NASA's ATM Technology Demonstration 1 (ATD-1): Integrated Concept of Arrival Operations

31th DASC

14-18 October 2012

Williamsburg, VA

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Overview

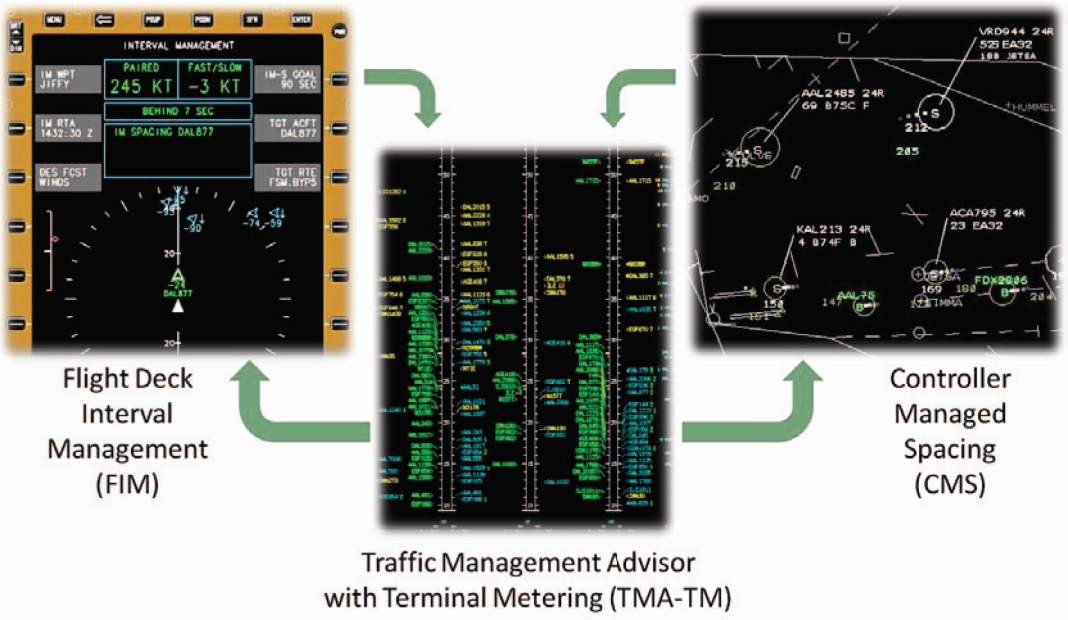
- Arrival Operations
  - Operational Problem
  - NASA's Approach
  - ATD-1 ConOps Description
- ATD-1 Component Technologies
  - TMA with Terminal Metering (TMA-TM)
  - Controller Managed Spacing (CMS)
  - Flight deck Interval Management (FIM)
- ATD-1 Concept of Operations
  - ATD-1 ConOps Overview
  - Five Phases
  - Sample Clearances
- Challenges
- Summary

Operational Problem

- Predicted average 3.7% increase in commercial aviation operations from 2011 – 2031
- Domestic flights in 2008 had 3.2 million hours delay
  - In particular, arrivals into high-density airports experience significant inefficiency due to delays and step-down procedures
- OPDs are available at a few locations, but control techniques and arrival scheduling do not support these operations during high-density operations
- Capacity at high-density airports near limit for current technologies and procedures
- In general, research has separated en route and terminal airspace problem; studies independent

