International Civil Aviation Organization

Ninth Meeting of the Surveillance Implementation Coordination Group (SURICG/9)

Bangkok, Thailand, 7 – 10 May 2024

Agenda Item 7: Update on surveillance activities and explore potential cooperation opportunity
a) States/Administrations

ADS-B IN RETROFIT SPACING (AIRS) EVALUATION PROJECT UPDATE

(Presented by United States/Federal Aviation Administration)

SUMMARY

This paper provides an update on the ADS-B In Retrofit Spacing (AIRS) evaluation project, a large-scale operational evaluation of ADS-B In applications that was the subject of SURICG/6-IP/08. The project engages the FAA with ACSS and American Airlines (AAL) in a public-private partnership to equip 288 AAL A321 aircraft with an ADS-B-In retrofit solution that supports Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS) and Interval Management (IM) capabilities.

1. INTRODUCTION

1.1. The ADS-B In Retrofit Spacing (AIRS) evaluation project was initiated in September 2017, with the aim of conducting a large-scale operational evaluation of two ADS-B In applications: Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS) and Initial Interval Management (I-IM).

1.2. The project was subsequently expanded in 2020 to include the CDTI-Assisted Separation on Approach (CAS-A) operation. From a pilot's perspective, CAS-A operations are similar to CAVS operations, with the principal difference being that controllers provide the Aircraft ID of the traffic-to-follow directly to the aircraft performing CAS-A via voice communications. Additionally, CAS-A uses the CAVS avionics functionality in ceiling and visibility conditions that would not qualify for "pilot-applied visual separation" in the U.S. under FAA Order 7110.65, "Air Traffic Control." However, CAS-A operations require that the airport of intended landing must be VMC (ceiling at the airport greater than or equal to 1,000 feet AGL and horizontal visibility of 3 statute miles or greater) – a principal reason for this limitation is to enable tower controllers to apply visual separation on the runway between the CAS-A aircraft and its traffic-to-follow.

1.3. Appendix B of FAA Advisory Circular (AC) 90-114B, Change 1 contains more information on CAVS. Appendix F of this AC contains more information on Interval Management. (see https://drs.faa.gov/browse/excelExternalWindow/DRSDOCID1293172039202212230006 44.0001). Note that the I-IM operations being conducted in this FAA project are a limited subset of the IM operations described in RTCA DO-328B / EUROCAE ED-195B. For specific details on I-IM operations, see SP-AIRB14-IP06.1, Appendix E.

1.4. FAA provided an operational description of CAS-A in SP-AIRB14-IP02.1, Appendix D. Based on experiences from the operational trial, including controller feedback on streamlining the phraseology, FAA has updated the CAS-A operational description in SP-AIRB17-IP01.

1.5. The project involves the FAA with ACSS and American Airlines (AAL) in a public-private partnership to equip at least 288 AAL A321 aircraft with an ADS-B-In retrofit solution supporting CAVS, CAS-A, and I-IM operations. The AAL A321 fleet consists of a mixture of A321ceo and A321neo aircraft with two different types of ACSS TCAS units – the TCAS-3000SP and the T^{3}CAS. The system installed in these aircraft is shown in Figure 1. Figure 2 shows the AGD display for the CAVS function, which is compliant with [E]TSO-C195b. Figure 3 shows the AGD display for various operating modes of the ACSS I-IM implementation.

