (CLT), DFW, Los Angeles International Airport (LAX), Philadelphia International Airport (PHL), and Phoenix Sky Harbor International Airport (PHX) had enough American Airlines A321 flights to be considered for the operational evaluation. FAA feedback suggested initial TBO (iTBO) activities would conflict with demonstrations at LAX and PHL. Therefore, CLT, DFW, and PHX became the focus of the site analysis. PHX was determined to have limited opportunities for CAS-A based on frequently experiencing weather conditions that are above MMC (where CAS-A is expected to be beneficial). CLT and DFW were the top remaining choices. The following was found for the two airports.

- Both airports had:
  - Enough American Airlines A321 aircraft
  - Visual operations that occurred
  - A reasonable amount of time below VMC
  - Increased throughput in VMC as compared to IMC
    - DFW was higher
  - Similar reductions in spacing between aircraft in high demand periods (approximately 0.34 NM reduction)
  - The potential to expand into other CAS activities

Both airports also had dedicated arrival runways. CLT had one and DFW had three dedicated independent arrival runways. CLT appeared to have some activities that could conflict with an operational evaluation (Bone, et. al 2021).

The FAA considered the analysis results and had discussions with the facilities. DFW was ultimately the preferred and final choice of the FAA.

DFW consists of seven runways with five of them being north/south parallel runways. While there are many runway configurations that can be used at DFW, DFW typically operates in either a North or South operation, with the departure and arrival runways as listed in Table 2.

Table 2 – DFW Runway Configurations

Op	Arrival Runways	Departure Runways	Number of Hours	Percent of Hours
South	13R, 17C, 17L, 18R	17R, 18L	4,763	54%
North	31R, 35C, 35R, 36L	31L, 35L, 36R	1,121	13%
South	13R, 17L, 18R	17R, 18L	762	9%
North	31R, 35R, 36L	31L, 35L, 36R	544	6%

D10 primarily used visual approaches when weather conditions permitted, which was estimated to be approximately 75% of the time. The remaining 25% of the time, D10 used instrument approaches either due to IMC weather or VMC with visibility or ceiling values being too low to efficiently run visual approaches.

2.5 Flight Deck Equipment

CAVS and CAS-A are conducted using the same system that is defined for CAVS operations, per FAA Technical Standard Order (TSO)-C195b (FAA, 2015). The ACSS SafeRoute+ ADS-B In avionics was installed in the American Airlines A321 aircraft. The installation is a retrofit implementation available on the market at a lower cost-point than a forward-fit implementation. A retrofit implementation was also to be installed in the existing fleet without having to wait for forward-fit aircraft installations (most forward-fit installations are expected to be limited to new aircraft deliveries). The SafeRoute+ suite includes the existing Navigation Display (ND) for the display of ADS-B traffic along with Traffic Collision Avoidance System (TCAS) traffic; the existing Multi-Function Control Display Unit (MCDU) for flight crew data entry and access to operation-specific information; and a new display called an ADS-B In Guidance Display (AGD) for the display of ADS-B traffic, TCAS traffic, and operation-specific information (see Figure 4).

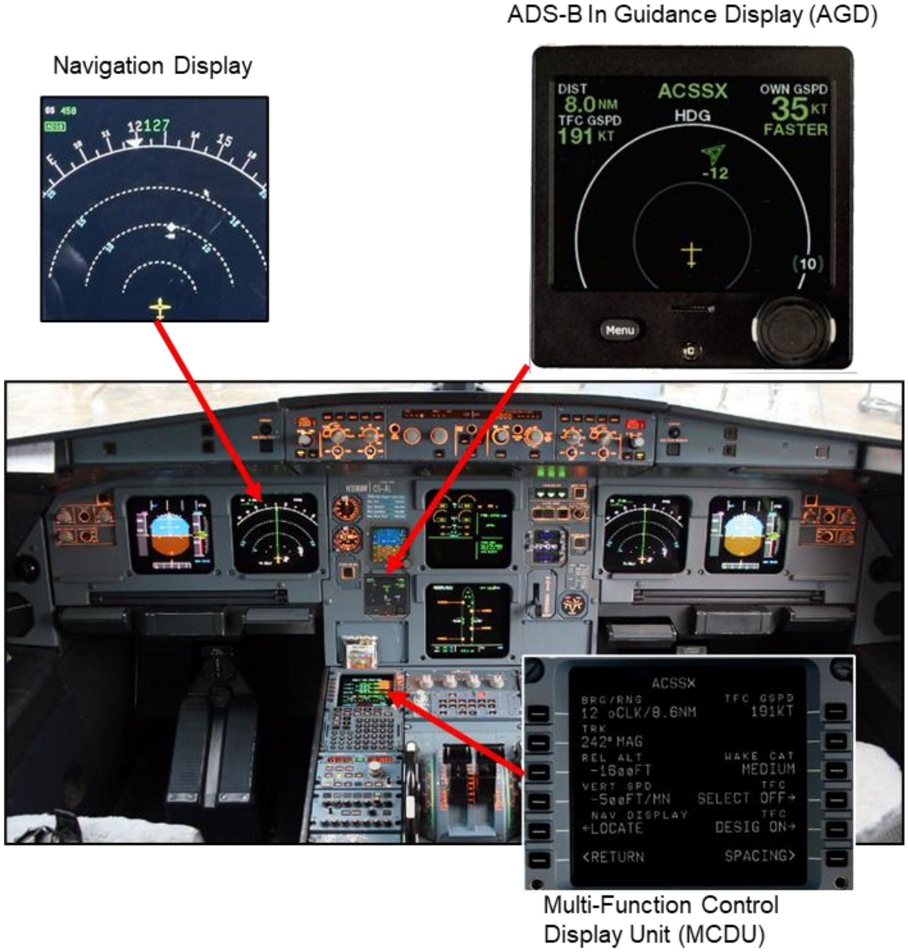


Figure 4 – ACSS SafeRoute+ Avionics Components

The TCAS Traffic Display (overlaid on the ND) provides traffic situation awareness by displaying TCAS traffic (as provided in today's flight decks) as well as ADS-B traffic using TCAS symbology. The ND does not provide CAVS or CAS-A specific information other than indicating the designated traffic through pulsing of the traffic symbol.

The MCDU allows the flight crew to interact with the SafeRoute+ system for functions such as entering application data and requesting the display of additional traffic information.

The AGD provides enhanced traffic situation awareness in the flight crew's forward-field-of-view with a graphical representation of surrounding traffic much like the existing TCAS display but adds traffic directionality and additional traffic information. The AGD traffic display depicts a top-down view of surrounding traffic.

The AGD traffic display range can be adjusted to a range of 2.5, 5, 10, 20 or 40 NM. The selected range is indicated above the AGD control knob. When the acknowledge ("ACK") prompt is displayed above the AGD control knob, the control knob button can be pressed to dismiss a displayed message. The AGD display orientation can be either heading (HDG) or track (TRK) with the orientation indicated at the top of the range ring.

Traffic is represented on the AGD using symbol shapes and colors. The most relevant are shown in Figure 5. The color philosophy used for the traffic symbols is defined as follows:

- White – Airborne basic traffic
- Cyan – Airborne selected traffic (and related text)
- Green – Airborne designated traffic (and related text)
- Amber – Traffic caution alerts such as TCAS Traffic Advisory (TA)
- Red – Traffic warning alerts such as TCAS Resolution Advisory (RA)
- Light Brown/Tan – Ground Traffic
- Gray – Circular background to a traffic symbol to indicate selected traffic

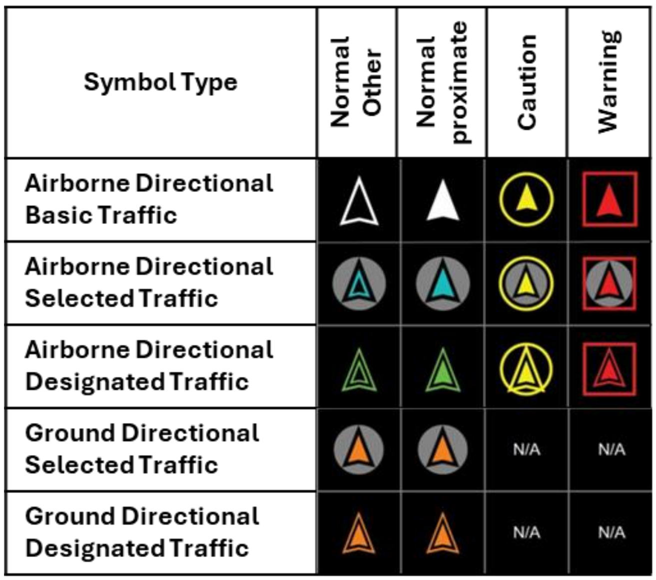


Figure 5 – Selected Most Relevant AGD Traffic Symbols

Traffic data tags are associated with each traffic symbol. If available, each traffic symbol includes the following information:

- Flight identification (ID)/call sign
- Traffic Vertical Direction Indicator (Climb or Descent)
- Traffic Relative Altitude (in hundreds of feet)

Individual traffic can be selected in the MCDU for basic traffic awareness. When traffic is selected on the MCDU Traffic List page, the MCDU Traffic Information page provides the following additional traffic information:

- Flight ID/call sign
- Traffic Bearing (in clock direction)
- Traffic Range (NM)
- Traffic Track Angle (magnetic or true referenced, based on installation aircraft configuration file)
- Traffic Relative Altitude (feet)
- Traffic Vertical Speed (feet/minute)
- Traffic Emitter Category
    - Light
    - Medium
    - Heavy
- Traffic Ground Speed (KT)

When traffic is selected, the AGD traffic display provides flight ID/call sign, distance, and ground speed of the selected traffic as shown. The selected traffic is also highlighted on the AGD (see Figure 6).

Figure 6 – Example AGD - Selected Traffic

In addition to selection, individual traffic can be designated. Designation is expected to be done to perform a specific operation (e.g., CAVS, CAS-A) from a TTF but could also be done on any aircraft for additional traffic awareness. The flight crew designates traffic from the MCDU Traffic Information page by selecting the designate on/off prompt shown in Figure 7. The traffic designate on/off prompt is only displayed on the Traffic Information page when a traffic has sufficient quality for performing a CAVS and CAS-A operation.

Figure 7 – Partial Screen from the MCDU Showing the Traffic Select On/Off Prompt

The MCDU Traffic Information page for the designated traffic provides additional traffic information. An example of the MCDU Traffic Information page for CAVS and CAS-A designated traffic is shown in Figure 8.

Figure 8 – Example MCDU Traffic Information Page with a CAS-A Designated Traffic

When traffic is designated, a selectable range alert threshold is displayed on the MCDU Traffic Information page in cyan with a default value of 2.5 NM, as shown in Figure 9. The flight crew can modify the default value by entering a valid value (from 1.4 to 10 NM) into the field.

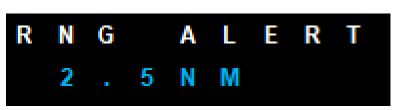


Figure 9 – Partial Screen from the MCDU Showing the Traffic Range Alert

During designation, the AGD highlights the aircraft symbol and provides designated traffic flight ID/call sign, distance from own aircraft, designated traffic ground speed, and differential ground speed (i.e., difference in ground speeds between own aircraft and designated traffic), as shown in Figure 10.

Figure 10 – Example AGD CAS-A Display Layout

Differential ground speed provides the flight crew with an indication of closure or opening on the designated traffic. Differential ground speed is represented as the amount ownship's ground speed that is "FASTER" or "SLOWER" than the designated traffic's ground speed. The example shown in Figure 10 indicates that ownship ground speed is 10 kts slower than the designated traffic's ground speed.

If the distance (horizontal range) to the designated traffic, becomes less than the traffic range alert threshold, the advisory message "TRAFFIC RANGE" is displayed in reverse white on the AGD as shown in Figure 11. There is no associated aural indication. The advisory is inhibited when either ownship or the designated traffic is on-ground. The advisory is acknowledged by pressing the AGD control knob button. When acknowledged, the advisory is removed from the AGD. It is also removed when the designated traffic horizontal range becomes greater than the range alert threshold.

Figure 11 – Traffic Range Alert

Two other situations can lead to alerts on the designated traffic: One is a caution and the other is also an advisory. The caution is reviewed first. When the designated traffic horizontal range is less than 1.4 NM, a caution message "TRAFFIC MIN RANGE" is displayed in reverse amber on the AGD, as shown in Figure 12. An aural "TRAFFIC RANGE" is also provided. The caution message is inhibited when either ownship or the designated traffic is on the ground. The "TRAFFIC MIN RANGE" message cannot be cleared by pressing the AGD control knob button. This message is removed when the designated traffic horizontal range becomes greater than 1.4 NM.

Figure 12 – Traffic Minimum Range Alert

When the CAVS or CAS-A designated traffic no longer meets the qualification criteria for the operation, the advisory message "TRAFFIC LOST" appears in reverse white on the AGD, as shown in Figure 13. There is no associated aural indication. The advisory is acknowledged by pressing the AGD control knob button. When acknowledged, the advisory and designated traffic information are removed from the AGD.

Figure 13 – Traffic Lost Message

2.6 TRACON Ground Equipment

The D10 TRACON controllers used their current capabilities (e.g., Standard Terminal Automation Replacement System (STARS)) for CAS-A operations. Those capabilities were used to inform the controllers which aircraft were able to conduct CAS-A and which aircraft were conducting CAS-A.

Since CAS-A operations are initiated by a controller, the controller needed to know which aircraft could perform CAS-A and had trained flight crews. Ideally, the STARS display would have provided this indication, but the FAA had not yet developed this feature, and it was not available for the operational evaluation.

The lack of a STARS capability indicator required the AIRS team to define a "workaround" for identifying the CAS-A-capable aircraft. The workaround involved American Airlines filing different International Civil Aviation Organization (ICAO) aircraft type designators in flight plans. American Airlines A321ceo and A321neo that were capable (i.e., equipped with SafeRoute+ avionics) were filed using the "A321" type designator. Those that were not capable (i.e., not equipped) filed the flight plan using the "A21N" type designator. This allowed the controller to initiate a CAS-A operation for any American Airlines aircraft filed as "A321."

Furthermore, controllers knew not to issue CAS-A instruction to any American Airlines aircraft filed as “A21N.”

The FAA conducted a safety analysis on the proposed workaround prior to implementation. A Safety Risk Management Panel (SRMP) of FAA, NATCA, Professional Aviation Safety Specialists (PASS), ACSS, SMEs, and American Airlines stakeholders was convened in July 2021. The panel evaluated the workaround for the STARS and En Route Automation Modernization (ERAM) automation systems. The SRMP reviewed the proposed change and identified three low-risk hazards that could occur because of the workaround. Results of this SRMP are documented in FAA (2022) which was approved in February 2022.

Based on the approval of the SRMP, the workaround was used until all A321ceo and A321neo were equipped with the SafeRoute+ avionics in January 2024. At that point, all aircraft were filed in the flight plan with their standard type designator, and CAS-A could be conducted on all American Airlines A321 aircraft. This was still an interim solution for the operational evaluation and not a replacement for a STARS capability indicator.

In addition to knowing who was equipped, the controller needed to know which aircraft were conducting CAS-A. This was done by entering two letters in the STARS scratchpad. “IC” (Instrument approach CAS-A) was entered into the scratchpad if the aircraft was conducting CAS-A during an instrument approach. “VC” (Visual approach CAS-A) was entered if the aircraft was conducting CAS-A during a visual approach. Figure 14 shows a “VC” example in the lower left data block for AAL727. The IC or VC remained visible to the controller that made the entry and to any downstream controller including the Local/Tower controller.

Figure 14 – Partial Screen Capture from STARS Display with CAS-A Relevant Information

2.7 CAS-A Operations

CAS-A is comprised of four phases: (1) TTF identification and verification; (2) Instruction for maintaining CAS-A from the TTF; (3) Maintaining CAS-A on the approach; and (4) Cancellation or rejection.

2.7.1 TTF Identification and Verification

The objective of this phase is that, at the end, the flight crew of the CAS-A aircraft has designated an aircraft on the CDTI corresponding to the TTF and verified the CDTI data matches the call sign provided by the controller.

At D10, the CAS-A equipage was available to the controllers via the aircraft type designator in the flight plan (as reviewed in Section 2.6). The CAS-A procedure was initiated by the Feeder or Final controller who had assessed the applicability of providing an instruction for maintaining CAS-A from the TTF. After deciding to conduct a CAS-A operation, the controller issued the designation instruction to the flight crew.

On receipt of the designation instruction with the TTF call sign, the flight crew is expected to:

- Look at the CDTI to identify and designate traffic corresponding to the TTF call sign.
- Confirm with the controller the identity of the TTF if the identity of the TTF is in question.
- Readback the designation instruction to the controller and notify the controller if they are looking for traffic or have traffic designated.
- Inform the controller that detection and/or designation of the TTF is not possible if identification is not achieved.

The controller uses alternate procedures if the flight crew reports no traffic was displayed that corresponds to the TTF, the traffic corresponding to the TTF does not qualify to support CAS-A, or the flight crew is otherwise unable to conduct CAS-A.

While CAS-A operations are initiated by the controller, in the operational evaluation, some the flight crews took the initiative to advise the controller of being capable and interested in conducting CAS-A. It was then at the discretion of the controller whether to initiate a CAS-A operation. Similar procedures are followed during current pilot-applied visual separation operations. The AIRS team discussed whether this was acceptable for CAS-A operations. D10 controllers did not oppose it as was done in the trial, so it was allowed to occur so lessons could be learned.

The identification and verification step communicates the call sign to the flight crew, allows the flight crew to identify and designate the TTF, and ensures the correct TTF is identified. This is a mandatory step and needs to be completed prior to issuing the CAS-A instruction. At any point in the traffic identification process, the flight crew can verify the call sign of the TTF with the controller if there are questions about the TTF location or identity.

2.7.2 Instruction for Maintaining CAS-A from the TTF

After designation is reported to the controller, the applicability conditions for the CAS-A operation can be reassessed. If satisfied, the controller can issue the CAS-A instruction to "follow" the TTF in conjunction with or after an approach clearance.

The flight crew then reassesses their ability to conduct CAS-A and reads back the CAS-A instruction to "follow" the TTF.

2.7.3 Maintaining CAS-A on the Approach

After accepting the CAS-A instruction, the flight crew uses the TTF information provided by the CDTI as a substitute for the out-the-window information to follow the TTF as done today on visual approaches when using pilot-applied visual separation. The flight crew performs this task by using the CDTI in the forward field of view with the ground speed information (i.e., the individual ground speeds and the differential ground speed) and the digital read-out of the horizontal range to the TTF (see Section 2.5 for the information provided by the CDTI). These parameters allow for a better evaluation of the actual distance from the TTF and for an earlier detection of speed variations. In particular, a speed reduction of the TTF can be extremely difficult to detect visually out-the-window and only the consequence (i.e., a distance reduction) can be visually detected. Using the range and differential ground speed information on the CDTI, flight crews are able to detect speed reductions of the TTF and maintain CAS-A from it more accurately and quickly.

The flight crew is able to use speed adjustments and configuration changes as needed to manage the spacing between their aircraft and the TTF. The CAS-A aircraft is not authorized to use turns or lateral maneuvering to manage spacing with the TTF, without controller coordination. Such maneuvering is only acceptable when needed to capture and maintain the final approach course. Any turn or lateral maneuver that is not part of CAS-A is governed by the type of approach the aircraft is conducting and through controller restrictions/coordination.

If visual out-the-window contact is achieved at any point, the flight crew can use the information for traffic awareness but cannot rely solely on out-the-window contact to conduct CAS-A. Once CAS-A has started, the CAS-A operation ends when:

- The TTF lands
- The Traffic Lost Advisory Alert (aka Traffic Lost Message) is triggered
- CAS-A is cancelled by the controller
- The flight crew reports "unable" CAS-A and it is cancelled by the controller

It is an on-going task of the controller to ensure the requirements for the weather conditions at the airport for CAS-A operations are met. If conditions were met at the start of a CAS-A operation and then drop below VMC during a CAS-A operation, the controller will determine the appropriate action.

After having accepted the instruction for maintaining CAS-A from the TTF, the flight crew:

- Flies the approach
- Looks at the TTF information (i.e., distance and relative speed) provided by the CDTI
- Reacts to any alerts (see below) as appropriate
- Adjusts the speed and configuration of the aircraft to maintain CAS-A from the TTF

Three alerting functions are provided in the flight deck equipment to support CAS-A operations (see Section 2.5 for the information provided on the AGD).

- An operational advisory "Traffic Range" alert is generated when the horizontal range to the designated traffic falls below the default value[2]. When an advisory "Traffic Range" alert is generated, the flight crew determines if any subsequent response is required.
    - Subsequent flight crew responses could include adjusting speed or contacting the controller for non-visual separation/non-CAS-A instructions.
- A technical performance Traffic Minimum Range Caution Alert is generated when the horizontal range to the designated traffic became less than 1.4 NM. The objective is to alert the flight crew the ADS-B data quality is no longer sufficient to maintain CAS-A from the TTF. When a Traffic Minimum Range Caution Alert is triggered, the flight crew:
    - Contacts the controller; if they are unable to contact the controller, they execute a missed approach or go-around.
    - If, when contacting the controller, the flight crew has out-the-window visual contact, they advise the controller, who may elect to issue a visual separation instruction.
- A Traffic Lost advisory alert is generated when the TTF is no longer qualified to support CAS-A, due to the ADS-B signal not meeting performance parameters. The flight crew:
    - Contacts the controller; if they are unable to contact the controller, they execute a missed approach or go-around.
    - If, when contacting the controller, the flight crew has out-the-window visual contact, they advise the controller, who may elect to issue a visual separation instruction.

No alerts are generated when the TTF is on the ground to avoid unnecessary alerts very late in the approach as the TTF rapidly decelerates after landing. When the TTF lands during a CAS-A operation, the Traffic Range and Traffic Minimum Range Alerts are disabled, the differential groundspeed is removed from the AGD, and the TTF symbol changes from a green double chevron to a brown double chevron.

In case of abnormal modes (e.g., TTF no longer qualified to support CAS, or triggering of a Traffic Minimum Range Caution Alert without out-the-window visual contact) the procedure is identical to current visual approaches with TTF (respectively, loss of visual contact and/or too close from the TTF).

[2] When traffic was designated, the range alert threshold was displayed with a default value of 2.5 NM. The flight crew could modify the default value by entering a valid value (1.4 - 10 NM) into the avionics.

2.7.4 Cancellation or Rejection

CAS-A nominally ends when the TTF lands. CAS-A can also end abnormally. In current operations, one of the reasons for abnormal cancellation of visual separation instructions occurs when the flight crew perceives visually that the distance from the TTF becomes unsafe. In such situations, the flight crew applies contingency procedures (e.g., increase distance, conduct a missed approach/go-around, or contact the controller). Since CAS-A allows for the use of the CDTI information as a substitute for out-the-window visual information, the current contingency procedures also apply when the flight crew perceives that the distance from the TTF becomes too small using the information provided by the CDTI (e.g., displayed parameters, advisory Traffic Range Alert) or when a Traffic Minimum Range Caution Alert is triggered.

Another CAS-A event that can lead to an abnormal cancellation is the loss of support from the CDTI (e.g., TTF no longer qualified to support CAS-A). In this situation, the flight crew applies the same contingency procedures as in current visual approach with TTF operations when the flight crew loses out-the-window visual contact (e.g., conduct a missed approach/go-around or contact the controller).

2.8 Roles and Responsibilities

2.8.1 Air Traffic Controller

The roles and responsibilities of the Approach and Tower Controllers for the current operations where flight crews maintain pilot-applied visual separation from the TTF are still valid. The controller remains responsible for setting up the sequence and the spacing so the CAS-A operation will be successful.

During visual approach operations, controllers position aircraft to meet the following criteria:

- To be clear of clouds
- On a published approach procedure so that the flight crew can use the instrument approach navigation information to support the visual clearance
- Limit the turn on to the final approach course to 30 degrees or less to comply with 7110.65 (FAA, 2024) procedures for separation between parallel runways, when applicable
- Establish an orderly sequence

Using CAS-A during visual approaches makes use of these criteria. Similarly, any procedures or requirements for visual or instrument approaches will be used during CAS-A.

The controller that issues the designation instruction can either be an upstream controller (e.g., a Feeder Controller) or the controller (i.e., the Final Controller) that will issue the CAS-A instruction to follow traffic. If a controller other than the one that will issue the CAS-A instruction issues the designation instruction, that controller will need to coordinate and convey the status of designation with the downstream controller.

Designation of TTF is required prior to issuing a CAS -A instruction. In addition, the CAS-A aircraft and TTF must be established on the final approach course, be established on an arrival procedure that connects to the final approach course, or vectored to intercept the final approach course. The CAS-A instruction must be issued after the issuance of the approach clearance, whether in the same or a later transmission.

Before the flight crew of the CAS-A aircraft has accepted the instruction to maintain CAS-A from the TTF, the controller is responsible for providing separation between both aircraft. After having accepted the CAS-A instruction, the flight crew of the CAS-A aircraft becomes responsible for maintaining CAS-A from the TTF. The controller remains responsible for providing separation between the CAS-A aircraft and all other aircraft for which they have separation responsibility, expect the TTF. The controller monitors the spacing for any significant issues but allows the flight crew of the CAS-A aircraft to conduct CAS-A from the TTF. The Tower Controller is still responsible for runway separation and issuing landing clearances for all the aircraft pairs, including the CAS-A pair.

A responsibility that exists in current day operations and remains in effect for CAS-A operations is the issuance of safety alerts by the controller. Two paragraphs of FAA JO 7110.65AA (FAA, 2024) apply to safety alerts.

- Para. 2−1−2. DUTY PRIORITY
    - Give first priority to separating aircraft and issuing safety alerts as required in this order. Good judgment must be used in prioritizing all other provisions of this order based on the requirements of the situation at hand.
- Para. 2−1−6. SAFETY ALERT
    - Issue a safety alert to an aircraft if you are aware the aircraft is in a position/altitude that, in your judgment, places it in unsafe proximity to terrain, obstructions, or other aircraft. Once the pilot informs you action is being taken to resolve the situation, you may discontinue the issuance of further alerts. Do not assume that because someone else has responsibility for the aircraft that the unsafe situation has been observed and the safety alert issued; inform the appropriate controller.
- Note−
    - 1. The issuance of a safety alert is a first priority (see paragraph 2−1−2, Duty Priority) once the controller observes and recognizes a situation of unsafe aircraft proximity to terrain, obstacles, or other aircraft. Conditions, such as workload, traffic volume, the quality/limitations of the radar system, and the available lead time to react are factors in determining whether it is reasonable for the controller to observe and recognize such situations. While a controller cannot see immediately the development of every situation where a safety alert must be issued, the controller must remain vigilant for such situations and issue a safety alert when the situation is recognized.
    - 2. Recognition of situations of unsafe proximity may result from MSAW/E−MSAW [Minimum Safe Altitude Warning], automatic altitude readouts, Conflict/Mode C Intruder Alert, observations on a PAR [precision approach radar] scope, or pilot reports.
    - 3. Once the alert is issued, it is solely the pilot’s prerogative to determine what course of action, if any, will be taken.

If the flight crew of the CAS-A aircraft reports that CAS-A can no longer be maintained, the same contingency procedure used in today's operations applies. That is, after having been informed by the flight crew of the CAS-A aircraft, the controller becomes responsible for providing appropriate instructions to establish another form of separation between the two aircraft (as the spacing achieved visually from the TTF can be less than other more restrictive separation minima).

As with other current day operations, the controller needs to ensure the requirements for the weather conditions at the airport for CAS-A operations are met.

2.8.2 Flight Crew

The flight crew is responsible for conducting CAS-A relative to the TTF using the information on the CDTI. The flight deck procedures include the flight crew's use of the CDTI to assist in identifying the TTF with call sign and maintaining CAS-A from it. Separately, the flight crew is also responsible for notifying the controller if they cannot accept an approach clearance.

The flight crew of the CAS-A aircraft must undertake the appropriate actions to maintain CAS-A from the TTF. If it is no longer possible for the flight crew of the CAS-A aircraft to maintain CAS-A, the flight crew must inform the controller as soon as possible and must proceed in accordance with the alternative instructions given by the controller. Depending on the situation, the flight crew can initiate a missed approach or go-around procedure even before informing the controller.

If it becomes necessary for a flight crew to discontinue a CAS-A operation due to equipment failure or for other reasons, but can maintain visual separation from the TTF, the flight crew may advise the controller they are able to maintain visual separation for the remainder of the approach. The controller will either issue a visual separation instruction or provide other instructions.

If visual out-the-window contact is achieved at any point, the flight crew can use the information for traffic awareness but cannot rely solely on out-the-window contact to conduct CAS-A.