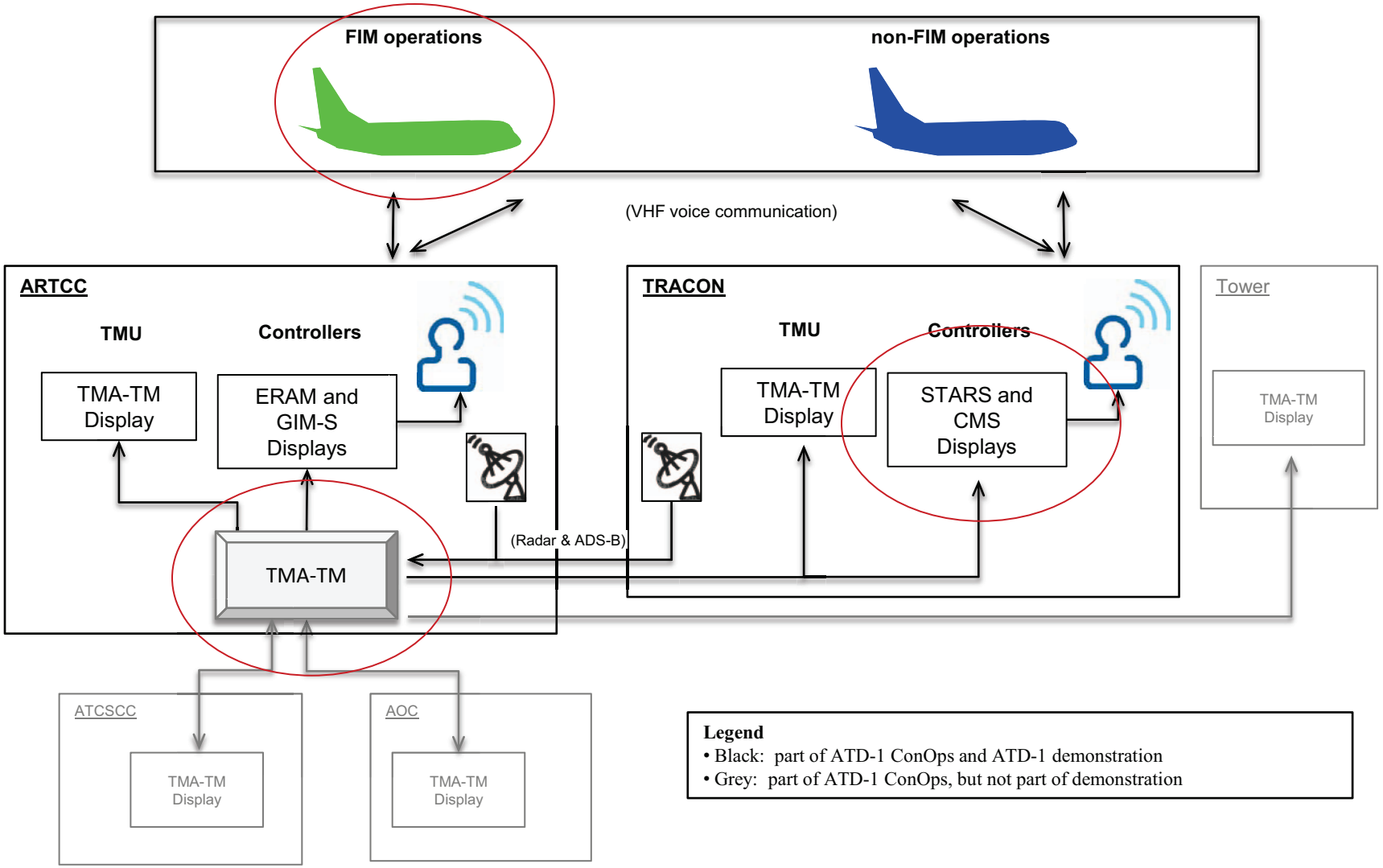
NASA's Approach

- Integrate three mature research technologies to achieve high throughput, fuel-efficient arrival operations in complex airspace
  - Trajectory-based operations from en route cruise altitude to assigned runway threshold
  - Feasible and comprehensive schedule, with precise control tools for controllers and pilots



ATD-1 User Diagram

Three NASA technologies in ATD-1



Legend
- Black: part of ATD-1 ConOps and ATD-1 demonstration
- Grey: part of ATD-1 ConOps, but not part of demonstration

ATD-1 ConOps Description

- Time-based schedule for all arriving aircraft:
  - Assign runway, establish appropriate sequence
  - Establish times at runway and merge points (Center and TRACON) to deconflict aircraft and meet flow rate
  - Schedule provided to TRACON and Center controllers
- Center controllers:
  - Issue aircraft speed instructions to achieve schedule, and issue pilots of equipped aircraft a spacing clearance
- TRACON controllers:
  - Issue aircraft speed instructions to achieve schedule
- Flight crew:
  - Enter spacing clearance into avionics, fly speed calculated

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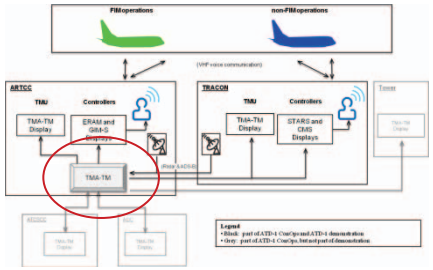
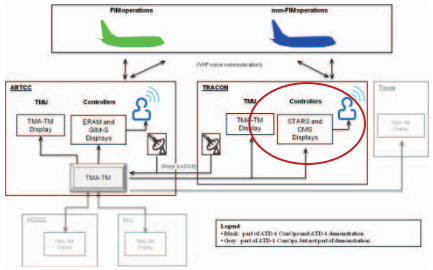
TMA-TM: TMA with Terminal Metering

