NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing
US Army PAT25, Sikorsky UH-60L and
PSA Airlines flight 5342
MHI RJ Aviation CL-600-2C10 (CRJ700), N709PS
Midair Collision in Washington, DC
January 29, 2025

Docket No.	SA-544
EXHIBIT	
2-AIR-Q	

Improving Aviation Safety Through Technology

(6 Pages)

NTSB Investigation No. **DCA25MA108**

Improving Aviation Safety Through Technology

Throughout the history of aviation, the deployment of advanced technology solutions has often significantly reduced, and at times eliminated entire categories of aircraft accidents. Examples include the deployment of live doppler weather radar to address wind-shear accidents and the introduction of enhanced ground proximity warning systems to address controlled flight into terrain accidents.

In the case of collision avoidance systems, mid-air collisions for commercial airliners in the enroute environment have been eliminated by the introduction of the Traffic Alert and Collision Avoidance System (TCAS). However, due to limitations in the quality of data used by TCAS, the same is not the case for operations near airports where aircraft are inherently closer to each other. The advent of ADS-B and the resulting availability of high-quality position and velocity data provides the opportunity to close this remaining gap. Collision alerting systems that take advantage of this improved data exist and provide a low-cost opportunity to dramatically improve aviation safety.

Layers of Conflict Management

To keep aircraft apart, the FAA employs the internationally standardized framework of Three Layers of Conflict Management: Strategic Conflict Management (airspace structure/route design), Separation Provision (Air Traffic Control), and Collision Avoidance (airborne warning systems).[1] Mid-air collisions occur only when all three layers fail, as happened in three recent incidents: the collision between an Army helicopter and a commercial aircraft in Washington, DC (Jan 2025), the collision of a firefighting aircraft with a drone in Los Angeles (Jan 2025), and the GA aircraft collision in Arizona (Feb 2025).

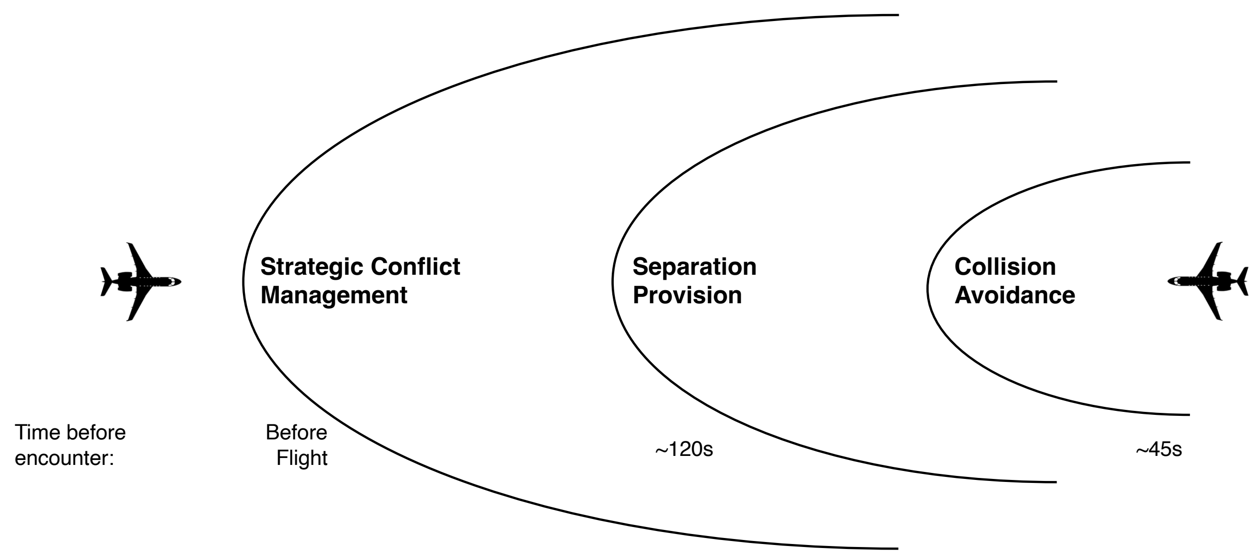

Figure 1: Layers of Conflict Management – defined in ICAO Document 9854

[1] ICAO Document 9854: Global Air Traffic Management Operational Concept

Increasingly crowded skies have started to reveal vulnerabilities in this three-layer approach. This document discusses existing technologies that would prevent further accidents, strengthen the existing safety framework, and simultaneously improve the efficiency and access to our national airspace.

