Exploring Air Traffic Control Operations and Applications for Required Time of Arrival Use in a Real-Time Simulation Environment

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Four-Dimensional (4D) Trajectory-Based Operations (TBO) is a key component of the Next Generation Air Transportation System (NextGen), integrating an aircraft's navigation capability in space and time to improve efficiency and predictability in the Air Traffic Management (ATM) system. NextGen envisions that ATM will require the widespread implementation of 4D Trajectories (4DT) in all phases of flight, which will precisely describe an aircraft's path and uncertainty in space and time;

One enabling component of TBO is the system capability for issuance and compliance with Required Time of Arrival (RTA) clearances for the en route and descent phases of flight. Although the RTA function already exists in many FMSs, the feature is not widely used or well understood by all flight crews. In addition, ATC does not assign RTAs, and ATC systems are not currently well-configured for the selection and dissemination of RTAs.

The MITRE Center for Advanced Aviation System Development (CAASD) along with its 4D TBO project partners have conducted a number of activities meant to define, characterize and validate 4D TBO concepts that utilize the RTA functionality in the context of arrival management. Most notably, these activities consisted of a larger scale Flight Trials activity that was conducted in Seattle from November 30 to December 22, 2011 and a series of Human-in-the-Loop (HITL) simulations in the summer of 2012 that have explored that utility of using RTA with other TBO initiatives.

This paper provides a description of the real-time simulation platform and the associated tools that were utilized to support the RTA simulation studies. Additionally, it will also provide a description of the innovative ATC applications that were investigated using the platform to accommodate RTA operations, along with some interesting results.

Figure 1 provides a high level overview of the simulation components used to conduct the HITL simulations. A research platform developed by the National Aeronautics and Space Administration (NASA) was leveraged to provide the required scheduling functions, en-route controller workstations as well as the background traffic generation and associated pilot stations. This platform was then interfaced with a set of software and part task training FMSs that represented different aircraft models and associated RTA functionality. This architecture thus provided a realistic depiction of the existing RTA functionality onboard aircraft.

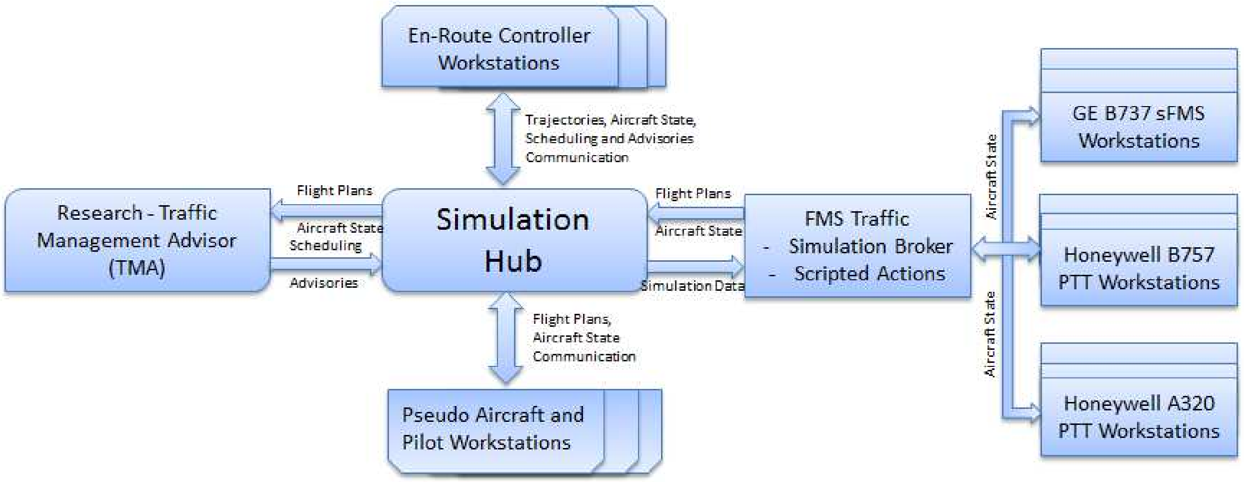

Figure 1. Real Time Simulation Architecture

A description of the ATC applications for RTA that were identified to be explored using this platform will then follow along with the rationale behind selecting these applications. An example of a type of application that will be described consists of using the RTA to meet a designated TRACON Meter Fix Schedule Time of Arrival (STA) for RTA equipped aircraft while a speed advisory system was used for non-RTA equipped aircraft, thus providing a more efficient flow in a mixed equipage environment. Figure 1 provides an example of the logic that was implemented in the ATM system while Figure 2 provides an example of the Meter Fix STA meet-time advisory that was presented to HITL controllers.

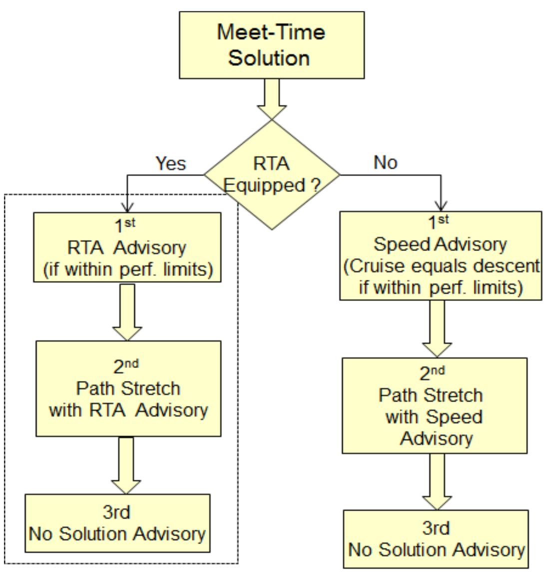

Figure 2. Hybrid Speed / RTA Logic

Figure 3. Hybrid Speed / RTA Advisory

Finally, a set of quantitative results that were obtained will be presented. Table 1 provides an example of the en-route RTA performance vs. conventional ATC methods in meeting an STA at an en-route metering point.