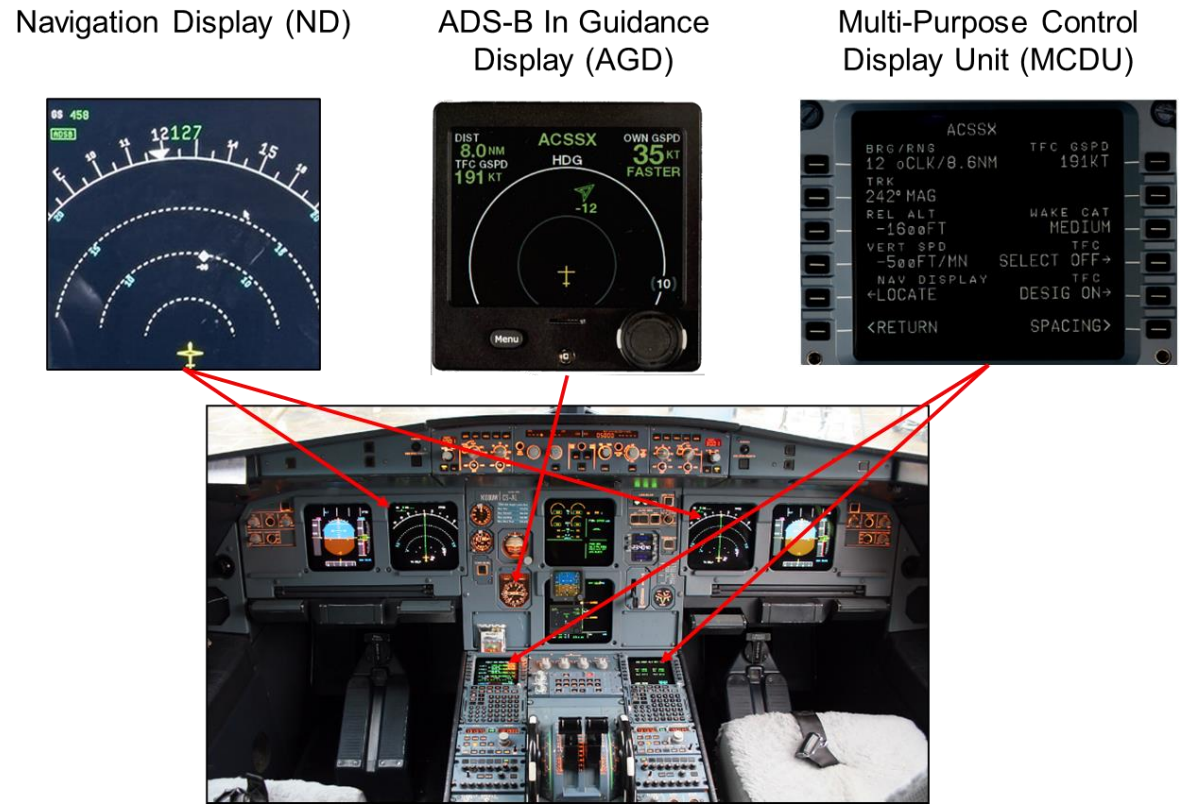

Figure 1 – ACSS avionics being installed in AAL A321s (the only new hardware is the AGD)
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Figure 2 –AGD display details for the [E]TSO-compliant CAVS function as implemented by ACSS
Copyright ACSS. Used by permission.

IM (airspeed command) (time-based ASG)

IM (Mach command) (time-based ASG)

IM (Mach command) (distance-based ASG)

Figure 3 – AGD display for various operating modes of the ACSS I-IM implementation
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1.6. Note that, based on feedback from the I-IM operational evaluation, ACSS is certifying a software update which will make various changes to the flight crew interface shown in Figures 2 and 3. These changes will be documented in a future version of this paper.

1.7. CAVS arrival operations do not require ATC involvement and can be performed at any airport. On the other hand, CAS-A and I-IM operations are limited to airspace where controllers have an indication of which aircraft are equipped. For I-IM, controllers must also have a method to assign proper spacing goals.

2. DISCUSSION

2.1 Avionics certification for SafeRoute on the TCAS-3000SP is complete and the final installation in an AAL A321ceo aircraft was completed in January 2024. Avionics development for SafeRoute functionality hosted on the T3CAS was completed and installed in all AAL A321neo aircraft. As of 15-January-2024, all 288 AAL A321 aircraft have been equipped.