ADS-B Addresses Limitations in Legacy Collision Avoidance Systems

Army helicopter PAT25 was flying Route 4 – a low altitude corridor limited to 200ft above ground level (AGL) while PSA flight 5243 was on approach to runway 33 at Washington Reagan's DCA airport. Those two paths are intended to be strategically deconflicted – the first layer of conflict management – through airspace and route design. In the case of Route 4 and the approach path to runway 33 at DCA this separation was inadequate: The distance between the flight paths was less than the vertical separation tolerances of the altimeter systems used, creating a situation where even compliant aircraft could unknowingly encounter each other.

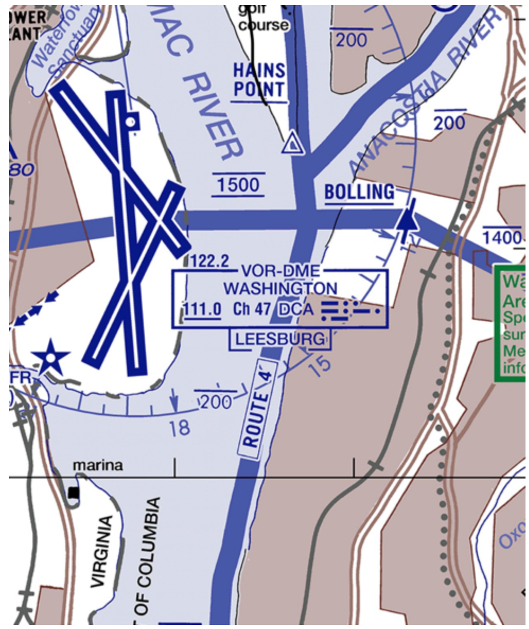

Figure 2: DCA, Route 1 and Route 4

Additionally, at low altitudes, legacy collision avoidance systems (layer three) have inherent limitations: when originally introduced in the late 80s, the industry standard Traffic Alert and Collision Avoidance System (TCAS II) was unable to differentiate between ground and airborne aircraft, resulting in nuisance alerts being issued against aircraft on taxiways or parked at the gate. To address this, Resolution Advisories ("Climb, Climb!") are automatically inhibited below 1,000ft and aural Traffic Advisories ("Traffic, Traffic!") below 500ft AGL. The net result is that exactly around an airport where airspace and route design inherently bring aircraft closer to each other, TCAS II provides lower levels of support, driving a need for increased vigilance by the flight crew and Air Traffic Control (ATC).

Modern aircraft, however, continuously broadcast air/ground status via ADS-B messages. Equipping aircraft with ADS-B receivers improves the visualization of nearby traffic in the cockpit and provides a high-precision data source to onboard collision avoidance systems. While cost-effective retrofit solutions for ADS-B receivers exist, current regulations do not require their adoption, leaving a critical gap in situational awareness for many aircraft. Further, discussed below, collision avoidance systems that could then take advantage of this high-quality data also exist and have led to a significant reduction in mid-air collision risk for equipped aircraft.

Beyond the safety benefits, the FAA estimates that equipping commercial airliners with ADS-B receivers would provide up to $1.8B per year in cumulative benefits from operational improvements, of which over $500M would benefit airlines directly through a reduction in fuel burn and other aircraft operating costs.[2] Concurrently, increasing onboard capabilities in

[2] https://www.faa.gov/sites/faa.gov/files/air_traffic/technology/adsb/quicklinks/ADS-B_In_Strategy.pdf

commercial aircraft enables air traffic modernization more broadly by transitioning air traffic management functions away from ageing ground systems. While the safety benefit alone justifies equipping with ADS-B receivers, these public and economic benefits would more than offset the costs associated with equipping the entire US fleet.

Broad Adoption of ADS-B Out to Improve Situation Awareness

Figure 3: Left leading edge of SuperScooper after the collision with a drone. Credit: CNN

The capability to receive ADS-B messages is only valuable when other aircraft broadcast ADS-B messages ("ADS-B Out"). SuperScooper Quebec 1 was fighting the historic fires in Los Angeles on January 10th, 2025, when it collided with a small Uncrewed Aircraft System (sUAS), or drone. The drone punctured the leading edge of the wing, lodged itself into the structure of the aircraft, grounding the aircraft during a critical emergency response. The drone operation was in violation of a Temporary Flight Restriction (an example of layer 1) issued by the FAA over LA and occurred out of sight of the operator – a further violation of federal regulations. With the failure in layer 1, layers two and three now relied solely on the SuperScooper pilot's ability to visually pick out the drone against the urban clutter backdrop – something that is nearly impossible as any pilot will tell you.

