JPDO TBO Summit

NextGen Avionics Roadmap and TBO
JPDO Aircraft Working Group

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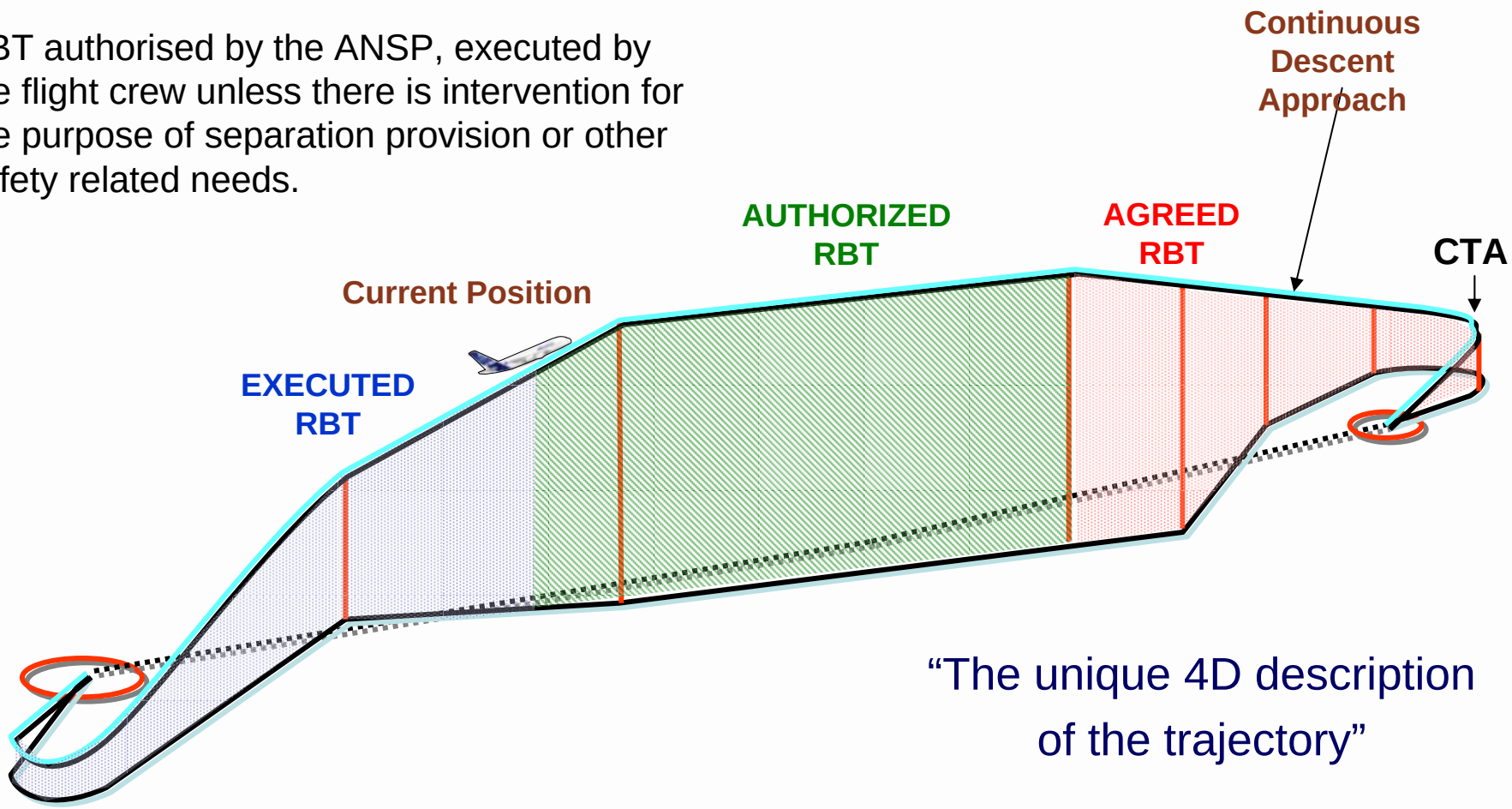
SESAR: Reference Business Trajectory (RBT)

RBT authorised by the ANSP, executed by the flight crew unless there is intervention for the purpose of separation provision or other safety related needs.