On any flight, the flight crew may designate traffic on the CDTI for general traffic awareness, CAVS or CAS-A. However, CAS-A operations can only be conducted if the controller issues a CAS-A instruction. General traffic awareness and CAVS can be conducted without specific controller knowledge.

2.9 Phraseology

This section reviews phraseology for CAS-A operations. There are no changes to phraseology related to the approach clearances, so those communications are only reviewed when related to a CAS-A communication.

2.9.1 Identification of TTF

Controllers use the call sign of the TTF when identifying that aircraft in the designation instruction. The use of other information, such as distance and clock position, is at the discretion of the controller.

- Controller message: "[CAS-A aircraft call sign] DESIGNATE [TTF call sign]"
  - Example: "American 452, designate Southwest 387"

There is a potential for flight crews to be unaware of the three-letter designator associated with the call sign. Controllers may use a phonetic or individual letter version of the call sign for clarification. (e.g., "Romeo Papa Alpha" or "R-P-A" for Brickyard)

  - Example: "American 452, designate R-P-A 3732"

The flight crew will acknowledge with their aircraft identification, either at the beginning or at the end of their transmission, and one of the words "Wilco," "Roger," or other appropriate remark. A readback is also appropriate. However, to minimize the use of third-party call sign confusion[3], it is preferable to limit the flight crew use of the TTF callsign to the communication verifying the TTF.

2.9.2 Verification of TTF

The controller must receive confirmation of the TTF call sign prior to issuing the CAS-A instruction. This ensures that the controller and the flight crew concur on the call sign prior to the controller being relieved of the requirement to apply radar separation.

- Flight crew message: "[CAS-A aircraft call sign] HAS DESIGNATED [TTF call sign]"
  - Example: "American 452 has designated Southwest 387"

If confirmation of the TTF call sign is not received from the flight crew prior to issuing the CAS-A instruction, the controller must ensure with the flight crew that the correct traffic is designated.

- Controller message: "[CAS-A aircraft call sign] VERIFY TRAFFIC DESIGNATED"
  - Example: "American 456 verify traffic designated"
- Flight crew message: "[CAS-A aircraft call sign] DESIGNATED [TTF call sign]"
  - Example: "American 456 designated Southwest 123"

2.9.3 CAS-A Instruction

The CAS-A instruction must be issued after the issuance of the approach clearance, whether in the same or in a later transmission. To avoid providing the flight crews with too much information at once, the controller should use good judgement when combining the approach clearance with the CAS-A instruction.

[3] Third party call sign confusion happens when the flight crew of another aircraft (e.g., the TTF) hears their own call sign in a communication and wonders whether they were being addressed (versus spoken about). For example, if the flight crew of Southwest 387 hears their call sign in the designation instruction, they may ask the controller if the communication was for them.

In today's operations, controllers often issue a speed instruction along with a pilot-applied visual separation clearance (e.g., "…follow the Southwest Boeing 737, cleared visual approach Runway Three-Three-Left, maintain one-seven-zero knots to…"). This is done to maintain an evenly spaced flow of traffic but is not intended to interfere with the flight crew's ability to follow the TTF. These same procedures should be followed during CAS-A operations.

CAS-A is directly analogous to pilot-applied visual separation as defined in FAA Order 7110.65 (FAA, 2024). Like pilot-applied visual separation, CAS-A relieves the approach controller from having to enforce the otherwise-applicable surveillance separation minima. The approach controller monitors the CAS-A operation and provides speed instructions to the flight crew as the controller deems necessary.

- CAS-A instruction in same transmission as approach clearance
    - Controller message: "[CAS-A aircraft call sign], [approach clearance] FOLLOW TRAFFIC"
        - Example 1: "American 452, six miles west of JEANS, turn left heading one-three-zero, maintain three thousand until established on the localizer, cleared ILS Runway one-zero approach, follow traffic"
        - Example 2: "American 452, turn left heading one-three-zero, join the localizer, cleared visual approach Runway One-Zero, follow traffic"
    - Flight crew message: "[CAS-A Aircraft call sign], [Approach Clearance] FOLLOWING (or FOLLOW) TRAFFIC"
        - Example 1: "American 452, heading one-three-zero, maintain three thousand until established, cleared ILS Runway One-Zero, follow traffic"
        - Example 2: "American 452, heading one-three-zero to join the localizer, cleared visual approach Runway one-zero, follow traffic"
- CAS-A instruction after the approach clearance
    - Controller message: "[CAS-A aircraft call sign] FOLLOW TRAFFIC"
        - Example: "American 452, follow traffic"
    - Flight crew message: "[CAS-A aircraft call sign], FOLLOW (or FOLLOWING) TRAFFIC"
        - Example: "American 452, follow traffic"

Controllers and flight crews may optionally use the term "designated" when issuing or responding to the CAS-A instruction for clarity or emphasis. (e.g., "…follow designated traffic.")

In the context of the CAS-A instruction, "follow traffic" allows flight crews to transition through IMC conditions only when they had previously designated the TTF and been issued an instrument approach clearance.

2.9.4 Abnormal Cancellation or Rejection

While rare, there may be times when the flight crew needs to reject a CAS-A instruction (e.g., report "unable") or discontinue an ongoing operation. In addition, the controller may need to cancel an ongoing operation. In either case, the controller issues alternate control instructions. The sections below contain the phraseology to be used in those events.

2.9.4.1 Rejection of CAS-A by the Flight Crew

Flight crews may reject a CAS-A instruction during the Traffic Identification phase or when the CAS-A instruction has been issued. This may be due to flight crew prerogative or the inability of the avionics to display the TTF on the CDTI.

- Controller message: "[CAS-A aircraft call sign] DESIGNATE [TTF call sign]"
    - Example: "American 452, Designate Southwest 387"
- Flight crew message: "UNABLE, [CAS-A aircraft call sign]"
    - Example: "Unable, American 452"

2.9.4.2 Abnormal Cancellation of CAS-A Initiated by the Flight Crew

After the initiation of the CAS-A operation, the flight crew may report that they are unable to continue with the operation or have an avionics failure. For example, when the flight crew is unable to monitor the designated traffic on the CDTI (i.e., they can no longer maintain CAS-A), the flight crew informs the controller. If the flight crew deems the inability to monitor the designated traffic on the CDTI to be a temporary condition, they may inform the controller of the cause using plain language. The flight crew can optionally communicate the reason. The controller then issues alternate control instructions.

- Flight crew message: "UNABLE TO FOLLOW DESIGNATED TRAFFIC. [Optional reason]. [CAS-A aircraft call sign]."
    - Example: "Unable to follow designated traffic. Traffic lost. American 452"
- Controller message: "[CAS-A aircraft call sign], [alternate control instructions]"
    - Example: "American 452, reduce to final approach speed"

2.9.4.3 Abnormal Cancellation of CAS-A by the controller

If the controller has to cancel an ongoing CAS-A operation, the controller issues the cancellation instruction and alternate control instructions.

- Controller message: "[CAS-A aircraft call sign], DISREGARD DESIGNATED TRAFFIC, [alternate control instructions]"
    - Example: "American 452, disregard designated traffic, reduce speed to 170 knots"

2.10 Training

Training was required for both American Airlines flight crews and D10 controllers prior to being authorized to conduct CAS-A. The sections below provide a summary of the training conducted.

2.10.1 Pilot Training

All American Airlines Airbus narrow body aircraft flight crews (A321, A320, and A319) completed distance learning (DL) computer-based training (CBT) for CAS-A operations. The training material covered topics such as the following.

- The CDTI features and their use for CAS-A
- The CAS-A concept
- The weather requirements to conduct CAS-A
- The AIRS operational evaluation
- Flight crew actions
- Flight crew and controller roles and responsibilities
- Phraseology
- Contingencies

Pilots also had access to a CAS-A quick reference guide in the airplane on their company issued iPads.

American Airlines also published additional information in the form of Crew Check In (CCI) memos. These CCI memos included messages to reinforce training material and/or update flight crews on areas of special emphasis.

2.10.2 Controller Training

D10 controllers were trained via briefing and simulation sessions. The briefing covered the following topics.

- The CAS-A concept
- The weather requirements to conduct CAS-A
- Controller and flight crew roles and responsibilities
- Phraseology
- The equipment used by the flight crew
- Alert functions and recovery from a failed CAS-A operation

There was a refresher briefing conducted in August 2023. The refresher consisted of the same material as the initial briefing. A phraseology change (discussed in Section 4.3.2.2) occurred in November of 2023 and controllers were briefed on the change at that time.

The simulator training involved watching a demonstration of CAS-A operations followed by running CAS-A operations in the Enhanced Target Generator lab. The Enhanced Target Generator is an environment that simulates a TRACON control room with STARS equipment. It can include multiple controller stations, simulated traffic, and voice communications via “pseudo-pilots.” It is used to train controllers on different techniques and procedures in a realistic setting but without live traffic. To ensure familiarization, all controllers conducted the simulator training on two separate occasions prior to the start of the operational evaluation.

Controllers had access to a CAS-A “cheat sheet” at their control positions reminding them of the operation and the phraseology. They also had access to the feedback sheets if they had interest in providing feedback on a particular CAS-A operation. Another feedback form was available during weekly team briefings for more information on CAS-A operations and suggestions. Occasionally, American Airlines personnel attended controller team briefings to discuss CAS-A operations with controllers, get feedback, and share information on CAS-A operations.

2.11 Safety Risk Management Activities Prior to the Operational Evaluation

Safety Risk Management (SRM) work was conducted before starting the operational evaluation. An SRM panel was convened January 11-12, 2022 to identify and assess hazards associated with the proposed CAS-A operational evaluation in D10 airspace. The panel was comprised of stakeholders representing the FAA Flight Standards Service (AFS), FAA Air Traffic Services (AJT), FAA Mission Support Service (AJV), D10, NATCA, American Airlines management and flight operations, the APA, and SMEs in air traffic operations, ASAs, flight operations, and safety. The assessment was conducted in accordance with the FAA Air Traffic Organization (ATO) Safety Management System (SMS) Manual dated April 2019 (FAA, 2019).

The SRM panel identified one hazard with four effects. The hazard, “Designate the wrong TTF,” is defined when either the flight crew or the controller mistakenly identifies or designates an incorrect TTF. Several controls were identified to minimize the severity of impacts leading to all effects having a severity rating of 5 (Minimal) and 4 (Minor). All four effects were found to be Low risk. Table 3 below summarizes the identified hazard.

Table 3 – Summary of Identified Hazards

Hazard Title	Effect	Initial Risk & Predicted Residual Risk
Designate the wrong TTF	CAS-A aircraft and TTF are too close to apply runway separation	**Severity:** 5 – Minimal **Likelihood:** D – Extremely Remote **Risk:** Low
	Increased communication/ increased workload	**Severity:** 5 – Minimal **Likelihood:** C – Remote **Risk:** Low
	Loss of situational [i.e., situation] awareness on flight deck	**Severity:** 5 – Minimal **Likelihood:** C – Remote **Risk:** Low
	Loss of separation with another aircraft	**Severity:** 4 – Minor **Likelihood:** D – Extremely Remote **Risk:** Low

The SRM panel reviewed the operational description (FAA, 2023) as part of the hazard assessment and provided input to assist the operational evaluation site in finalizing their Standard Operating Procedures (SOPs) and phraseology.

The SRM panel results were documented in a Safety Risk Management Document (SRMD) which was reviewed and approved in March 2022.

2.12 Operational Evaluation Activities during Operations

AIRS was a public-private partnership that included collaboration between the FAA, American Airlines, ACSS, NATCA and APA. Due to the collaborative and multi-organizational nature of this work, significant coordination and communication was required to successfully conduct the operational evaluation.

Since the operational evaluation was conducted using certified aircraft operating in revenue service, all equipment and procedures had to be coordinated within the AIRS CAS-A team and approved by the proper FAA organizations prior to the start of the operations. Significant data collection and analysis efforts were required by all parties to achieve the primary goal of demonstrating the operational feasibility and value of CAS-A.

AIRS project reviews were held to identify any operational safety concerns, gain insights into the operations from data collected and analyzed, and determine if any changes could be made to improve operations. These reviews included insights from controllers, flight crews, and experts in avionics systems, procedures, and other aspects of CAS-A.

These reviews were conducted through telecons and in-person meetings hosted by D10. Initially telecons were held weekly, but as the project matured, these telecons occurred bi-weekly. The telecons provided a status of the recent CAS-A usage and timely insights into any issues identified during recent operations. In-person meetings were initially held monthly, but as the project matured these meetings were held bi-monthly. These in-person meetings were used to provide a more comprehensive review of the CAS-A and CAVS data. During these meetings, AIRS CAS-A team members examined trends in the data, conducted detailed reviews of key operations, and developed solutions for any observed issues.

2.13 Aircraft Equipage and Flight Crew Chances of Experiencing a CAS-A Operation

At the start of the CAS-A operational evaluation on March 1, 2023, 242 of the 288 American Airlines A321ceo and A321neo used during the first year of the operational evaluation were equipped. By January 2024, all 288 American Airlines A321 aircraft flying at the time were equipped (see Figure 15). Prior to the start of CAS-A, aircraft were being equipped and were capable of traffic designation and general CDTI use. CAVS operations could have started NAS-wide as early as May 2021.

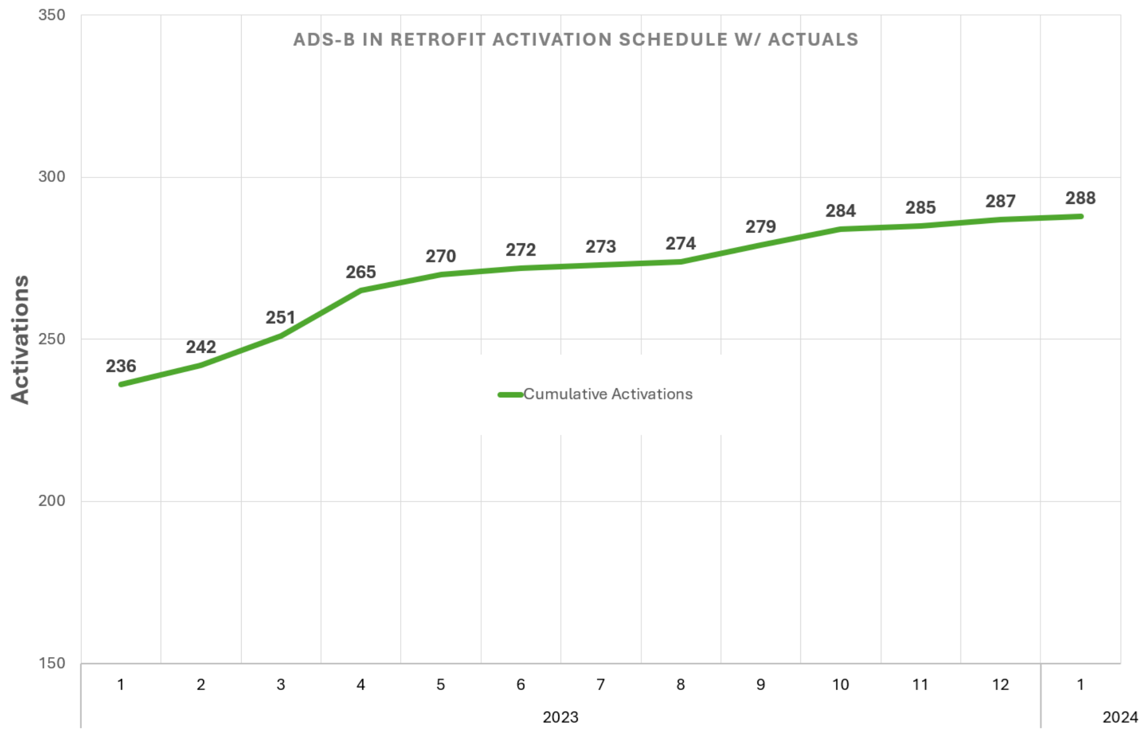


Figure 15 – A321 Equipage Rate During the Operational Evaluation

At the end of year one, American Airlines had approximately 6,000 pilots qualified on the American Airlines Airbus fleet (A321 as well as A319 and A320) of 469 aircraft. With such a large number of pilots, the odds of a flight crew flying a CAS-A operation were low because they would need to be in an aircraft (i.e., an A321) that was equipped, arriving at DFW, in a situation where CAS-A could be utilized, and in an aircraft where the controller decided to utilize CAS-A when the opportunity arose. Therefore, flight crew members had fewer opportunities to experience a CAS-A operation than the smaller set of controllers working at D10.

3 Data Sources and Collection Method

Data was collected to examine CAS-A benefits and operational topics, CAVS benefits, as well as traffic designation and general CDTI use benefits. The data used, the collection methodology, and approach to the analyses is covered in this section. The benefits data is covered first then the operational data.

As noted in Section 2.13, aircraft equipage increased from approximately 250 to 288 aircraft during the first year of the data collection. However, the change in the number of equipped aircraft may have had little impact on the data collection or the data itself.

3.1 Benefits Data Sources

The benefits analysis included flights where the flight crews designated traffic: (1) at any point during the flight, (2) within 25 NM radius of an airport (with some operations assumed to be CAVS), and (3) when conducting CAS-A. CAVS operations are like CAS-A and have some of the same benefits mechanisms. CAVS operations could have started as early as May 2021 when American Airlines flight crews were trained on the use of the equipment and CAVS operations. Traffic designations could have occurred prior to May 2021. CAS-A operations started at D10 in March 2023. Therefore, CAVS and traffic designation data were analyzed for a longer time compared to the one year of CAS-A data. When presented, the CAVS and traffic designation data will be noted, and it will be noted when CAS-A data is also included as a superset.

3.1.1 IOAA Trajectory Data

The Instrument Flight Procedures (IFP), Operations, and Airspace Analytics (IOAA) Tool provides analysis capabilities to study flight operational metrics and implementation and use of IFP[4]. It enables analysis of fused operational usage metrics (e.g., arrival procedure usage), aircraft performance metrics (e.g., climb gradient distributions, final approach deviations), and weather conditions at various points of interest in the NAS. Users can dynamically filter parameters within the tool to correlate between metrics and identify flights of interest. The fused surveillance data used to derive operational usage, safety, and aircraft performance metrics is available for both display and download.

The historical track data, available via the IOAA tool, is fused from surveillance data sources including FAA radars, Airport Surface Detection Equipment Model X (ASDE-X), and ADS-B data to create a smoothed, end-to-end trajectory for each flight. The trajectory data undergoes multiple quality checks before release. For AIRS, this trajectory data was downloaded to examine individual flight profiles for all arrivals into six major American Airline hub airports: CLT, DFW, LAX, Miami International Airport (MIA), PHL, and PHX.

[4] FAA, The IFP, Operations, and Airspace Analytics (IOAA) Tool, Airspace Usage Module, URL: https://sda.faa.gov/login.htm (Data retrieved January 2022 through February 2024).

3.1.2 CountOps

CountOps is an FAA automated system that utilizes data from the National Offload Program (NOP), STARS, and Common Automation Radar Terminal System (CARTS) to provide hourly counts of air traffic activity at TRACONs, towers, and airports. It includes counts for more than 2,000 towers and airports[5]. CountOps also contains information on individual arrival and departure operations.

For AIRS, CountOps was particularly useful because it contained scratchpad information for individual flights. As noted earlier, D10 used the scratchpad to indicate a CAS-A operation by entering either the code “IC” or “VC.” The data collection team used this information to count CAS-A operations and correlate the data with flights from the IOAA trajectory data.

3.1.3 ACSS SafeRoute+ Data

ACSS SafeRoute+ data refers to parameters recorded by the TCAS surveillance processor. These data included parameters related to surrounding ADS-B traffic, the CAVS/CAS-A aircraft (aka ownship), and the SafeRoute+ applications. SafeRoute+ data was used to identify flights where aircraft designation was used and provided useful metrics.

ACSS developed a process to obtain SafeRoute+ data from the aircraft using Compact Flash cards placed in the TCAS surveillance processor. American Airlines maintenance retrieved the Compact Flash cards from the TCAS units periodically, typically twice a month. After receiving the data, ACSS used the following process:

1. Download the raw data files for storage and processing
2. Identify flights with ADS-B In equipment, those using target designation, and those using CAS-A parameters
3. Calculate SafeRoute+ data parameters
4. Provide the SafeRoute+ data to the FAA semi-monthly

See Figure 16 for this process.

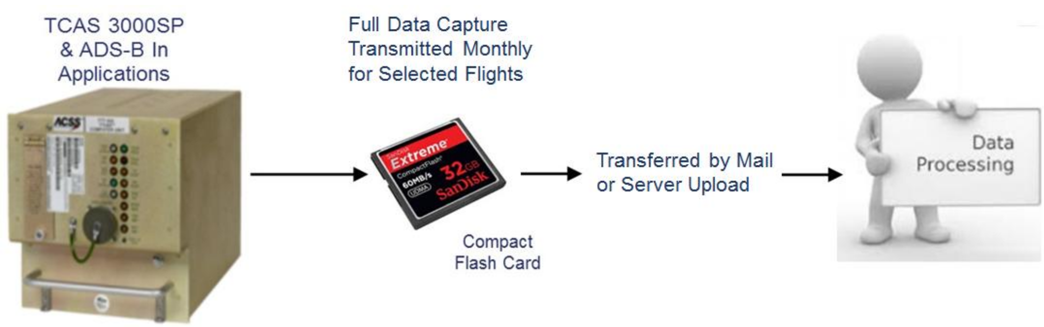


Figure 16 – Processes to Obtain SafeRoute+ Data from the Aircraft

[5] FAA, CountOps (Count of Operations) web access, URL: https://aspm.faa.gov/cops/sys/main.asp (Data Retrieved March 2023-February 2024).

Each set of data could have contained information from previous months. For this reason, there was a lag in the availability of complete monthly data sets for all flights. The lag depended on when the data was physically downloaded from each aircraft. Typically, the lag was three months in duration.

For general designation, CAVS, and CAS-A, ACSS recorded a single row of data each time aircraft designates traffic with the information indicated in Table 4.

Table 4 – ACSS-Provided Data per Designated Traffic Operation

ACSS Designated Traffic Data Elements	Format
Own Tail Number	Tail Number
Own Flight ID/call sign	Three-letter call sign and number
Own Pressure Altitude	Pressure altitude of ownship at beginning of designation (feet above mean sea level [ft MSL])
Own Ground Speed	Ground speed at beginning of designation (knots)
Designated Traffic Flight ID/call sign	Three-letter callsign and number
Designation Date Start	Time Coordinated Universal Time (UTC) (HH:MM:SS)
Designation Time Start	Time UTC (HH:MM:SS)
Designation Time End	Time UTC (HH:MM:SS)
Traffic Pressure Altitude	Pressure altitude of traffic at beginning of designation (ft MSL)
Horizontal Range	Horizontal range from designated aircraft at beginning of designation (NM)

3.1.4 ASPM

ASPM is an FAA-maintained database that contains a variety of flight and airport information[6]. ASPM data falls into two categories: flight data containing information on individual flight performance and airport data containing information on airport efficiency. Data comes from ARINC's Out-Off-On-In (OOOI), Traffic Flow Management System (TFMS), US Department of Transportation's Airline Service Quality Performance (ASQP) survey, weather data, airport arrival and departure rates (in 15-minute intervals), airport runway configurations, delays, cancellations, and arrival/departure rates. For this effort, data from ASPM was correlated with the ACSS data to limit analysis to aircraft call signs arriving at airports of interest, and to define different periods of meteorological conditions at the relevant airports.

[6] FAA, Aviation System Performance Metrics (ASPM) Web Data System, URL: https://aspm.faa.gov/apm/sys/main.asp (Data Retrieved January 2022 through February 2024).

3.2 Benefits Data Analysis Approach

3.2.1 Number of Relevant Operations

As described in the previous section, ACSS provided a row of data every time a flight crew designated traffic. Data from ASPM was used to identify the registration number of all American Airlines A321 aircraft arriving at each destination airport. An inventory of equipped aircraft was used to track equipped flights that arrived at each airport. The data collection team correlated the aircraft call sign date and time from the ACSS data with IOAA trajectory data to determine flight destination, destination airport runway, and distance from destination airport. The data were aggregated by airport and analyses performed at six American Airlines hubs.

The following traffic designation count metrics were examined per airport:

- Monthly number of equipped arrivals.
- Monthly number and percent of equipped arrivals using traffic designation within 25 NM of the airport. This metric is used to determine which arrivals are using traffic designation during the approach (and potentially conducting CAVS or CAS-A).

The CAS-A operation is exclusively used at D10 for DFW arrivals. CountOps data (see Section 3.1.2) included the specified code (either "VC" or "IC") entered in the scratchpad to indicate a CAS-A operation.

The following CAS-A count metrics were examined at DFW:

- Monthly number of equipped arrivals
- Monthly number and percent of equipped arrivals using CAS-A

3.2.2 Inter-Arrival Time (IAT) and Inter-Arrival Distance (IAD)

On an individual aircraft basis, inter-aircraft spacing, in time and distance, at the runway threshold were used to examine the effectiveness of traffic designation and CAS-A operations. The primary metrics used for the analyses were:

- Inter-Arrival Time (IAT) – the time between the traffic designation/CAS-A aircraft's threshold crossing time and TTF's threshold crossing time for the same runway.
- Inter-Arrival Distance (IAD) – the distance between the traffic designation/CAS-A aircraft and TTF when the TTF crossed the threshold.

The following data was gathered per arrival for all flights into each runway for six American Airlines' hub airports. The IAT and IAD were calculated, and the following factors were used to group results:

- Use of the traffic designation capability
- Use of CAS-A (if the flight was arriving to DFW airport)
- Aircraft type
- Carrier name
- Weather conditions

- Demand at the airport in terms of number of arrivals preceding the CAVS/CAS-A aircraft during the past 15 minutes
- Weight class of heavy for TTF aircraft

The metrics were grouped into sets and analyzed, including direct examination of the distributions and descriptive statistics (e.g., mean, median, mode, and standard deviation), statistical tests on the difference of the means and standard deviations, average value versus demand, and multiple linear regression using ordinary least squares regression.

For the CAS-A distribution, statistical testing, and trend analysis the following restrictions were applied to compare relevant sets:

- Limited analysis to Airbus A321 aircraft (included both A321 ceos and A321 neos) arriving at DFW
- Removed arrivals with IATs greater than 220 seconds or less than 40 seconds
- Removed arrivals behind a heavy aircraft
- Removed arrivals during IMC (less than 1000-ft ceiling or less than 3 miles visibility).

For the Traffic Designation analyses, the data was filtered as outlined above and then the means, distributions, and trends were examined comparing American Airlines aircraft which used Traffic Designation within 25 NM of the airport to those which did not. Within 25 NM of the airport was chosen as it was assumed that flight crew designation of a TTF in this environment means they were likely monitoring a TTF for the approach and likely conducting CAVS. However, the designation could have been for other reasons. At airports with many non-American Airlines A321 arrivals, the analyses also examined the metrics for the non-American Airlines aircraft.

Regression analyses were also used to examine simultaneous impacts. For the Traffic Designation regression analyses on IAT and IAD the following specification was used:

- Arrival demand (number of arrivals at the airport during the past 15 minutes)
- Arriving aircraft behind a heavy aircraft (0 = No, 1 = Yes)
- Air carrier (0 = non-AAL, 1 = AAL)
- Traffic Designation used within 25 NM of runway (0 = No, 1 = Yes)

Regression results included the coefficients of each independent variable, the significance of the coefficient (in terms of the P-value) and the overall goodness of fit of the model (adjusted R-Square).

For the CAS-A analysis, the approach was like what was used for Traffic Designation except the sets of aircraft were limited to CAS-A aircraft and non-CAS-A aircraft. The CAS-A regression analyses on IAT and IAD used the following specification was used:

- Arrival demand (number of arrivals at the airport during the past 15 minutes)
- Arriving aircraft behind a heavy aircraft (0 = No, 1 = Yes)
- CAS-A in use (0 = No, 1 = Yes)

3.2.3 Flight Time/Path Length in the Terminal Area

One possible impact of decreasing IAT and IAD is a reduction in flight time or path length for the equipped aircraft and nearby aircraft. The analysis focused on flight time and path length inside a 25 NM radius ring centered on the airport. Figure 17 shows such a ring around DFW, as well as sample flight paths.

The primary metrics used were:

- Flight time – The time flown between entering a 25 NM radius ring centered on the airport and the runway threshold.
- Flight distance – The distance flown between a 25 NM radius ring centered on the airport and the runway threshold.