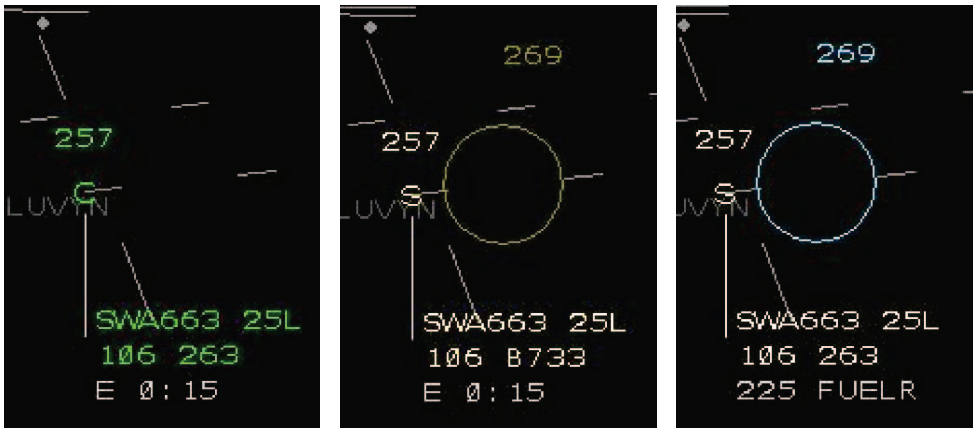


- Strategic planning, tactical control
  - Performs trajectory predications for arriving aircraft along route (OPD, step-down, etc.)
  - Establishes ETA for each aircraft at metering points, merge points, Final Approach Fix, and runway
  - Runway assigned and STA established when aircraft crosses the ‘freeze horizon’ (load balancing, wake class)
  - The schedule:
    - Is available as a meter list to Center and TRACON controllers
    - Provides the data to drive the CMS software
    - Formatted into FIM clearance

CMS: Controller Managed Spacing

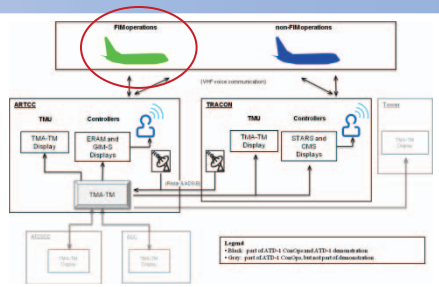


- TRACON controller tool to assist in maximizing the frequency of OPDs during high-density operations
- Based on TMA-TM output, calculates the airspeed required for aircraft to achieve the schedule
- Should reduce need for vectors



FIM: Flight deck Interval Management

- Pilots actively assist in maximizing throughput by precisely achieving the assigned spacing interval behind the preceding aircraft
- FIM clearance issued by Center controller once speed control alone is sufficient
- Pilot enters FIM clearance into avionics, confirms feasibility, then flies arrival using FIM speed