2.2 AAL received FAA operational approval to conduct CAVS operations in May 2021, and initial benefits analyses for KDFW arrivals during the period March 2023 to September 2023 are shown in Figure 4 and Figure 5. In this figure, Inter-arrival Time (IAT) is the time between when the CAVS aircraft crosses the runway threshold and when the previous arrival crossed the same runway's threshold. Threshold Spacing is the distance between the CAVS aircraft and the previous arrival when the previous arrival crossed the runway threshold. The Designated Target line shows when flight crews were performing CAVS1; the other line shows when flight crews were not performing CAVS. To provide a fair comparison, this analysis considered only Airbus A321 aircraft (A321, A21N) arriving at KDFW, from all airlines. The analysis excludes arrivals with IATs > 220 seconds or < 40 seconds, excludes any arrivals behind a Heavy (as wake vortex rules require a larger following distance), and arrivals when the airport is IMC (<1000 feet ceiling OR <3 miles visibility). The results indicate that the Mean IAT is smaller by an average of 13 seconds for aircraft performing CAVS compared to other aircraft, and that the Mean Threshold Spacing is

[1] This was defined as aircraft that Designated a Target between 25 NM from the airport and the arrival runway

smaller by an average of 0.6 NM for aircraft performing CAVS compared to other aircraft. In addition, the results show that flight crews using the CAVS avionics achieve more consistent interarrival distances at the runway threshold (lower standard deviation values). Similar results for CAVS have been observed at other major U.S. airports with significant AAL A321/A21N traffic (KCLT, KPHL, KPHX, KLAX, and KMIA).

Regression Results

Factors that impact IAT	Impact (NM)	Interpretation
Baseline IAT	5.59	A321 behind large at low demand
Arrivals in past 15 min airport	-0.06	Spacing decreases as demand increases
Behind a Heavy	1.74	Spacing increases when behind heavy
Designating Traffic (includes CAS-A)	**-0.58**	Designating Traffic arrivals reduce the spacing
CAS-A	Not significant	No additional impact beyond Designating

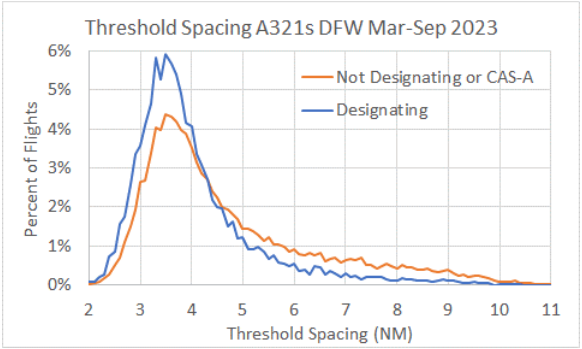


Figure 4 – CAVS threshold spacing results in NM from March 2023 to September 2023 for KDFW arrivals

Regression Results

Factors that impact IAT	Impact (seconds)	Interpretation
Baseline IAT	134.9	A321 behind large at low demand
Arrivals in past 15 min airport	-1.4	IAT decreases as demand increases
Behind a Heavy	39.2	IAT increases when behind heavy
Designating Traffic (includes CAS-A)	**-12.7**	Designating Traffic arrivals reduce the IAT
CAS-A	Not significant	No additional impact beyond Designating

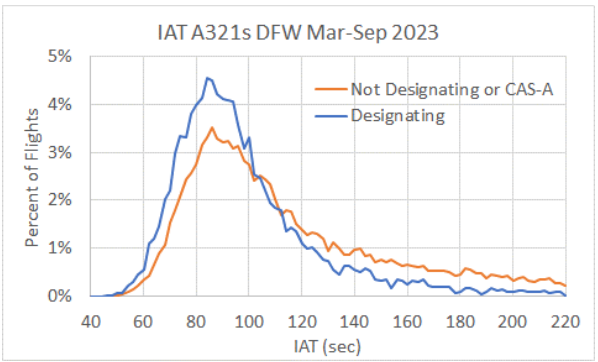


Figure 5 – CAVS threshold spacing results in seconds from March 2023 to September 2023 for KDFW arrivals

2.3 AAL received FAA operational approval to conduct I-IM operations in October 2022 and I-IM operations began in ZAB airspace on 7-Nov-2022. During the period from 7 November 2022 to 6