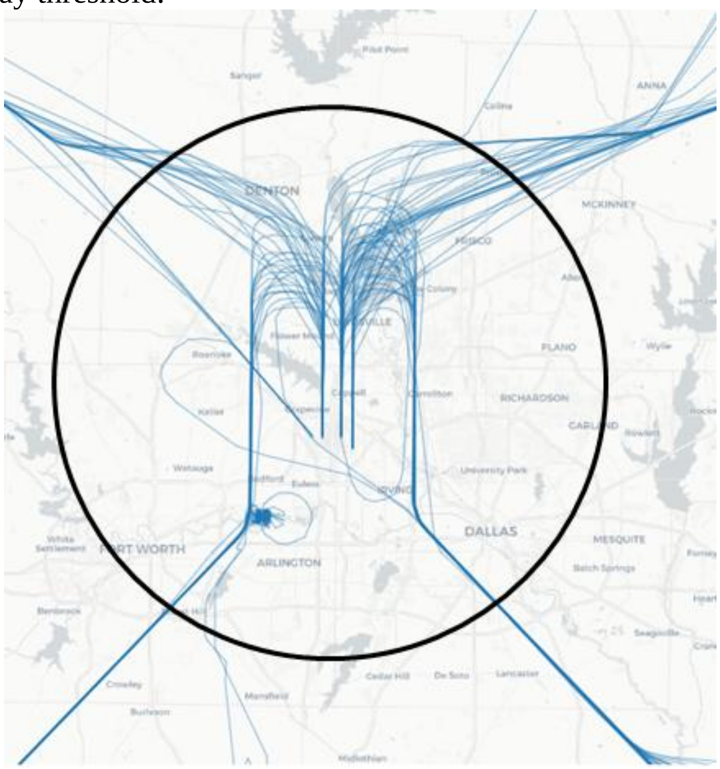


Figure 17 – Sample DFW Arrival Flight Paths with a 25 NM Radius Circle Around Airport

Most airports have established weather minima below which visual separation cannot be conducted. This limitation is in part due to the difficulty in visually acquiring traffic in such conditions. While weather is not an operational metric, it is an important factor in the analyses. The analyses categorize weather by ceiling and visibility at the airport (as opposed to on arrival or during approach) primarily because this data is available. The following weather category definitions were used:

- IMC uses basic minimums (less than 1000 ft ceiling or less than 3 miles visibility)
- MMC1 is based on a Visual Approach Threshold value listed in ASPM for DFW (less than 3500 ft ceiling or less than 5 miles visibility)
- MMC2 is based on information gathered from the facility personnel (less than 6000 ft ceiling or less than or equal to 8 miles visibility)

While IMC is a common definition in air traffic management, MMC1 and MMC2 were defined by the AIRS team for this study to better examine the impact of weather conditions on CAS-A operational use. The MMC2 definition is based on input from the D10 facility personnel and is believed to more accurately represent the point where visual operations are typically suspended. Figure 18 presents a diagram of the ceiling and visibility regimes used in the DFW analyses.

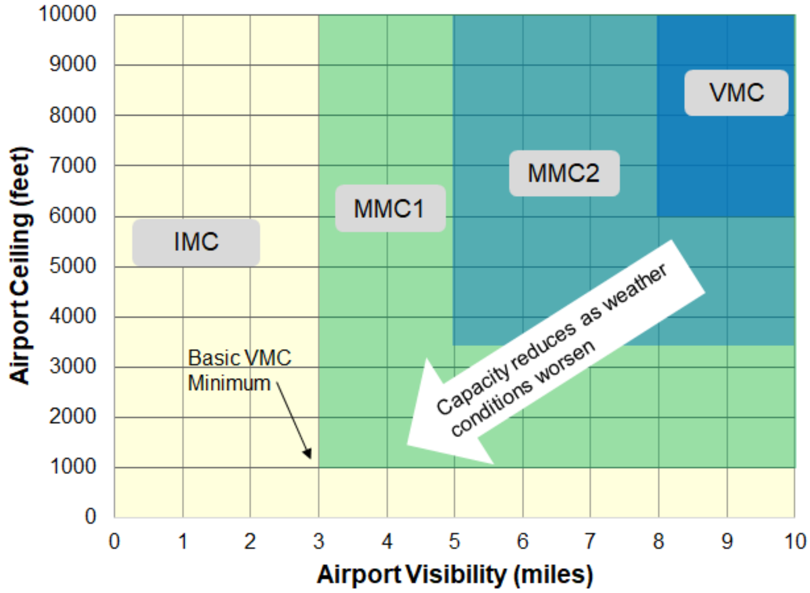


Figure 18 – Weather Regimes used in DFW Analyses

Multiple linear regression was used to control for various factors that affect flight time and distance in the terminal area. The only data removed from the analysis were flights during IMC. The dependent variables were gathered for all aircraft and the regressions included dependent demand variables to test the impact of different types of aircraft or operations landing in front of each flight. Different interaction terms were also examined (e.g., CAS-A from downwind or number of CAS-A arrivals in 15 minutes and MMC2) to test impacts that may only occur in certain situations. Correlation matrices were examined to make sure the independent variables were not correlated above a threshold (leading to misleading results). Different regression specifications were used for different analyses of the data. The results section lists the variables used in each analysis. Regression results included the coefficients of each independent variable, the significance of the coefficient (expressed as the P-value), and the overall goodness of fit of the model (adjusted R-squared).

3.3 Operational Data

Of the total number of CAS-A operations that occurred over the year (as recorded from VC/IC entries in the NAS Data Warehouse), a subset was examined and logged in an operational database. The method for selecting and examining the subset is reviewed in this section. Operational data only includes data from CAS-A operations (i.e., no data for designation for traffic awareness or CAVS), other than a set of broader questions asked of pilots. The operational data was captured through the methods noted below.

- Observations of CAS-A operations by AIRS team SMEs.
- Flight crew feedback forms through interviews, and the completion of feedback forms, by APA.
- Air traffic controller feedback through self-submitted event feedback forms and reports of pilot rejections or "unables."

Initial observations of CAS-A operations were conducted by AIRS team SMEs (supporting the FAA) at D10 in-person in the first few weeks of the operational evaluation. After that, observations were conducted while watching video (air traffic control STARS display) with audio (controller and flight crew communications) replays of the operations. Watching the videos allowed the researchers to review operations without having to be at the D10 facility. A form was completed with details of each CAS-A operation. The observation form is included in Section 8.1. The form evolved in minor ways (e.g., adding a field for a new topic) over the course of the operational evaluation as a new topic, or detail, became of interest to the AIRS CAS-A team.

For the video observations, operations were identified for review based on an hourly log of CAS-A operations. The hourly log contained data from the NAS Data Warehouse database. CAS-A operations were identified in that database by a VC or IC entered in the scratchpad by the controller when executing a CAS-A operation. The hourly log was reviewed on a weekly basis and groupings of CAS-A operations were identified for observation. Videos were made for groupings of approximately five CAS-A operations in an hour. The teams determined that number justified the effort required to make a video. However, there were weeks when no times met the criteria. In those cases, videos would be made of the available operations. The hourly log also showed hours that included one or two operations. Since those operations had the potential to be different, or unique (i.e., if there were several opportunities to conduct CAS-A but only one occurred), those operations were also sampled on a regular basis. Similarly, instrument approach CAS-A operations occurred much less frequently than visual approach CAS-A operations, so they were also sampled when they did not meet the hourly criteria.

Once a CAS-A operation, or set of CAS-A operations, was identified to be reviewed, a replay was made with the Falcon Replay System. The Falcon Replay System is a software platform owned by the FAA that requires specific authorization for FAA employees for its use. Falcon uses track data offloaded from the NOP and ASDE-X data from the System-Wide Information Management (SWIM) system. The software can be used to replay voice communications and radar data. Falcon was used to replay the chosen CAS-A operations for recording (typically using the Camtasia video capture software) for later viewing and data collection. The replays allowed a researcher to view, pause, and rewind the video to capture details in the observation form. Videos were useful for capturing details that could be missed in real-time, in-person observations, particularly when several CAS-A operations were being conducted all at once. Most of the detailed operational data on the CAS-A operations was captured in these observations. The observational information includes several parameters and provides much insight into the flight crew and controller communications as well as details of the operations such as the approach type and the locations of specific events. However, data that could only be captured when present in the D10 TRACON (e.g., offline controller discussions) or in the flight deck (e.g., intra-flight deck communications, interactions with the flight deck equipment) is not present in this data. Some of that information may be captured in the feedback data from flight crews and controllers.

Flight crew feedback was received by APA interviews with pilots involved in a CAS-A operation. Interviews were conducted on a workload permitting basis and could include a variety of operations (e.g., rejected or "unabled" and completed operations). Interviews could be initiated by APA based on information it had about an operation or by an ADS-B In SMEs (supporting the FAA) bringing a particular operation to its attention. The purpose of these interviews was to gather subjective feedback from flight crews on topics like their general experience when conducting CAS-A, the phraseology, the use of the avionics, and training. Most operations were identified for interviews based on the need to fix a potential issue or to gain further information on an operation of interest. Therefore, abnormal or problematic operations may be overrepresented in this data. This rationale and method of conducting interviews was based on the limited time available for APA to conduct interviews and the need to resolve any issues in the operational evaluation. In addition to the CAS-A questions, pilots were also asked a set of questions related to the broader use of the CDTI.

To get feedback, APA contacted pilots via text messages to request a feedback interview for a specific operation. Pilots had the option of accepting or declining participation in a discussion. Most pilots accepted the offer and were supportive of providing feedback. Once a pilot accepted, APA would connect with that pilot and ask a series of questions from a feedback form developed by the AIRS CAS-A team. The feedback form is included in Section 8.2. When de-identified feedback forms were completed, they were provided to the researcher managing the operational database for entry and analysis. The data received from these interviews is a combination of direct quotes from pilots, summarizations by the interviewer, and comments by the interviewer. The results of these interviews were also briefed to and discussed with the AIRS CAS-A team during in-person meetings. APA representatives also attended several controller team briefings and provided direct feedback from the pilot interviews to help the controllers understand the pilots' perspectives.

Air traffic control feedback was received from the D10 facility from individual line controllers who initiated an operation and chose to provide feedback for any reason. As with the flight crew data, the forms were likely submitted when there was a situation that needed to be addressed or brought to the AIRS CAS-A team's attention. Therefore, abnormal or problematic operations may be overrepresented in this data as well. When a controller completed a form, they were collected by other D10 personnel and then provided to the researcher managing the operational database for entry and analysis. The controller feedback form is included in Section 8.3.

The other feedback received from controllers was a manual flagging of flight crew unable events via a keyboard entry of “ZP” when the controller was actively working traffic and attempting to run a CAS-A operation. This method of capturing unable events was necessary because if an operation did not get past designation, the controller will not enter VC or IC in the scratchpad and that event would not be flagged for the development of a video and the associated observation and data collection. In other words, “unabled operations” could only be flagged by a controller or flight crew. “ZP” entries by a controller were tracked and printed out. These forms were also collected by D10 personnel and provided to the researcher managing the operational database for entry and analysis.

When comparing the flight crew feedback and controller feedback, there is likely a difference in experience levels between the individual pilots and controllers. Based on the number of American Airlines flight crew members of the Airbus aircraft and the number of CAS-A opportunities, it is likely an individual pilot had seen fewer operations than a D10 controller. See Section 2.13 for more information.

All the operational data for each CAS-A operation was captured in an Excel file. A CAS-A operation was logged if there was at least an attempt by the controller to have a flight crew designate a TTF. Some operations may have ended at that point, some operations continued then ended prematurely, but the majority were completed. An individual operation may have data from only one source or all the sources, depending on which forms were completed. However, most data in the operational database was obtained from Falcon video observations.

Capturing data in an active, complex operational environment can lead to issues such as missing data points of interest. Getting desired feedback from pilots and controllers, volunteering their time to provide that feedback, can also be challenging. Therefore, some data points may be missing from the overall data set. Missing data is noted in the results.

Most operational data in the results is compared to the number of operations in the operational database. However, some of the operational data is more logically compared to the number of overall CAS-A operations (i.e., the total number of operations as tracked by VC and IC entries) conducted in year 1. This latter comparison will be noted in the data.

Finally, as noted earlier in this section, over the course of the operational evaluation, new topics or details became of interest to the AIRS CAS-A team and started to be tracked or tracked more closely (mostly in the observation forms). If data on a topic was not collected at the start of the operational evaluation, the start date will be noted.

3.4 Line Operations Safety Audit (LOSA)

The American Airlines’ Line Operations Safety Audit (LOSA) Program is based on AC 120-90, Line Operations Safety Audits (FAA, 2006), and is part of American Airlines’ SMS. It is one of the few LOSA programs that operates on a continuous basis. LOSA observers are line-qualified pilots who are trained to identify both threats (external) and errors (internal) using the American Airlines Threat and Error Management model. LOSA data is objective in nature. It allows a unique third-person flight-deck perspective of line flights, and how the crew interacts with and manages threats and errors that occur.

To assist the AIRS project, the American Airline's LOSA Program conducted targeted observations of A321 flights where CAS-A clearances could potentially have been issued. Since this was being conducted as a part of the continuous LOSA program examining a range of topics, flight crews were unaware that observers were collecting data on CAS-A operations or other data. This provided unique, unbiased information on the use of avionics and operations.

During the first year of the operational evaluation, there were limited opportunities to sufficiently coordinate opportunities to examine CAS-A operations. This was in part due to the ramp-up of aircraft equipage. Therefore, no data is provided in this report. Any observations conducted in the second year of the operational evaluation will be reported there.

4 Results

4.1 Safety Hazard Assessment

During the Safety Panel for this operational evaluation, one hazard was identified with four effects (as discussed in Section 2.11). This hazard and the effects were monitored and assessed throughout the operational evaluation through weekly telecons and monthly in-person meetings. Operations at D10 involving CAS-A aircraft were reviewed with a team that included SMEs from the FAA SBS Group, D10, NATCA, American Airlines, and ACSS. The team reviewed the identified safety concerns, as well as benefits. For the overall hazard, there was no data that indicated an incorrect TTF was designated and used as a TTF for a CAS-A operation.

The results of monitoring the effects are noted below.

- **Effect 1: CAS-A aircraft and TTF are too close to apply runway separation**
  - The team reviewed all associated go-arounds/missed approaches. Because the team concluded none of the go-arounds/missed approaches were caused by CAS-A operations, its likelihood was not increased from the panel's predictions.
- **Effect 2: Increased communication/Increased workload**
  - It was expected that there may be some confusion by flight crews with the initiation of the CAS-A operation, which was found to have occurred for a significant number of events. Considering the quantitative likelihoods, even just three events of increased likelihood raise the effect to Frequent. Although the actual hazard of designating the wrong TTF was not realized leading to the effect of increased communication and workload, it was observed that there was increased communication overall. Either way, the risk remained Low, and it could be assumed as the operation expands and becomes more regular, those events would be reduced.
- **Effect 3: Loss of Situational Awareness on flight deck**
  - This effect was not recognized in any reports gathered by APA. There was reported confusion over call signs, or about which was the correct aircraft to designate; however, the pilots apparently maintained situational [i.e., situation] awareness of the arrival and operation of the aircraft.
- **Effect 4: Loss of separation with another aircraft**
  - None of the CAS-A operations realized a loss of separation with another aircraft.

4.2 Benefits Data

4.2.1 Traffic Designation, CAVS, and CAS-A Use

The SafeRoute+ equipment allows traffic designation any time during a flight and can be used multiple times per flight to gain additional traffic awareness in all phases of flight. Table 5 lists the number of flights that used traffic designation, the number of separate traffic designations, and the duration of traffic designation use grouped by arrival airport for the period of September 2020 to December 2023 (40 months). While designation for general traffic awareness could have occurred at any point in that period, May 2021 was when American Airlines was approved to conduct CAVS operations, and March 2023 is when CAS-A operations started.

This analysis used the ACSS traffic designation data and ASPM to determine the arrival airport based on flight number and time of designation. The table is sorted by the number of flights that used traffic designation at each arrival airport.

Table 5 – Traffic Designations by Arrival Airport

Arrival Location	Flights	Traffic Designations	Hours of Use
DFW	30,514	40,512	9,413
CLT	19,349	25,021	4,852
LAX	10,167	14,155	6,119
PHL	9,369	12,960	3,080
PHX	8,489	11,005	4,461
MIA	4,362	5,806	1,960
JFK	3,498	4,874	1,827
LAS	2,901	3,863	1,003
BOS	2,781	3,667	847
SFO	2,669	3,651	1,213
MCO	2,534	3,195	757
MMUN	2,511	3,428	790
ORD	2,118	2,821	590
SAN	1,991	2,594	806
SEA	1,979	2,716	724
DEN	1,321	1,649	362
FLL	1,291	1,631	409
TPA	1,158	1,472	310
DCA	1,147	1,499	332
ATL	1,076	1,365	256
Other	15,730	20,765	8,153
Total	126,955	168,649	48,262

CAVS and CAS-A operations are focused on traffic designation during approach. Table 6 presents the monthly number of arrivals using traffic designation within a 25 NM radius around each airport for the six American Airlines hubs during the period of January 2022 to December 2023 (24 months). The analysis used the ACSS traffic designation data and IOAA trajectory data to determine the distance from the arrival airport. Use of traffic designation within 25 NM of the airport generally increased over the period.

Table 6 – Traffic Designation within 25 NM of Airport (January 2022-December 2023)

APT	1/22	2/22	3/22	4/22	5/22	6/22	7/22	8/22	9/22	10/22	11/22	12/22	CY22
CLT	55	68	116	160	280	267	279	262	139	165	402	552	2,745
DFW	90	149	237	385	603	587	537	482	244	231	488	765	4,798
LAX	24	42	47	55	123	128	109	135	81	78	113	201	1,136
MIA	7	24	34	24	47	52	69	45	29	27	55	85	498
PHL	27	40	70	92	133	158	202	178	78	92	141	276	1,487
PHX	21	31	55	36	70	95	74	70	42	51	120	153	818

APT	1/23	2/23	3/23	4/23	5/23	6/23	7/23	8/23	9/23	10/23	11/23	12/23	CY23
CLT	495	574	762	749	932	1,101	1,033	1,125	1,081	1,312	1,222	904	11,290
DFW	659	829	1,354	1,146	1,453	1,546	1,226	1,498	1,542	1,744	1,471	1,254	15,722
LAX	153	195	291	284	353	373	381	387	431	387	321	279	3,835
MIA	85	94	153	127	120	163	153	140	166	153	151	145	1,650
PHL	247	214	307	362	399	447	470	422	442	497	397	390	4,594
PHX	184	231	238	277	220	202	195	204	255	292	321	242	2,861

CAS-A operations are exclusively used by controllers at D10 for DFW arrivals. Their use began in March 2023. CountOps data records CAS-A operations directly and does not require downloading data from the aircraft, so there is practically no lag in obtaining the data. Table 7 presents the monthly number of DFW arrivals using CAS-A at D10 during the period of March 2023 through February 2024 (12 months). The analysis used the CountOps scratchpad data to identify CAS-A operations. Table 7 shows the total number of arrivals, the American Airlines (AAL) A321 arrivals, and the use of traffic designation (during months where that data overlaps), for comparison. The number of arrivals designating traffic is not available for the last two months due to the lag in collection data described in Section 3.1.3.

Table 7 – CAS-A Operations at DFW (March 2023-February 2024)

Month	Total Arrivals	AAL A321 Arrivals	Arrivals Designating Traffic within 25 NM of Runway	CAS-A Arrivals
3/2023	28,364	5,521	1,354	280
4/2023	27,549	5,326	1,146	102
5/2023	29,202	5,707	1,453	273
6/2023	30,502	5,871	1,546	225
7/2023	31,564	6,113	1,226	180
8/2023	31,827	6,086	1,498	327
9/2023	28,890	5,501	1,542	276
10/2023	30,215	5,847	1,744	116
11/2023	28,602	5,396	1,471	106
12/2023	29,040	5,937	1,254	71
1/2024	25,114	5,143	[unavailable]	52
2/2024	27,334	5,113	[unavailable]	106

4.2.2 IAT and IAD

IAT and IAD were examined in multiple ways. The analyses were limited to A321 arrivals during the period of January 2022 to December 2023 (24 months). The analysis only considered IATs between 40 and 220 seconds apart to focus on periods of high demand. Arrivals behind a heavy aircraft and arrivals in IMC were removed.

The first analysis presents descriptive statistics for each airport for three cases: Non-American Airlines A321 arrivals (Non-AAL), American Airlines A321 arrivals not using traffic designation on approach (AAL [not Designating]), and American Airlines aircraft A321 using traffic designation within 25 NM of the airport (AAL Designating). Table 8 presents the IAT results for all airports and cases.

Table 9 presents the corresponding IAD results. In every case, the AAL Designating case exhibited lower mean, median, and standard deviation values than the other two cases.

Table 8 – IAT Metrics at American Airlines Hubs

Airport	A321 IAT Metrics	Non-AAL	AAL (not Designating)	AAL Designating
DFW	Mean IAT Seconds (sec)	117	112	98
	Median IAT (sec)	106	101	91
	Standard Deviation IAT (sec)	37	36	27
	Observations	7,739	77,190	17,528
CLT	Mean IAT (sec)	115	110	94
	Median IAT (sec)	107	100	87
	Standard Deviation IAT (sec)	37	37	27
	Observations	1542	61,992	11,991
LAX	Mean IAT (sec)	133	134	124
	Median IAT (sec)	128	129	118
	Standard Deviation IAT (sec)	35	36	31
	Observations	29,136	28,409	4,268
MIA	Mean IAT (sec)	128	129	112
	Median IAT (sec)	119	121	105
	Standard Deviation IAT (sec)	39	40	32
	Observations	6535	12703	1506
PHL	Mean IAT (sec)	123	116	100
	Median IAT (sec)	114	106	93
	Standard Deviation IAT (sec)	37	37	28
	Observations	4,748	23,802	5,050
PHX	Mean IAT (sec)	120	120	105
	Median IAT (sec)	110	111	97
	Standard Deviation IAT (sec)	39	39	31
	Observations	8,063	28,482	3,068

Table 9 – IAD Metrics at American Airlines Hubs

Airport	A321 IAD Metrics	Non-AAL	AAL (not Designating)	AAL Designating
DFW	Mean IAD (NM)	4.7	4.5	3.9
	Median IAD (NM)	4.1	4.0	3.6
	Standard Deviation IAD (NM)	1.6	1.6	1.2
	Observations	7,738	77,190	17,519
CLT	Mean IAD (NM)	4.7	4.6	3.9
	Median IAD (NM)	4.2	4.1	3.5
	Standard Deviation IAD (NM)	1.7	1.7	1.2
	Observations	1542	61,983	11,991
LAX	Mean IAD (NM)	5.5	5.6	5.1
	Median Spacing (NM)	5.1	5.2	4.7
	Standard Deviation IAD (NM)	1.8	1.7	1.5
	Observations	29,132	28,404	4,267
MIA	Mean IAD (NM)	5.2	5.3	4.5
	Median IAD (NM)	4.7	4.9	4.2
	Standard Deviation IAD (NM)	1.8	1.9	1.5
	Observations	6535	12703	1506
PHL	Mean IAD (NM)	4.7	4.5	3.9
	Median IAD (NM)	4.3	4.1	3.6
	Standard Deviation IAD (NM)	1.6	1.5	1.1
	Observations	4,748	23,800	5,050
PHX	Mean IAD (NM)	5.1	5.0	4.3
	Median IAD (NM)	4.6	4.5	3.9
	Standard Deviation IAD (NM)	1.9	1.8	1.4
	Observations	8,060	28,478	3,068

A visualization of the spacing distributions was also prepared. The left side of Figure 19 presents the IAT and IAD distributions at DFW.

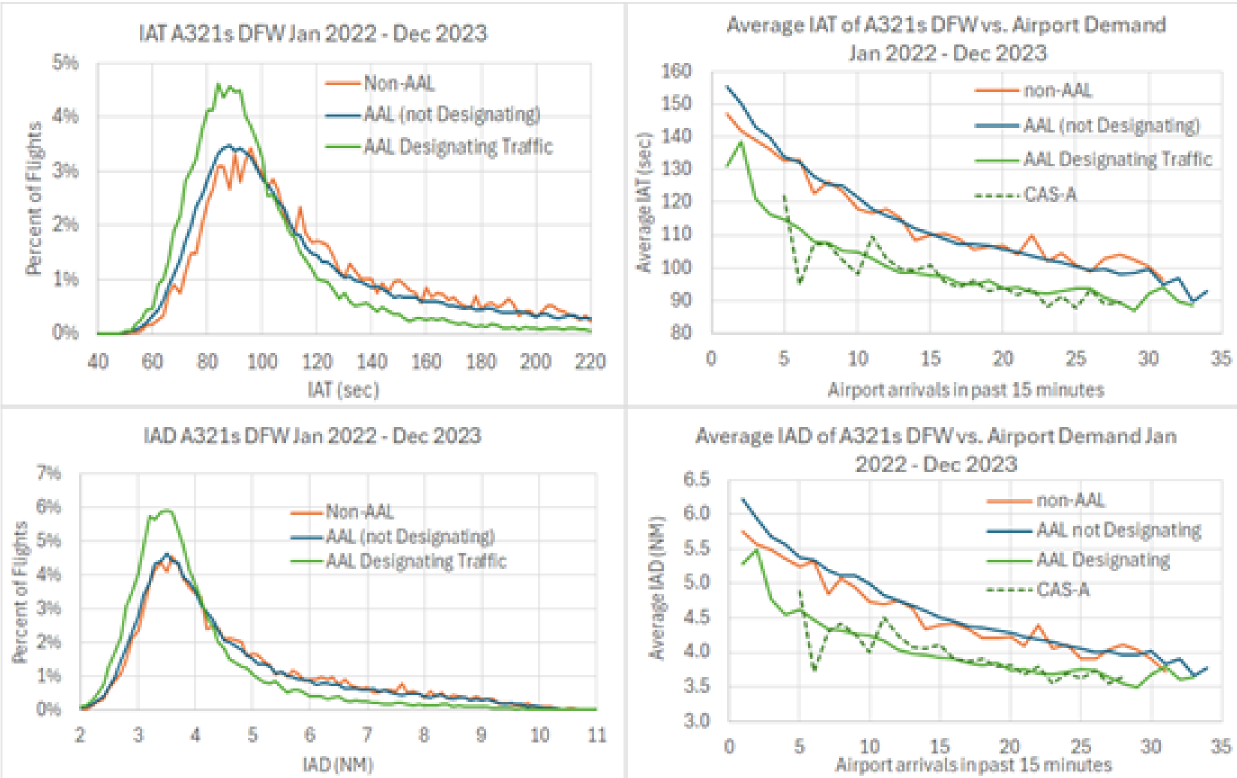


Figure 19 – Distributions and Demand Trends at DFW

For both IAT and IAD, the AAL Designating distribution is much more peaked and the peak skews slightly to the left. This mirrors the descriptive statistics presented above. Note that the minimum for all distribution curves is approximately the same, indicating that traffic designation is not changing the current minimum spacing; it is just shifting the mean in that direction.

One possible reason for the apparent difference in mean and variation results between the cases is that they represent different levels of demand at the airport. One might expect times of higher demand to naturally exhibit lower IATs and IADs with less variation. To test this hypothesis, the mean IAT and IAD was plotted versus arrival demand (see right side of Figure 19). Arrival demand was approximated by measuring the number of arrival aircraft that had landed during the past 15 minutes at the airport for each flight. The number of arrivals at the airport was used instead of the number of arrivals at the individual runway because DFW (and many of the other hubs) have arrival runways that interact with each other.

The right side of Figure 19 shows a steady decrease in both mean IAT and IAD values as demand increases. However, the average IAT and IAD is less for the AAL Designating case compared to the other cases for every level of demand. This indicates that the reduction seen in the distributions is not solely the result of different demand loads, but represents some different behavior by the flight crews.

A last feature of Figure 19 are the dotted lines on the right side of the figure. These represent the subset of flights designating traffic that are CAS-A operations. The behavior for CAS-A flights is very similar to the full set of AAL Designating flights. This suggests that the impact on IAT and spacing is similar and likely not additive (i.e., CAS-A does not appear to have a separate impact on IAT or threshold spacing, it appears to have the same impact as other designating traffic).

Figure 20 displays the IAT distribution and the average IAT versus arrival demand values for the other five American hubs. Figure 21 repeats this information for IAD. The results at the other five hubs are like DFW. While the shapes of the distributions change some, the trends are the same as exhibited by AAL Designating traffic. IAT and IAD values and trends are lower than for flights not designating. Note that CLT does not have a non-AAL curve because there was not enough non-AAL A321 data at CLT to form reasonable distributions.

