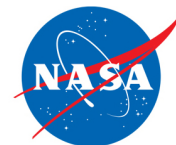


National Aeronautics and
Space Administration



TECHNOLOGY SOLUTION

Information Technology and Software

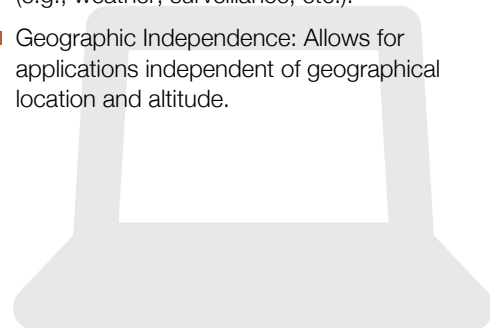
Near-Real Time Verification and Validation of Autonomous Flight Operations

Universally applicable process for standardized data collection
and auditing from autonomous systems

Autonomous systems necessitates timely technological audits to evaluate their performance, conformance, and compliance. For the aviation industry, such a need has already been recognized by the Federal Aviation Administration (FAA) for the vehicles, sensors, and systems participating in Extensible Traffic Management (xTM) systems. xTM systems include the Unmanned Aircraft Systems (UAS) Traffic Management (UTM), Advanced Air Mobility (AAM), and Upper-Class E Traffic Management, and are complementary to the Air Traffic Management (ATM) system. xTM systems enable new entrants such as UAS and AAM vehicles to safely participate in the national airspace. To facilitate timely technological audits of the xTM participants, NASA Ames developed a novel technology that provides near-real-time verification and validation of autonomous flight operations of an individual vehicle or numerous diverse vehicles being managed by the xTM systems.

BENEFITS

- **Universal Applicability:** A modular process enables a standardized, digital, data driven audit and oversight from automated or autonomous systems.
- **Successful Flight Testing:** Functions and features of this process were successfully developed, and flight tested by NASA Ames Research Center using thousands of live and simulated small UAS operations.
- **Total Data Verification and Validation:** This process allows for total data verification and validation as opposed to sample data testing, enabling accurate and holistic reporting.
- **Fraud Detection:** This process enables automated and/or human-in-the-loop detection and prevention of system fraud, wastage, or abuse such as identification of unnecessary reservation of excess airspace for UTM flight operations, etc.
- **Platform Agnostic:** Applicable to all types of UAS and AAM platforms, autonomous systems, their Ground Control Systems, sensors, and other data or service providers (e.g., weather, surveillance, etc.).
- **Geographic Independence:** Allows for applications independent of geographical location and altitude.



THE TECHNOLOGY

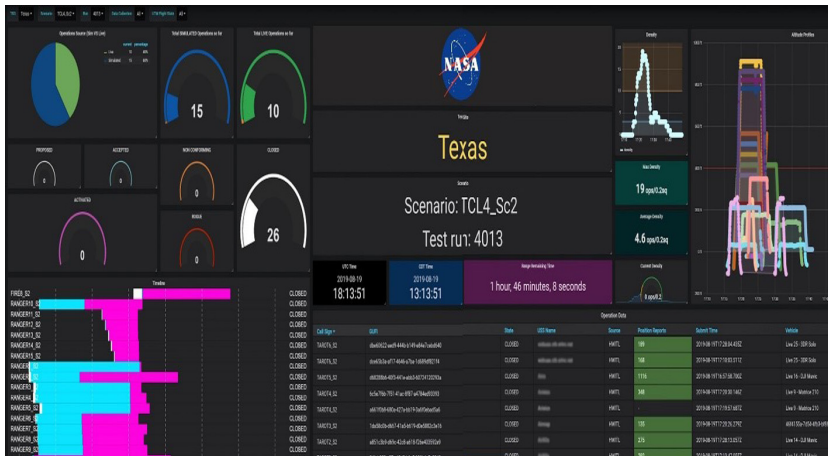
NASA's Extensible Traffic Management (xTM) system allows for distributed management of the airspace where disparate entities collaborate to maintain a safe and accessible environment. This digital ecosystem relies on a common data generation and transfer framework enabled by well-defined data collection requirements, algorithms, protocols, and Application Programming Interfaces (APIs). The key components in this new paradigm are:

Data Standardization: Defines the list of data attributes/variables that are required to inform and safely perform the intended missions and operations.

Automated Real Time And/or Post-Flight Data Verification Process: Verifies system criteria, specifications, and data quality requirements using predefined, rule-based, or human-in-the-loop verification.

Autonomous Evolving Real Time And/or Post-Flight Data Validation Process: Validates data integrity, quantity, and quality for audit, oversight, and optimization.

The verification and validation process determines whether an operation's performance, conformance, and compliance are within known variation. The technology can verify thousands of flight operations in near-real time or post flight in the span of a few minutes, depending on networking and computing capacity. In contrast, manual processing would have required hours, if not days, for a team of 2-3 experts to review an individual flight.



An illustration of a dashboard showcasing near-real time verification and validation of small UAS flight operations according to an embodiment of the invention.

APPLICATIONS

The technology has several potential applications:

- UAS industry
- UTM service suppliers
- Autonomous cars and trucks
- Autonomous ships and submarines
- Autonomous robots
- Autonomous manufacturing facility
- Large fleets of autonomous vehicles
- Automotive industry
- Aviation industry
- Technology industry
- Air and space traffic management systems
- Wildland Fire Management
- Internet-of-Things (IoT)
- Edge computing
- Space systems (including systems for transportation, communication, sensing, navigation and timing, manipulation, resource utilization and information and data processing)

PUBLICATIONS

Patent Pending

<https://ntrs.nasa.gov/search?q=UAS%20Traffic%20Management>

<https://nari.arc.nasa.gov/events/utm2021tim/>

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