Table 1. En-Route RTA Performance

Type	# Flts	Crossing Error Statistics (seconds)			
		Range	Mean	Std Dev	95% CI
Metering using RTA	40	-26 to 24	-1.9	9.1	-4.7 : 0.9
Metering using Conventional Methods	81	-138 to 86	9.5	38.3	-273.9 : 61.6

Issues related to RTA operations will also be explored. Conflicts between aircraft (RTA/non-RTA and RTA/RTA) will be examined via a post simulation in-trail spacing analysis. Figure 4 provides an example of such an analysis for two in-trail aircraft executing RTA.

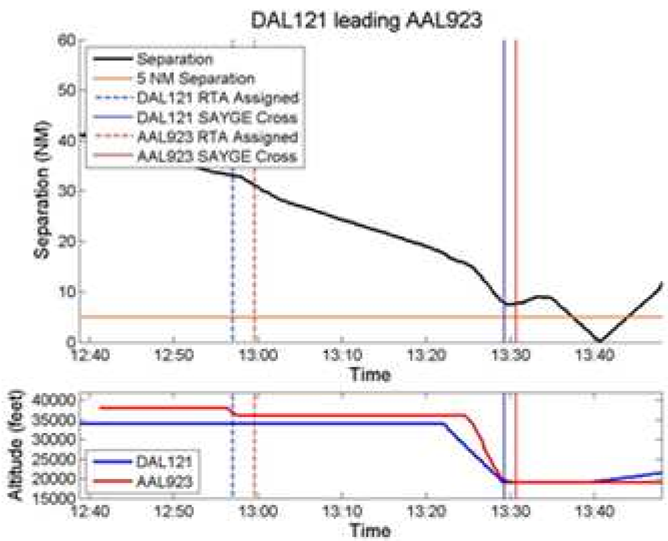

Figure 4. In Trail Separation (RTA Aircraft)

Since speed variations is also a commonly cited concern with RTA operations, a speed strategy analysis comparing the meet-time speed strategy executed by the aircraft onboard FMS RTA function with the meet-time speed strategy computed by ground systems will also be presented. An example of such an analysis for an aircraft executing RTA is presented in Figure 5.

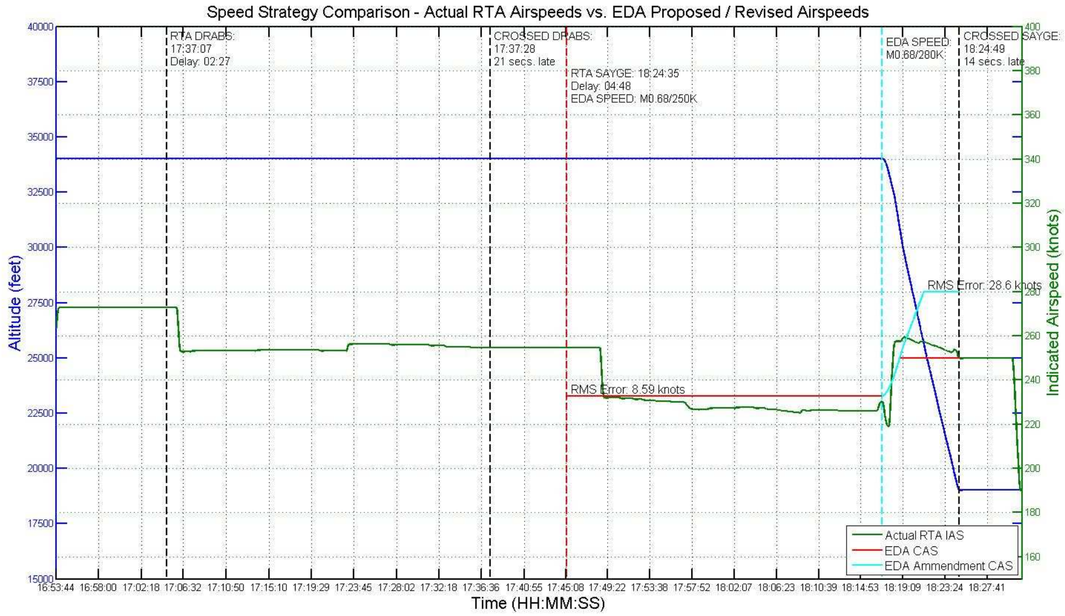

Figure 5. RTA Aircraft - Speed Strategy Analysis

Finally, a summary of the main issues identified with RTA operations from an ATC perspective along with some possible mitigation strategies will be provided. Although the enhancements to ATC systems described in this paper were initiated on a laboratory scale, this paper could provide guidance to future RTA research by investigating the capabilities and limitations of current ATC systems.