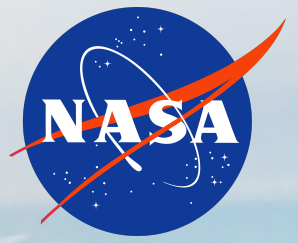




Traffic Aware Strategic Aircrew Requests

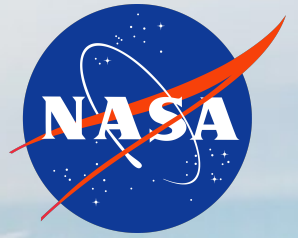


TASAR Roadmap

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TASAR Roadmap



In 2016, five-step roadmap¹ developed to achieve the full benefits of Airborne Trajectory Management (ABTM), a key enabler of the *Digital Flight* Vision²

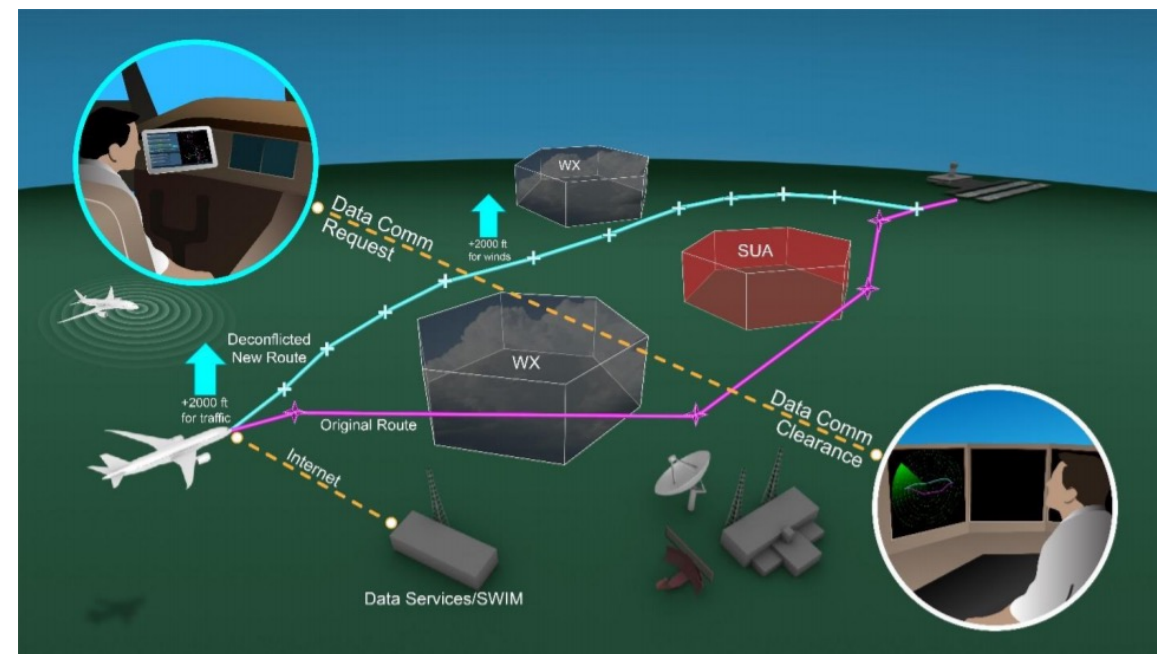
1. **Basic TASAR:** Uses airborne automation to compute optimized trajectory change requests made via voice exchange between pilots and controllers.
2. **Digital TASAR:** Replaces the voice exchange of the trajectory request and re-clearance of Basic TASAR with Data Comm
3. **Four-dimensional (4D) TASAR:** Extends the optimization dimensions of Basic and Digital TASAR to include the speed/time dimension
4. **Strategic Airborne Trajectory Management (SATM):** Integrates the Digital and 4D TASAR capabilities with ATC automation
5. **Full ABTM:** Extends Strategic Airborne Trajectory Management to include airborne separation responsibility in the current sector
 - Provides authority to make tactical trajectory changes without prior ATC approval.

¹ Cotton, et al., "[A Vision and Roadmap for Increasing User Autonomy in Flight Operations in the National Airspace](#)," in 16th AIAA Aviation Technology, Integration, and Operations Conference, Washington, D.C., 2016

² Wing, D J, and Levitt, I M, "New Flight Rules to Enable the Era of Aerial Mobility in the National Airspace System," [NASA/TM-20205008308](#), Hampton, Virginia, Nov 2020.

Simplified operating procedures for making complex trajectory modification requests

- **Efficiency:** Dynamic *3D trajectory optimization produces DOC and emissions-reducing solutions* that are de-conflicted from known airspace hazards and nearby traffic
- **Flexibility:** FAA Data Comm message set and operating procedures allows optimization algorithm to find *complex trajectory solutions*
- **Predictability:** Trajectory modifications respect known altitude, speed constraints
- **User Preferences:** Optimization process considers known business preferences
- **Leverages:**
 - On-board intelligent optimization automation
 - *“Connected” FMS technologies*
 - *Data Comm avionics, Full Enroute Data Comm services*