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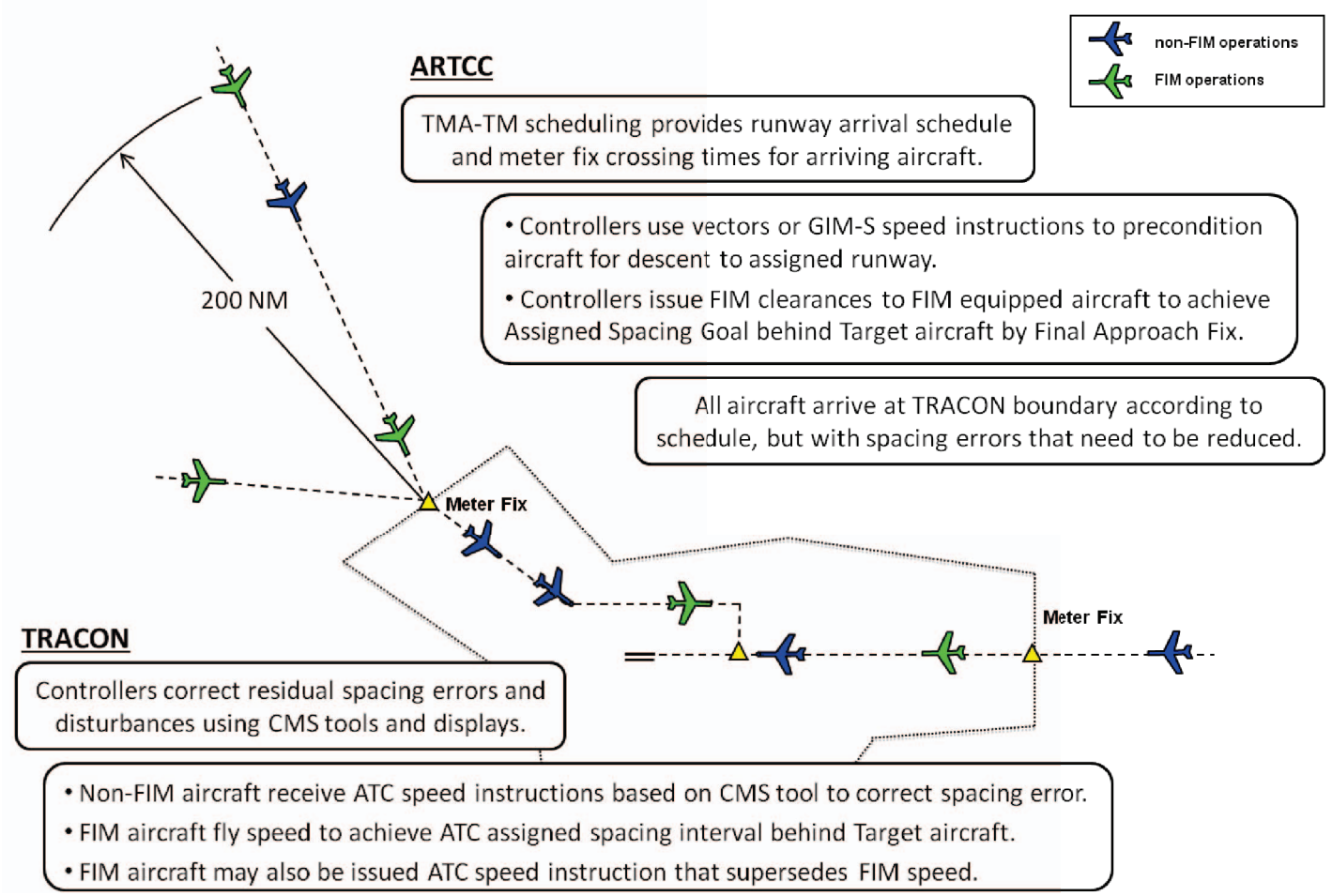
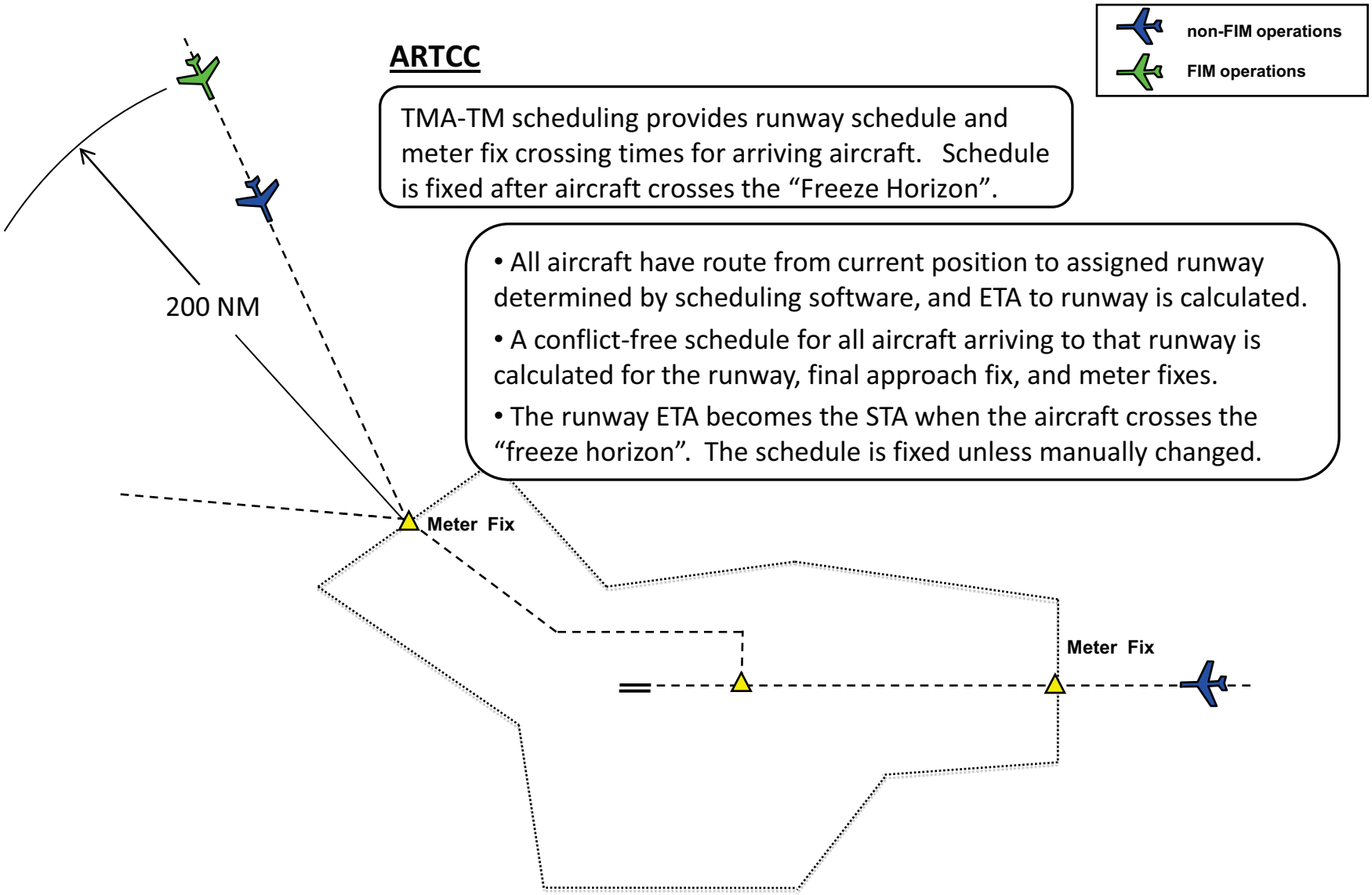
ATD-1 ConOps Overview