November 2023, I-IM operations were occurring for westbound arrivals through Albuquerque Air Route Traffic Control Center (ZAB) to Phoenix Terminal Radar Approach Control (P50) airspace, with I-IM clearances issued by ZAB controllers prior to the top of descent and terminated at or prior to the P50 boundary. Figure 6 shows an example I-IM operation on the EAGUL arrival to KPHX. Figure 7 shows an example I-IM operation on the PINNG arrival to KPHX. For arrival operations, ZAB controllers have used miles-based or time-based ASG's. I-IM operations were also occurring for aircraft overflying through ZAB airspace to other locations in the U.S., such as Los Angeles, Dallas, and Las Vegas. For such operations, ZAB controllers used miles-based ASGs (typically to achieve the Miles-In-Trail restriction at the ZAB boundary with an adjacent Center). Figure 8 shows an example I-IM operation on one of these "overflight" operations. The controllers do not have any special ground automation support for this operational evaluation; alternative methods are provided to inform controllers which aircraft have I-IM capability and what spacing goals should be assigned to the aircraft. Over 589 I-IM clearances were issued in ZAB's airspace as part of the first year of the trial.

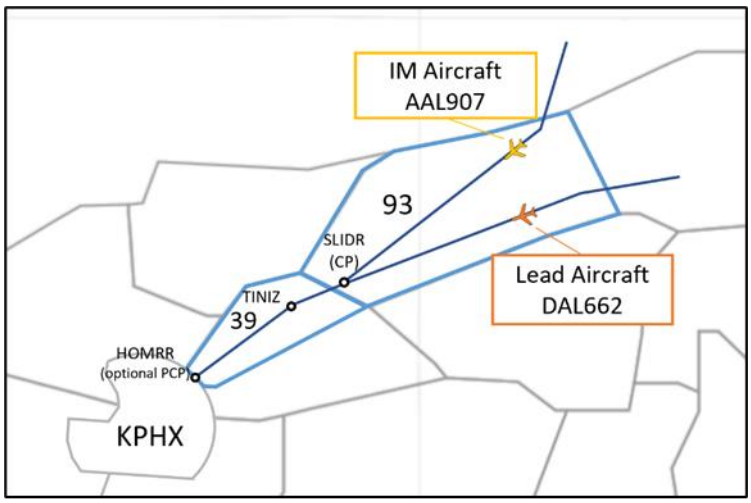


Figure 6 – I-IM operation on the EAGUL arrival to KPHX (terminates at or before HOMRR)

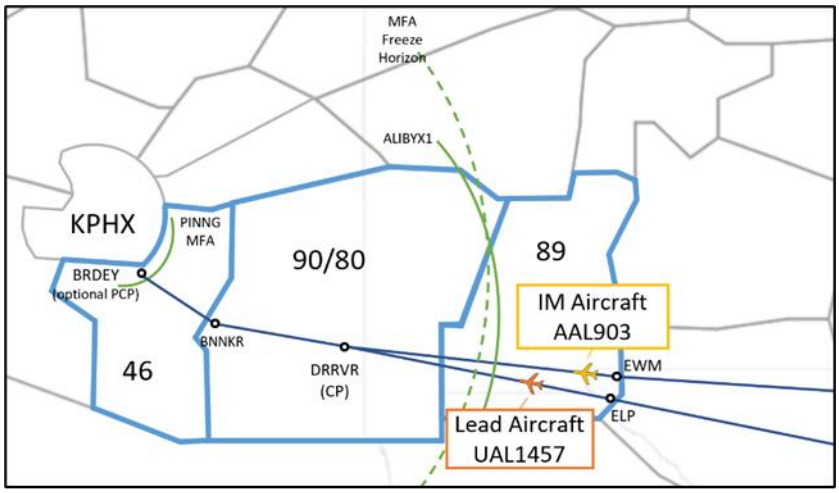


Figure 7 – I-IM operation on the PINNG arrival to KPHX (terminates at or before BRDEY)

