Session 84-GNC-49:
“Highlights from the FAA Support of the National Airspace System”

Paper AIAA-2009-6080:

“Improving Ground- Based Trajectory Prediction Through Communication of Aircraft Intent”

Presented to: AIAA GNC, Chicago, IL
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The Boeing FAA CRDA TBO

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Boeing FAA CRDA
No. 02-CRDA-0171
Five-year collaboration designed to facilitate technology development in Trajectory-Based Operations

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Improving Ground-Based Trajectory Prediction Through Communication of Aircraft Intent
12 August 2009
Boeing FAA CRDA

Duration: 2007- 2011

2007/2008:
• Proof of Concept
• The outcome was published last year at AIAA
  – “A Demonstration of an Aircraft Intent Interchange Specification for Facilitating Trajectory-Based Operations in the National Airspace System”

2009 :
• Demonstration
  – Study accuracy of trajectory prediction with and without using AIDL.

2010/2011:
• Further expand the efforts in demonstration and validation of AIDL
Motivation

• Supporting the *NextGen Implementation Plan and SESAR*
  – SESAR concept of operations requires a system that relies on coordinated, strategic trajectory deconfliction
  – NextGen focused on equipage of three core avionics capabilities for the midterm (2012-2018)
    • Area Navigation (RNAV) and Required Navigation Performance (RNP)
    • Automatic Dependent Surveillance-Broadcast (ADS-B)
    • Data Communications.
Technical Overview

• **Experiment Design**
  – Examine Common Trajectory Prediction Problems
  – Emulating Ground-Based Prediction of a Real Flight
  – Improving with Aircraft Intent Communication

• **Experiment Results**
  – Comparing the Predictions
  – Common TP Metrics Put to Use

• **Conclusion**
  – Aircraft Intent Communication Greatly Improves Trajectory Prediction
Common Sources of Trajectory Prediction Uncertainty

Top-of-Descent Uncertainty
(source: Mondoloni³)

Unknown lateral change
Research Objectives

• Identify a Real Flight to Use for Test
  – Contains examples of identified sources of uncertainty
  – Cleveland to Denver flight with an Optimized Profile Descent

• Emulate Ground-Based TP

• Reverse Engineer the Aircraft Intent

• Generate the Trajectory

• Compare the Accuracy
  – predicted vs. generated
  – using standard TP metrics
  – expect improvements in cross-track error, vertical error, time error, and speed error
Experiment Tools

• **Trajectory Predictor - URET**
  – **User Request Evaluation Tool**
  – Developed at MITRE's Center for Advanced Aviation System Development (CAASD)
  – Deployed and fully operational at all 20 en route air traffic control facilities
  – Laboratory prototype version used for this study

• **Trajectory Generator – TGF**
  – **Target Generation Facility** at FAA Technical Center
  – Real Time, Controller-in-the-Loop simulator

• **Intent Communication – AIDL**
  – **Aircraft Intent Description Language**
  – Developed at Boeing Research & Technology Europe
  – Formal language designed to describe aircraft intent information in a rigorous but flexible manner
CMS Track of Test Flight

In Denver Airspace
Improving Ground-Based Trajectory Prediction Through Communication of Aircraft Intent

12 August 2009
Analysis of Test Flight
Indicated Airspeed in the Descent
Extracting Aircraft Intent

• Assumptions
  – Lateral path is known, including path stretch
  – Weight is known
  – TOD is known (2.9 nm before AMWAY)
  – Idle thrust descent along a geometric path angle
URET prototype

- Path Stretch
URET prototype

• Path Stretch
URET prototype

- Initial Descent
URET prototype

• Initial Descent
Post-AIDL Trajectory

- Path Stretch - clearance to AMWAY

![Graphs showing cross path, altitude, time, and groundspeed error vs. path distance.](image-url)
Post-AIDL Trajectory

- Path Stretch - LBF to AMWAY
Post-AIDL Trajectory

• Initial Descent
Post-AIDL Trajectory

• Error Metrics for Initial Descent
Concluding Remarks

• Communicate Aircraft Intent - errors reduced
  – cross-track, time, and vertical

• Improvements in speed error not realized
  – accurate weather modeling needed

• Without Aircraft Intent Communication
  – In steady-state flight, accuracy comparable to a trajectory generator using aircraft intent
  – Frequent monitoring required to maintain tolerable accuracy

• With Aircraft Intent Communication
  – Stable representation of the flight
    • little variation with large look-ahead times
References
