Big Aviation Data Mining for Robust, Ultra-Efficient Air Transportation

Co-Principal Investigators: Richard DeLaura & Tom Reynolds (Massachusetts Institute of Technology Lincoln Laboratory)

Co-Investigators: Hamsa Balakrishnan & John Hansman (Massachusetts Institute of Technology Department of Aeronautics & Astronautics)

Abstract:

1. Background
The performance of the National Airspace System (NAS) is the result of the interplay of four major elements: demand (flight schedule); capacity (NAS structure and resources); resource constraints; and control decisions to ensure a manageable, safe, and efficient balance between resource demand and capacity. The processes that create these elements evolve on several spatial and temporal scales. Schedules are developed in response to economic and business trends that may evolve over months or even years. Changes in NAS structure and resources may require several years of planning and implementation, while operational procedures may be developed in a matter of weeks or even improvised during operations. Resource constraints, such as adverse weather, and control decisions that manage demand to match available resource capacity, may evolve over time scales ranging from hours to minutes and spatial scales ranging from nationwide to individual airports. At each scale, these processes leave a wide range of data artifacts: flight schedules, flight plans, flight trajectories, and cancellations; air traffic management decisions; observed, analyzed, and forecast weather; and other performance metrics such as delays, cancellations, diversions, etc. This set of data artifacts constitutes a true 'big data' set, characterized by high data volumes, velocities, and significant variability. As increasing amounts of operational data ("big data"), novel analytical techniques, and computational power become available, it becomes possible to generate significant insights into the dynamics of complex NAS behavior. From these insights come opportunities to create efficient, robust operating paradigms which will lead to major performance improvements, including increased capacity and reduced delay, fuel and environmental impacts.

2. Objectives
The objective of the work is to:

- Develop advanced metrics and analytics using big data approaches which better characterize and predict NAS operations.
- Generate data-driven insights into complex NAS behaviors through the application of these novel analytical methods across the spectrum of spatial and temporal scales of relevance in NAS operations.
- Analyze links between control strategies, constraints and NAS behaviors to identify inefficiencies in NAS operations.
- Use case studies to demonstrate the utility of these insights and to promote a more robust and efficient NAS.
- Make recommendations for high value follow-on activities.

3. Expected Significance & Relevance
The potential performance improvements are fundamental to NAS operations, so they would have profound effects. The research team has extensive experience with issues underlying these challenges plus a track record of leading-edge research to diagnose core issues and develop operationally

realistic solutions to address them. The work aligns well with LEARN objectives of safe, efficient growth in global operations and development of ultra-efficient commercial vehicles. In addition, extensive discussions have been and will continue to be held with researchers at NASA, including on SMART-NAS, New York Metro Initiative and Sherlock data warehouse programs to ensure the activity leverages and maximizes potential utility to broader programs. Strong interest in the work is also expected from stakeholders (including ATC facilities, ATC System Command Center and airline flight planning departments). The team is leveraging their extensive contacts across these stakeholder groups and generating publications to maximize visibility and impact of the work.

4. Opportunities for Phase 2

High value opportunities for further work in Phase 2 include:

- Development diagnostic and predictive models to incorporate insights from Phase 1.
- Develop a framework and reference implementation for exploitation of aviation-focused big data to improve, measure and control NAS performance.
- Demonstrate framework utility through case studies which include proof-of-concept prototyping, evaluation, and benefits analysis to guide further development.
- Extensions to incorporate data from and to simulations of future concepts for flight management lifecycle, unmanned flight, etc.
- Design of interfaces between the big data framework and relevant NASA programs, e.g., the Shadow Mode Assessment using Realistic Technologies for the NAS (SMART-NAS), UAS Traffic Management (UTM) and Airspace/ATM Technology Demonstration (ATD) programs.