

REDUCING THE IMPACT OF TURBULENCE



MITRE's vision is for a radical improvement in the safety of flight in the presence of increasing turbulence.

A Turbulent Situation

The National Transportation Research Board (NTSB) has identified turbulence as the leading cause of serious injury in commercial aviation—and turbulence is becoming more frequent.

While some forms of turbulence can be forecasted and visually identified, there are no technologies to detect clear air turbulence and upgrowth convectively induced turbulence (U-CIT). This means aircraft can encounter turbulence without warning.

Once turbulence is reported in an area, pilots may be unwilling to fly through the affected area for an extended period, even if the turbulence has since dissipated. This leads to inefficiency and additional costs.

As part of MITRE's Independent Research and Development (IR&D) program, a multidisciplinary team has approached this challenge from two directions: by developing an onboard system to give pilots advance warning that turbulence is ahead and through the novel use of weather satellite data to deliver real-time alerts of potential U-CIT™ nationwide.



With the increase in clear air turbulence, the ability to detect clear air turbulence and U-CIT is transformative. By giving pilots enough advance warning of clear air turbulence in their flight path, it will enable them to either avoid the area altogether or secure the cabin in advance of the encounter, protecting passengers and cabin crew.

Ted Thrasher, MITRE Senior Principal Aviation Systems Engineer & Principal Investigator



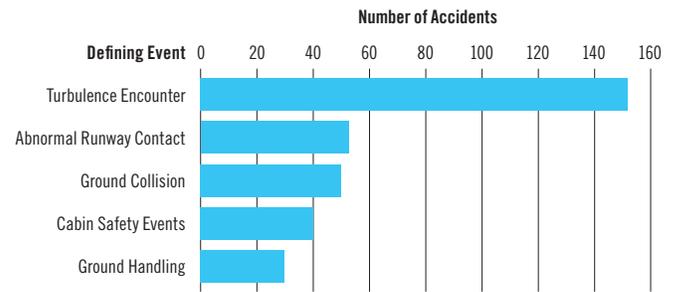
Both approaches allow time to ensure everyone is wearing their seatbelt and possibly avoid the turbulence. MITRE is now collaborating with experts and a variety of stakeholders to ensure the concepts are operationally relevant and scalable.

Solving for Safety

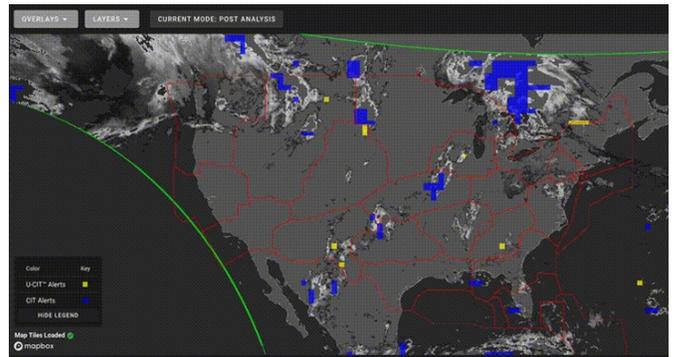
Aircraft Laser Remote Detection: MITRE’s proposed onboard system is analogous to the onboard radar used by pilots today to identify thunderstorms along their route—except this system is designed to detect turbulence. The concept uses a pulsed laser combined with specialized detectors and a novel sensing mechanism that aims to provide a 2 to 5-minute warning that turbulence is ahead. MITRE’s modeling and simulation have demonstrated the potential of this technique to detect clear air turbulence at distances exceeding 16 nautical miles (roughly 2 minutes flying time at cruise altitude). Indoor laboratory experiments have validated laser wavelength and power assumptions. The team is now preparing for outdoor, “real-world” testing of the prototype system.

Satellite Detection and Alerting of U-CIT: U-CIT turbulence encounters are the result of aircraft unknowingly flying over areas of rapid convective initiation prior to it becoming a mature thunderstorm. MITRE’s approach builds on research by National Aeronautics and Space Administration, academia, and industry to make the most of the 16 spectral bands collected by the National Oceanic and Atmospheric Administration Geostationary Operational Environmental Satellite (GOES)-19 that became operational in 2025 to provide nationwide U-CIT updates every five minutes. The GOES-19 satellite’s rapid refresh imaging captures critical rates of change associated with rapidly developing convection, particularly at stages when potentially impactful cumulus clouds are forming beneath unsuspecting flights at cruise altitudes. Detection of these features are validated against observed turbulence encounters and ground based remotely sensed convection. This algorithm can generate nationwide, near real-time U-CIT™ alerts every five minutes.

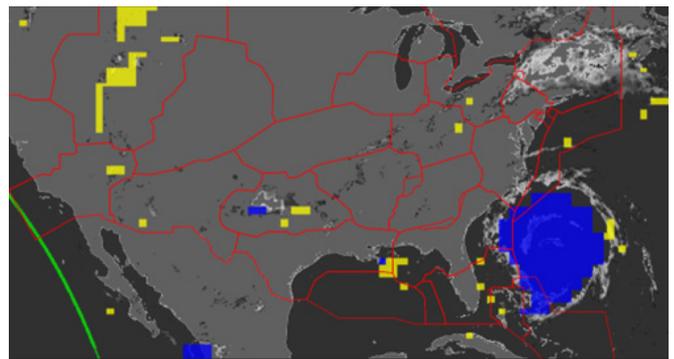
Testing and Implementation: MITRE is finalizing development of its prototype onboard detection system. Initial outdoor testing is planned for 2026, followed by flight testing in 2027. Additionally, MITRE has filed for a provisional patent for the onboard system. In parallel, MITRE is collaborating with stakeholders to make prototype U-CIT™ alerts available for evaluation and feedback. Both technologies show significant promise and aim to make injuries from unexpected turbulence encounters a hazard of the past.



NTSB Part 121 Top Five Accident Defining Events 2003-2023



U-CIT™ alert prototype user interface identifying level 1 (blue) alerts where mature storms are visible and likely to have turbulence and level 2 (yellow) alerts are where new rapid storms, not visible, may develop and result in severe turbulence.



U-CIT™ alerts during Hurricane Erin on 19 August 2025. Blue alerts are defined as active convection where flights should be able to visually identify the storms and expect turbulence. Yellow alerts are U-CIT™ alerts where immature clouds might be rapidly developing into storms but are not visually identifiable yet.

MITRE’s Independent Research and Development (IR&D) program invests in projects that address the critical problems and priorities of government sponsors through applied research that reflects our sponsors’ near-, mid-, and far-term research needs.

Through our public-private partnerships and federally funded R&D centers, we work across government and in partnership with industry to tackle challenges to the safety, stability, and well-being of our nation.

