Air Traffic Management Simulations

NASA Langley Research Center (LaRC) is developing and testing ideas for the Next Generation Air Transportation System (NGATS) using realistically modeled aircraft systems.

4D-Airborne Separation Assistance System (4D-ASAS)
An aircraft equipped with ASAS functions and 4-dimensional trajectory (4DT) management capabilities can have significant, transforming value to Air Traffic Management (ATM) at local and system levels. ATM is and will remain a system-level objective, not an individual aircraft objective; however, the future air traffic environment is envisioned by the Joint Planning and Development Office (JPDO) to be characterized in part by net-enabled information access, performance-based services, and aircraft trajectory-based operations. These assumptions lay the groundwork for redistributing ATM functions based not on information location, but rather on performance achievement capability. By using 4D-ASAS capabilities, aircraft can become a valued ATM resource in a manner that enables safe and efficient operation of a complex, high-density ATM environment. Vital characteristics envisioned in the NGATS enable ATM functions to be distributed to properly equipped aircraft. Recent research and development at LaRC of this proposed aircraft equipage for en-route and terminal-arrival operations promises significant reduction of ground infrastructure cost, scaling to traffic demand while building in security and safety.

Airspace and Traffic Operations Simulation (ATOS)
The Air Traffic Operations Laboratory (ATOL) is a simulation facility where NASA evaluates new air traffic management (ATM) concepts, maintaining appropriate levels of compatibility with real-world avionics system architectures and emerging National Airspace System (NAS) infrastructure. The simulation environment is called the Airspace and Traffic Operations Simulation. It is comprised of over 20 computer workstations used as pilot stations flown by real pilots who interact with each other in a simulated airspace environment in various configurations and air traffic scenarios with hundreds of additional automated aircraft. The lab supports 'pseudo-pilot' (imulti-aircraft) control and remotely piloted and non-piloted aircraft operations. ATOS also connects to high-fidelity flight-deck simulators as part of the traffic environment.


Airborne decision tools improve airport efficiency

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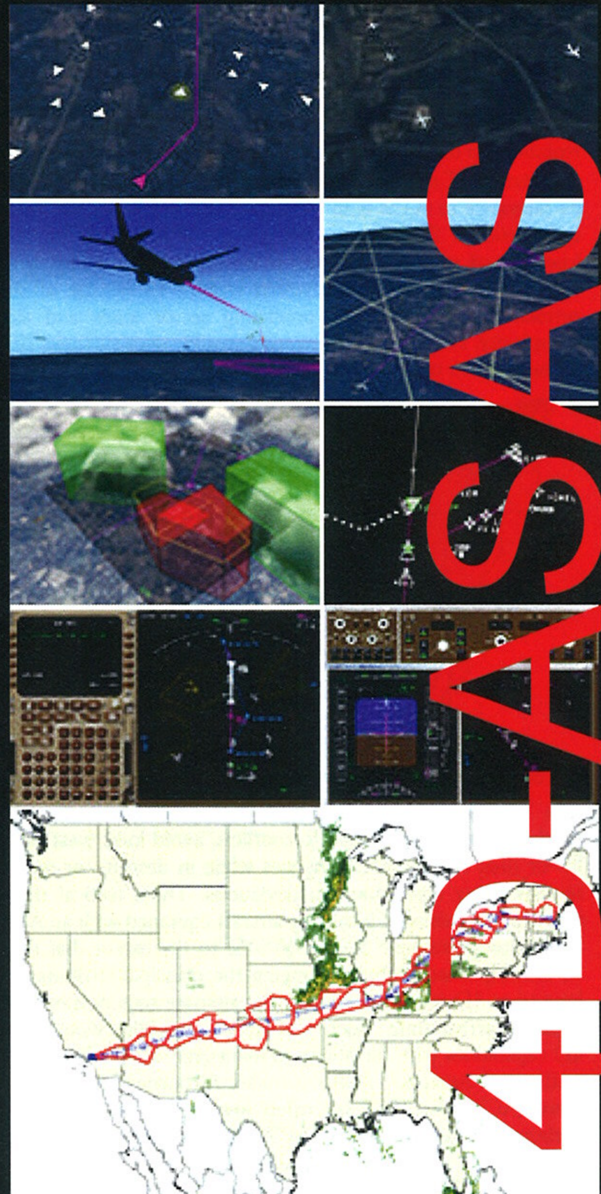
Capacity Takes Flight