ADS-B Out on sUAS – or any other aircraft – would have announced its presence to *all* participants in the firefighting activities, allowing for air traffic control and pilots to separate larger aircraft from the drone. Known as Separation Provision, the second layer of conflict management adjusts aircraft trajectories about two minutes in advance to avoid an encounter: Air Traffic Control giving direction to pilots, or, where ATC is not available, a pilot making operational decisions to remain Well Clear (14 CFR § 91.113 (b)).[3] ADS-B makes aircraft visible to ATC and other aircraft in the vicinity, triggering layers two and three to provide significantly improved safety for all participants in the airspace.

While ADS-B Out is currently required in large volumes of airspace such as above 10,000ft and around large airports, many areas remain where aircraft can legally operate without broadcasting ADS-B messages. Additionally, federal exemptions allow certain operations (e.g., military, national security) to be conducted with ADS-B Out switched off, others to not equip at all (e.g., aircraft without an electrical system), and prohibit some from equipping altogether

[3] The responsibility to apply this layer can be transferred between ATC and pilot. The interaction between ATC and PAT25 to "request visual separation" was a transfer of who was responsible for applying this layer of conflict management. Once approved, ATC is relieved of the legal responsibility to provide separation services and the pilot takes on that responsibility.

(e.g., sUAS). As a result, even in airspace where ADS-B Out is otherwise required, aircraft with ADS-B receivers may still unknowingly encounter other, untrackable aircraft.

As discussed above, the ability to reliably provide collision alerting in low altitude airspace where mid-air collisions are most common requires aircraft to broadcast high-precision data via ADS-B. Here, too, low-cost equipment and policy solutions exist (e.g. the FAA's existing Traffic Awareness Beacon System (TABS) policy) that address the concerns often cited to justify these exemptions, and would allow the remaining gap in aircraft equipage to be closed in the near term.

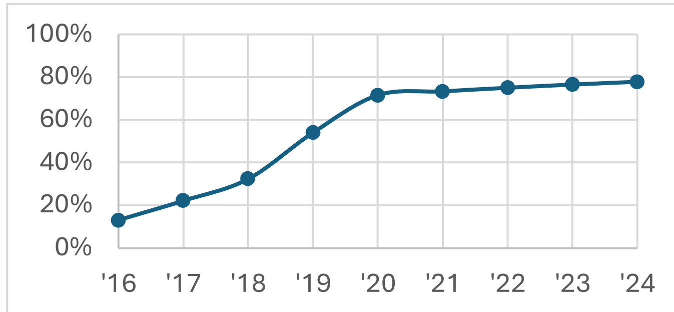

Figure 4: ADS-B Out Equipage in the US. Source: FAA

Taking Advantage of 21st Century Precision to Avoid Collisions

While pilots bear the responsibility to avoid collisions with other aircraft as outlined in various regulations, including 14 CFR Part 91 §91.3, §91.111, §91.113, collision avoidance systems provide crucial support in this task and have significantly improved the safety of the flying public since their introduction. Such systems, together with pilots visually scanning the surroundings, make up the last layer of defense in the conflict management framework.