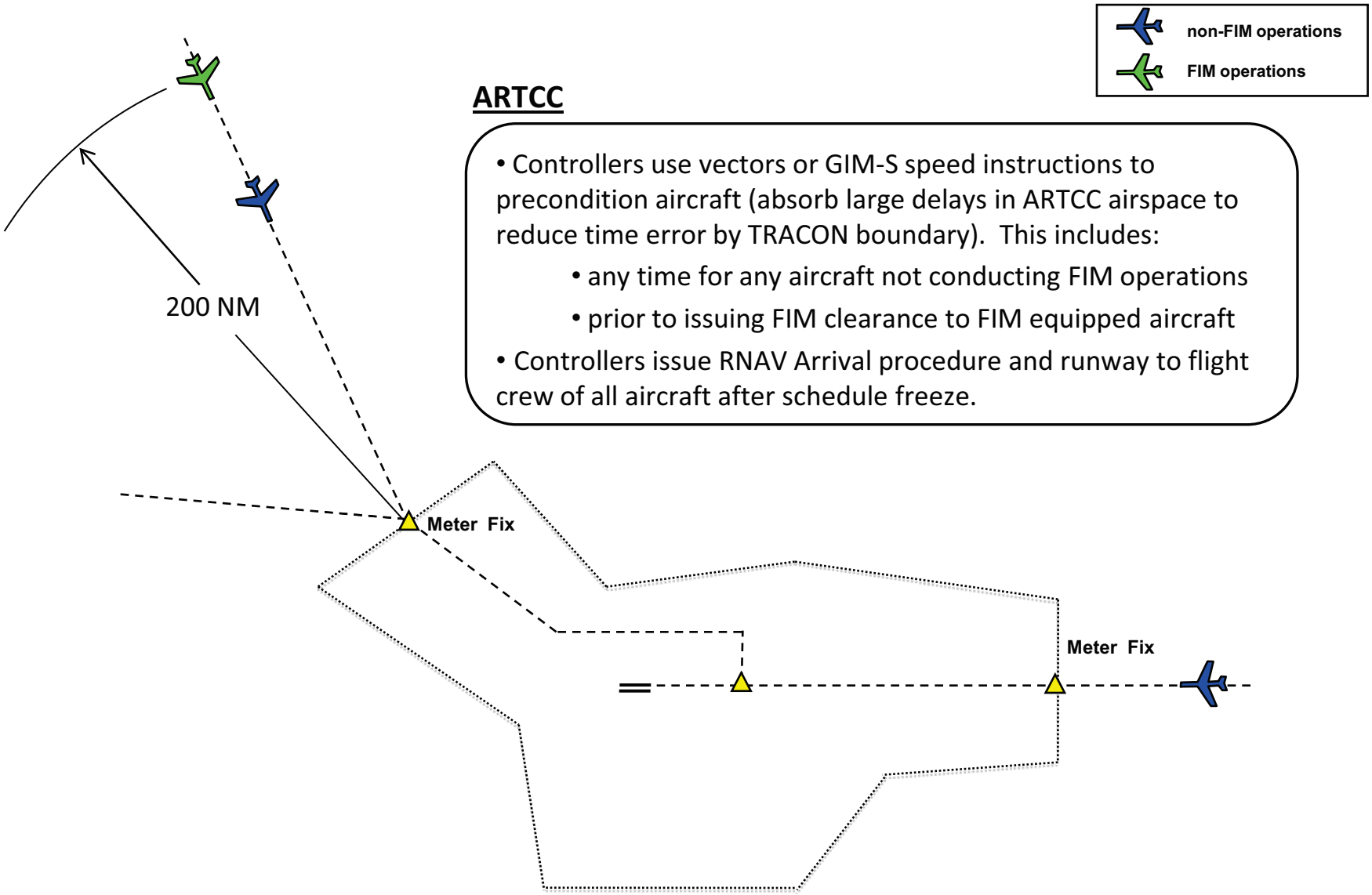
- Begins en route prior to ‘freeze horizon’, continues until touchdown on assigned runway



