**Project Title:** Novel, Multidisciplinary Global Optimization under Uncertainty

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**Abstract:**

In Phase I research, the Saab Team innovatively integrated two diverse techniques—Bayesian Networks (BNs) and Genetic Algorithm (GA)—to develop a methodology called PROCAST (Probabilistic Robust Optimization of Complex Aeronautics Systems Technology) for global optimization under uncertainty. PROCAST is generally applicable to a wide range of complex problems displaying certain characteristics. One such problem is integrated arrival-departure-surface (IADS) air traffic management. In Phase I, we generated an IADS traffic management tool for efficiently managing traffic on an airport surface and in the terminal airspace while maintaining robustness to unforeseen disturbances. We conducted proof-of-concept simulation experiments, which showed that PROCAST, if applied at the John F. Kennedy Airport (JFK), will provide significant savings over today’s traffic management system.

We are encouraged by the Phase I PROCAST proof-of-concept demonstration. The research objective of the Phase II project is to expand and generalize the promising Phase I results to problems of greater scope, complexity, and uncertainty. Specifically, we propose to enhance PROCAST in multiple ways—(i) We enhance PROCAST’s Phase I scheduling algorithms in three ways—(a) expansion of the algorithm to a multi-airport scope (we call this capability metroplex-PROCAST or m-PROCAST), (b) addition of multi-objective cost functions with complex modeling of (primarily) safety factors and other competing objectives, (c) addition of sub-algorithms for improved traffic coordination under severe weather re-routing and de-icing operations; (ii) We enhance Phase I BNs by incorporating operational insights from our subject matter expert (SME) consultants, and enable BN learning over large-scale, historical operational data for more accurate prediction of future traffic; (iii) We develop fast online BN inference methods and machine learning (ML) methods to synthesize best flight control strategies, for facilitating m-PROCAST’s future infusion into a real-time decision support tool (DST), (iv) We enhance NASA’s surface platform to generate a complete metroplex surface and airspace simulation capability for benefits analysis, and (v) We conduct simulation-based benefits analysis of m-PROCAST and provide NASA/FAA/industry with credible data for evaluating viability of m-PROCAST’s infusion into their research programs/ processes/ commercial products.

The proposed Phase II work extends the state-of-the-art of metroplex traffic scheduling research by innovatively integrating diverse aeronautics and non-aeronautics technologies—ATM traffic scheduling, Multi-objective Optimization, Statistical Modeling (BNs), Machine Learning (surrogate modeling based machine learning for finding statistically-best controls), distributed/parallel computing (fast BN learning and inference), and artificial intelligence (coding SME knowledge in BNs)—for developing a convergent metroplex traffic management solution. The proposed Phase II work enables weather-sensitive traffic planning, a key research need in NASA’s ATM research portfolio, and incorporates critical capabilities such as uncertainty mitigation strategies, safety assurance, airline preferences, and equity considerations into existing traffic planning functions. It provides a method for coordinating traffic planning across the surface and terminal airspace for multiple proximate airports in a complicated
metroplex—New York—and is transferable to other metroplex sites. As explained in the proposal body, it also supports three of ARMD’s six strategic thrusts (Assured Autonomy for Aviation Transformation; Safe, Efficient Growth in Global Operations; and Real-time System-Wide Safety Assurance), and would directly benefit NASA sub-projects Network Enabled ATM and Autonomous Traffic Flow Management (TFM).