Airspace Technology Demonstration 3 (ATD-3)

Dynamic Routes for Arrivals in Weather (DRAW)

Technology Transfer Document Summary

Version 1.0

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Revision History

Rev	Date	Sections Affected	Description of Change	Author
1.0	06/22/2018	All	Initial version	DIsaacson ABiederman EWang

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Introduction

Airspace Technology Demonstration – 3 (ATD-3) is part of NASA's Airspace Operations and Safety Program (AOSP) – specifically, its Airspace Technology Demonstrations (ATD) Project. ATD-3 is a multi-year research and development effort which proposes to develop and demonstrate automation technologies and operating concepts that enable air navigation service providers and airspace users to continuously assess weather, winds, traffic, and other information to identify, evaluate, and implement workable opportunities for flight plan route corrections that can result in significant flight time and fuel savings in en route airspace. In order to ensure that the products of this tech-transfer are relevant and useful, NASA has created strong partnerships with the FAA and key industry stakeholders.

This summary document and accompanying technology artifacts satisfy the third of three Research Transition Products (RTPs) defined in the Applied Traffic Flow Management (ATFM) Research Transition Team (RTT) Plan. This transfer consists of NASA's Dynamic Routes for Arrivals in Weather (DRAW) – Arrival Metering Operations. This research enables continued use of arrival metering operations while efficiently rerouting traffic in weather.

DRAW is a trajectory-based system that combines the legacy Dynamic Weather Routes (DWR) weather avoidance technology with an arrival-specific rerouting algorithm and arrival scheduler to improve traffic flows on weather-impacted arrival routes into major airports. First, DRAW identifies flights that could be rerouted to more efficient Standard Arrival Routes (STARs) that may have previously been impacted by weather. Second, when weather is impacting the standard arrival routing, DRAW proposes simple arrival route corrections that enable aircraft to stay on their flight plan while avoiding weather. The DRAW system proposes reroutes early enough to allow Time Based Flow Management (TBFM) to make the necessary schedule adjustments. As a result, metering operations can be sustained more consistently in the presence of weather because the arrival schedule accounts for the dynamic routing intent of arrival flights to deviate around weather.

1) Public Outreach Materials

This section contains high-level descriptions and multi-media products appropriate for the general public. Distribution outside of the U.S. Government is permitted without restrictions.

1.01. ATD-3 Fact Sheet (April 2017)

The ATD-3 factsheet describes NASA's concept for improving efficiency and throughput in the en-route and arrival phases of flight through the integration of ground- and flight-deck based technologies, including DRAW. The factsheet is publicly available on the NASA Ames Aviation System Division webpage: (http://www.aviationsystemsdivision.arc.nasa.gov/research/strategic/atd3.shtml).

1.02. ATD-3 Integrated Concept Animation V1.1 (May 2017) [External Link]

This animation illustrates the current operational challenge of convective weather and the goals of the ground and flight-deck tools that comprise the ATD-3 integrated concept. The 5-minute animation,

geared for technical audiences, is available for viewing at the NASA Ames Aviation System Division webpage: https://www.aviationsystems.arc.nasa.gov/research/strategic/atd3.shtml.

1.03. ATD-3 Integrated Concept Animation V1.2 (October 2017) [External Link]

This animation provides a high-level overview of the ATD-3 integrated concept. The 2-minute animation for broader audiences is available for viewing at the NASA Ames Aviation System Division webpage: https://www.aviationsystems.arc.nasa.gov/research/strategic/atd3.shtml.

2) High-Level Documents

This section contains the high-level documents that describe the ATD-3 or DRAW Concept of Operations. Distribution outside of the U.S. Government is permitted without restrictions.

2.01. NASA/TM–2018–219930 ATD-3 Operational Concept for the Integration of ATD-3 Capabilities, V1.0 (KSheth, Jun 2018)

This document provides the concept of operations for the ATD-3 project, and describes how the integration of NASA-developed automation tools, both ground- and flight-deck-based, can reduce en-route delays by identifying amendments to inefficient or outdated constraint avoidance routes that improve aircraft efficiency and enable controllers to maintain arrival throughput in the presence of airspace constraints, e.g. convective weather.