Scheduling Phase



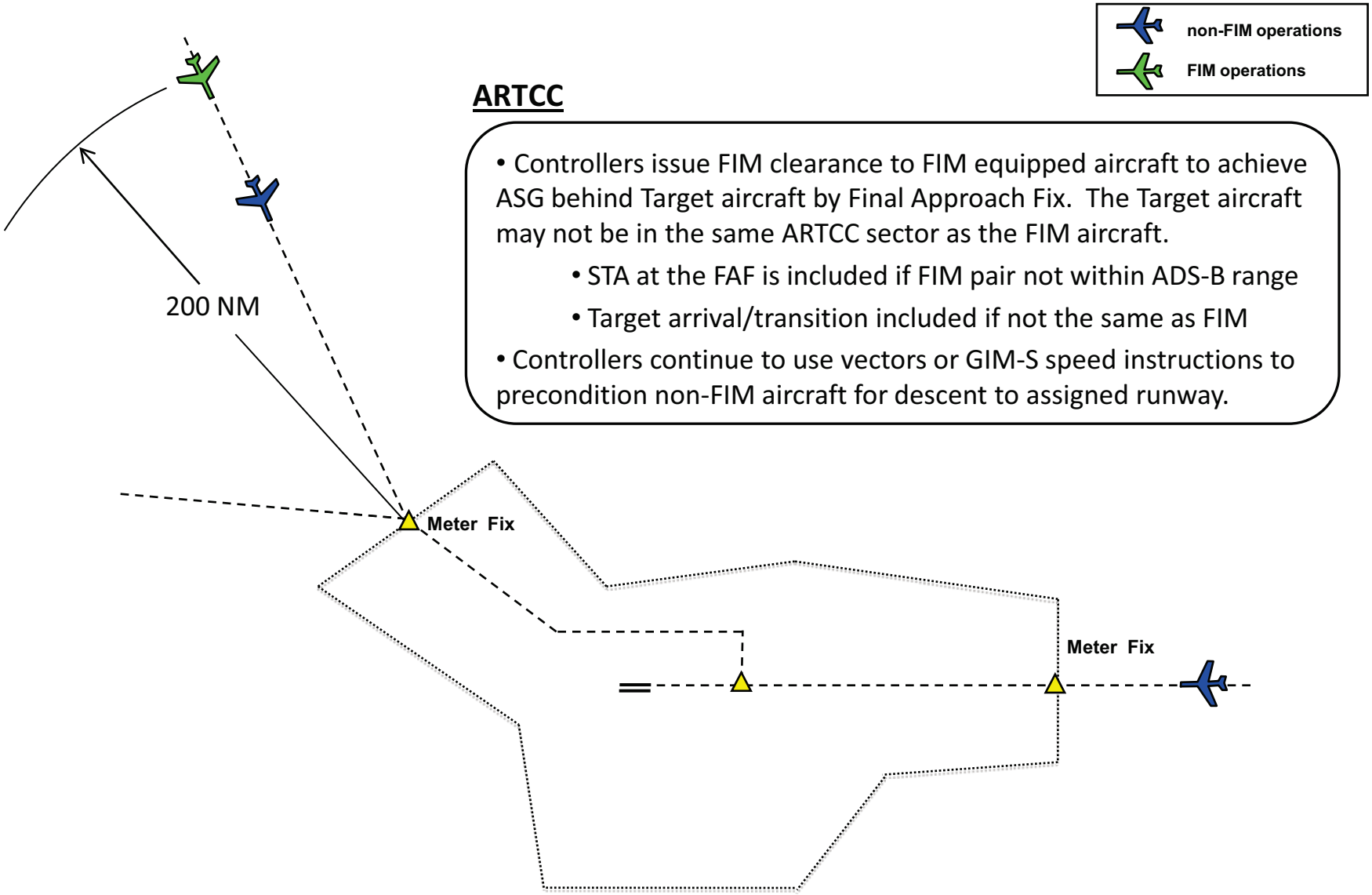
Preconditioning Phase



ARTCC

- Controllers use vectors or GIM-S speed instructions to precondition aircraft (absorb large delays in ARTCC airspace to reduce time error by TRACON boundary). This includes:
  - any time for any aircraft not conducting FIM operations
  - prior to issuing FIM clearance to FIM equipped aircraft
- Controllers issue RNAV Arrival procedure and runway to flight crew of all aircraft after schedule freeze.