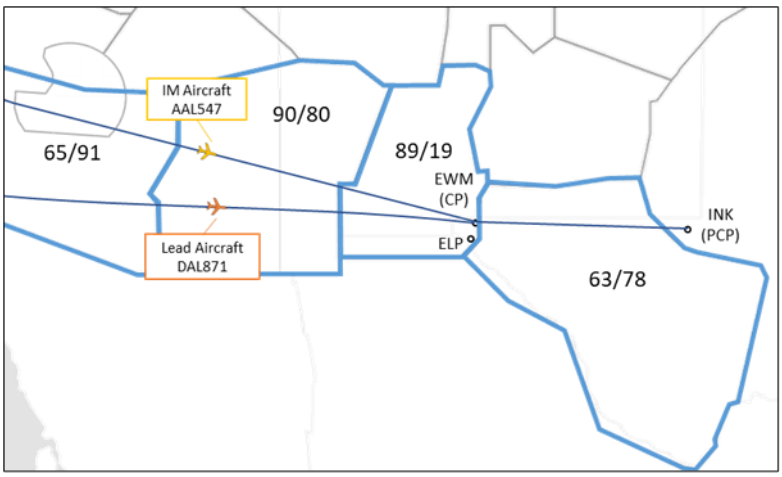
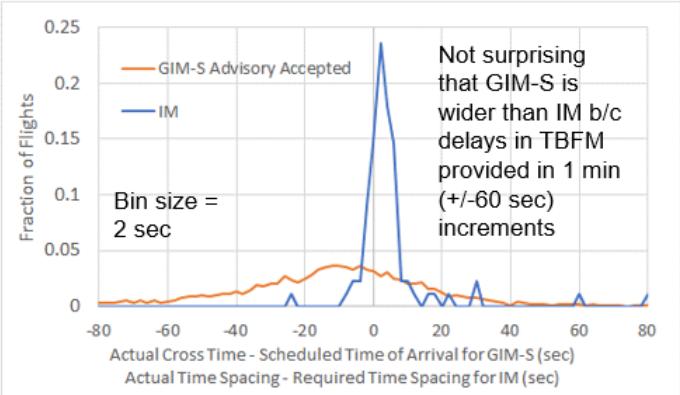


Figure 8 – I-IM operation on an "overflight" operation

2.4 A comparison of delivery accuracy using FAA's time-based arrival management automation (Time-Based Flow Management, TBFM) and I-IM operations from November 2022 – October 2023 (full year of data) is shown in Figure 9. The blue line shows the fraction of I-IM flights which achieved the indicated error in the Assigned Spacing Goal at the Achieve By Point (ABP), while the orange line shows the fraction of non-I-IM flights which achieved the indicated error from the Scheduled Time of Arrival at the arrival fix. "GIM-S" is the term used within the FAA to describe a set of features within TBFM, including controller speed advisories to assist controllers in spacing traffic over arrival fixes at the scheduled times. Of major note is the significant improvement in delivery accuracy that I-IM operations have thus far achieved.



		Actual Time Spacing – Required Time Spacing (sec)		Actual Cross Time – Scheduled Time of Arrival (ATA-STA)	
Operation	Observations	Average	StdDev	Average	StdDev
IM (Time-based)	89	4	12		
GIM-S	4266			-16	45

Figure 9 – Preliminary comparison of ground-based automation and I-IM delivery accuracy

2.5 FAA decided to extend the ZAB operational evaluation for approximately another year. Since 7 November 2023, I-IM operations are only occurring in the ZAB airspace shown in Figure 6. This airspace is where over one-half of the first year I-IM operations occurred. A total of 690 operations have taken place from 7-Nov-2023 to 16-Apr-2024.

2.6 AAL received FAA operational approval to conduct CAS-A operations in October 2022 and CAS-A operations commenced on 1-Mar-2023 for CAVS-capable AAL A321 aircraft arriving at the KDFW airport. The arrival/approach controllers do not have any special ground automation support for this operational evaluation; alternative methods are provided to inform controllers which aircraft are capable of performing CAS-A and to communicate among the controllers regarding which aircraft are performing CAS-A. 2,305 CAS-A operations have been conducted for KDFW arrivals as of 17-Apr-2024.

2.7 Initial benefits analyses for the CAS-A operational trial have shown similar IAT improvements as shown above in Figure 4 and Figure 5 for aircraft performing CAS-A operations (Mean IAT smaller by 13-20 seconds for aircraft performing CAS-A compared to other aircraft, and that the Mean Threshold Spacing is smaller by 0.6-0.8 NM for aircraft performing CAS-A compared to other aircraft). In addition, the results show that flight crews using the CAVS avionics during CAS-A operations achieve more consistent interarrival distances at the runway threshold (lower standard deviation values).