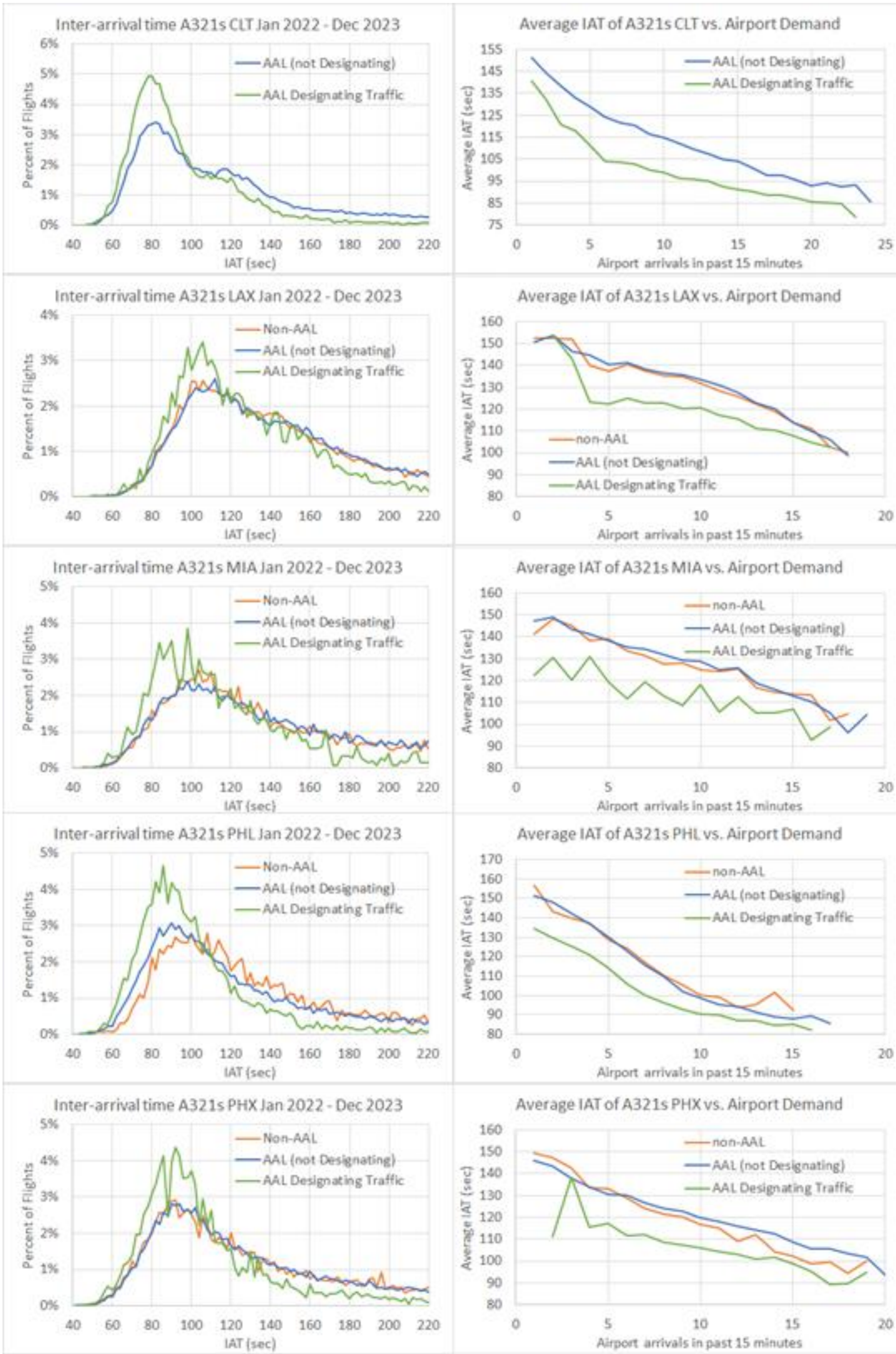


Figure 20 – IAT Distributions and Demand Trends at CLT, LAX, MIA, PHL, and PHX

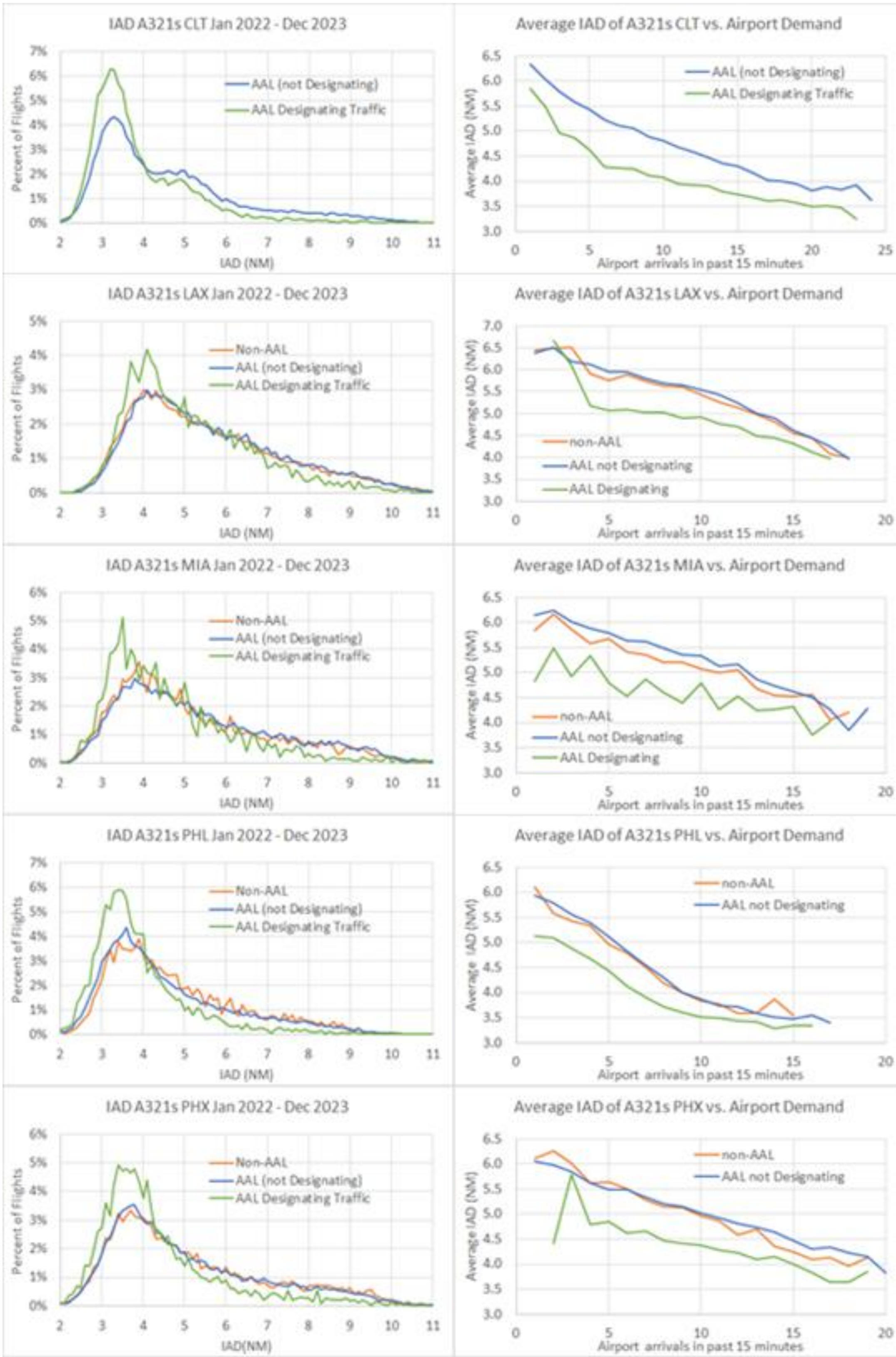


Figure 21 – IAD Distributions and Demand Trends at CLT, LAX, MIA, PHL, and PHX

To capture the impacts of both demand and traffic designation simultaneously, regression analyses were performed with the following specifications:

Dependent Variables:

- IAT
- IAD

Independent Variables:

- Arrivals in the past 15 minutes at the airport
- Behind a heavy (0 = No, 1 = Yes)
- American Airlines (AAL) (0 = No, 1 = Yes)
- American Airlines (AAL) Designating Traffic (Using AGD to Designate traffic between 25 NM and runway) (0 = No, 1 = Yes)

Table 10 presents the results of the regression analysis.

Table 10 – IAT and IAD Regression Analysis Results at American Airlines Hubs

Airport	Predictors	IAT Coefficient (sec)	P-Value	IAD Coefficients (NM)	P-Value
DFW	Baseline IAT	135	<< 0.05	5.41	<< 0.05
	Arrivals in past 15 min	-1.4	<< 0.05	-0.06	<< 0.05
	Behind a Heavy	41.8	<< 0.05	1.80	<< 0.05
	AAL	-1.4	0.08**	0.08	0.00001
	AAL Designating Traffic	-12.7	<< 0.05	-0.57	<< 0.05
CLT	Baseline IAT	143	<< 0.05	5.89	<< 0.05
	Arrivals in past 15 min	-2.3	<< 0.05	-0.10	<< 0.05
	Behind a Heavy	40.3	<< 0.05	1.86	<< 0.05
	AAL	-4.3	0.002	-0.02	0.5**
	AAL Designating Traffic	-12.3	<< 0.05	-0.56	<< 0.05
LAX	Baseline IAT	156	<< 0.05	6.63	<< 0.05
	Arrivals in past 15 min	-2.5	<< 0.05	-0.13	<< 0.05
	Behind a Heavy	26.9	<< 0.05	1.19	<< 0.05
	AAL	1.1	0.00003	0.09	<< 0.05
	AAL Designating Traffic	-10.7	<< 0.05	-0.53	<< 0.05
MIA	Baseline IAT	148	<< 0.05	6.09	<< 0.05
	Arrivals in past 15 min	-2.2	<< 0.05	-0.10	<< 0.05
	Behind a Heavy	27.3	<< 0.05	1.18	<< 0.05
	AAL	1.6	0.003	0.18	<<0.05
	AAL Designating Traffic	-14.7	<< 0.05	-0.70	<< 0.05
PHL	Baseline IAT	154	<< 0.05	5.94	<< 0.05
	Arrivals in past 15 min	-5.0	<< 0.05	-0.19	<< 0.05
	Behind a Heavy	29.0	<< 0.05	1.21	<< 0.05
	AAL	-0.7	0.12**	0.06	0.003
	AAL Designating Traffic	-11.1	<< 0.05	-0.46	<< 0.05
PHX	Baseline IAT	141	<< 0.05	6.05	<< 0.05
	Arrivals in past 15 min	-2.3	<< 0.05	-0.11	<< 0.05
	Behind a Heavy	26.7	<< 0.05	1.14	<< 0.05
	AAL	2.7	<< 0.05	0.05	0.01
	AAL Designating Traffic	-13.5	<< 0.05	-0.63	<< 0.05

** Note for Table 10: A p-value greater than 0.05 is considered "not significant" and indicates that there is no statistically significant effect or relationship between the variables being studied. So, while the regression produces a coefficient for each variable, the p-value indicates whether it should be considered when making a prediction.

The resulting IAT or IAD is a linear combination of the independent variables multiplied by the relevant coefficients added to the baseline IAT or IAD. For IAT, this can be written as a formula:

> IAT for a flight is equal to the sum of Baseline IAT plus the Coefficient multiplied by the Number of Arrivals in past 15 minutes plus the Coefficient multiplied by (1 if behind a heavy and 0 if not) plus the Coefficient multiplied by (1 if AAL aircraft and 0 if not) plus the Coefficient multiplied by (1 if AAL Designating Traffic and 0 if not). Coefficients that are not statistically significant are not used (e.g., "AAL" for DFW).

For example, at DFW if we assume an aircraft had 20 aircraft arriving at the airport in past 15 minutes, was not behind a heavy, and was also Designating we get the following values:

> IAT (seconds) = 135 + (-1.4) * 20 + 26.7 * 0 + (-12.7) * 1 = 94 seconds.

The results from Table 10 suggest the following considering all the hubs:

- The coefficient of AAL Designating traffic indicates reductions in the IAT ranging from 11 to 13 seconds and reductions in IAD ranging from 0.5 to 0.6 NM., which agrees with the previously mentioned examination of the means.
- The coefficient multiplied by AAL are somewhat small and sometimes statistically insignificant, so the impacts on IAT seen during the period are not just related to AAL arrivals, but mostly to those AAL that are designating traffic.

If all 15 aircraft arriving to DFW in the 15-minute window were designating and received the 13-second IAT reduction, the runway throughput could be increased by 4 aircraft per hour for each arrival runway. The benefit is derived in the manner shown below.

- The IAT regression analysis for DFW shows a baseline IAT of 135 seconds between aircraft and -1.4 seconds for every arrival ahead of that arrival during the past 15 minutes.
- With 15 aircraft arriving at the airport in the 15-minute window:
    - The IAT is 135 seconds – 15 aircraft * 1.4 seconds = 114 seconds per aircraft.
    - The throughput is (60 * 60 seconds/hour) / (114 seconds/aircraft) = 32 aircraft per hour.
    - Each designating aircraft (for CAVS or CAS) results in an additional 13 seconds is saved for each designated aircraft so (60 * 60 seconds/hour) / (114 - 13 seconds/aircraft) = 36 aircraft per hour.

The same benefit for 20 aircraft arriving at DFW in the 15-minute window is an increase of 5 aircraft per hour for each arrival runway.

CAS-A operations, while a subset of traffic designation flights, were recorded over a different period and from a different data source. A separate examination of CAS-A versus Not CAS-A flights was completed. That analysis repeats the steps used for the larger Traffic Designation analyses. The Not CAS-A case includes many American Airlines A321 flights that are designating traffic (and potentially conducting CAVS) but did not receive a CAS-A operation (see Table 7). As a result, trends like those in the analyses presented above are expected, but somewhat less pronounced. This is because the Not CAS-A set is diluted by arrivals that are designating traffic.

Table 11 presents descriptive statistics for IAT and IAD for CAS-A and Not CAS-A flights. Figure 22 presents the distribution and demand trends for the cases and Table 12 presents the regression analysis results.

Table 11 – IAT and IAD Metrics for Not CAS-A and CAS-A at DFW

Airport	A321 Metrics	Not CAS-A	CAS-A
DFW	Mean IAT (sec)	111	102
	Median IAT (sec)	100	96
	Standard Deviation IAT (sec)	36	28
	Observations	54,529	2,043
	Mean IAD (NM)	4.5	4.1
	Median IAD (NM)	3.9	3.8
	Standard Deviation IAD (NM)	1.6	1.2
	Observations	54,529	2,043

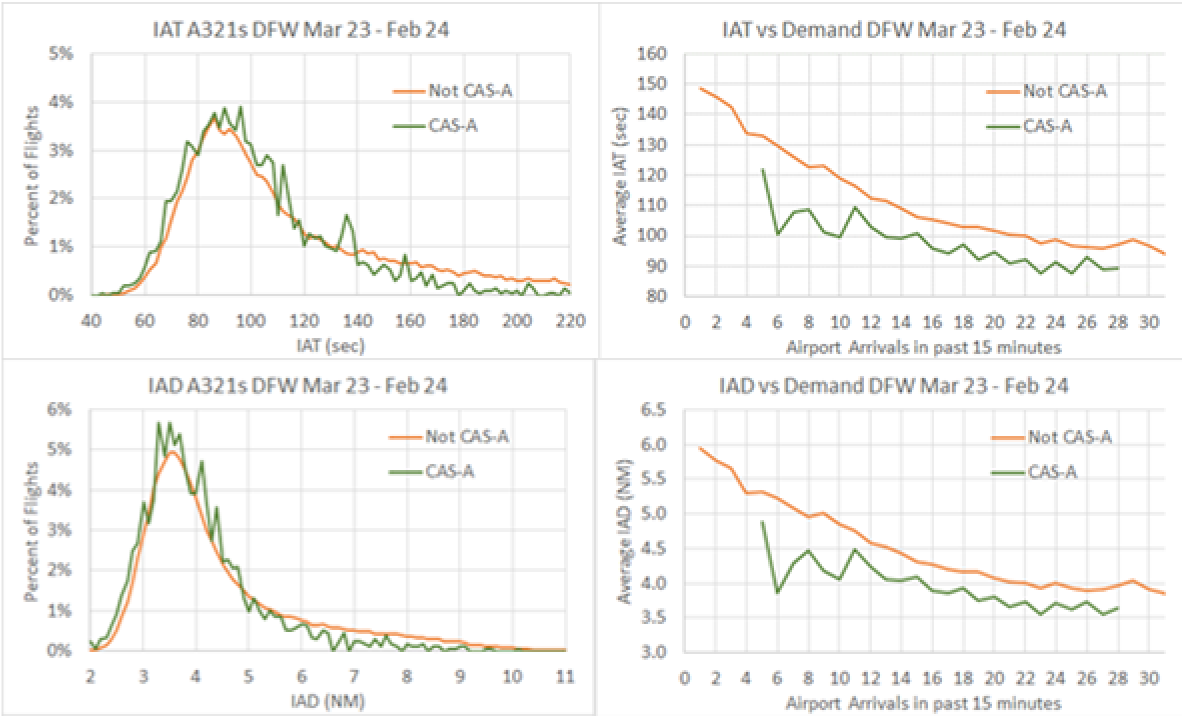


Figure 22 - Distribution and Demand Trends at DFW (CAS-A vs. Not CAS-A)

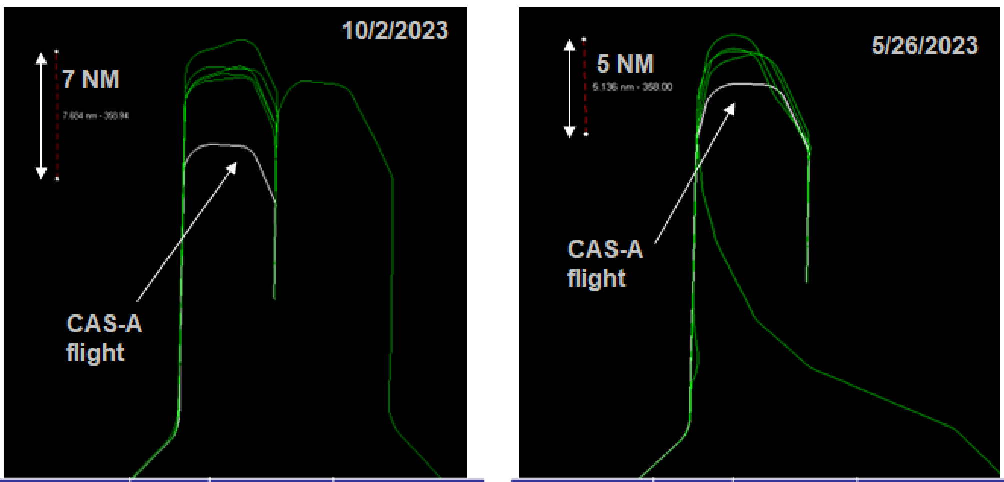
Table 12 – IAT and IAD Regression Analysis Results Examining Use of CAS-A at DFW

Airport	Predictors	IAT Coefficient (sec)	P-Value	IAD Coefficients (NM)	P-Value
DFW	Baseline IAT	134	<< 0.05	5.4	<< 0.05
	Arrivals in past 15 min airport	-1.6	<< 0.05	-0.1	<< 0.05
	Behind a Heavy	38.9	<< 0.05	1.7	<< 0.05
	CAS-A	-11.1	<< 0.05	-0.4	<< 0.05

As expected, the results for the statistical measures, the trends and the regression are like the results found in the AAL Traffic Designation analyses (see Tables 5, 6, 7 and Figures 4 and 5). However, the reduction for CAS-A is somewhat less than designating traffic because the Not CAS-A case includes many flights that are designating traffic but did not receive a CAS-A operation but may still have been conducting similar operations when designating.

4.2.3 Flight Time and Distance in Terminal Area

While reducing IAT and IAD for Traffic Designation and CAS-A arrivals appears to be beneficial, it was also considered important to examine the impact on time and distance flown. Controllers at D10 reported using CAS-A to reduce the flight distance during certain conditions. In one scenario, their increased confidence in the ability of CAS-A aircraft flight crew to acquire and keep track of the TTF has allowed them to reduce the downwind flight distance significantly by moving the aircraft into what would have previously been an unused or partially unused slot. Figure 23 shows a few examples where CAS-A flights flew a considerably shorter downwind and final approach (measured within 25 NM of the airport) compared to other traffic during the same period. Figure 23 includes noticeable examples, although the statistical analysis suggests the average impact is lower. Controllers also indicated that they are more likely to use CAS-A to shortcut a flight path in reduced weather conditions. Some controllers reported being able to cut the final approach significantly. When the CAS-A flight can reduce the flight path it also impacts the flights behind it allowing those flights to recover some of the space previously committed to the unused slot. However, only so much space can be recovered if additional aircraft are not available to fill the unused slots created in the traffic flow when CAS-A operations are used. To take advantage of the unused slots, aircraft would have to be scheduled to the airport based on the anticipated use of CAS-A.



ACID	Type	Landing	Flight distance (NM)
AAL1288	B738	19:32	57.5
AAL390	B738	19:33	54.8
SKW3285	CRJ7	19:35	53.1
AAL1304	A321	19:37	54.1
AAL1174	B738	19:39	53.6
AAL384	A321	19:41	45.2
AAL1068	A321	19:43	53.2

ACID	Type	Landing	Flight distance (NM)
AAL1967	A321	20:33	50.5
ENY3486	E170	20:42	57.1
AAL1372	A321	20:43	47.8
AAL1225	A321	20:46	52.1
AAL1097	A319	20:48	51.0

Figure 23 – Weather Regimes Used in DFW Analyses

To examine possible terminal area flight path and time changes, a regression analysis was conducted using for a single year of CAS-A operations at DFW. The data included aircraft trajectories from IOAA, CAS-A determination from CountOps, and airport weather from ASPM. Flights during IMC were removed from the data because CAS-A is not allowed during those conditions. The regression used the following specification:

Dependent Variables:

- Flight Time 25 NM to runway
- Flight Distance 25 NM to runway

Independent Variables:

- Downwind (0= No, 1=Yes)
- Go-around (0= No, 1=Yes)
- MMC2 (ceiling less than 6000 feet and visibility less than or equal to 8 miles)
- MMC1 (ceiling less than 3500 feet and visibility less than 5 miles)
- CAS-A ownship aircraft downwind
- CAS-A ownship aircraft non-downwind
- Arrivals at airport in past 15 minutes (number of aircraft in front)
- Heavy arrivals at airport in past 15 minutes (number of heavy aircraft in front in all non-IMC conditions)
- CAS-A arrivals in airport in past 15 minutes (number of CAS-A aircraft in front)
- CAS-A arrivals in airport in past 15 minutes during MMC2
- CAS-A arrivals in airport in past 15 minutes during MMC1

Table 13 presents the regression analysis results for both flight distance and flight time.

Table 13 – Flight Time and Distance Regression Results Examining Use of CAS-A at DFW

Factors that impact Flight Distance and Time	Flight Distance Impact		Flight Time Impact	
	Coefficient (NM)	P-value	Coefficient (sec)	P-value
Minimum distance	23.6	<< 0.05	436	<< 0.05
Downwind	26.5	<< 0.05	342	<< 0.05
Go-around	44.9	<< 0.05	764	<< 0.05
MMC2	2.1	<< 0.05	50	<< 0.05
MMC1	4.1	<< 0.05	94	<< 0.05
CAS-A ownship aircraft downwind	-0.6	<< 0.05	-20	<< 0.05
CAS-A ownship aircraft non-downwind	0.3	0.14**	-1	0.68**
Arrivals in past 15 min airport	0.2	<< 0.05	4	<< 0.05
Heavy arrivals in past 15 min	0.1	<< 0.05	3	<< 0.05
CAS-A arrivals in past 15 min	-0.3	<< 0.05	-9	<< 0.05
CAS-A arrivals in past 15 min during MMC2	-0.3	0.02	-5	0.01
CAS-A arrivals in past 15 min during MMC1	0.2	0.12**	1	0.46**
Observations	331,241		331,241	
Adjusted R-square	86%		77%	

** Note for Table 13: A p-value greater than 0.05 is considered "not significant" and indicates that there is no statistically significant effect or relationship between the variables being studied. So, while the regression produces a coefficient for each variable, the p-value indicates whether it should be considered when making a prediction.

The results of the regression analysis suggest the following:

- For each CAS-A downwind arrival there is a reduction in flight distance of 0.6 NM or flight time of 20 seconds.
- For each arrival during non-IMC weather conditions (i.e. VMC, MMC1 and MMC2) there is a reduction in flight distance of 0.3 NM or flight time of 9 seconds for every CAS-A arrival ahead during the past 15 minutes.

- For each airport arrival during MMC2 there is an additional reduction in flight distance of 0.3 NM or flight time of 5 seconds for every CAS-A arrival ahead during the past 15 minutes for a total reduction of 0.6 NM or 14 seconds during this condition.

This analysis was repeated using Designating Traffic aircraft as opposed to CAS-A operations and was unable to identify any statistically significant results for Designating Traffic aircraft. This result suggests that this mechanism for terminal area flight time/distance reduction may only be available if controllers have knowledge of which aircraft capable of traffic designation and the aircraft conduct CAS-A.

4.2.4 Monetizing the Terminal Area Benefit

The results of the previous subsection can be monetized using the measured data and some simple assumptions. Table 14 summarizes the regression results and shows the benefits to the CAS-A aircraft (ownship) as well as the benefit to any arrival aircraft if there was one CAS-A arrival in the 15 minutes before their arrival. The benefits for any arrival aircraft increases by the same value shown in the table if more CAS-A aircraft are in that same 15-minute window. As an example, if there are two CAS-A aircraft in front of an arrival during MMC2 weather conditions, that arriving aircraft would experience a reduction in distance of 1.2 NM.

Table 14 – Flight Distance and Time Benefits Summary from Regression

CAS-A (Ownship) Arrival Benefit	Downwind	
Distance (NM)	0.6	
Time (seconds)	20	
Benefit for Each Arrival per CAS-A Arrival in the 15 Minutes Before Their Arrival	**MMC2**	**Other Non-IMC Weather**
Distance (NM)	0.6	0.3
Time (seconds)	14	9

Between March 2023 and February 2024 there were 1,158 CAS-A downwind arrivals; this value can be multiplied by the top part of Table 14 to calculate a benefit. Table 15 presents the number of DFW arrivals that had specific numbers of CAS-A aircraft land in the past 15 minutes for different weather conditions during the same period. The bottom part of Table 14 can be combined with the information in Table 15 to calculate a benefit for arrivals where different numbers of CAS-A aircraft arrived in the previous 15 minutes. For example, there were 80 arrivals that had three CAS-A arrivals in front of them in the past 15 minutes during MMC2, so the flight time benefit for these flights is 80*3*14 = 3,360 seconds or 56 minutes.

Table 15 – Frequency of CAS-A Arrivals in the Past 15 minutes

Frequency of CAS-A Arrivals in Past 15 Minutes	Arrivals in MMC2	Arrivals in all Non-IMC Weather
0	17,617	291,212
1	711	14,677
2	245	4,625
3	80	1,531
4	7	428
5		77
6		24
7		7

Combining the data from Table 14 and Table 15, we can determine aircraft conducting CAS-A and all other aircraft arriving at DFW within 15 minutes after a CAS-A operation, results in a total savings of 10,819 NM in flight distance or 5,350 minutes of flight time. Assuming an airline cost of approximately $60 per minute, the total result sums to $321,016 over the period. Transforming the measured time benefit into fuel and emissions benefits results in a savings of approximately 490,000 pounds of fuel and 700 metric tons of carbon dioxide. Considering that there were only 2,114 CAS-A operations during the year (about 3.3% of the total American Airlines A321 arrivals), this benefit represents only a small part of the possible benefit from this mechanism. For example, if we assume all equipped American Airlines A321 arrivals into DFW (i.e., ~64,000) had conducted CAS-A, the total benefit would be closer to 162,000 minutes of flight time savings with a value of $9.7 million as well as a savings of 15 million pounds of fuel and 21,000 metric tons of carbon dioxide.

4.3 Operational Data

Figure 24 shows the total number of CAS-A operations over year one (as recorded from VC/IC entries in the NAS Data Warehouse). The total number of operations was 2115.[7] Of that total number of operations, a sub-set was examined and logged in the operational database (as reviewed in Section 3.3). The following sections review the operational details of those operations.