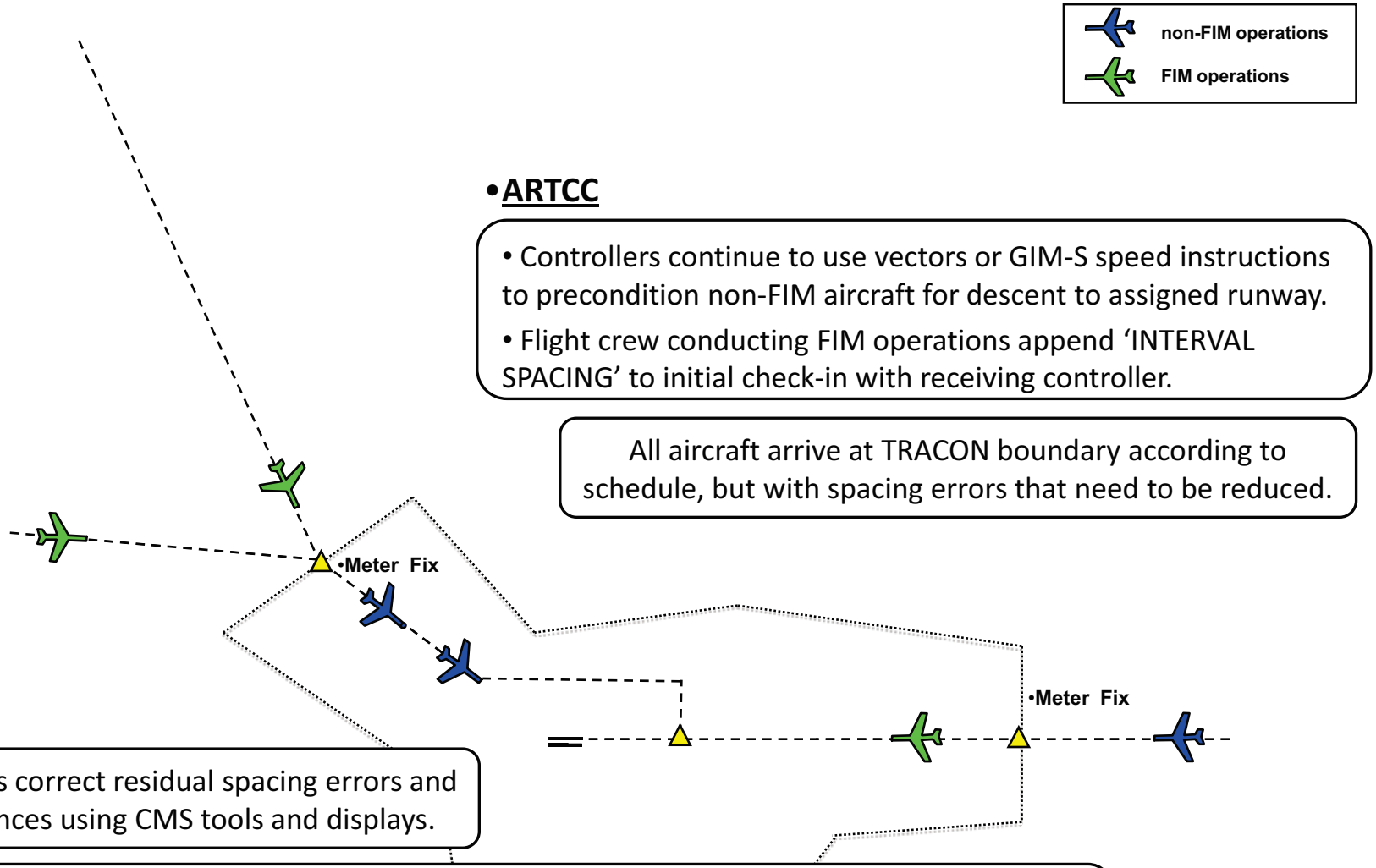
Initiation Phase



ARTCC

- Controllers issue FIM clearance to FIM equipped aircraft to achieve ASG behind Target aircraft by Final Approach Fix. The Target aircraft may not be in the same ARTCC sector as the FIM aircraft.
  - STA at the FAF is included if FIM pair not within ADS-B range
  - Target arrival/transition included if not the same as FIM
- Controllers continue to use vectors or GIM-S speed instructions to precondition non-FIM aircraft for descent to assigned runway.

Operations Phase



•**ARTCC**

- Controllers continue to use vectors or GIM-S speed instructions to precondition non-FIM aircraft for descent to assigned runway.
- Flight crew conducting FIM operations append 'INTERVAL SPACING' to initial check-in with receiving controller.