2.8 Additionally, D10 controllers have reported using CAS-A to reduce arrival flight paths during certain conditions. Therefore, arrival flight paths to KDFW during the period from the beginning of March 2023 through the end of November 2023 were examined. Figure 10 shows a representative set of arrival/approach flight paths to KDFW when the airport is in "south flow" – the black ring is approximately 25 NM from the centre of the airport. The analysis measured both flight distance and flight time for all aircraft arriving at KDFW during the analysis timeframe. For analysis purposes, various weather conditions were defined as shown in Figure 11; the numbers and percentages shown are for the period from 1 March 2023 to 31 November 2023.

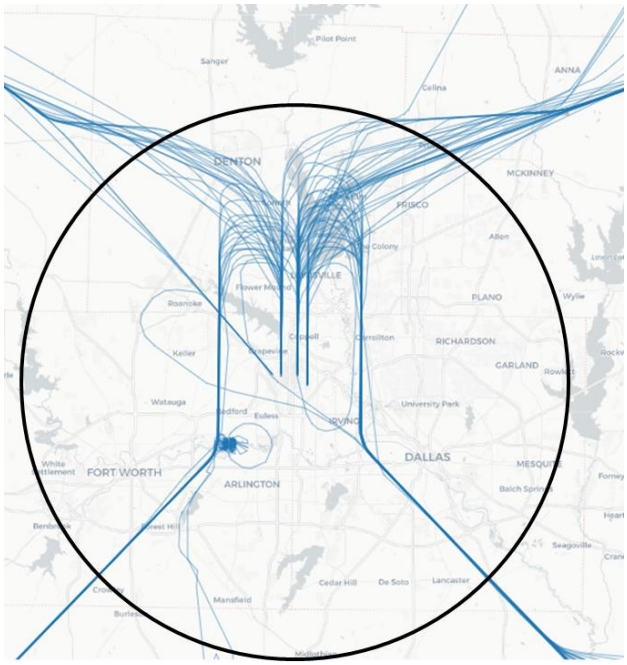


Figure 10 – Example arrival/approach flight paths to KDFW, south flow

Weather Condition	Arrivals	% of Arrivals
IMC	3,524	2%
MMC1	13,869	8%
MMC2	11,595	6%
VMC	150,021	84%
Total	179,009	

There were no instances of IMC, MMC1, or MMC2 recorded in August 2023

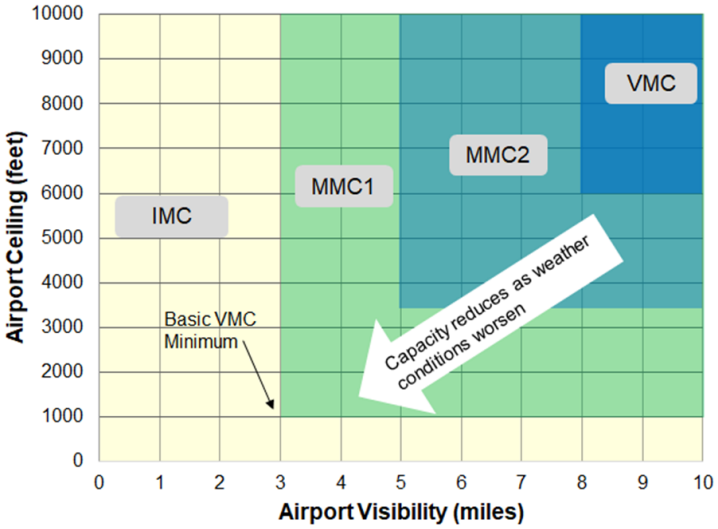


Figure 11 – Weather conditions defined for CAS-A analysis

2.9 Preliminary analysis results under the weather conditions shown in Figure 11 indicate that for each arrival, there was a flight distance reduction of 0.6 NM for every CAS-A arrival ahead of a given aircraft in the past 15 minutes during MMC2, and a flight distance reduction of 0.3 NM for every CAS-A arrival ahead of a given aircraft in the past 15 minutes in all other weather conditions. Additionally, any aircraft performing CAS-A and flying a downwind segment to final will have a flight distance reduction of 0.7 NM. FAA will continue to gather and analyse further data to better understand this CAS-A benefit mechanism.

3. ACTION BY THE MEETING

The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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