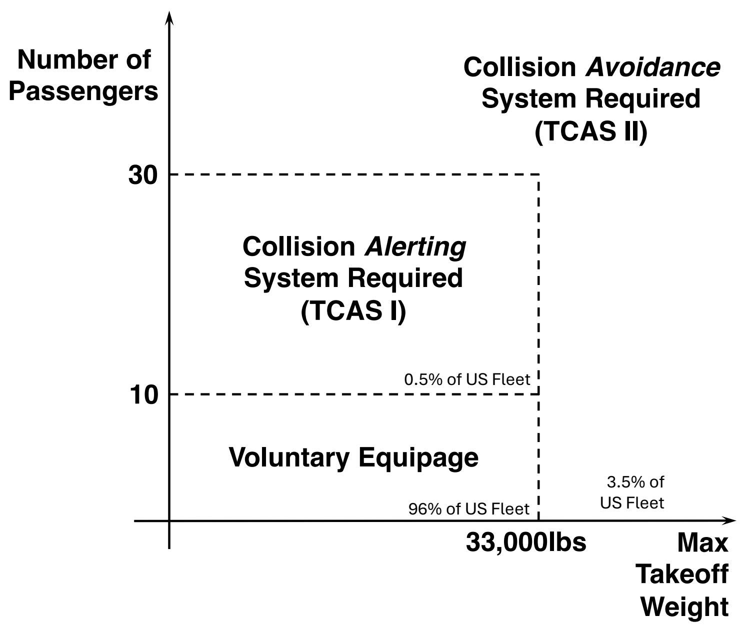

Figure 5: TCAS I and TCAS II Equipage Requirements; 14 CFR §121.356

The task of visually acquiring other aircraft is difficult, as has been documented in many scientific studies.[4] To support the pilot in this task, systems like TCAS I (alerts the pilot to the presence of other aircraft) and TCAS II (alerts *and directs* the pilot on how to avoid the collision) are required on aircraft with more than 10 passengers or heavier than 33,000lbs. TCAS I & II were first introduced by a 1987 congressional mandate and have significant limitations: inability to determine ground/air status, poor horizontal position accuracy (thus limiting

[4] For example, MIT Lincoln Laboratory: https://archive.ll.mit.edu/mission/aviation/publications/publication-files/atc-reports/Andrews_1991_ATC-152_WW-15318.pdf

avoidance commands to only vertical maneuvers), and pilot desensitization due to excessive nuisance alerting in busy environments.

Through exemplary collaborative efforts between the FAA and industry, two replacement systems have been introduced: ATAS and ACAS X. The FAA funded MIT and Avidyne to develop an ADS-B based Traffic Alerting System (ATAS) for the low altitude, high density operational environment where TCAS I & II performance is limited. A study of historic mid-air collisions identified that they most often occur in the airport pattern, in some cases very close to the ground, exactly where existing alerting systems are either turned off automatically or are plagued by high rates of nuisance alerts.[5] Given the focus on this low-altitude, high-workload operational environment, a key design objective was to avoid unnecessary alerts, to ensure flight crews would not ignore alerts when one is issued. The system was validated with extensive human factors studies, internationally harmonized, certified and fielded in 2014.[6] The global install base is in the tens of thousands, with no known mid-air collision involving an equipped aircraft to date. A preliminary analysis of the DCA flight tracks showed that ATAS would have provided an alert in time to avoid the DCA accident.

While General Aviation has adopted this technology and ADS-B more generally, commercial airliners often lack either the ability to receive ADS-B messages altogether or are not equipped with the ATAS algorithm and continue to use TCAS with its known limitations. Sadly, this is consistent with a broader trend in aviation: The accommodation of legacy systems while better solutions are available, reducing the safety of the air transportation system as a whole. ADS-B with ATAS on commercial airliners is a low-cost, near-term solution to provide significantly improved mid-air collision protection to the flying public exactly where TCAS II is ineffective.

Similarly, ACAS X is a family of algorithms that replaces TCAS II altogether across multiple segments of aviation, including aircraft without an onboard pilot. Where ATAS provides a traffic alert to the pilot, ACAS X also provides a directive command for resolving the conflict. The ACAS X program has completed the technical development of multiple variants of the algorithm, expanding avoidance commands to altitudes below 300ft above ground. What remains is the completion of the industry consensus standard and an In-Field Evaluation to transition this critical system from development to broad adoption over the next two to three years.

Improving Aviation Safety Through Technology

Practical and deployable 21st century technologies are available to significantly upgrade the three-layered approach to aviation safety that has served us so well over the years. Some of the solutions identified here have been standing recommendations from the NTSB for years.

ADS-B deployment has demonstrated significant safety benefits, but gaps remain. The highlighted events demonstrate that expanded use of ADS-B – along with ATAS and ACAS X – provides an exceptional opportunity for improved safety and other operational improvements as the FAA embarks on is national airspace modernization efforts.

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[5] https://dspace.mit.edu/bitstream/handle/1721.1/81821/Hansman_Mid-air%20collision.pdf

[6] The full system design, including the collision algorithm can be found here: https://dspace.mit.edu/handle/1721.1/87479