Flight Management System Four Dimensional Intent Data

The MITRE Corporation’s Center for Advanced Aviation System Development (MITRE/CAASD) is a key participant in a recently initiated Federal Aviation Administration (FAA) activity to validate standards needed to meet mid-term Four Dimensional (4D) Flight Management System (FMS) Trajectory-Based Operations (TBO) goals.

Background
One of the primary components of the Next Generation Air Transportation System (NextGen) vision for TBO is the provision of FMS generated trajectories to Air Traffic Control (ATC) for decision support. While various FMSs with the ability to generate and provide aircraft trajectory information are already in existence and installed on various aircraft operating in the National Airspace System (NAS), the infrastructure to access and use this data on a “real-time” basis does not exist. This is an issue which needs to be addressed to allow for concept vetting, standards validation, and field demonstrations that are needed.

Airline Partner Agreements
MITRE/CAASD has entered agreements with multiple airline partners to obtain 4D downlink data from their Boeing 737 Next Generation (NG) aircraft. These agreements span several years and have been initiated both as part of a MITRE Sponsored Research (MSR) project as well as under FAA sponsorship. Over 80 aircraft from the different airline partners are currently providing data. It is anticipated that additional aircraft from these partners and new airline partners will be added in the future.

Intent Data Description
The B737s providing data are equipped with General Electric (GE) Smiths FMSs that meet the standards and specifications set forth in ARINC 429, a specification which describes how avionics systems on an aircraft communicate with each other. The ARINC Flight Management Computer (FMC) System Characteristic 702A-1 provides specifications for all the data outputted on the 429 data bus from the FMS, including state, intent, uplinked winds, etc.

The ARINC 702A-1 Characteristic describes intent data as consisting of “A string of four dimensional points that describe the predicted trajectory of the aircraft along with the point type and turn radius associated with the flight path transition.”

The Intent Downlink (IDL) message as illustrated in Figure 1 defines the flight path from the aircraft’s current position all the way to the runway, both laterally and vertically. Figures 2 and 3 illustrate the vertical and lateral paths that can be defined using information from the IDL. Intent data updates to the data bus occur generally as follows:

- When there is a flight plan change
- When new lateral waypoint(s) are sequenced
- When tactical or weather changes cause changes to the predicted trajectory
- When a certain period of time has passed since the previous update

![Figure 1. Downlink Message Example](image-url)
In addition to the predicted path, other information from the FMS useful for trajectory analysis such as aircraft state, Required Time of Arrival (RTA) windows, actual winds, entered forecast winds, etc., can also be downlinked either as separate messages or attached to the IDL message by modifying the Adaptable Data-Link Database (ADDB) on the aircraft. This data can be downlinked periodically, upon request or based on events. Partner airline aircraft are currently downlinking IDL messages with either a five or ten minute frequency starting approximately 20 minutes after departure and continuing until touchdown at the destination.

**Data Collection and Processing**

Aircraft Communications Addressing and Reporting System (ACARS) is a message exchange system that has been in existence over the last 30 years and allows airlines to exchange simple messages with their aircraft. Many airlines currently use the ACARS system to communicate with their aircraft over Very High Frequency (VHF), High Frequency (HF), and satellite communications. MITRE/CAASD has entered into an agreement with ARINC to receive ACARS messages from partner airline flights on a real-time basis.

As messages arrive at MITRE/CAASD via the ACARS subscription, they are parsed and correlated with other sources of information such as flight plan data, navigational data, etc. prior to being stored in a database for use by analysts. A web-service infrastructure fed by this data has also been established to allow for ATC/Airline Operations Center (AOC) displays to be created and accessed from field facilities. Figure 4 illustrates a Traffic Management Unit (TMU) display that was installed at the Seattle Center (ZSE) to support December 2011 RTA flight trials with Alaska Airlines (ASA).

**Research Activities**

MITRE/CAASD uses this data for the following:

- Analyzing parameters of importance for 4D operations to inform standards
- Characterizing FMS trajectory predictions under current operations
- Development and evaluation of the utility of 4D downlink information among air traffic specialists and airline operations personnel, including integration with planned ground automation and displays
- Real-time displays to support RTA flight trials with RTA