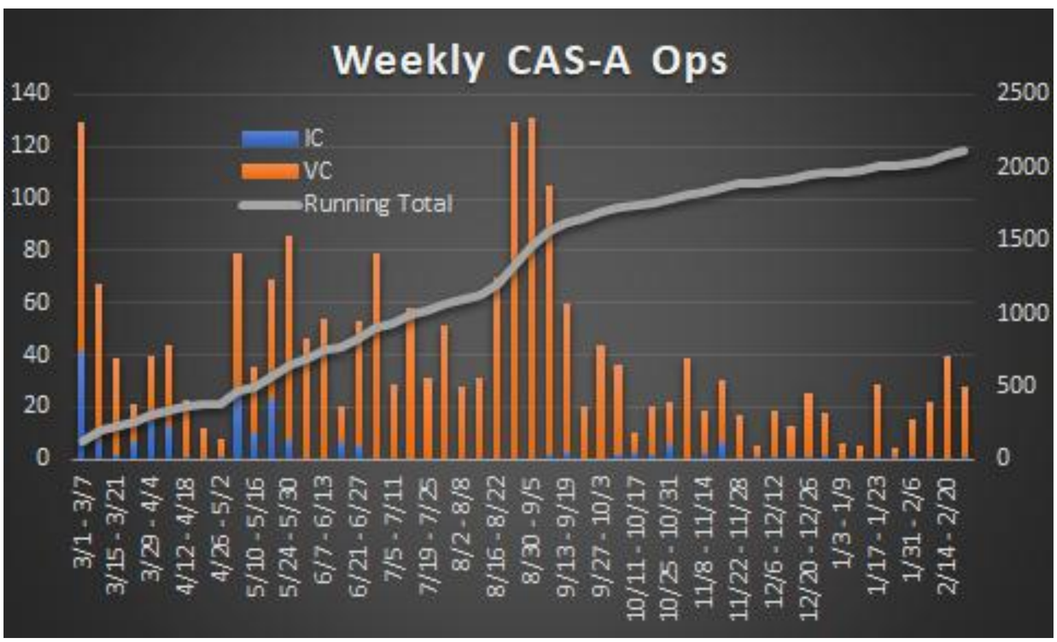


Figure 24 – Number of CAS-A Operations per Week and Overall Year One Total

4.3.1 Operational Database – CAS-A Operations

In the first year, there were 621 CAS-A operations logged in the operational database. That is 29% (621/2115) of the total operations that occurred over the period (as recorded from VC/IC

[7] One more operation than seen in the benefits data based on an issue when converting to Greenwich Mean Time.

entries in the NAS Data Warehouse). Figure 25 shows the total number of events logged per month.

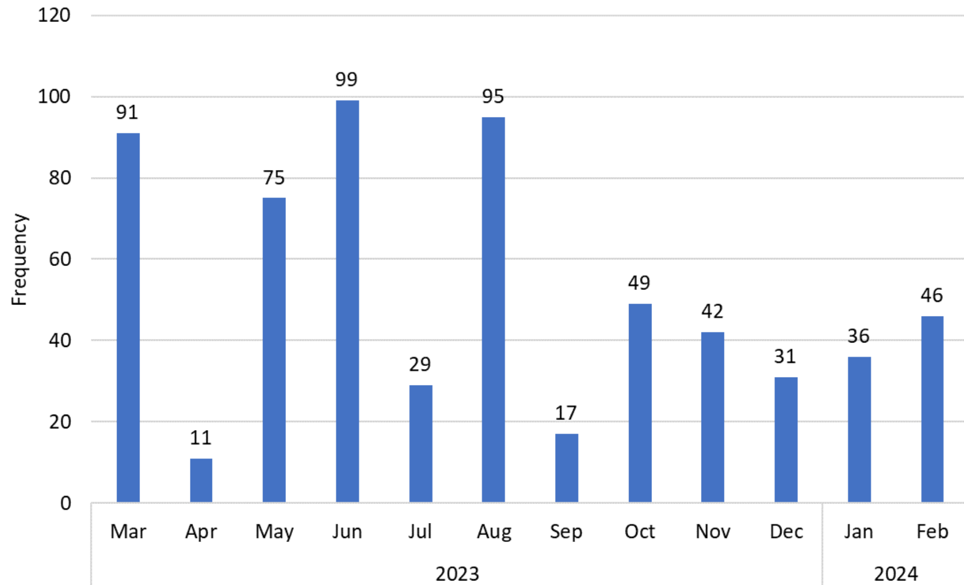


Figure 25 – CAS-A Operations Logged per Month

While there were 621 logged events, some of those individual events could include data from only one source (e.g., an AIRS team SME observation) or a set of sources (e.g., an AIRS team SME observation and flight crew feedback), as noted previously. Figure 26 shows the sources and their percentage of the overall database. As shown, the majority (81%) of the data was from AIRS team SME observations.

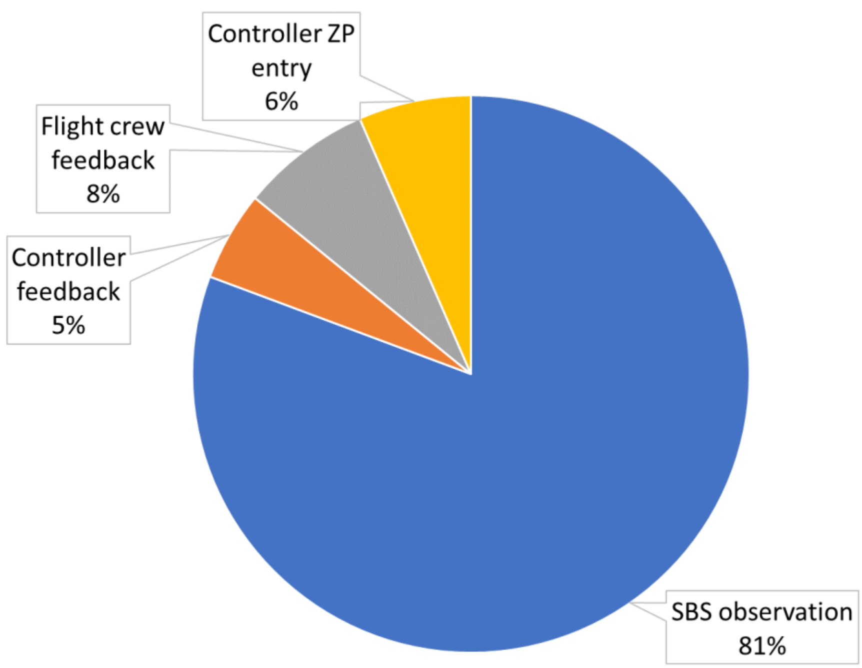


Figure 26 – CAS-A Operation Data Sources

4.3.2 CAS-A Initiation

4.3.2.1 Designation Conduct

CAS-A initiation started with the controller instruction to designate a TTF. The location of the CAS-A aircraft when the controller issued the designation instruction was logged as one of the following locations based on the standard rectangular traffic pattern at an airport.

- Beyond the traffic pattern
  - A location not yet in the traffic pattern (e.g., "extended" intercept/dogleg to final when a downwind was not flown (arriving from the northwest to land south)).
- Downwind
- Base
- Dogleg/intercept to final
- Final

Most of the time the CAS-A aircraft was beyond the traffic pattern (37%) or on downwind (44%) when the controller issued the designation instruction (see Figure 27).

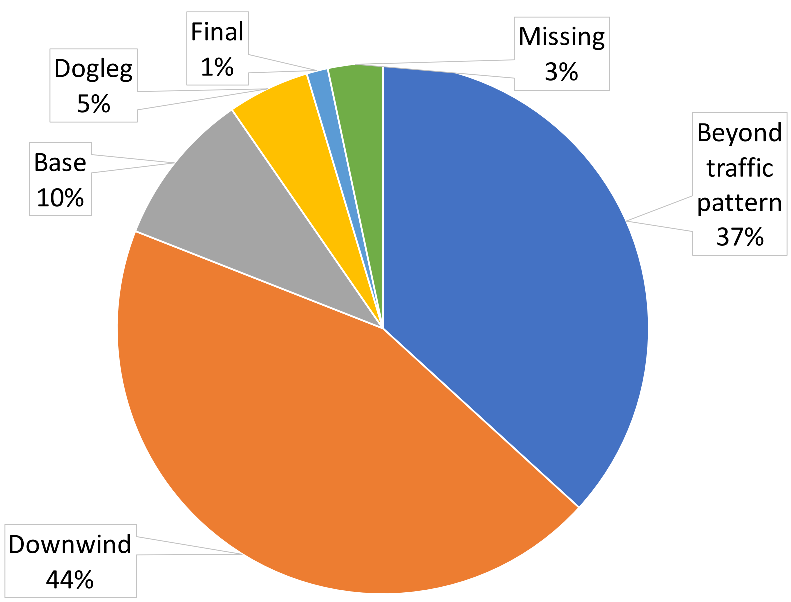


Figure 27 – Location of CAS-A Aircraft when the Controller Issued the Designation Instruction

Designation could be done by the Feeder or the Final Controller. Of the 621 logged events, 520 (84%) had information on which controller designated the traffic. Figure 28 shows the majority (89%) of the time, the Final Controller designated traffic. While Feeder designations were fewer, no unique problems were noted when the Feeder controller chose to issue the designation instruction. In the "Feeder/Final" combined category, the designation was initiated by the Feeder controller and completed by the Final controller.

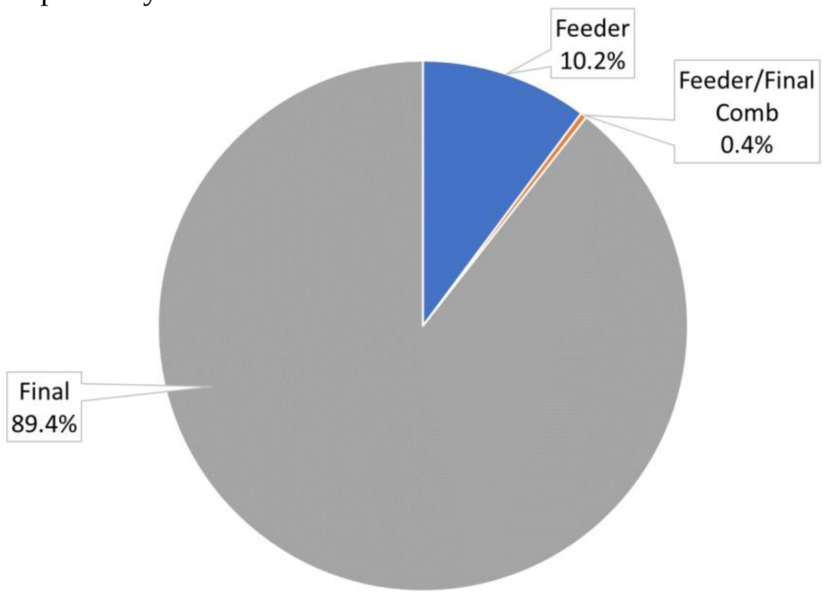


Figure 28 – Role of the Controller that Issued the Designation Instruction

The initiation of a CAS-A operation could start in another way. Prior to the controller issuing a designation instruction, the flight crew could have asked the controller who they were following or could offer to do a CAS-A operation. For this operational evaluation, these were called "pilot-prompted" operations. Pilot prompts started to be actively recorded in August of 2023. In that period, 18 pilot-prompts occurred (6% of total operations logged in the operational database between August and the end of year one; 18/315) (see Figure 29).

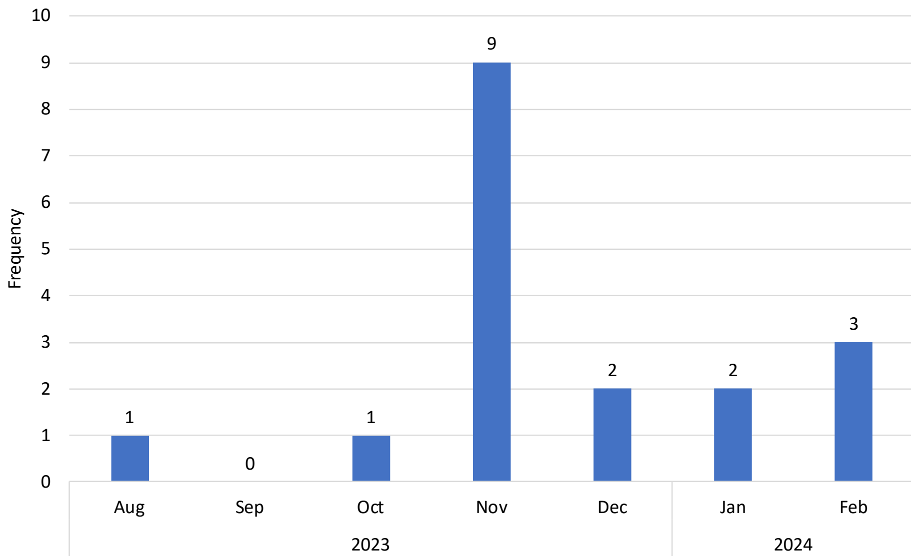


Figure 29 – Frequency of Pilot-prompted CAS-A Operations between August 2023 and the end of Year 1

Some of the pilot prompts occurred after the controller had pointed out that traffic visually and the flight crew asked about the TTF call sign. Typical pilot prompts are listed below.

- Pilots said something like, "Who should we designate?" or "Who are we following today?"
- Pilots asked for the TTF's call sign or asked if they "are following the Envoy?"
- Pilots reported the TTF designated (when not already instructed to do so) and asked if the controller wanted them to follow that aircraft.

While pilot prompts indicate the flight crew is prepared and willing to do the operation, they also could be prepared but not offer, or ask, to do CAS-A. Being prepared could include a pre-briefing by the flight crew and the designation of an expected TTF. This "pre-designation" started to be actively tracked in May of 2023. The flight crew was considered "pre-designated" if they reported traffic designated immediately after the controller issued the designation instruction. There was a total of 71 (14% of total operations logged in the operational database between May and the end of year one; 71/519) operations where the flight crew was pre-designated. Figure 30 shows when those pre-designations occurred. The number of flight crew pre-designations observed may be an indication of how often flight crews are already using the equipment to prepare for a CAVS or CAS-A operation or for increased traffic awareness.

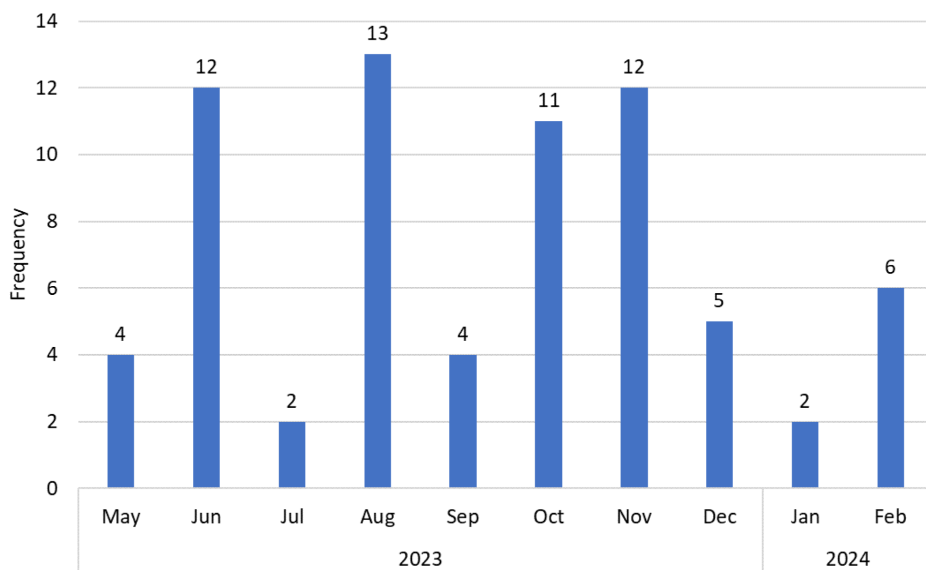


Figure 30 – Frequency of Flight Crew Pre-designations between May 2023 and the end of Year 1

When the controller issued the designation instruction, the flight crew was able to accept or reject/report being "unable." There were 87 unables. Figure 31 shows the frequency of flight crew reports of being unable to conduct CAS-A when receiving the designation instruction from the controller. Data is shown for the number of unables compared to the total number of CAS-A operations (as recorded from VC/IC entries in the NAS Data Warehouse). The percentage of unabled operations compared to the total operations is below 9% and generally trended downward or remained low (except for a spike to 12.5% in January, for unknown reasons).

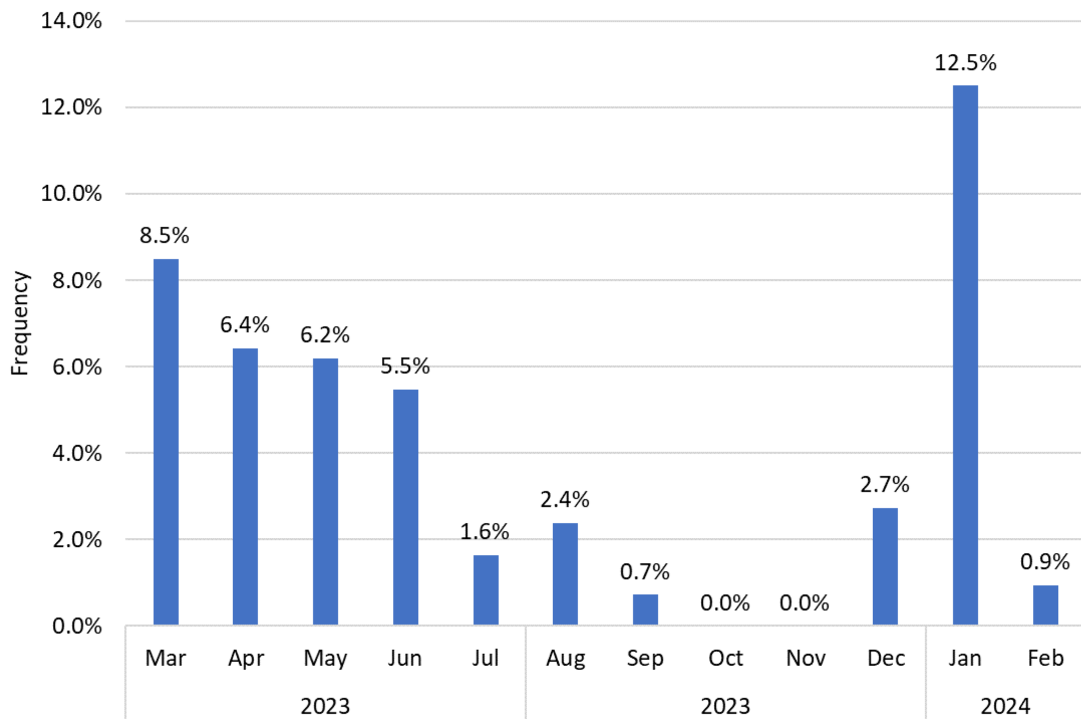


Figure 31 – Frequency Percentage of Flight Crew Unables at Designation by Total Number of CAS-A operations

It should be noted that unables are only known if the controller flags them, or they are found in Falcon videos that were already being watched for other CAS-A operations (flagged with VC or IC entries). Therefore, the numbers could be under or overrepresented. The data may be skewed toward a higher number of unables due to the high number of "ZP" entries received early in data collection, or the data may be skewed toward lower number of unables if "ZP" entries were not being submitted later in data collection.

While providing a reason for not accepting the CAS-A operation was not required, reasons for the unables were of interest to the data collection team because it could point to an issue that needed to be addressed. Of the 87 unable reports, 23 (26%) included a reason. Most reasons were reported in APA pilot feedback forms, but some were from controllers after querying pilots or pilots offering a reason after reporting unable. There were 45 reasons that were binned in 19 categories (see Figure 32). Some pilots reported multiple reasons for one unable report.

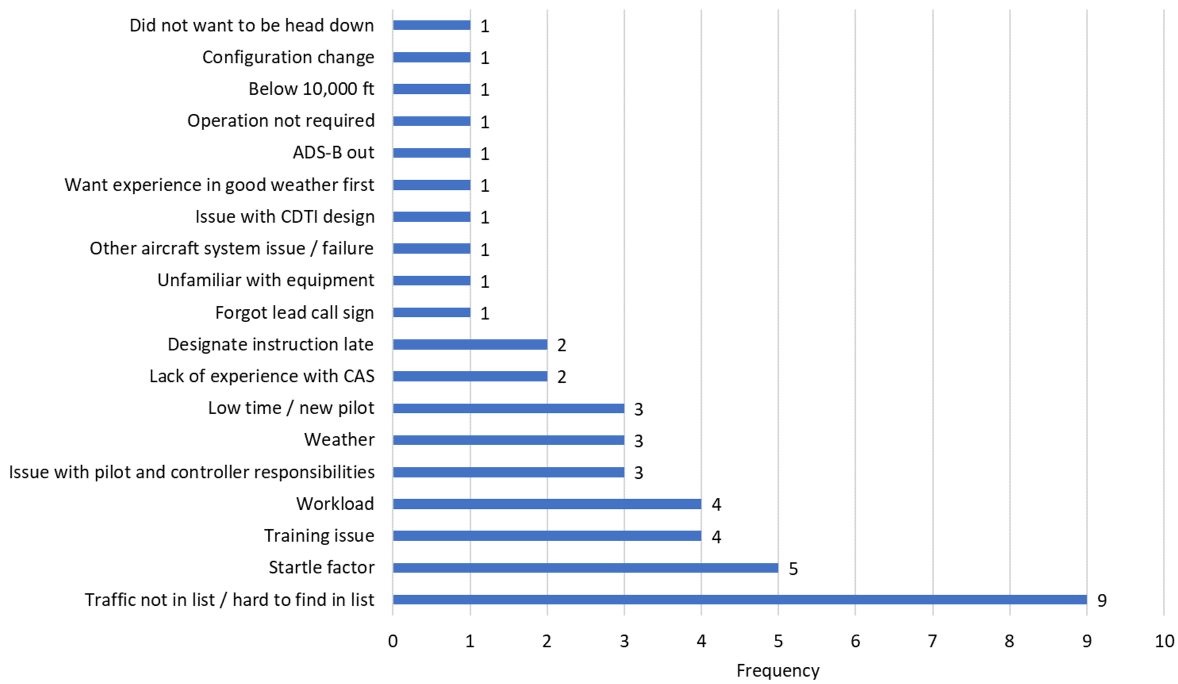


Figure 32 – Frequency of Flight Crew Unable Reasons at Designation

4.3.2.2 Designation Communications

CAS-A operations are initiated by designation instructions, as noted in Section 2.7.1. The designation instruction is specified in controller training. At the beginning of the operational evaluation, it was "[CAS-A aircraft call sign] expect to follow [TTF call sign], report designated." That changed in August of 2023 to "[CAS-A aircraft call sign] designate [TTF call sign]" with an optional "and report." A mix of the two options were seen after the change. The new phraseology was used 41% (128/136) of the time between August 2023 and February 2024.

Slight modifications to the new phraseology was seen with at least one controller who "offered" CAS-A designation to the flight crew by using phrases like, "…if you want to do designated, let me know," "…advise if you would like to do designated," "…you want to designate the heavy in front of you?", and "…advise designated [TTF call sign] if you want."

Overall, controller communications during designation had very few issues. However, flight crew communications during designation had issues and were tracked. After receiving the designation instruction, the flight crew was expected to readback the instruction with the TTF call sign or simply reply with "wilco" and their call sign. If they already had the TTF designated and coordinated on the TTF call sign within the flight deck, they could also report designation (see earlier pre-designation results). If they did not have the TTF designated, they were to readback the instruction (or simply reply with "wilco" and their call sign) and later report designation.

Errors in flight crew designation communications were tracked closely as of early June 2023 through the end of year 1 (444 operations were logged in that period). Figure 33 shows the number of errors that occurred in those 444 operations. Multiple issues could occur in one communication or set of communications. Note a CS abbreviation is used for call sign in this figure and others.

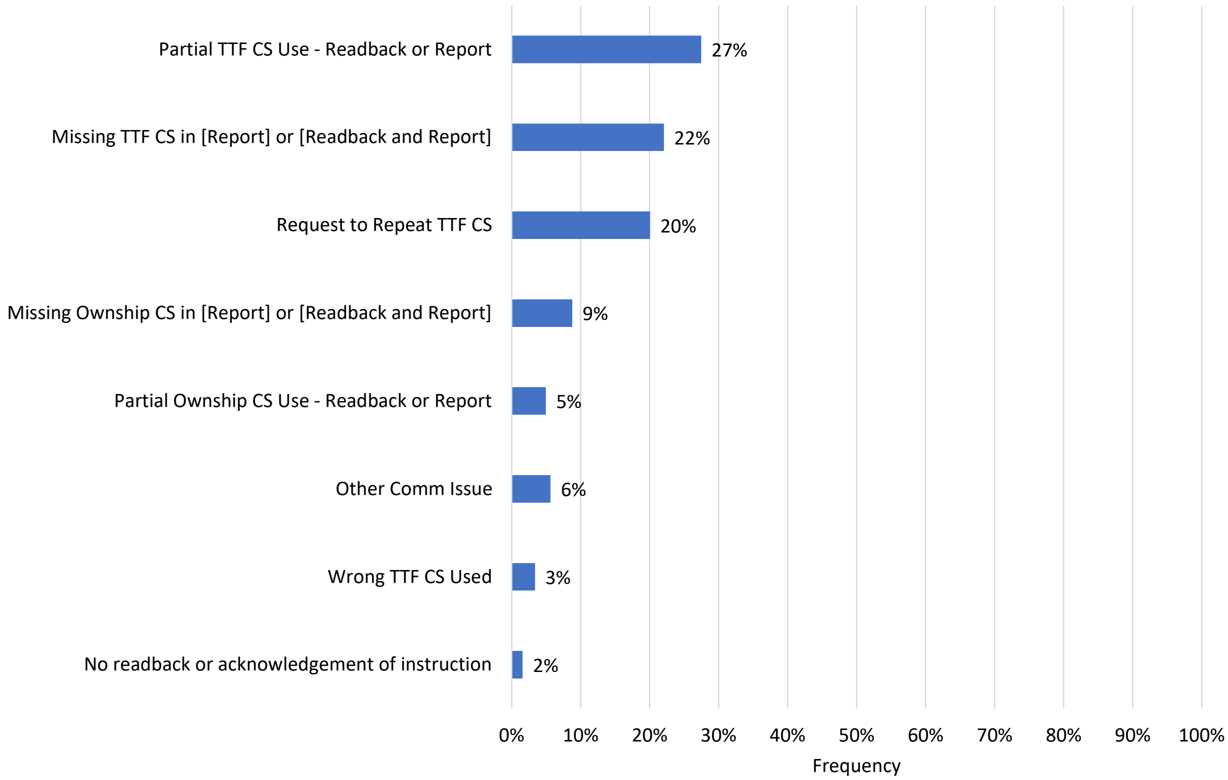


Figure 33 – Percentage of Flight Crew Designation Communication Issues

The most common issues were related to the flight crew not including, or including a partial, TTF call sign in the designation report or the readback and report. The next most frequent issue was a request for the TTF call sign. The other issues were less frequent. Few of these communication issues led to further issues.

In addition to tracking the appropriate designation communications from the flight crew, issues related to using the call sign of another aircraft (sometimes referred to as a third-party call sign) in the designation instruction were tracked. Use of the wrong call sign of a third party (i.e., the TTF) by the controller can lead to CAS-A aircraft flight crew confusion about which aircraft to follow. Use of the correct call sign of a third party (i.e., the TTF), can lead to confusion for the TTF flight crew who could hear their own call sign and believe an instruction was for them. The use of two correct call signs (that of the CAS-A aircraft and TTF) in one communication can also be confusing for the flight crew of the CAS-A aircraft who must keep their own call sign and the TTF's call sign separate and clear in their mind. Managing two call signs from the same company ("American" in this case) can be confusing as flight crews are routinely changing call signs with each new flight and any call sign number is a reasonable one for them, and therefore, either one could be used.

These call sign communication issues were tracked closely as of early June 2023 through the end of year 1 (444 operations were logged in that period). There were 34 instances (8%; 34/444) of call sign confusion. In those 34 instances, most of the time, the CAS-A aircraft flight crew was the party that had the call sign issue (53%), followed by the TTF (41%), and, much less infrequently, the controller (6%) (Figure 34). Figure 35 shows the percentage of call sign confusion issues within those 34 instances.