2.02. DRAW Concept of Operations, V1.0 (DIsaacson, Jun 2018)

The purpose of this document is to provide the concept of operations for the DRAW project and describe how DRAW provides automated rerouting capabilities for Traffic Management Coordinators in response to inefficient or obsolete weather avoidance routes so that time-based metering may be maintained. This ConOps describes the essential conceptual and operational elements associated with DRAW operations that serve to inform development of solutions across many actors and interested parties involved in implementing DRAW.

2.03. ATD-3 Dynamic Routes for Arrivals in Weather (DRAW) Measures of Performance Specifications Document, V1.1 (MAmer, March 2018)

This document provides the DRAW System's Measures of Performance. The Measures of Performance described in this document explain which performance characteristics of DRAW were used in driving development forward and were considered crucial to DRAW's success. Each Measure is explained with a description, a threshold value, a goal value, the calculation method, and the data sources used in calculation. These specifications are used to assess the outcomes of each DRAW activity, including human-in-the-loop simulations and fast time simulations.

3) Technical Publications

This section describes DRAW at the technology level – including simulation or field trial results, algorithm descriptions, and data analyses. Distribution outside of the U.S. Government is permitted without restrictions.

3.01. Laboratory Evaluation of Dynamic Routing of Air Traffic in En Route Arrival Metering Environment (DIsaacson, Aviation2018)

The purpose of this document is to formally present the experimental setup, methodology, results, and conclusions of the DRAW HITL #2 simulation evaluation, conducted in October 2017 at NASA Ames Research Center.

4) Dynamic Routes for Arrivals in Weather Technology Artifacts

This section contains the DRAW functional requirements and internal documentation related to development of the DRAW prototype implementation. Distribution outside of the U.S. Government is permitted without restrictions.

4.01. ATD-3 Dynamic Routes for Arrivals in Weather (DRAW) Systems Requirements Document, Phase 1 – Arrival Metering Operations, V1.3 (MAmer, March 2018)

This document provides the system requirements for the development of the DRAW Phase 1 simulation systems and products. The requirements provided in this document are maintained in NASA's ATD-3 CORE™ model-based systems engineering database. Each requirement includes a hierarchical number, permanent project unique identifier (PUID), requirement title, rationale, and verification method. It defines the system conditions and requirements to allow the capabilities to function properly to produce benefits.

5) Simulation and Evaluation Results

This section contains the in-depth summaries of DRAW human-in-the-loop simulations and evaluations.

5.01. Executive Summary: Dynamic Routes for Arrivals in Weather (DRAW) Human-in-the-Loop (HITL) Simulation #1 (CGong, June 2017)

The DRAW HITL #1 evaluation was conducted in the Air Traffic Control Laboratory at NASA Ames from 16-25 May 2017. The primary technical objective of DRAW HITL #1 was to obtain feedback on DRAW tool usage and concept of operations from traffic management and air traffic control subject matter experts (SME) for current single-scheduler, arrival metering operations. This document provides a brief summary of the HITL #1 outcome, preliminary results, and any anomalies presented during the experiment.

5.02. <u>ATD-3 Outbrief for Dynamic Routes for Arrivals in Weather (DRAW) Simulation Evaluation #1</u> (CGong, August 2017)

The DRAW HITL #1 evaluation was conducted in the Air Traffic Control Laboratory at NASA Ames from 16-25 May 2017. The purpose of this outbrief is to provide a detailed description of how the HITL was conducted as well as the results; it includes: the test outcome, analysis and results, Measures of Performance (MOP) results, and future development needs.