"The unique 4D description of the trajectory"

Avionics Road Map
Aircraft-Centric Capabilities

1. Safety Enhancement

Affected by TBO

2. Published Routes/Procedures

3. Negotiated Trajectories

4. Delegated Separation

5. Low-Visibility Approach/Departure/Taxi

NAV

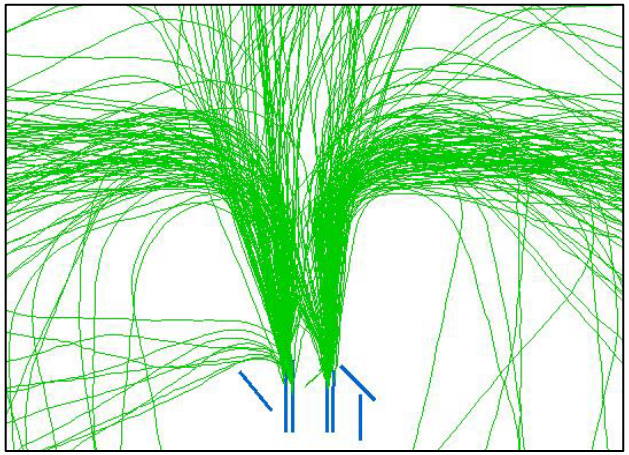
+COMM

+ADS-B In

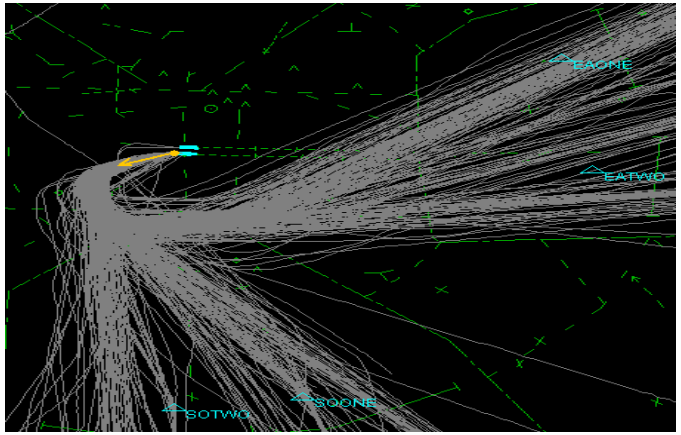
6. ATM Efficiencies

Published Routes and Procedures: 2D Trajectory Clearance