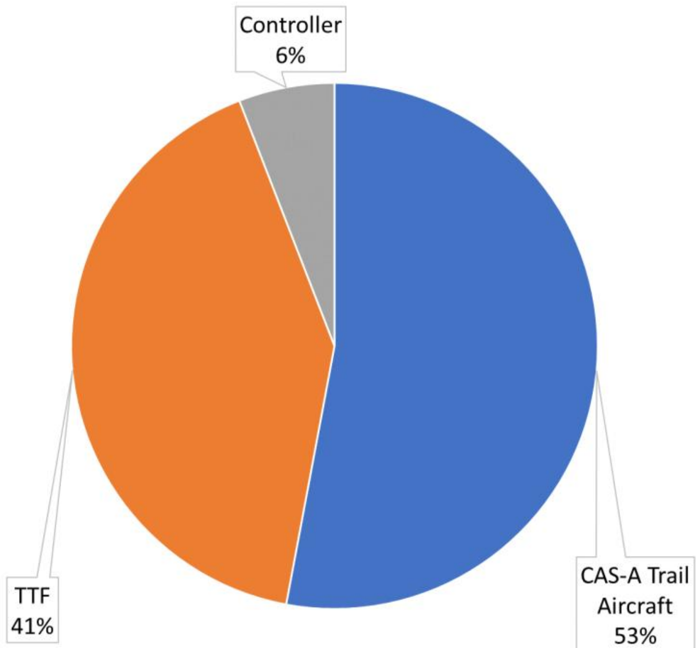


Figure 34 – Frequency of Call Sign Issues by Role

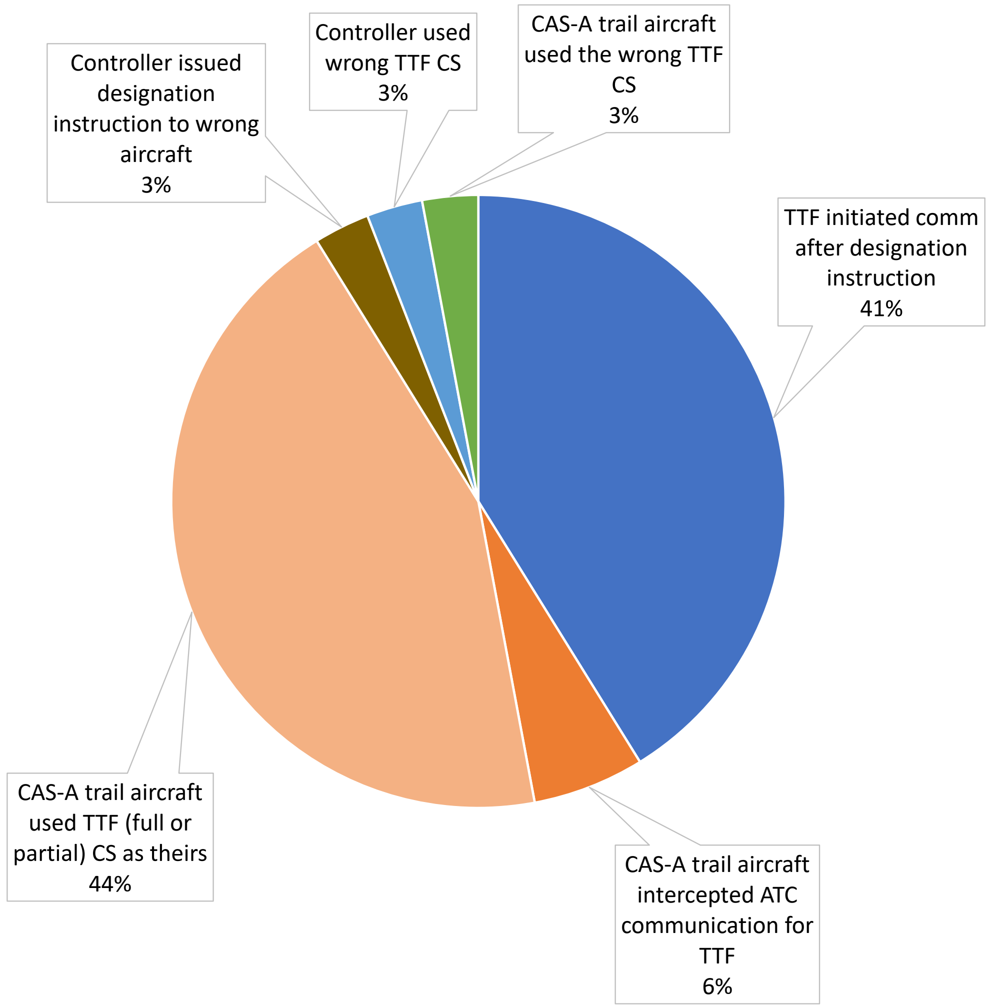


Figure 35 – Percentage of Call Sign Issues in Designation Communication

The most frequent (44%) issue was when the CAS-A aircraft flight crew used the full, or portion, of the TTF call sign as their own. See the following for an example.

- **CAS-A aircraft call sign**: AAL 2635 and **TTF call sign**: AAL 8214
    - **Sample communication from CAS-A aircraft:** "American 82-35 'er American 26-35 has American 82-14 designated"

While the resolution of these issues was not specifically logged, the majority were observed to be quickly corrected by the flight crew in the same communication or did not lead to a significant operational issue. No events led to the following of an incorrect TTF.

The next most common (41%) issue was when the TTF flight crew heard their own call sign and initiated a communication based on that. An example would be when a TTF heard their call sign in the communication for the CAS-A aircraft flight crew and said, "…was that for us?" These cases were all quickly resolved by the controller (including, in some cases, an explanation of why their call sign was used) and did not lead to further issues.

There were two cases (6%) where the CAS-A aircraft flight crew heard an instruction from the controller telling the TTF to contact the tower and replied to that communication as if it were for them. This is another case of the flight crew confusing the TTF call sign with their own. Both cases were quickly corrected by the controller. The other three issues occurred less frequently and are noted in the figure.

While not specifically tallied in the operational database, it should be noted that there were times when the controller chose to spell out the airline code instead of saying the airline call sign. For example, “November Kilo Sierra” or “N-K-S” was said instead of “Spirit Airlines.” It is assumed this was done when the controller believed the flight crew might have difficulty associating “Spirit Airlines” with the “NKS” seen on their CDTI or to avoid the flight crew of the TTF hearing their own call company.

4.3.3 CAS-A Conduct

After designation was successfully completed, the controller could issue a CAS-A instruction (“i.e., “follow traffic”) either along with, or after, an approach clearance. Figure 36 shows that most of the time (97%), the controller issued the CAS-A instruction along with the approach clearance. There was one case noted where the controller issued the CAS-A instruction before the approach clearance. This runs counter to the CAS-A operational description that says, “The CAS-A instruction must be issued after the issuance of the approach clearance, whether in the same or in a later transmission” (FAA, 2023, p. 18). However, there were no further issues with the operation.

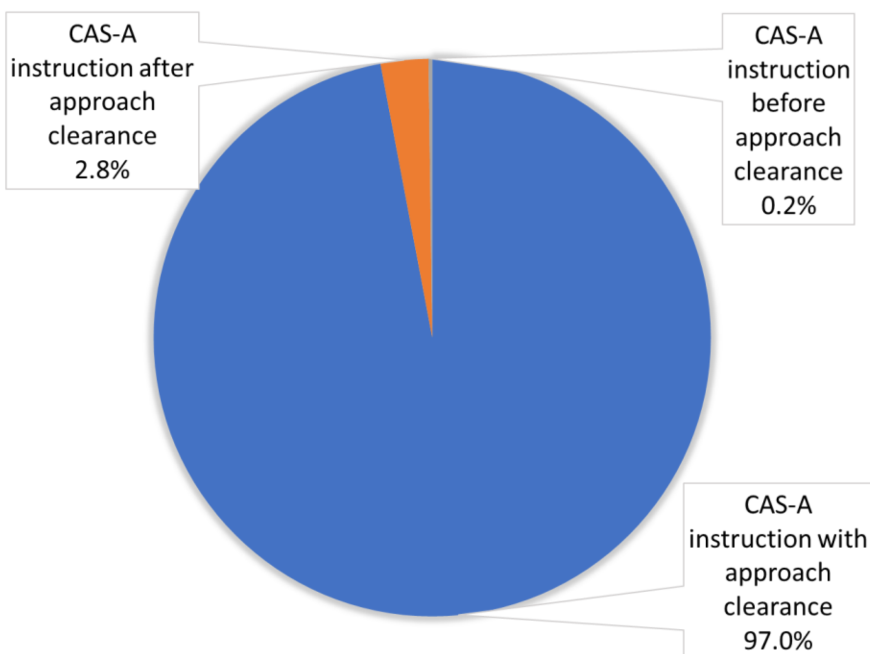


Figure 36 – Issuance of CAS-A Instruction Relative to the Approach Clearance

CAS-A could have been conducted during visual or instrument approaches. Of the 621 logged events, 510 (82%) had an associated approach flown and had information about the type of approach issued. As can be seen in Figure 37, the majority (91%) of the operations were conducted during visual approaches. While instrument approaches were fewer, the data indicates instrument and visual approaches run equally well (although the limited number of instrument approach operations makes a comparison challenging).

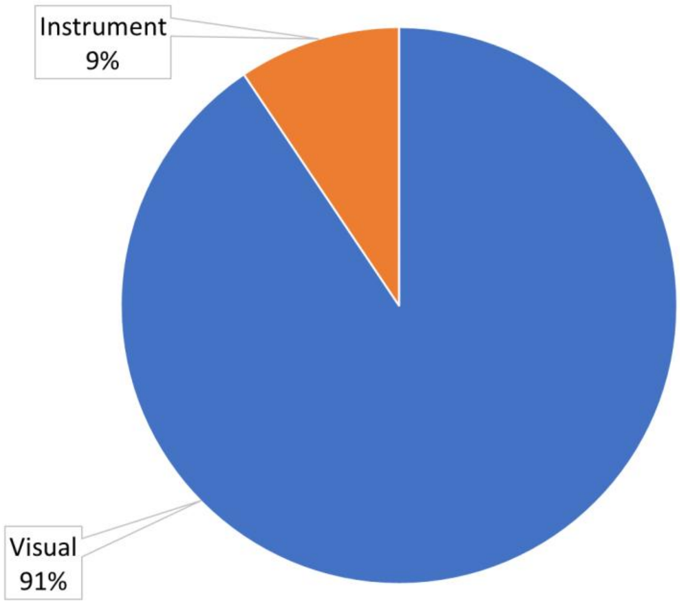


Figure 37 – Type of Approach Clearance Issued

When the flight crew read back the instruction to "follow traffic," controllers entered a code in the scratchpad to indicate the type of approach clearance that was issued. VC was used for visual approach clearances and IC was used for instrument approach clearances. Observations of the CAS-A operations showed that VC and IC were sometimes entered into the scratchpad when either the Final or Feeder Controller got confirmation of TTF designation from the CAS-A aircraft flight crew. In those cases, VC and IC remain in the scratchpad from designation until the CAS-A aircraft landed (provided the CAS-A instruction was issued and accepted).

One operation was noted where the CAS-A instruction was given to an American Airlines non-CAS-A/A321 aircraft. The controller did a standard traffic point out and said, "report designated." He did not use the TTF call sign. The flight crew said they were looking. A bit later, the controller pointed out the TTF without using the call sign again. The flight crew found the TTF out the window. The controller said, "follow designated traffic" and the flight crew said they would. VS was put in the scratchpad. No clear issues arose from the operation.

There were also three cases where either the flight crew never reported designated, or the CAS-A instruction was never issued, but VC was in the scratchpad. No clear issues arose from the operations.

During the approach, the controller could issue a speed for the CAS-A aircraft flight crew to fly on final. Of the 621 logged events, 468 (75%) had details on whether a speed was issued. Figure 38 shows the majority (59%) of the time the controller did not issue a speed.

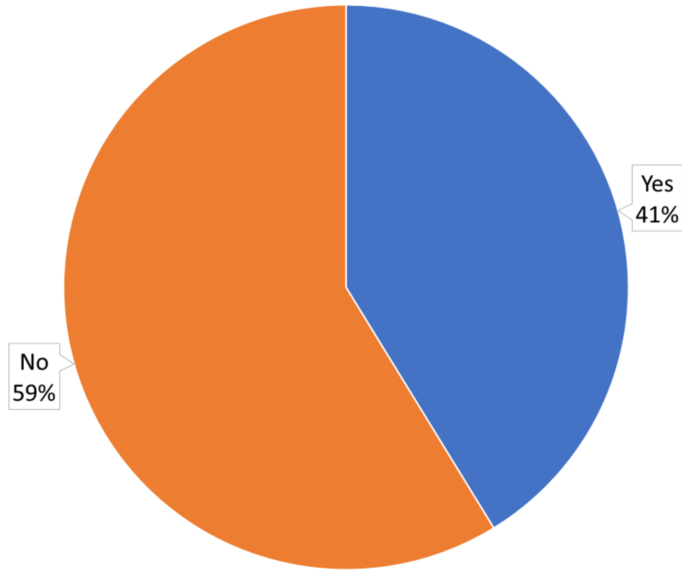


Figure 38 – Percentage of the Time the Controller Issued a Speed for the CAS-A Aircraft Flight Crew to Fly on Final Approach

It should be noted that depending on the set-up, the controller may have determined issuing a speed was unnecessary (e.g., when there was a large spacing between the CAS-A aircraft and the TTF) or the controller may have determined the spacing could be managed by the flight crew with CAS-A.

While it is not part of the CAS-A operation to achieve or maintain a specific distance from the TTF, there were 9 operations where a distance was mentioned. Five of them were on the same day. In each case the controller mentioned a particular distance (i.e., 3.0, 3.5, 6, no-closer-than 4, 2.5 miles) and asked the flight crew if that was something they could do. All but one flight crew acknowledged the distance and said they would work toward it. After these events, D10 clarified for their controllers that this is not part of a CAS-A operation and should not be included in a CAS-A instruction.

Several different types of aircraft and companies acted as the TTF. Of the 621 logged events, 494 (80%) had details on the TTF aircraft type. As can be seen in Figure 39 and Figure 40, the majority of TTFs were American Airlines Airbus A321 aircraft.

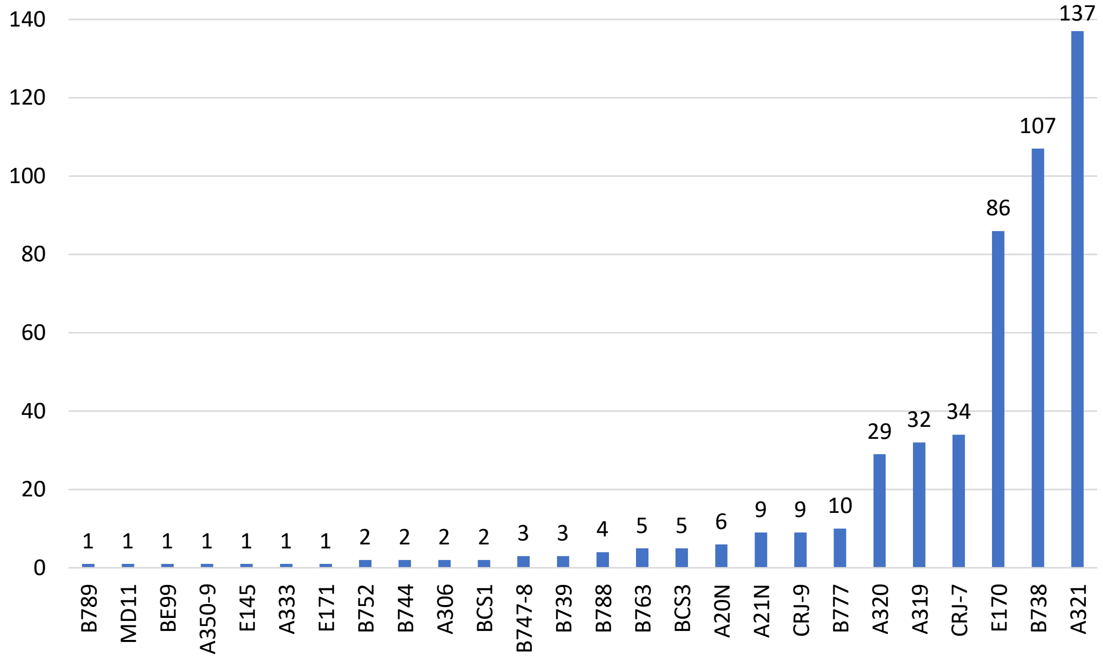


Figure 39 – TTF Aircraft Type

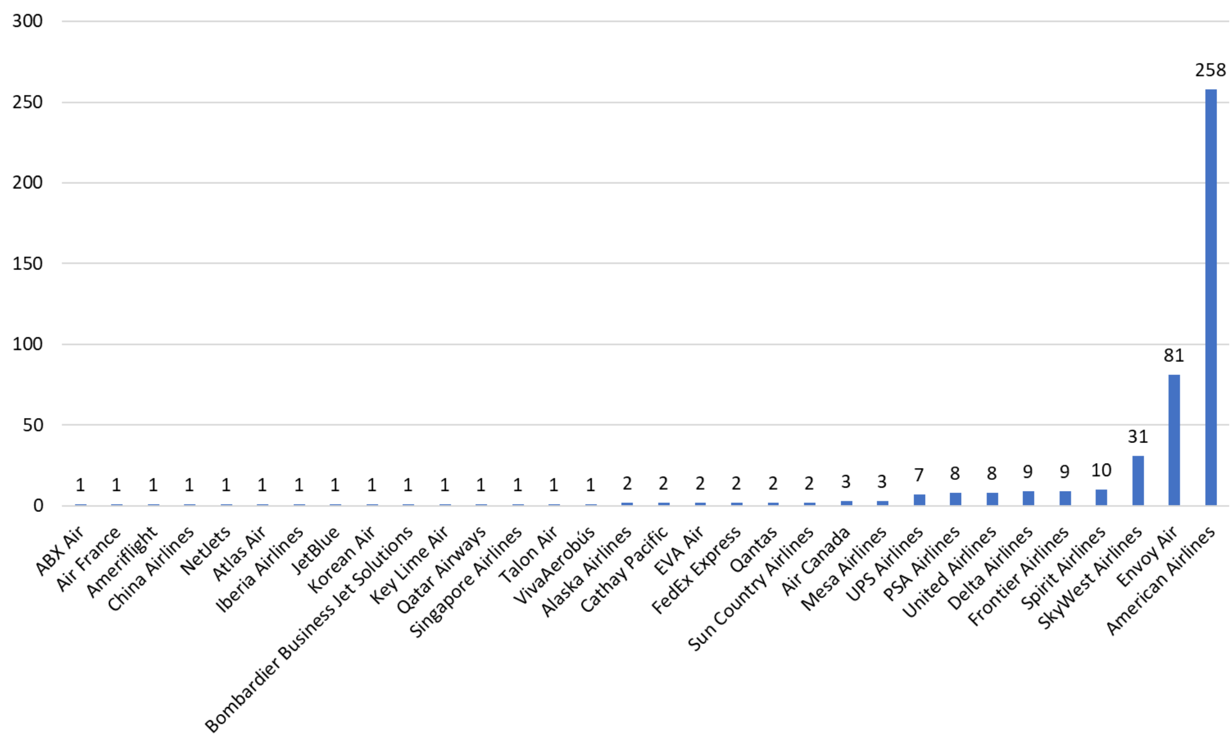


Figure 40 – TTF Airline

As noted previously, issues after designation were limited. However, certain events could end the CAS-A operation. For example, a go-around or missed approach would end CAS-A. Go-arounds and missed approaches were tracked in the FAA's Performance Data Analysis and Reporting System (PDARS) database. Fourteen go-arounds or missed approaches had a CAS-A aircraft as part of the approach. That is 0.7% (14/2115) of the total CAS-A operations (i.e., the total number as recorded from VC/IC entries in the NAS Data Warehouse) that occurred during year 1. Figure 41 shows when those go-arounds or missed approaches occurred. Each event was examined by the CAS-A AIRS team, and none were clearly linked to a CAS-A specific issue. They were all determined to be caused by issues unrelated to CAS-A.

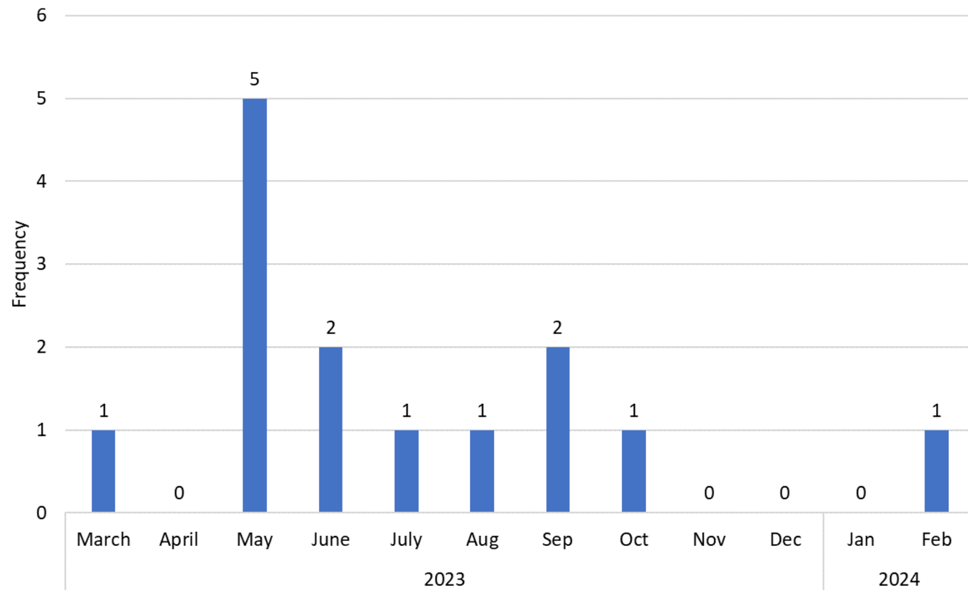


Figure 41 – Go-arounds and Missed Approaches Where a CAS-A Aircraft was Part of the Approach

Five (0.8%; 5/621) other CAS-A operations ended for reasons other than a go-around or missed approach. Four of the events were due to the TTF being “lost” / no longer displayed on the CDTI. One other operation was canceled by the controller for unknown reasons. Figure 42 shows when those events occurred. All cancelations were during visual approaches.

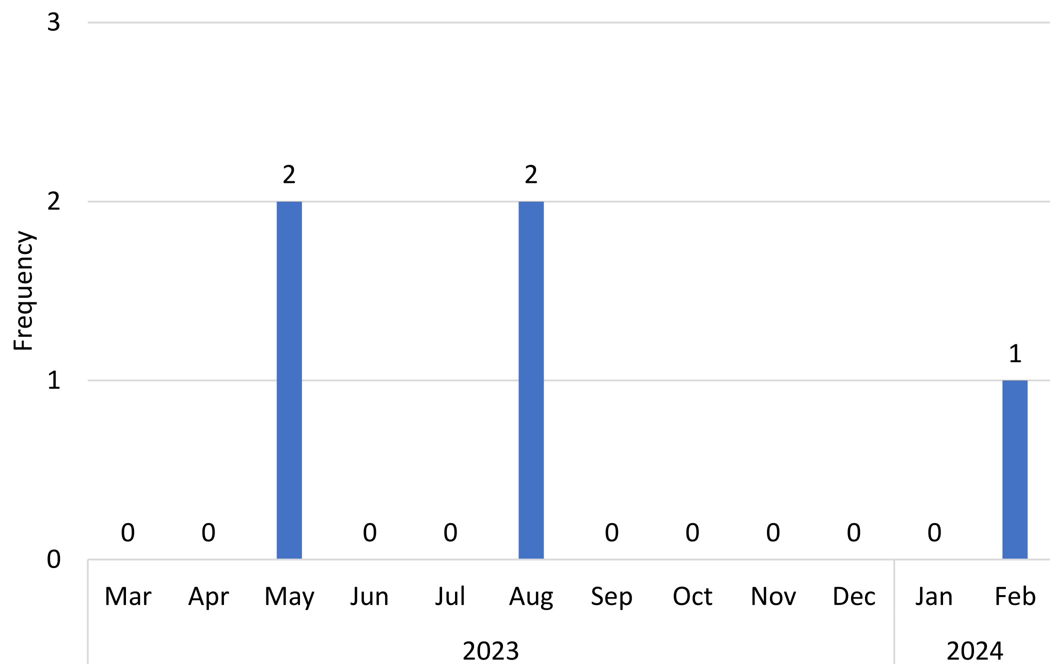


Figure 42 – Frequency of CAS-A Operations Ending for Reasons other than a Go-around or Missed Approach

4.4 Operational Data - Flight drew Feedback from APA Interviews and Feedback Forms

Fifty-one pilots provided feedback on 40 operations. Figure 43 shows when the feedback forms were received.

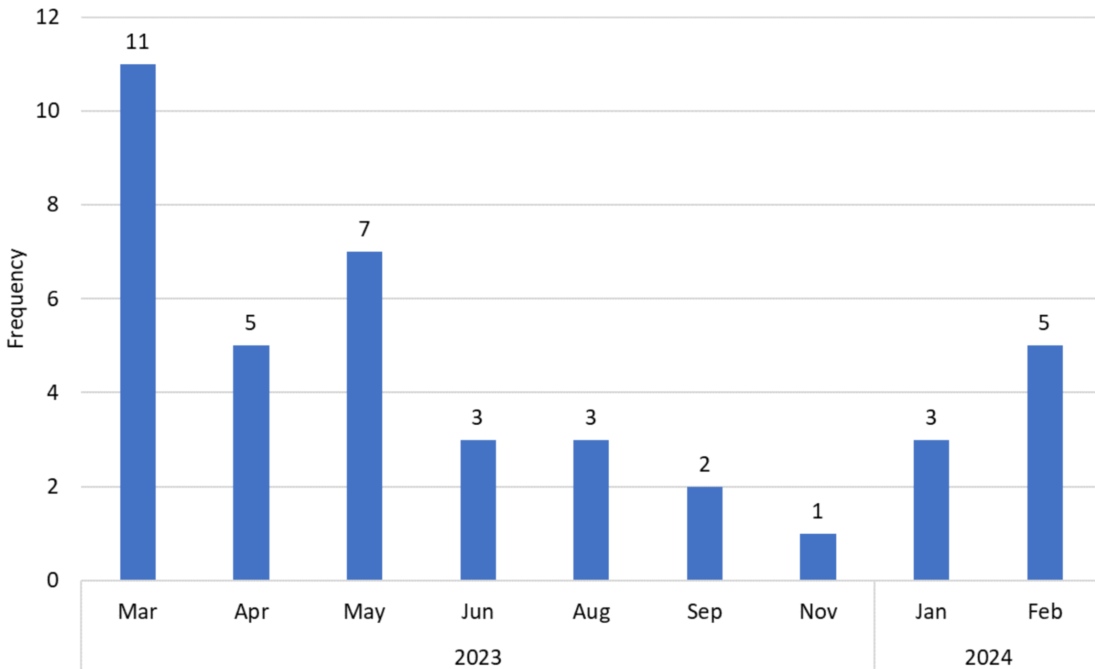


Figure 43 – Frequency of Pilot Feedback Forms by Month

Both the Pilot Flying (PF) and Pilot Monitoring (PM) (22 pilots) provided feedback for 11 operations while only one pilot (29 PFs or PMs) provided feedback on the other 29 operations. It should be noted that most feedback sought from flight crews was to get additional information to "fix" or understand an issue (e.g., why a flight crew reported "unable" for a CAS-A operation). This was done because APA interview time was limited and there was a desire to ensure the operations were running well and any issues were resolved before becoming a larger issue. Additionally, flight crew members had limited opportunities to experience a CAS-A operation (as noted in Section 2.13). The feedback proved could be on the first CAS-A operation the flight crew experienced, which could be one of the most challenging operations. Therefore, the feedback is likely skewed to negative responses.

Flight crews were asked five questions for a specific CAS-A operation they conducted and then five additional questions on broader CDTI operations. Due to the high number of missing responses, the figures in this section will show counts for pilot replies versus percentages of total replies. The number of missing replies will be noted for each question. Comments included in the replies are put in order of frequency with the number of related comments provided in parentheses. All bullets and sub-bullets include their own independent counts (i.e., sub-bullet totals are not included in the main bullet count).

4.4.1 Questions for a Specific CAS-A Operation

Flight crews were first asked about their general experience with the specific CAS-A operation. Note the question to five of the pilots was their "overall impression" and not their "general experience." This was based on the use of an older feedback form for the first five pilots interviewed. Five replies (10%) were missing or NA. The provided replies are shown in Figure 44. Twenty pilots reported a positive experience, 15 reported a neutral experience, and 10 reported a negative experience. One pilot chose a combined "positive and negative."