5.03. <u>DRAW HITL #1 Verification and Validation Report</u> (MAmer, July 2017)

The Dynamic Routes for Arrivals in Weather (DRAW) software verification of Airspace Technology Demonstration – 3 (ATD-3) requirements was completed for requirements selected per the ATD-3 Simulation Requirements Verification Matrix (RVM) and evaluated during DRAW HITL #1 Simulations. The verification of these requirements using the ATD-3 DRAW test procedures is documented in this report, which contains the results (PASS/FAIL) and supporting comments by the DRAW Systems Engineer.

5.04. <u>Executive Summary: Dynamic Routes for Arrivals in Weather (DRAW) Human-in-the-Loop (HITL) Simulation #2</u> (CGong, November 2017)

The DRAW HITL #2 evaluation was conducted in the Air Traffic Control Laboratory at NASA Ames over eleven days in October 2017. HITL #2 expanded the Traffic Management Coordinator (TMC)-focused HITL simulation capability from single to multiple arrival-corner-post operations. Improvements to the experiment design for HITL #2 allowed for more data points for analysis and additional SME feedback. This document provides a brief summary of the HITL #2 outcome, preliminary results, and any anomalies presented during the experiment.

5.05. <u>ATD-3 Outbrief for Dynamic Routes for Arrivals in Weather (DRAW) Simulation Evaluation #2</u> (CGong, January 2018)

The DRAW HITL #2 evaluation was conducted in the Air Traffic Control Laboratory at NASA Ames over eleven days in October 2017. The purpose of this outbrief is to provide a detailed description of how the HITL was conducted as well as the results; it includes: the test outcome, analysis and results, Measures of Performance (MOP) results, and future development needs.

5.06. <u>ATD-3 DRAW HITL #2 Verification and Validation Report</u> (MAmer, November 2017)

The Dynamic Routes for Arrivals in Weather (DRAW) software verification of Airspace Technology Demonstration – 3 (ATD-3) requirements was completed for requirements selected per the ATD-3 Simulation Requirements Verification Matrix (RVM) and evaluated during DRAW HITL #2 Simulations. The verification of these requirements using the ATD-3 DRAW test procedures is documented in this report, which contains the results (PASS/FAIL) and supporting comments by the DRAW Systems Engineer.

5.07. <u>Executive Summary: Dynamic Routes for Arrivals in Weather (DRAW) Human-in-the-Loop (HITL) Simulation #3</u> (DIsaacson, May 2018)

The DRAW HITL #3 evaluation was conducted in the Air Traffic Control Laboratory at NASA Ames over ten days in April and May 2018. HITL #3 expanded to a new airspace and assessed DRAW operations in a more realistic arrival metering environment. Improvements to the experiment design for HITL #3 allowed for more efficient data collection for analysis and additional SME feedback. This document provides a brief summary of the HITL #3 outcome, preliminary results, and any anomalies presented during the experiment.

5.08. <u>ATD-3 Outbrief for Dynamic Routes for Arrivals in Weather (DRAW) Simulation Evaluation #3</u> (DIsaacson, June 2018)

The DRAW HITL #3 evaluation was conducted in the Air Traffic Control Laboratory at NASA Ames over ten days in April and May 2018. The purpose of this outbrief is to provide a detailed description of how the HITL was conducted as well as the results; it includes: the test outcome, analysis and results, Measures of Performance (MOP) results, and future development needs.

5.09. <u>ATD-3 DRAW HITL #3 Verification and Validation Report </u>(ABiederman, June 2018)

The Dynamic Routes for Arrivals in Weather (DRAW) software verification of Airspace Technology Demonstration – 3 (ATD-3) requirements was completed for requirements selected per the ATD-3 Simulation Requirements Verification Matrix (RVM) and evaluated during DRAW HITL #3 Simulations. The verification of these requirements using the ATD-3 DRAW test procedures is documented in this report, which contains the results (PASS/FAIL) and supporting comments by the DRAW Systems Engineer.

5.10. <u>DRAW HITL Requirements Verification Matrix</u> (ABiederman, May 2018)

The verification of DRAW requirements using the ATD-3 DRAW test procedures is summarized in this document, which contains the results (PASS/FAIL) and supporting comments by the DRAW Systems Engineer.