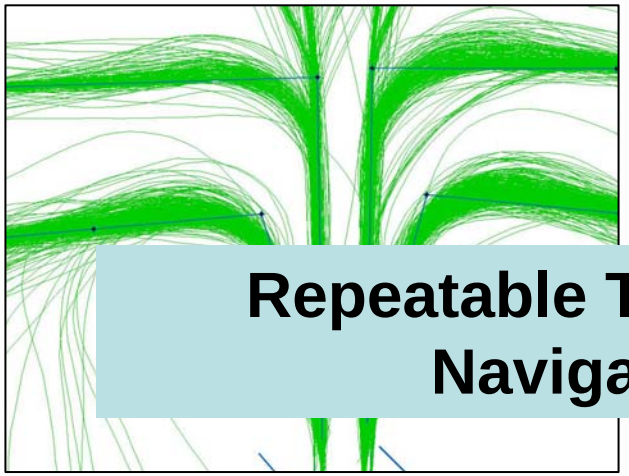
DFW



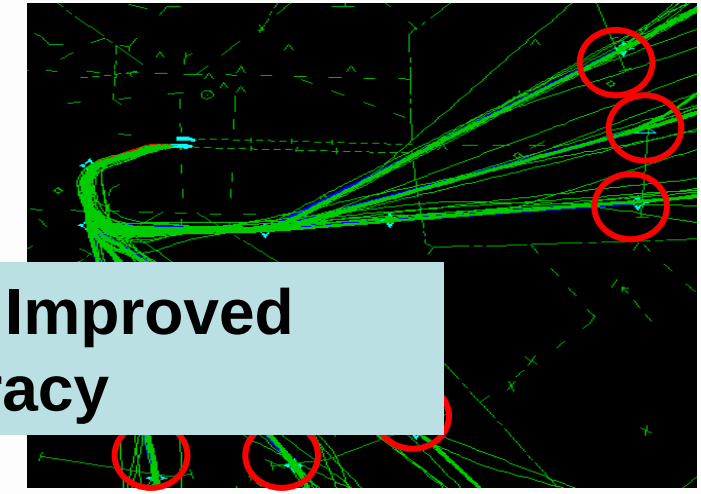
ATL



Before RNAV



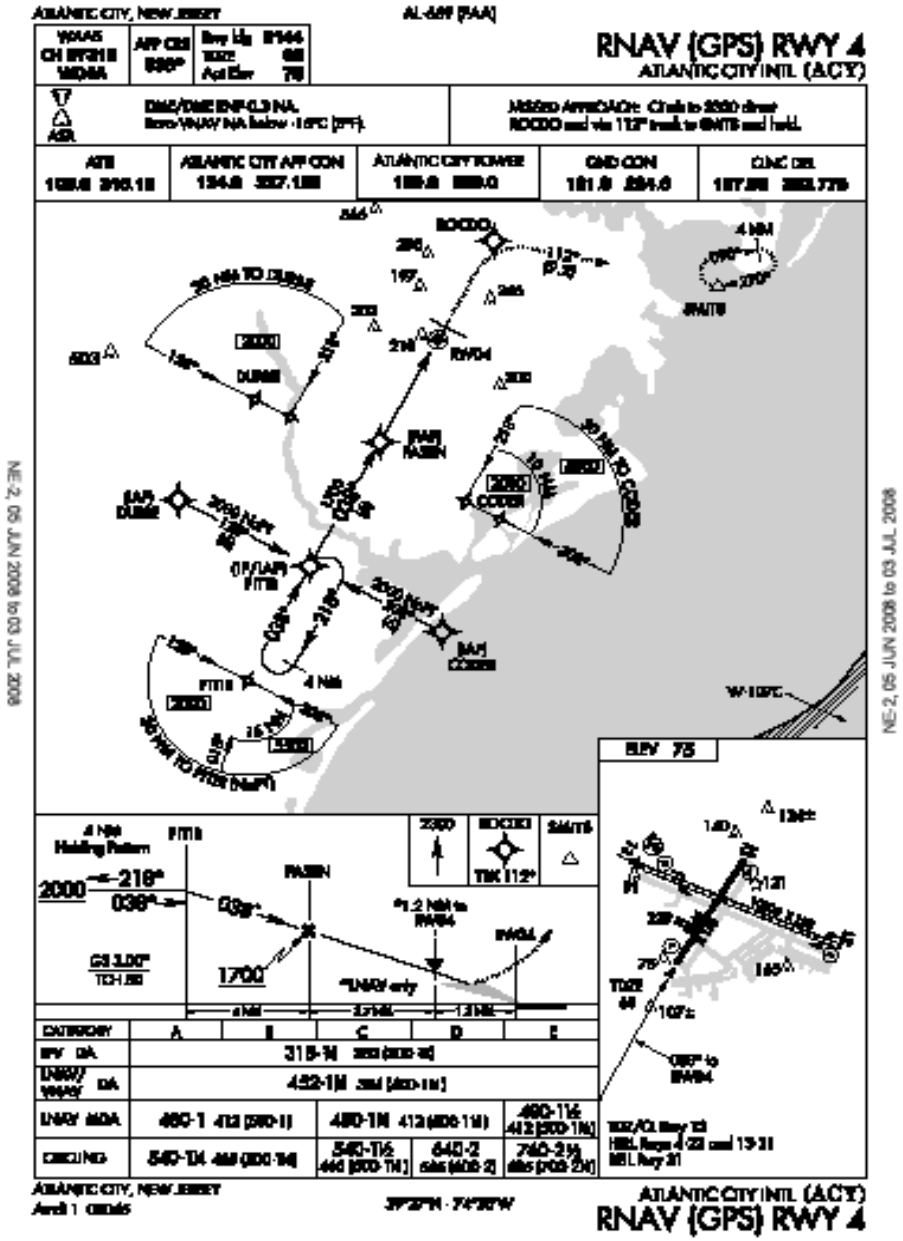
After RNAV



Repeatable Tracks and Improved Navigation Accuracy

Published Routes: 3D Trajectory Clearance

- RNAV(GPS) and RNAV(RNP) approaches add precise vertical path on final approach
- RNAV(RNP) also adds capability for curved path (RF) capability