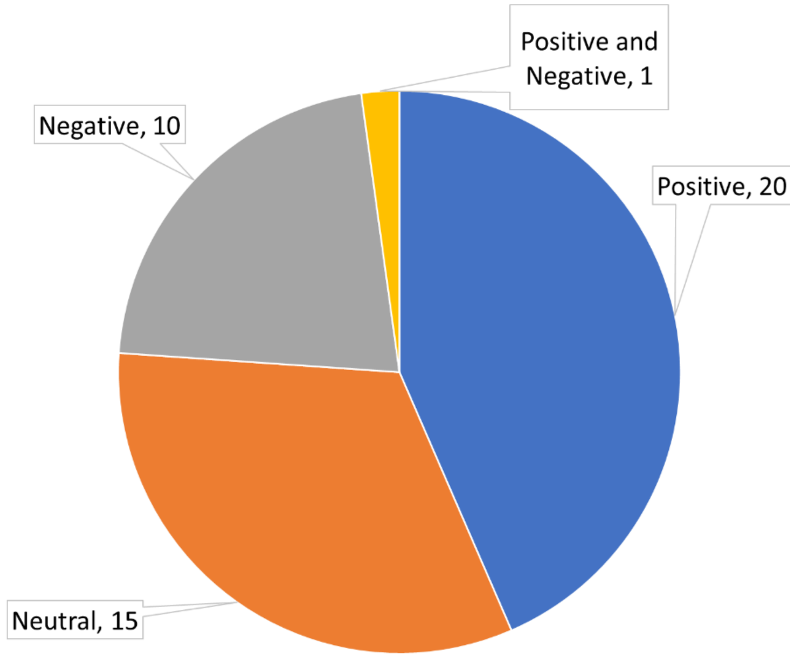


Figure 44 – Pilot Replies to "What was your general experience with this specific CAS-A operation?"

Pilots provided the following comments.

- Pros (or neutral)
    - Generally positive operation, e.g., “easy” (7)
        - Controlled visual
    - System is useful (4)
    - Adds situation awareness (4)
        - Nice to see overtake (2)
            - Changed speed to avoid overtake (2)
        - Particularly useful when following a regional jet that most often is the cause of a go-around
        - Knowing the TTF is helpful
    - Pre-briefing the operation is helpful (4)
    - Uses the CDTI often (3)
    - Helpful to designate before getting controller instruction to designate (3)
    - Has requested a CAS-A operation and was issued one by the controller (2)
    - Eases radio congestion
    - Receiving the designation instruction is helpful
    - Pilots use it more when it becomes familiar
- Cons (or topics to consider)
    - Getting the designation instruction late in the traffic pattern is challenging (8)
        - Particularly when flying it for the first time
        - Leads to heads-down time and increased workload
    - Difficult when the other flight crew member is new (5)
    - Surprised by the designation instruction (5)
    - Difficulty finding TTF call sign in traffic list (4)
    - Expected to get more details from the controller on what to do (e.g., distance to achieve/maintain) (4)
    - Need more/different training (3)
    - Not able to note the TTF call sign when issued (2)
    - Difficult when already in a high workload situation (2)
    - Shifting responsibility to flight crew (2)
    - A mention of distance from the controller led the flight crew to select another operation (i.e., I-IM)
    - Interface is challenging
    - First time is challenging

Flight crews were asked if they had any challenges with the specific CAS-A operation. Fifteen replies (30%) were missing or NA. The replies provided are shown in Figure 45. Twenty-one pilots said they did and 15 said they did not. All the issues mentioned for this question were noted in the previous question. Several comments for this question referred to the comments for the previous question. Therefore, the challenges are not repeated here.

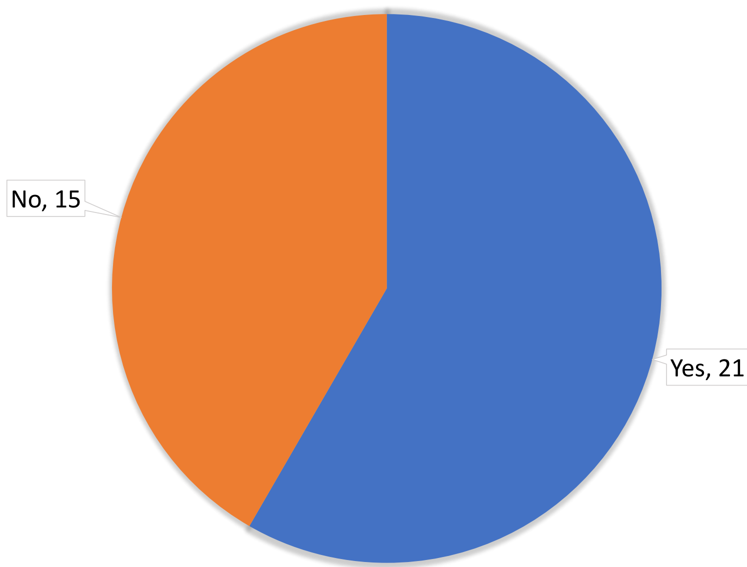


Figure 45 – Pilot Replies to "Were there any specific challenges for this CAS-A operation?"

Flight crews were asked if the CAS-A phraseology was explicit and understandable. Twenty replies (37%) were missing or Not Applicable (NA). The replies provided are shown in Figure 46. The majority (28) that provided replies reported it was explicit and clear. Those that said, "no" as part of their reply reported the following issues.

- Expected to get more details from the controller on what to do (e.g., distance to achieve/maintain) (3)
- Did not know it since they had not prepared (2)

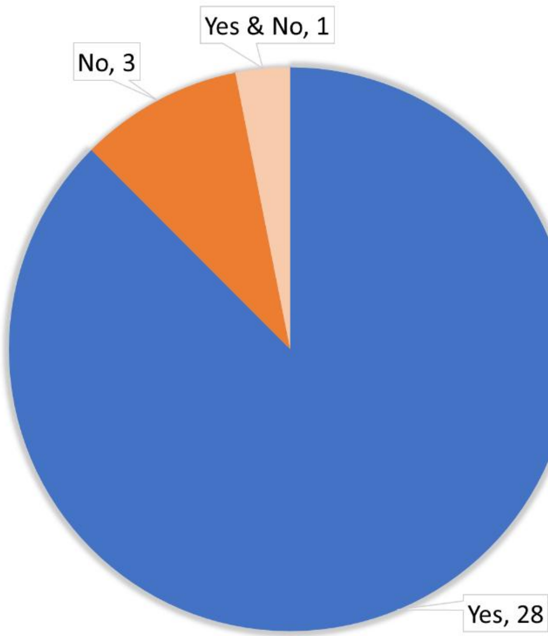


Figure 46 – Pilot Replies to "Was the CAS-A phraseology explicit and understandable?"

Flight crews were asked if they had any feedback on the avionics interface. Twelve replies (24%) were missing or NA. The replies provided are shown in Figure 47. Sixteen pilots said they did and 23 said they did not. Comments that are more broadly applicable to a general design are provided below.

- Would be easier if integrated into the ND (6)
- Display location is challenging (2)
    - Viewing for pilot in right seat is challenging (2)
- Finding traffic in a traffic page is challenging
- Would like to see TTF type

Figure 47 – Pilot Replies to "Do you have any feedback related to the avionics interface (i.e., MCDU, ND, or AGD) for CAS[-A] operations?"

Flight crews were asked if any additional information would have been helpful in training. Thirteen replies (26%) were missing. The replies provided are shown in Figure 48. Sixteen pilots said there was additional information that would have been useful and 22 said there was not.

Figure 48 – Pilot Replies to "Is there additional information that would be useful in the training material?"

The following ideas for improvement or general comments were provided.

- Learned with experience (8)
    - Including before being asked to do it
- Pilots need to review the material (7)
    - Material is good to review after having conducted an operation
- Bulletin is insufficient (4)
- Training was limited (3)
- Would like to see other training (2)
    - Would like to see in recurrent training (3)
    - Hands-on training needed (3)
    - Videos are helpful (3)
    - CCI memos are effective (3)
    - Simulator scenario would help (2)
    - Application would help
    - Would prefer a procedures training tool
    - Needed in full motion simulators
    - Having it explained during in Initial Operation Experience flights would be beneficial
- Challenging when review of the material occurred long before conducting the operation (2)
- Quick reference card would help (2)
- Need to know what to do when have a speed from the controller and compression is observed
    - Following the TTF without a specified distance
- Guidance on searching for TTF call sign
- Material needs to be simplified and defined relative to what is being done with TCAS
- Details on how to incorporate it into the normal scan/use

4.4.2 Questions on Broader CDTI Operations

Flight crews were asked five additional questions on the broader use of the CDTI for other purposes. The first one asked flight crews if they conduct CAVS operations to gain comfort with the equipment. Fifteen replies (29%) were missing. The replies provided are shown in Figure 49. Twenty-nine pilots reported conducting CAVS to gain comfort and seven did not report doing so.

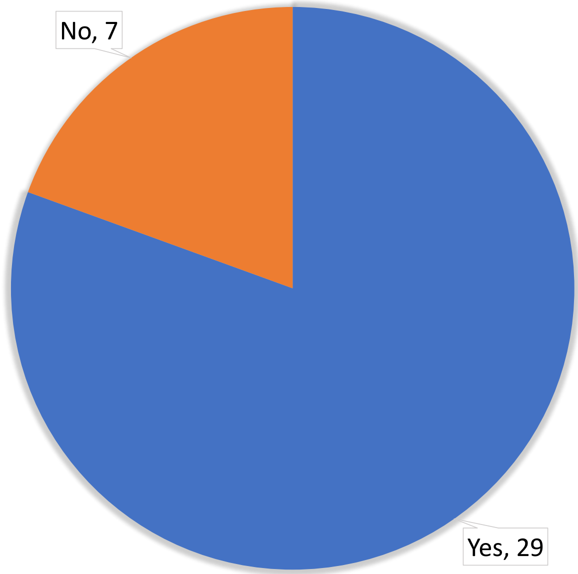


Figure 49 – Pilot Replies to "Have you used CAVS to gain a comfort level with the equipage?"

The following bullets provide highlights of the replies that went beyond using the equipment for CAVS. The equipment is used:

- For greater situation awareness (terminal and en route) (10)
- To become/stay familiar (3)
- To designate traffic (3)
- To monitor speed (3)
- For weather avoidance (2)
- At CLT (2)
- At PHL
- At Seattle–Tacoma International Airport (SEA), where spacing from lead can be close
- To monitor for overtakes to notify the controller
- To listen to holding instructions for other aircraft so able to preplan
- To monitor call signs

Flight crews were asked if they behave differently when following traffic and using the CDTI than they do when following traffic and not using the CDTI. Twenty-four replies (47%) were missing or NA. The replies provided are shown in Figure 50. Pilots were about evenly split as to whether they behave differently (14) or not (13).

Figure 50 – Pilot Replies to "Do you behave differently when using CDTI to follow traffic then you do when conducting visual separation without the equipment?"

The following bullets provide highlights of the replies.

- For speed and overtake awareness, and adjustments (8)
    - Without it, tendency is to slow sooner than needed (2)
- Use now instead of TCAS (4)
- More detailed/accurate information (4)
- More aware of instantaneous information (2)
- More head-down time
- Have become more diligent about separation
- More confidence
- To differentiate between traffic
- To discuss closure and proximity to traffic that normally does not occur when looking out the window
- Changed scan from out-the-window to the CDTI
- Doing something different might be against what the controller is expecting
- To make better decisions
- Does not feel much different. Have always used TCAS

Flight crews were asked if the CAS-A equipment helped when following traffic. Twenty-six replies (51%) were missing or NA. The replies provided are shown in Figure 51. Most pilots (22) said the equipment helped when following traffic and three said it did not.

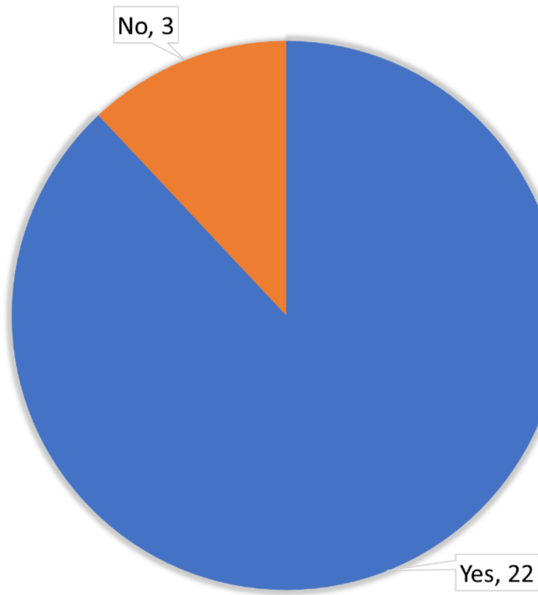


Figure 51 – Pilot Replies to "Has the CAS-A equipment helped when following traffic?"

Of the three pilots that said it did not, one said he/she had a technique that worked and did not use the equipment much. Another pilot said he/she mainly uses the equipment to observe the overall traffic environment. The other pilot did not provide a comment.

The following comments were provided on how it helps. Note that several comments pointed to previous replies from the question on behaving differently that was just reported.

- For increased situation awareness (4)
- Speed information is useful (4)
- Situation awareness on departure where the TTF is monitored until paths diverge
- Distance information is helpful
- Used to observe an overtake on an aircraft during descent that would have potentially resulted in a TCAS event. Notified the controller (who may not have been aware) who vectored the other aircraft to avoid the overtake
- To determine whether the Airbus Ground Speed Mini will be a factor in closure
- Better planning
- Avoiding slowing too early
- Increases confidence with separation
- To watch other flight crew's routes around weather
- Makes it easier to be aware of potential go around situations

Flight crews were asked if the CDTI enhanced safety. Nineteen replies (37%) were missing. The provided replies are shown in Figure 52. Twenty-eight pilots said the CDTI enhances safety and three said it did not. One pilot said it both did and did not.

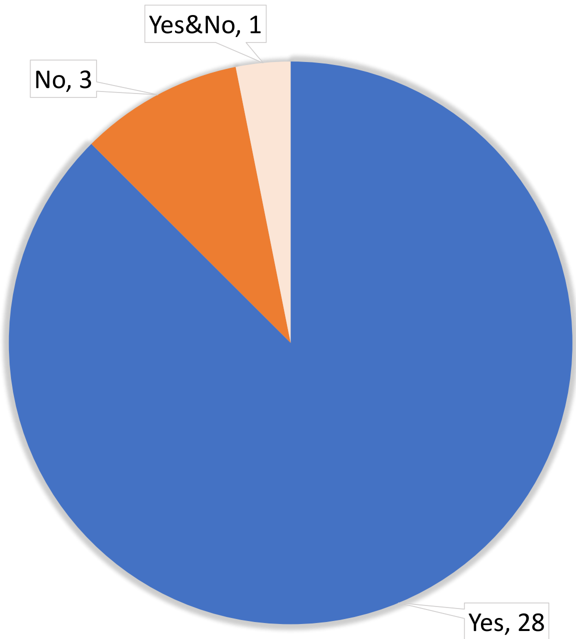


Figure 52 – Pilot Replies to "Do you believe the CDTI is an enhancement to safety?"

The following comments were provided.

- Increased situation awareness (8)
- Too soon to tell (6)
- More information (3)
- An enhancement (3)
- More so as get familiar with it (3)
- Concerned if it means more responsibility for pilots (3)
- Heads down time could be issue (2)
- No, but efficiency will
- Instantaneous traffic is good
- Prepared to do a go-around
- Less chance of a go-around
- Can be if not a distraction
- Does not add workload and benefits are large

Flight crews were asked if they found the traffic range advisory useful. Thirty-three replies (65%) were missing. The replies provided are shown in Figure 53. Seven pilots found the traffic range advisory useful and 11 did not.

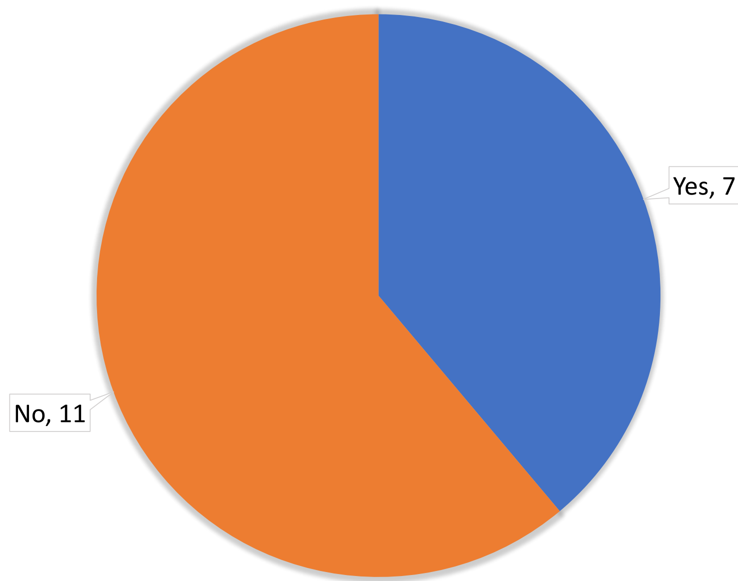


Figure 53 – Pilot Replies to "Do you find the traffic range advisory useful?"

The comments provided include the following.

- Not familiar with it (7)
- Aware but have not seen it activated (3)
- Has seen it activated but not familiar with it (2)
- Accurate and helpful/useful (2)
- Enhances situation awareness of the TTF
- Not needed
- Familiar with it

Based on inter-arrival distance data, there were a limited number of aircraft that got close enough (2.5 NM) to the TTF to have the advisory triggered, so pilots having limited awareness of the advisory is logical.

4.5 Operational Data - Controller Feedback

As mentioned previously, controllers were able to provide their feedback for a particular CAS-A operation. As with the flight crew data, the feedback was likely provided when there was a situation that needed to be addressed. Therefore, abnormal or problematic operations may be overrepresented in this data as well.

Controllers provided feedback on 34 operations. Figure 54 shows when the feedback forms were received. As can be seen, the majority of forms were received in the first month.

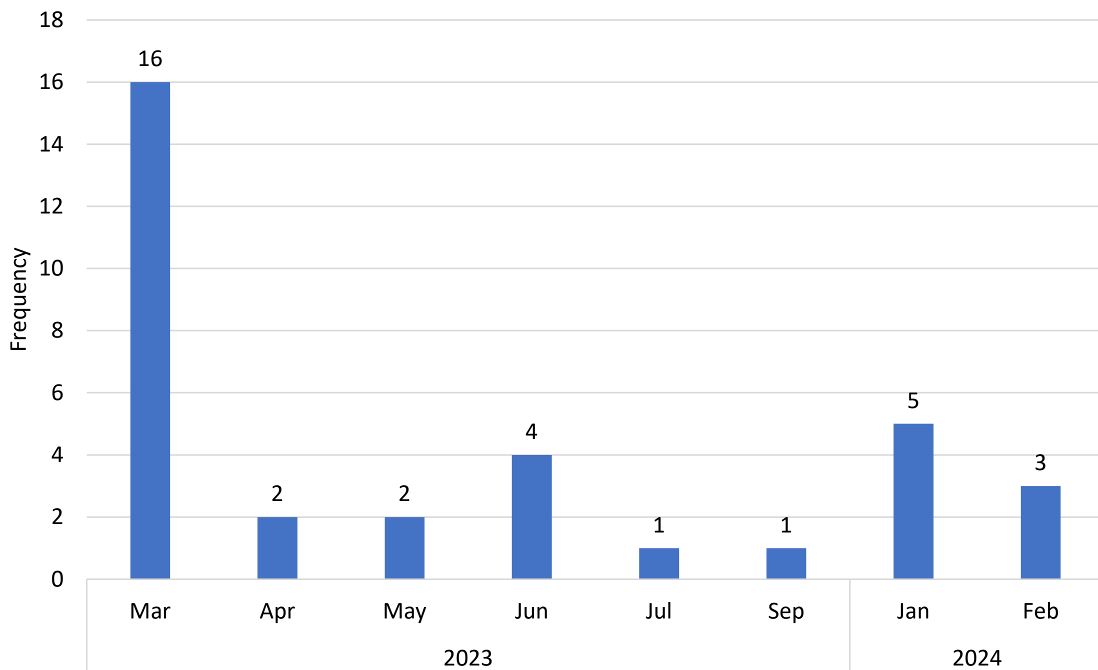


Figure 54 – Frequency of Controller Feedback Forms by Month

Thirty of the 34 reports (88%) were reporting an issue and four were not. Figure 55 shows the reasons provided and those without/“none”.

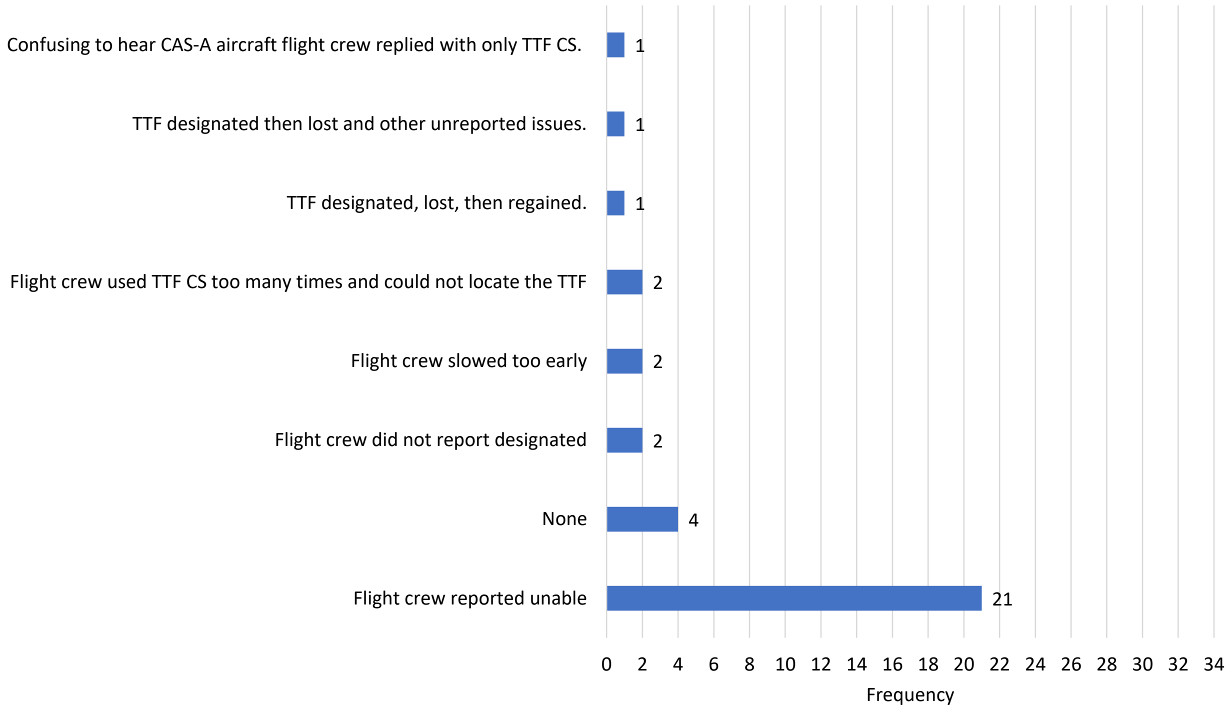


Figure 55 – Controller Comments in the Controller Feedback Form

As can be seen, most issues were related to a flight crew reporting being unable to conduct CAS-A. The other issues were related to flight crew topics: not reporting designation, slowing too early, use of the TTF call sign too often, losing the TTF in the flight deck equipment, and confusing use of call signs. Four (12%) did not report an issue.

Controllers were asked two questions on the form. First, controllers were asked about their overall impression of CAS-A. For the four reports without a reported issue, all controllers reported their overall impression of CAS-A as “positive.” Of the 30 reports with a reported issue, five replies were missing. For the rest, controllers reported their overall impression as negative (5), the majority as neutral (16), positive – neutral (1), and positive (3) (Figure 56).

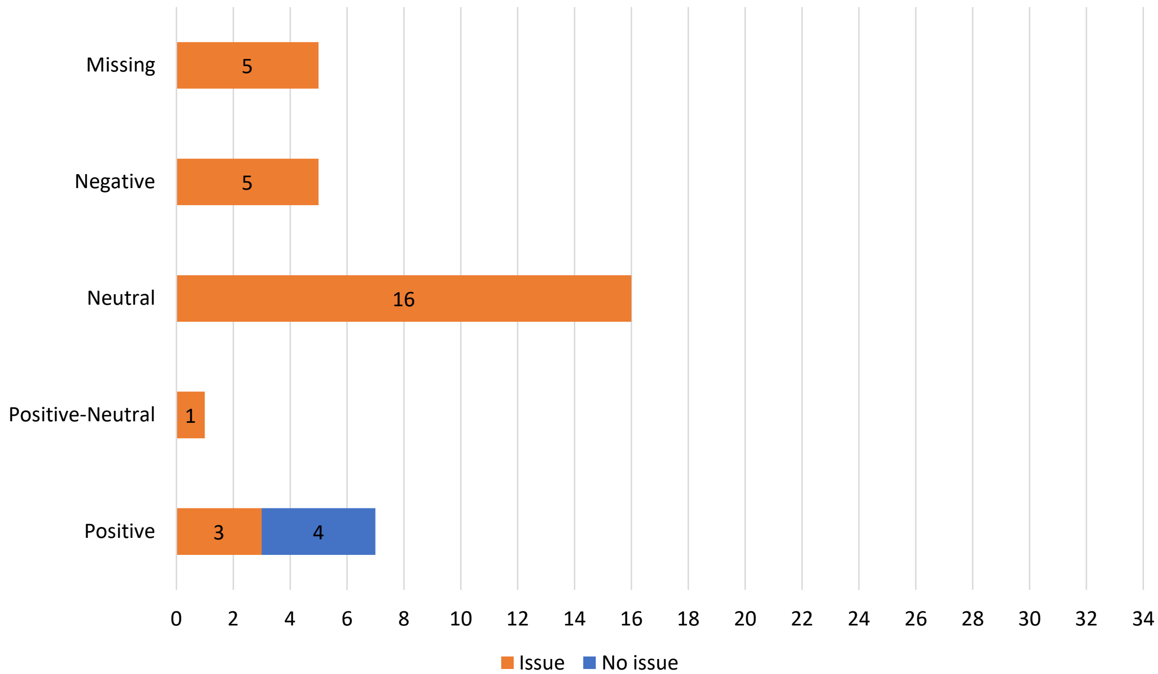


Figure 56 – Controller Replies to “What was your overall impression of CAS-A?” by whether an issue was also reported

The controllers were also asked to report whether CAS-A was: Useful, Helpful, Neither, or Unknown. Figure 57 shows a general mix of replies based on whether the controller reported an issue for the particular operation. For the four reports without a reported issue, controllers reported their impression to be unknown (1), neither useful nor helpful (1), useful (1), and useful and helpful (1). Of the 30 reports with a reported issue, five replies were missing. For the rest, controllers reported their impression to be unknown (5), the majority as neither useful nor helpful (17), useful, helpful, and neither (2), and useful and helpful (1). Zero replies were provided for helpful or useful.

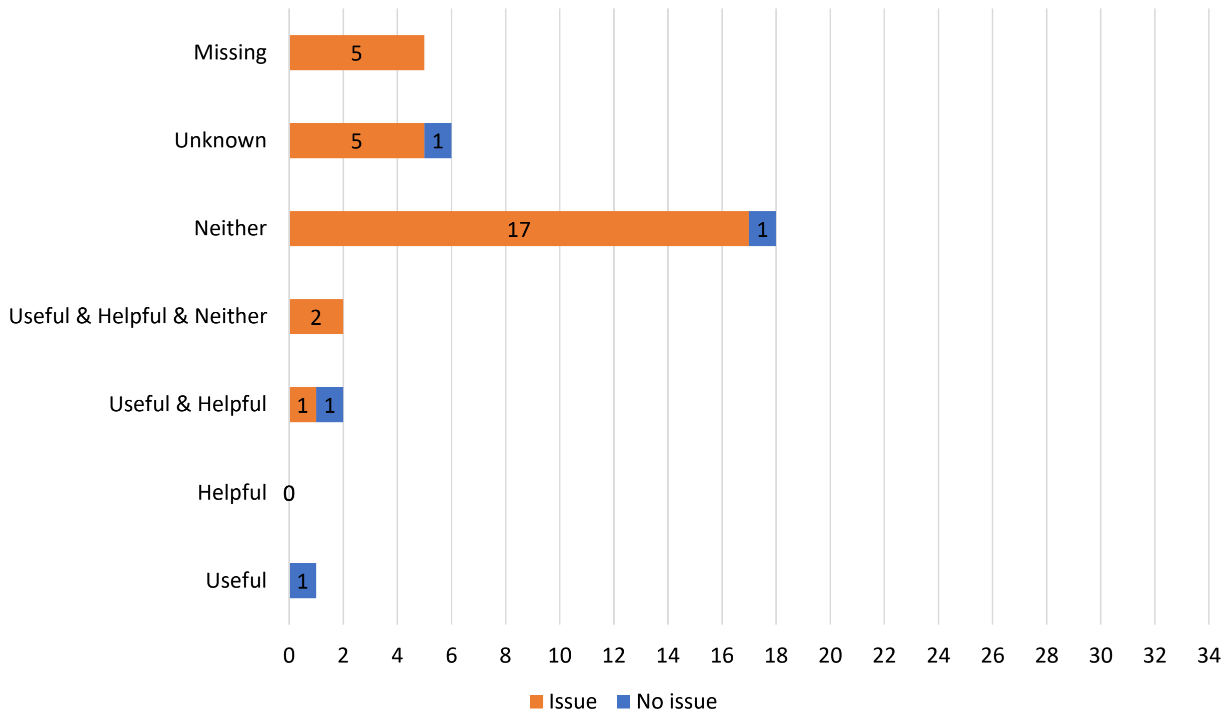


Figure 57 – Controller Replies to "CAS-A was:" by whether an issue was also reported

Besides the feedback provided in these reports, the feedback from the D10 facility is that recent waivers (e.g., the approval of widely spaced operations on the outboard runways) that have been put in place since CAS-A operations started have reduced the benefits of CAS-A at D10. They reported that they do see some benefits of CAS-A at D10 (e.g., the ability to reduce the downwind flight distance significantly by moving the aircraft into what would have previously been an unused or partially unused slot) and would like to continue using it. They also said they believe CAS-A has benefits (e.g., reduced IAT/IAD) for other airports in the NAS. They reported potential initial resistance from D10 controllers, and lack of use, because it was new, but now the current challenge is knowing which aircraft are equipped without equipage indicators on their STARS display and the limited number of equipped aircraft. They said indicators and more equipped aircraft are necessary before a larger number of operations can be expected.