Performance-Based 4D Trajectory Operations

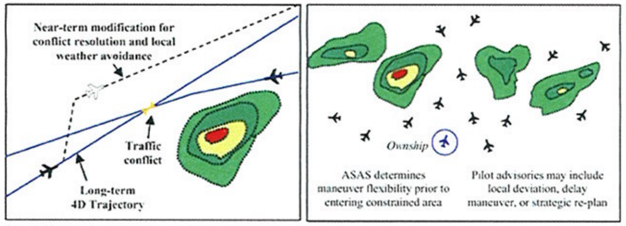
Revitalized demand for air transportation is causing many commercial and government organizations to take a new, hard look at the capabilities of the current air transportation system. The objective is to determine what changes are necessary to accommodate the anticipated future demand. In collaboration with other Government agencies, industry, and the international R&D community, NASA is developing, researching, and maturing components of the Next Generation Air Transportation System (NGATS).

In the future NGATS, Aircraft Traffic Management (ATM) in flow-constrained and airspace-constrained environments will likely involve managing aircraft movements using the language of 4D trajectories - 3D path plus time. NASA is developing and exploring concepts in which aircraft equipped with advanced ATM-related capabilities work in consort with ground-based Traffic Flow Management (TFM) systems to accomplish ATM goals. These goals include enabling safe, efficient, and flexible use of airspace resources to the benefit of the aircraft operator community.

Long-term 4DT operations would span the majority of the flight, and its relevance to ATM is in predicting and managing the impact of this particular flight on the overall air traffic system, i.e. airspace loading and resource demand. It would involve managing departure and arrival times, and would require knowledge of the approximate flight path for predicting sector loads and airspace complexity. *Near-term 4DT operations* would cover the next 20 to 40 minutes when tactical decisions regarding the flight may be necessary.

Long-term 4DT management considers key TFM-related attributes

Tactical decisions resulting in flight path modification may be needed to resolve local traffic conflicts, avoid local weather, make lift or drag configuration changes while in descent, or to accommodate other short-duration deviations. These tactical modifications can be managed locally by aircraft equipped with an Airborne Separation Assistance System (ASAS) to the extent that they can be accomplished without changing the principal attributes of the long-term 4D trajectory such as the airspace sectors traversed and expected arrival time. Such "4D-ASAS" capability would augment 4D capabilities with the ability to maneuver safely relative to other traffic and hazards. ASAS includes Airborne Conflict Management (ACM) functions for safely keeping aircraft separated and Airborne Precision Spacing (APS) functions for safely converging aircraft trajectories. The 4D-ASAS aircraft uses surveillance data received from other aircraft and airspace hazard information for three important ATM contributions to Airborne Conflict Management (ACM). They are: (1) conflict detection and resolution; (2) conflict-free maneuvering; and (3) traffic complexity monitoring and preservation of maneuver options. Each can require near-term deviations from the current 4DT to meet local constraints. Nevertheless, a principal goal for all three is to maintain the basic attributes of the long-term 4DT so ground-based TFM is not affected.