TBO Framework

- Mixed-capability TBO forms an inclusionary basis everywhere in the NAS
- All aircraft have an associated 4DT
  - ATM systems are repositories of 4DT
- Transition to 4DT begins with ATM supporting ConOps, and data communications
- 4DT is negotiated prior to flight, ATM tools set performance, windows, constraints
- Clearances modify trajectories

Spacing and Delegated Separation

- Spacing Applications
  - No change in roles and responsibilities for flight crew or controller
  - Enables precise navigation to be relative to another aircraft
    - Particularly valuable for in-trail and merging – dealing with fourth dimension of time or along-track
- Delegated Separation
  - Ability to delegate separation to flight crew for specific instances
    - Particularly valuable in approach operations, as in visual approaches today

Potential Interaction? Precision on 4D Trajectory Clearance Eliminates Flexibility for Aircraft-Based Spacing/Separation

Unifying TBO and Spacing/Separation

- TBO Concepts must allow aircraft operator some (predetermined) flexibility in the trajectory: a trajectory window
  - For flight optimization, when practical (e.g., Continuous Descent Arrival)
  - For maintaining spacing to another aircraft
- Improved efficiency under some conditions will occur with less-specific trajectory clearance
  - Larger window
  - Also enables flight-specific efficiencies where there is excess capacity

Phases of Trajectory Operations

Pre-Negotiation

- ANSP identifies constraints (airspace, airport, weather, minimum acceptable performance)
- Operator identifies objectives and constraints (performance capability, weather)

Negotiation

- Use all available data to define desired trajectory and resolve likely conflicts
- Can occur between ANSP & Flight Crew or ANSP and Flight Ops Center
- Can occur pre-flight or in-flight

Agreement

- Trajectory window and performance, request and acceptance
- Window can collapse to single trajectory
- ANSP verifies trajectory is acceptable
- Flight crew verifies trajectory is acceptable

Execution

- Aircraft operator is responsible for compliance to clearance
- ANSP maintains separation except where delegated

System-Wide Information Management

Data Commun-ication

ADS-B, Data Comm.

Trajectory Data

- Trajectory Objectives: **Aircraft operator objectives (e.g., departure/arrival airports and times, expected routes/procedures)**
- Intended Trajectory: **The specific path (in 4D) an operator intends to follow**
- Actual Trajectory: **The path an aircraft takes – only defined behind the aircraft.**
- Window: **A region (in any dimension) where the aircraft operator can place their intended trajectory and still be compliant with a trajectory clearance.**
- Performance: **The performance constraints around the intended trajectory (e.g., RNP type).**

Negotiating Trajectories

- Sharing Trajectory Data
  - With better information on aircraft trajectory, ANSP can make more efficient use of airspace
    - E.g., Flexible Entry Timing in Oceanic Airspace
- Issuing Trajectory Clearance
  - With data communication, can issue dynamic route to aircraft
    - E.g., 3D Path Arrival Management (PAM)
- 4DT
  - Future capability to issue complete 4D trajectory clearance

Adds fourth dimension and clearance flexibility to precise navigation

Conclusion: Implications for Aircraft

- Continue to use current aircraft capability
  - RNAV, RNP, VNAV, potentially FANS-1/A
- Full 4D TBO will require new aircraft capabilities
  - Navigation: Potentially better precision in vertical and along-track/time (SC-181 bis)
  - Communication: (SC-214 2011)
    - Ability to describe (or infer) trajectory windows and performance in all dimensions (ATC)
    - Ability to access available data and negotiate trajectory, or to coordinate with Flight Operations Center that delegates on aircraft's behalf (SWIM for APC, AOC??)
  - Surveillance: Ability to conduct relative navigation (spacing) or accept delegated separation (SC-186)
  - Flight Crew Controls/Displays: Flight crew awareness and management of TBO will be challenging (SC-186)

Key Attributes for Aircraft

- Lateral windows
- Vertical desired trajectories
- Vertical Performance
- Time
  - Trajectory, Window, Performance
- Safety Enhancement
- Display
- ITP

Key Attributes for NAS

- Performance Allocation
- Flight Object
- 2012 ICAO Flight Plan
  - A profile can be defined but ATM can accept it, but only 2D route structure is originally cleared. Estimated times are determined. Altitude profile is dynamic.
- Dynamic interaction of windows
- Clearance horizon
- Integration of Weather SAS
- Flow corridors
- Airspace Planning

Questions?