5 Conclusions and Recommendations

The CAS-A operational evaluation included participants from the APA, American Airlines, D10, DFW Tower, avionics manufacturer ACSS, the FAA organizations and their support, and NATCA. The primary goal of the AIRS operational evaluation was to demonstrate the operational feasibility and value of ADS-B In capabilities using a more cost-effective retrofit solution for airlines. American Airlines retrofitted their Airbus A321 aircraft fleet with the ACSS SafeRoute+ ADS-B In avionics suite. In total, 288 aircraft were equipped. American Airlines and D10 trained flight crews and controllers, respectively, on the operations and equipment. Additionally, a team with the partners noted above, was established to meet and discuss on-going operations, solve any issues, consider improvements, and collect and review data.

This report covered the first year (March 1, 2023, to February 29, 2024) of the AIRS CAS-A operational evaluation. In that year, there were 2115 CAS-A operations reviewed for benefits analyses and 621 of those were reviewed for operational data collection. Data was collected on the operational feasibility and benefits of the CAS-A operation. Benefits data was also collected for CAVS, traffic designation, and general CDTI use. This section provides conclusions and recommendations from the benefits and operational data analyses, as well as from the overall conduct of the AIRS operational evaluation.

5.1 Benefits

The benefits analysis presented an examination of IAT and IAD at six airports where American Airlines used traffic designation and further analysis of flight time and distance in the terminal area for CAS-A operation arrivals into DFW. The key findings were:

1. When flight crews designate traffic using the CDTI (for general designated traffic awareness, CAVS, or CAS-A), they tend, on average, to achieve more consistent and smaller interarrival distances at the runway threshold.
2. When flight crews used a CDTI and TRACON controllers recognized the equipped traffic and used CAS-A, there was flight time and distance flown savings in the terminal area.

While the mean IAT and IAD decrease when flight crews designate traffic, the minimums do not significantly change; this suggests that flight crews are better able to achieve a distance they are comfortable with based on the CDTI and are not trying to get below current minimum spacing. Put another way, the operation and flight crews are not increasing theoretical runway capacity. They are, however, shifting the mean IAT and IAD towards the minimum values resulting in an increase in mean throughput, allowing better use of the existing capacity. Further, and maximal, throughput benefits would be realized when aircraft are consistently at the theoretical runway capacity, when operations allow for it.

The small (but statistically significant) reductions in flight time and distance in the terminal area related to CAS-A are encouraging. However, they represent only a small part of the potential benefit from this technology when incorporated into air traffic management and a large number of aircraft are equipped. When the CAS-A flight can reduce its flight path, it also impacts the flights behind it, allowing those flights to recover some of the space previously committed to the unused slot. However, only so much space can be recovered if aircraft are not available to fill the unused slots created in the traffic flow when CAS-A operations are used. To take advantage of the unused slots, aircraft would have to be scheduled to the airport based on the anticipated use of CAS-A. If properly incorporated into display and metering automation, the ability to globally reduce the mean and variation of the IAT and IAD has the potential to significantly increase airport throughput and reduce NAS delay (Gryphon, et. al, 2018; Howell, Dean, and Paul, 2019). Realizing these benefits will require additional automation investment from the FAA and additional avionics equipage by the airlines.

5.2 Operational Topics

5.2.1 CAS-A Initiation and Designation

A CAS-A operation is initiated when the controller issues an instruction to designate a TTF to the CAS-A aircraft flight crew. There had been concerns that controllers may issue the designation instruction too late in the arrival to the airport and that it could prove challenging for flight crews. While there was feedback from flight crews that this did sometimes occur, it did not happen often, as most designations were on the downwind or earlier.

The designation could be done by the Feeder or the Final Controller. Most designations were done by the Final Controller. However, it may be desirable to have the Feeder Controller issue the designation instruction to the flight crew because that airspace is expected to be a lower workload environment for the flight crew than the Final Controller's airspace closer to the airport. In fact, flight crews reported challenges with getting a designation instruction late in the traffic pattern. However, Feeder designation can be challenging if the Feeder is assuming a certain sequence of aircraft that is not the same as that planned by the Final Controller. There are situations where the sequence is obvious (e.g., one flow to a runway) where the Feeder will very likely know the sequence and is able to issue the designation instruction. In such situations, it is desirable for the Feeder to issue the designation instruction to allow the flight crew more time to prepare for a CAS-A operation. If the Feeder is unable to do so, it would be desirable to have the Final Controller issue the designation instruction as soon as possible, even as early as when the flight crew checks in on the frequency. Late Final Controller designations (e.g., when the CAS-A aircraft is on base or final approach) may be possible, but are likely to prove more challenging to flight crews and could possibly lead to an "unable" reply.

There were some CAS-A operations where the pilots offered to do a CAS-A operation prior to the controller issuing a designation instruction. These pilot prompts seemed acceptable to controllers based on the number that were noted in the database and feedback from flight crews who reported doing so. There were some concerns expressed in AIRS CAS-A team discussions about these pilot prompts potentially proving challenging for the controllers if the flight crews caused extra workload for the controller by guessing the wrong TTF or making the request during a high workload period for the controller. These concerns did not seem to materialize in any significant way and the number pilot prompts and method of pilot-prompting seemed acceptable to the controllers based on the data and feedback at AIRS CAS-A team meetings. Similar procedures are followed during current pilot-applied visual separation operations. Further discussion may be necessary to determine when this is acceptable for CAS-A operations.

The number of operations where the flight crew reported being unable to conduct CAS-A were limited and the reasons for doing so were varied. Several reasons provided were sound operational reasons. However, rejecting a CAS-A operation for any reason can be frustrating for the controller and could lead to lack of use if it occurs too often and for unclear reasons. While providing a reason for not accepting the CAS-A operation is not required, it may help the controller understand the reason for the rejection and be less frustrating. Based on flight crew feedback, some unables can be anticipated by the controller for reasons such as issuing the designation instruction when the flight crew is close to the airport (e.g., already on final approach). Issuing the designation instruction at that point should generally be avoided unless necessary for an operational reason. While some situations can be predictable, others cannot be anticipated by the controller (e.g., high workload in the flight deck due to a pilot that is new to the aircraft or recently hired) and may often lead to an unable.

Most issues during CAS-A operations occurred in the flight crew designation communications, but few led to further issues. However, the flight crew not including the TTF call sign in the reply could lead to confusion about whether the correct TTF will be or is being followed. Additionally, not including ownship call sign can lead to confusion on the part of the controller about who is replying. For example, if the CAS-A aircraft flight crew said only, "[TTF call sign] is designated", it could be unclear to the controller whether (1) the intended CAS-A aircraft flight crew is reporting their TTF designated but not including their own call sign or (2) the TTF is reporting their TTF designated for another operation but is not using their TTF's call sign. Since managing two call signs can be challenging, the importance of proper use of full ownship and TTF call signs should be part of flight crew training. Additionally, it will be important for flight crews to avoid too many requests for the controller to repeat the TTF call sign. Requests for repeats of TTF call sign could be a memory issue or could be due to having difficulty finding the TTF call sign in the traffic list of the flight deck equipment. Repeat requests due to memory issues will likely be reduced when flight crews are conducting CAS-A operations on a regular basis and are less surprised when a designation instruction comes. Being surprised by the designation instruction was reported by several pilots in the pilot feedback. In this operational evaluation, pilots did report some difficulty in locating the TTF in the traffic list of the equipment, sometimes due to it being several pages down. American Airlines reminded pilots that a search function is available in the CDTI that allows for the flight crew entry of the TTF call sign number from which the equipment down-selects the list based on the entry of each digit, or letter of the call sign, thereby enabling quicker searches and less clicking though MCDU pages. This information was reported to be helpful by pilots and reported issues with locating the TTF have been decreasing.

Using a call sign of an aircraft that is being spoken about versus spoken to has the potential to cause confusion. For example, use of the wrong call sign by the controller can lead to flight crew confusion about which aircraft to follow. Use of the correct call sign of a third party (i.e., the TTF), can lead to confusion for the TTF flight crew who could hear their own call sign and believe an instruction was for them. The use of two call signs in one communication can also be confusing for the flight crew of the CAS-A aircraft, who must keep their own call sign and the TTF's call sign separate and clear in their mind. Managing two call signs (that of the CAS-A aircraft and TTF) from the same company ("American" in this case) can be confusing, as flight crews are routinely changing call sign numbers with each new flight and any call sign number is a reasonable one for them, and therefore, either one could be used. Call sign issues can lead to increased communications and even a flight crew taking the instruction intended for another flight crew. While there were limited downstream issues noted in this operational evaluation period, many general issues occurred in flight crew communications and the potential for downstream issues exists. As such, call sign confusion should be part of flight crew and controller training. The topic has been studied in detail in the past (see Bone, et al., 2013). Experience with the use of third-party call signs may reduce some of the questions and confusion and there are potential options for solutions. After the end of year 1 of the operational evaluation, D10 started limited testing of one of those methods. The method used was reversing the company name and number of the call sign of the TTF (i.e., instead of “United 123”, “123 United was used.) Data on the use of this technique may be available in the year 2 report.

5.2.2 CAS-A Conduct

Operational data indicates CAS-A operations work equally well during both visual and instrument approach procedures. Communication issues for flight crews and controllers were limited during the CAS-A “follow traffic” instruction. Issues after designation were limited. There were concerns expressed prior to the operational evaluation about including the CAS-A instruction along with the approach clearance. The concern was based on the amount of information being already high in an instrument approach clearance and adding the CAS-A instruction could be too much. While the number of instrument approach clearances are limited, pilots have not reported there being too much information in the instructions for the combined approach clearance and CAS-A instruction. This is most likely due to the CAS-A instruction being kept to simply “follow traffic.”

VC and IC use in the scratchpad appears to work well for both denoting designation for the Final Controller to remind themselves of designation success or for the Feeder Controller to notify the Final Controller that designation occurred in that Feeder’s airspace. It also appears to work well (as originally intended) for the Final Controller to inform the Local/Tower Controller that CAS-A is in effect for the CAS-A aircraft. If VC and IC were in the scratchpad for designation but the flight crew or controller was unable to “follow traffic,” VC and IC would need to be removed, so the Local/Tower Controller would know the appropriate separation requirement. This did not appear to be an issue during the operational evaluation but should be considered for future implementations.

Controllers issued speeds to the CAS-A aircraft flight crew when on final approach 41% of the time and did not 59% of the time. Controller use of a speed on final approach to manage the spacing between the CAS-A and the TTF aircraft appears to work well with CAS-A operations as it does with current pilot-applied visual separation operations.

While some flight crews expressed an expectation of getting a distance from the controller and some controllers attempted to give flight crews a distance (and flight crews generally accepted them), flight crews were not trained for achieving or maintaining a set distance. The CAS-A operational description does not describe such an operation (FAA, 2023). Additional work would be necessary to determine whether such an option is desirable, beneficial, and acceptable.

Numerous airlines and aircraft types have acted as TTFs for CAS-A operations but the most frequent TTFs were American Airlines Airbus A321 aircraft. No issues were reported related to following a specific airline or aircraft type (some issues such as high closure on regional jets were mentioned but that is common in non-CAS-A operations).

Of the 14 go-arounds or missed approaches that had a CAS-A aircraft as part of the approach, none were clearly linked to a CAS-A specific issue. They were all determined to be caused by issues unrelated to CAS-A.

5.2.3 Flight Crew Feedback from APA Interviews and Feedback Forms

When asked questions about their general experiences and challenges of the specific CAS-A operation in APA interviews, numerous topics were mentioned. Most pilots had a positive to neutral experience. For benefits of CAS-A, pilots reported added situation awareness for issues like overtakes. One pilot noted it was particularly helpful when following a regional jet that can often be the reason for a go-around (as noted in the previous section). Some pilots mentioned pre-briefing the operation and pre-designating the TTF were useful. The most noted issues were challenges related to getting the designation instruction late in the traffic pattern, conducting CAS-A with new flight crew members, being surprised by the designation instruction, having difficulty finding the TTF in the CDTI traffic list, and expecting to get information from the controller that is not part of the CAS-A operation (e.g., distance to achieve). In one CAS-A operation where the controller mentioned a distance, the flight crew thought they should perform another operation (I-IM) that is not authorized on final approach. While it did not lead to an issue during the CAS-A operation, flight crews should be clearly trained on the authorizations for the different operations. For other concerns, fewer pilots mentioned topics such as not being able to note the TTF call sign when issued from the controller, and concerns with shifting responsibilities to the flight crew.

Most pilots that replied said the CAS-A phraseology was explicit and understandable. Those that reported issues noted that they were not familiar with it because they were not prepared or they expected to get information from the controller that is not part of the CAS-A operation (e.g., distance to achieve). These replies indicate the phraseology is acceptable to flight crew. It may be useful to provide additional material in training about how and why the controllers will not issue information like a distance to achieve and how CAS-S operations parallel current pilot-applied visual separation operations. Pilots did not report issues with decoding TTF airline name to the three letters shown on the CDTI. This could be in part due to the lead aircraft was typically an American Airlines aircraft or the fact that controllers were found to include the three letters in the designation instruction for the more challenging airlines. However, it is worth noting that this decoding issue was not mentioned by pilots.

Comments pilots made on the avionics interface that are broadly applicable to CAVS/CAS-A avionics in general indicate a desire to have the CDTI display in a location that works well for both pilot positions and integration with the installed ND. This comment has been received in numerous other ADS-B In application research efforts (e.g., Bone, 2005; Bone and Mendolia, 2018); however, the cost of retrofit integration can be much less costly than a forward-fit, new display installation. Integration with the installed ND should be considered for forward-fit implementations. Another topic mentioned here, and in general challenges, was related to finding the TTF call sign in a traffic list, sometimes due to it being several pages down. The CDTI search function in the ACSS equipment allows for the flight crew entry of the TTF call sign number from which it down-selects the list based on the entry of each digit, or letter of the call sign, thereby enabling quicker searches and less clicking though MCDU pages. While not specified in CAVS equipment standards, this or another feature should be considered by other manufacturers to help the flight crew quickly find the TTF call sign to avoid flight crew workload and the controller waiting for extended periods of time before the flight crew reports the TTF designated.

Most pilots mentioned they needed to review the training material, and that pre-briefing and preparation is helpful, particularly when they infrequently get to conduct a CAS-A operation. Several also noted that they have been learning as they gain experience. Several pilots also reported wanting training beyond a bulletin (e.g., hands-on training, simulator training, videos, a simulator scenario, quick reference card). When the comments were made, some videos and a quick reference card were available. Pilots that made those comments did not realize that was the case. To address training feedback, American Airlines published additional information for flight crews to reinforce training material and/or update flight crews on areas of special emphasis. Additionally, a computer-based training application was added that gave flight crews the opportunity to virtually interact with the avionics.

When asked a set of questions on the broader use of the CDTI, pilots mentioned using the CDTI for numerous things. They mentioned greater situation awareness in the en route and terminal environments, including specific airports (CLT, PHL, and SEA). Specifically, they mentioned using it for monitoring the groundspeed of, distance from, and overtakes on other aircraft. It has also been used to differentiate traffic. For use related to go-arounds, the CDTI was mentioned as helping flight crew awareness of a potential go-around, reducing the chances of one occurring, being prepared for one, and notifying the controller of an impending go-around. Using the CDTI to monitor aircraft call signs was also mentioned. Pilots mentioned that the CDTI provided more useful information than TCAS when following traffic. Pilots reported the CDTI allowed for better planning/decisions and helping avoid slowing earlier than necessary. It was noted to increase confidence with separation when following traffic.

Some more unique uses were also mentioned. The CDTI was used to monitor other aircraft's paths to assist in weather avoidance and planning for holding procedures. It was mentioned that the CDTI led a pilot to be more diligent with separation from another aircraft. Another pilot mentioned how the CDTI led to flight crew discussions about the closure on and proximity to the TTF, which did not occur when only looking out the window. One pilot described using the CDTI to observe an overtake that was mentioned to the controller who then vectored the other aircraft to avoid the overtake. Another pilot described using the features to determine if the Airbus Ground Speed Mini function would be a factor when following the TTF. Another pilot mentioned using the CDTI for situation awareness on departure by acquiring the lead aircraft and monitoring it until their paths diverge. This idea is similar, or the same, as one that has been proposed as an extension of CAS-A where the CDTI information is used for CAS on Departure (Domino et al., 2010; Bone, 2022).

Some concerns mentioned were a changed scan from out-the-window, a potential distraction, and head-down time. Some also expressed concern if it means more responsibility for pilots. Based on APA discussions with pilots, it appeared some concerns may have been related to pilots not understanding CAS-A has the same responsibilities as current pilot-applied visual separation operations.

Pilot replies were limited on the usefulness of the traffic range advisory. Conclusions are difficult to make based on the number of replies and the limited number of aircraft that got close enough (2.5 NM) to the TTF to have the advisory triggered.

5.2.4 Controller Feedback

Controller feedback was somewhat limited and provided for 34 operations. Thirty of the 34 feedback forms were reporting an issue, and most were related to a flight crew reporting being unable to conduct CAS-A. For the four reports without a reported issue, all controllers reported their overall impression of CAS-A as "positive." Of the 30 reports with a reported issue, the majority were neutral. The controllers were also asked to report whether CAS-A was: Useful, Helpful, Neither, or Unknown. A general mix of replies were received regardless of whether the controller reported an issue, but more negative replies were received for operations with a reported issue.

Besides the feedback provided in these reports, the feedback from the D10 facility is that recent waivers (e.g., the approval of widely spaced operations on the outboard runways) that have been put in place since CAS-A operations started have reduced the benefits of CAS-A at D10. They reported that they do see some benefits of CAS-A at D10 (e.g., the ability to reduce the downwind flight distance significantly by moving the aircraft into what would have previously been an unused or partially unused slot) and would like to continue using it. They also said they believe CAS-A has benefits (e.g., reduced IAT/IAD) for other airports in the NAS. They reported potential initial resistance from D10 controllers, and lack of use because it was new, but now the current challenge is knowing which aircraft are equipped without equipage indicators on their STARS display and the limited number of equipped aircraft. They said indicators and more equipped aircraft are necessary before a larger number of operations can be expected.

5.3 Operational Evaluation Lessons Learned

As with the introduction of anything new, there can be initial resistance to change. This was noted in the operational evaluation for both flight crews and controllers. D10 leadership reported potential initial resistance from D10 controllers, and lack of use because it was new, but now the current challenge is knowing which aircraft are equipped without equipage indicators on their STARS display and the limited number of equipped aircraft. Similar resistance was reported for the flight crews. Flight crews also had the issue of not seeing the operation very often based on CAS-A only being conducted at D10 and needing to receive a CAS-A instruction from a controller. As both flight crews and controllers gained experience, this resistance and apprehension seemed to fade. However, the issue of limited opportunities for both flight crews and controllers will exist until the operations are expanded. That expansion will need to include equipage indicators for the controllers.

For the overall coordination of the AIRS CAS-A team during the operational evaluation, it was found to be particularly effective to have controllers, pilots, avionics manufacturers, and concept SMEs all participating in discussions and sharing their individual points of view. Not only did the collaboration result in a greater understanding of the operations, but it also enabled the representatives to communicate back to their organizations regarding some of the lessons learned, methods to improve operations, and the perspectives of the other organizations.

6 Acronyms

AAL	American Airlines
AAR	Airport Acceptance Rate
AC	Advisory Circular
ACSS	Aviation Communication & Surveillance Systems
ADS-B	Automatic Dependent Surveillance - Broadcast
AFS	Flight Standards Service
AGD	ADS-B Guidance Display
AIRS	ADS-B In Retrofit Spacing
AJT	Air Traffic Services
AJV	Mission Support Service
APA	Airlines Pilots Association
ARC	Aviation Rulemaking Committee
ASA	Aircraft Surveillance Application
ASDE-X	Airport Surface Detection Equipment Version X
ASPM	Aviation System Performance Metrics
ASQP	Airline Service Quality Performance
ATC	Air Traffic Control
ATO	Air Traffic Organization
CAPP	CDTI Assisted Pilot Procedure
CARTS	Common Automated Radar Terminal System
CAS	CDTI Assisted Separation
CAS-A	CAS on Approach
CAVS	CDTI Assisted Visual Separation
CBT	Computer-Based Training
CCI	Crew Check In
CDTI	Cockpit Display of Traffic Information
CEO	Current Engine Option
CLT	Charlotte Douglas International Airport
CS	Call Sign
D10	Dallas-Fort Worth TRACON
DFW	Dallas-Fort Worth International Airport
DL	Distance Learning
ERAM	En Route Automation Modernization
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	Federal Aviation Administration
ft	Foot/feet
HDG	Heading
HH	Hours
iTBO	Initial Trajectory Based Operations
I-IM	Initial-Interval Management
IAD	Inter-Arrival Distance
IAT	Inter-Arrival Time
IATA	International Air Transport Association
IC	Instrument approach CAS-A

ICAO	International Civil Aviation Organization
ID	Identification
IFP	Instrument Flight Procedures
IMC	Instrument Meteorological Conditions
IOAA	IFP, Operations, and Airspace Analytics
kt	Knot
LAX	Los Angeles International Airport
LOSA	Line Operations Safety Audit
MCDU	Multi-Function Control and Display Unit
MCO	Orlando International Airport
MIA	Miami International Airport
Min	Minute
MM	Minutes
MMC	Marginal Meteorological Conditions
MOA	Memorandum of Agreement
MOPS	Minimum Operational Performance Standards
MSAW	Minimum Safe Altitude Warning
MSL	Mean Sea Level
MVA	Minimum Vectoring Altitude
NA	Non-Applicable
NAS	National Airspace System
NATCA	National Air Traffic Controllers Association
ND	Navigation Display
NEO	New Engine Option
NextGen	Next Generation Air Transportation System
NM	Nautical Mile
NOP	National Offload Program
OOOI	Out-Off-On-In
PAR	Precision Approach Radar
PASS	Professional Aviation Safety Specialists
PDARS	Performance Data Analysis and Reporting System
PF	Pilot Flying
PHL	Philadelphia International Airport
PHX	Phoenix Sky Harbor International Airport
PM	Pilot Monitoring
RA	Resolution Advisory
RTCA	RTCA
SEA	Seattle-Tacoma International Airport
Sec	seconds
SM	Statute Mile
SME	Subject Matter Expert
SMS	Safety Management System
SOP	Standard Operating Procedure
SRM	Safety Risk Management
SRMD	Safety Risk Management Document
SRMP	Safety Risk Management Panel

SS	Seconds
STARS	Standard Terminal Automation Replacement System
SWIM	System Wide Information Management
TA	Traffic Advisory
TBO	Trajectory Based Operations
TCAS	Traffic alert and Collision Avoidance System
TFMS	Traffic Flow Management System
TRACON	Terminal Radar Approach Control
TRK	Track
TSO	Technical Standard Order
TTF	Traffic-To-Follow
UPS	United Parcel Service
UTC	Coordinated Universal Time
VC	Visual approach CAS-A
VMC	Visual Meteorological Conditions
VSA	Enhanced Visual Separation on Approach

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8 Appendices

8.1 CAS-A Observation Form

Date: ______________________**Local** / **UTC** Observer:__________________

CAS trail call sign	**ID AAL**_______________	
Lead call sign and type aircraft	**ID**_______________	**Type**_________________
ATC *designate* instruction location?	**Beyond traffic pattern** / **Downwind** / **Base** / **Dogleg** / **Final**	
New designate comm used?	**Yes** / **No**	& Report request? **Yes** / **No**
Modified Lead CS?	**Yes** / **No**	**Detail**______________________________
ATC offer designation?	**Yes** / **No**	
Pilot unable/reject *designation*?	**Yes / No / No, but no report back / No report until ATC ?**	
Who gave the *designate* instruction?	**Feeder** / **Final**	**Position:**____
Pilot reply to designate delayed?	**Yes** / **No**	
Designation comm issue?	**Yes** / **No** →	(see back)
Who gave the *follow traffic*?	**Feeder** / **Final**	**Position:**____ **Runway**____
When was the *follow traffic* issued?	**With** / **After** (the approach clearance)	
Pilot unable/reject/ignore *follow traffic*?	**Yes** / **No**	
Did ATC assign a speed on final?	**Yes** / **No**	**What speed?**_________
What was the initial spacing on final?	________________ **NM** between aircraft	
Did ATC assign a **second** speed?	**Yes** / **No**	**What speed?**_________
Did ATC mention lead spacing/speed?	**Yes** / **No**	
Was CAS canceled (after *follow traffic*)?	**Yes** / **No**	**Initiator**: **Pilot** / **ATC**
What type of approach?	**Visual** / **Instrument**	
What was the final spacing?	________________ **NM** when lead over threshold	
Call sign confusion?	**Yes** / **No**	**Detail**________________
Were there other unexpected events?	**Yes** / **No** (explain below)	
What were the weather conditions?	**Ceiling** _________ **Visibility** ______ **Other**_______	
Type of operation (hazy vis, trips)?		
Summary	**Completed no issue / Completed issue / Completed ukn / Incomplete at desig / Incomplete aft desig**	

Notes:

		Inc	Notes
Readback			
"Wilco," "roger," etc			
Ownship	**Company**		
	Number		
"Expect to follow/desig"			
Lead	**Company**		
	Number		
"Report designated"			
Other:			
Issue			No readback / Req to repeat lead CS / Wrong lead CS used / Other
Report			
Ownship	**Company**		
	Number		
"has designated"			
Lead	**Company**		
	Number		
Other:			
Issue			No report / Delay until ATC query / Wrong lead CS used / Other
ATC Issue			No wrong CS correction / Other

8.2 APA Pilot Feedback Form

Specific CAS Operation Questions

1) What was your general experience with this specific CAS-A operation? **Positive / Neutral / Negative**

   ____

2) Were there any specific challenges for this CAS-A operation? **Yes / No**

   ____

3) Was the CAS phraseology explicit and understandable? **Yes / No**

   ____

4) Do you have any feedback related to the avionics interface (i.e., MCDU, ND, or AGD) for CAS CAS-A operations? **Yes / No**

   ____

5) Is there additional information that would be useful in the training material? **Yes / No**

   ____

Broader CDTI Questions

6) Have you used CAVS to gain a comfort level with the equipage? **Yes / No**

   ____

7) Do you behave differently when using CDTI to follow traffic then you do when conducting visual separation without the equipment? **Yes / No**

   ____

8) Has the CAS-A equipment helped when following traffic? **Yes / No** How?

   ____

9) Do you believe the CDTI is an enhancement to safety? **Yes / No**

   ____

10) Do you find the traffic range advisory useful? **Yes / No**

   ____

8.3 D10 Controller Feedback Form

What was your overall impression of CAS-A? (circle one)

Positive	Neutral	Negative

CAS-A was: (*Circle one or two*)	Useful	Helpful	Neither	Unknown

Were there any **controller** issues? (e.g., procedures or phraseology) (*circle one*)	Yes	No

Were there any **AAL pilot** issues? (*circle one*)	Yes	No
Were there any other airline **pilot** issues with callsign use? (*circle one*)	Yes	No

Additional Feedback

Position Name	CAS-A status at position (circle one or more)	Date & Time (UTC)	Trail Aircraft ID	Lead Aircraft ID
AR1 AR2 AR3 AR5 AR6 FE FW	Pilot-Rejected CAS Issued Canceled			

Comments (provide any additional thoughts, particularly if you have ideas on how it was useful/helpful or if there was an issue): ______________________________________

____

____

____

____

____