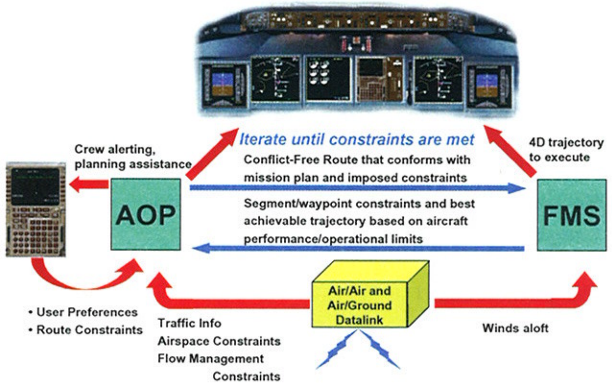


Airspace complexity management is possible by broadcasting near-term changes to the 4DT to maintain shared awareness of intent

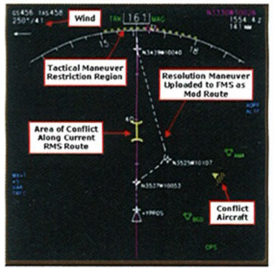
4D-ASAS represents a performance-level that exceeds 4D-only capability. Operators that equip for 4D-ASAS operations help the ATM system grow and run more smoothly and can therefore earn the highest access privileges. 4D conformance to constraints results in a more predictable impact on the NAS, and with ASAS capabilities the workload of tactical decision making is moved from the ground system to the flight deck. Distributing local 4D-trajectory management to 4D-ASAS-equipped aircraft is the foundation for ATM scalability.

Airborne Separation in 4D-Trajectory ATM

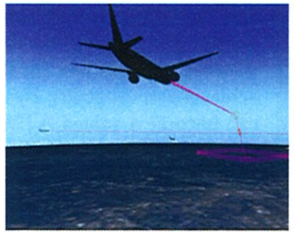
To support 4D-ASAS research, NASA is continuing development of interactive flight-deck decision-support tools, such as the Autonomous Operations Planner (AOP) - a tool set that functions as an ASAS for advanced performance-based 4D trajectory flight operations. The goal is to significantly increase capacity of the National Airspace System (NAS), while maintaining or improving safety. 4D-ASAS enables aircraft pilots to maintain traffic separation while conforming to traffic-flow-management constraints assigned by ground-based Air Traffic Service Providers. ASAS will enable aircraft to define maneuvers no longer just relative to fixed waypoints but also relative to other aircraft. The LaRC implementation of ACM uses knowledge of the own aircraft's state, current commanded and planned 4D trajectories, and any provisional (trial) trajectories to be explored. It also uses the state and broadcast intent from ADS-B (i.e. the near-term 4D trajectories) of local traffic. Full origin-to-destination 4D trajectories are not necessary to manage local traffic-separation issues. Taking into account aircraft performance limitations and the local airspace environment (e.g., winds, air-space restrictions), conflict-free RNAV trajectories are calculated for flight crew review, selection, and execution.



Integration of the AOP with the FMS and flight deck systems



Autonomous Operations Planner



4D-ASAS arrival trajectory with conflict detection

NASA is also developing airborne precision spacing (APS) flight guidance to help increase arrival efficiency and throughput at capacity-limited airports. APS allows the pilots to manage their speeds during descent and approach, to space precisely relative to another aircraft. By increasing precision with which aircraft are spaced, they can be safely spaced more tightly, allowing more aircraft to land during a period of time and decrease en-route delays. Research simulations and flight evaluations of APS have shown potential for achieving inter-aircraft arrival precision of around two seconds, even under unusual wind conditions. Significant design effort has been applied to ensure that pilot interactions are simple and intuitive, that the speed guidance behavior is acceptable to pilots and controllers, and that there are no destabilizing effects in long streams of aircraft performing APS.

APS improves airport efficiency and throughput

Oceanic operations, due to extended periods out of radar coverage have large longitudinal and lateral separation minima. These provide safe operations, but ones that are often not fuel-efficient. Current research uses the oceanic domain as a place to investigate a phased approach to integrating the various levels of separation authority delegation in a constrained 4D-ASAS environment. Use of airborne surveillance and onboard tools can facilitate altitude changes for greater fuel efficiency, from a phase 1 Altitude Change Request Advisory Tool to a phase 4 ASAS on a track.