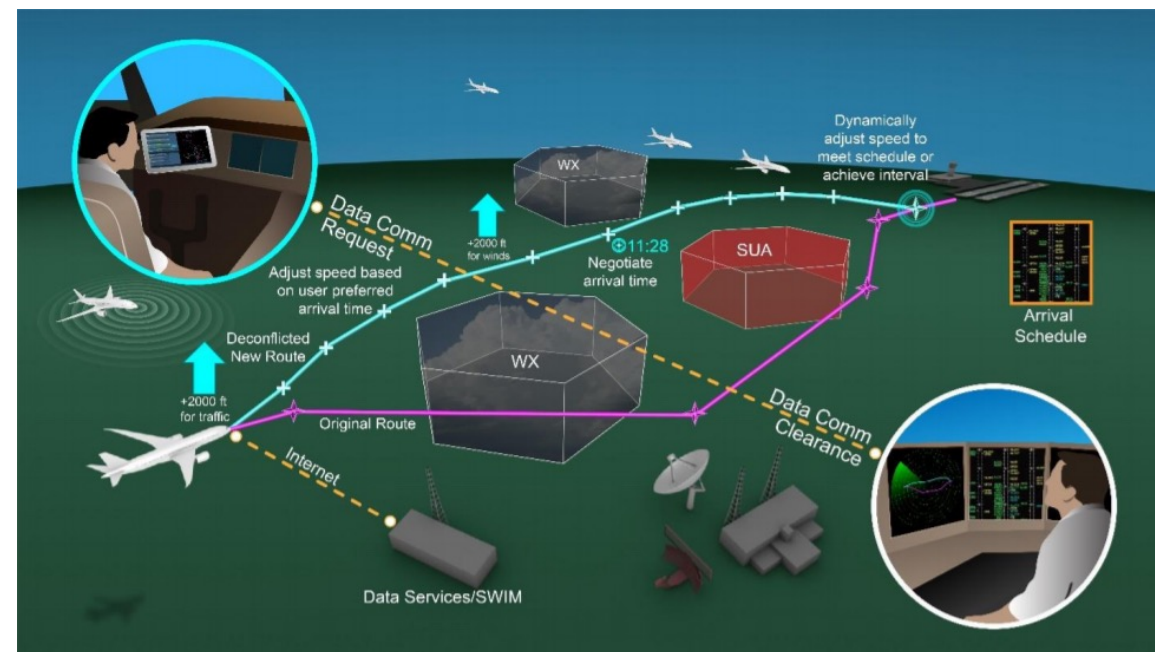


Underwood, M.C., et al., “Concept for Intelligent User-Preferred Reroutes Using Digital Data Communication,” [NASA/TM-20205002126](https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/202005002126), 2020.

NASA New Technology Case Number: LAR-19946-1, accepted on 11/16/2020

Four-dimensional trajectory optimization that considers time of arrival constraints

- **Efficiency:** Dynamic *4D trajectory optimization produces DOC and emissions-reducing solutions* that are de-conflicted from known airspace hazards and nearby traffic
- **Flexibility:** FAA Data Comm message set and operating procedures allows optimization algorithm to find *complex trajectory solutions that are time conforming and/or speed-optimal*
- **Predictability:** Trajectory modifications respect altitude, speed, *time of arrival constraints*
- **User Preferences:** Optimization process considers known business preferences
- **Leverages:**
 - On-board intelligent optimization automation
 - “Connected” FMS technologies
 - Data Comm avionics, Full Enroute Data Comm services
 - *FMS Required Time of Arrival (RTA) meeting, cost index capabilities*
 - *TBFM; coupled scheduling and extended metering*



Underwood, M.C., et al., “Incorporation of Time of Arrival Constraints in a Trajectory Optimization Technology,” [NASA/TM-20205005117](https://nasa.gov/patent/publications/NASA-TM-20205005117), 2020.

NASA New Technology Case Number: LAR-19953-1, accepted on 11/30/2020

Integration of airborne and ground-based automation to enable machine-to-machine coordination of acceptable trajectories

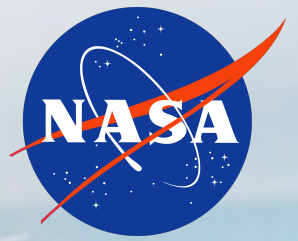
- **Efficiency:** Dynamic 4D trajectory optimization produces *highly-approvable* DOC and emissions-reducing solutions that are de-conflicted from known airspace hazards and nearby traffic
- **Flexibility:** *User has authority to update their strategic trajectory, starting in the next downstream sector to the destination airport.*
 - Leverages FAA Data Comm for “tactical” trajectory modifications.
- **Predictability:** Trajectory modifications respect time of arrival, altitude, speed constraints; *comply with known traffic management initiatives.*
- **User Preferences:** Optimization process considers known business preferences; *User’s entry point into the trajectory negotiation process.*
- **Extensibility:** While optimization objectives may differ for each mission type, *the concept and enabling technologies are extensible to various operational missions.*
- **Leverages:**
 - On-board intelligent optimization automation
 - “Connected” FMS technologies
 - Data Comm avionics, Full Enroute Data Comm services,
 - FMS Required Time of Arrival (RTA) meeting, cost index capabilities; TBFM coupled scheduling and extended metering
 - *System-Wide Information Management*
 - *TFMS: Trajectory Option Set (TOS), Route Amendment Dialogue (RAD), AirBorne ReRoutes (ABRR)*



Cotton, W.B., Underwood, M.C., Hubbs, C.E., “Strategic Airborne Trajectory Management,” [NASA/TM-20205007619](https://nasa.gov/publications/nasa-reports/NASA/TM-20205007619), 2020.



Value Proposition



Benefits increase in major increments with additional capabilities

- Basic TASAR proven benefits *enabled business case approval* for airlines and avionics companies to invest.
- Digital TASAR will create more “truly” optimized routes available and eliminate both voice and data entry limitations, *increasing potential benefits*.
- 4D TASAR adds new dimension for optimization (speed) and makes constrained flights candidates for trajectory optimization, *further increasing potential benefits*.
- SATM benefit could significantly increase the opportunities to *routinely realize the potential benefits of Digital/4D TASAR on extended trajectories* through automatic coordination of approval.