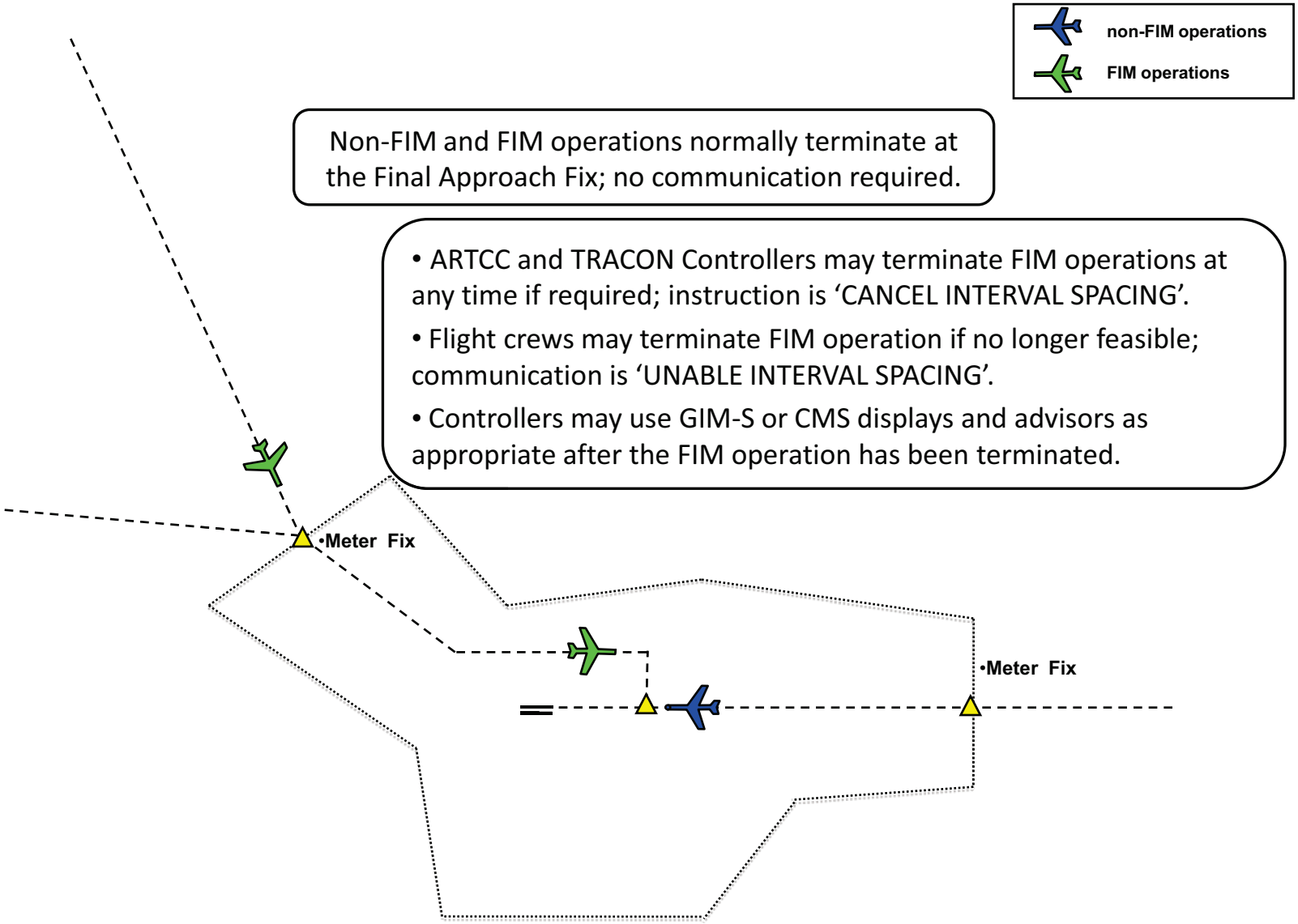
All aircraft arrive at TRACON boundary according to schedule, but with spacing errors that need to be reduced.

•**TRACON**

Controllers correct residual spacing errors and disturbances using CMS tools and displays.

- Non-FIM aircraft receive ATC speed instructions based on CMS tool to correct spacing error.
- FIM aircraft fly speed to achieve ATC assigned spacing interval behind Target aircraft.
- Controllers can issue speed instruction to FIM aircraft that supersedes FIM speed.

Termination Phase



Sample Clearances

- Route & runway assignment, STAR/SIAP connect
  - (Callsign), DESCEND VIA THE (MAIER TEN ARRIVAL, BOULDER CITY TRANSITION), EXPECT ILS (TWO SIX)
- Route & runway, STAR/SIAP do not connect
  - (Callsign), DESCEND VIA THE MAIER THREE ARRIVAL, BOULDER CITY TRANSTION, EXCEPT AFTER KUCOO EXPECT BLINE, CERUN, RUNWAY TWO-SIX
- FIM clearance
  - (Callsign), FOR INTERVAL SPACING, SPACE (NINE-FIVE) SECONDS BEHIND (NASA33) ON (SUNSS ARRIVAL)

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Challenges: Technology Integration

- Three technologies originally for different customers, slightly different problem, and variations in the methodology and lexicon
- Off-nominal events and conditions

Challenges: Operational Implementation

- 2017 time frame will not have all the capabilities envisioned in NextGen environment, which some of the concepts and tools were designed for
  - Expanded ADS-B message set, data comm, etc.
- 2017 time frame will not have ground infrastructure to support TMA-TM information displayed to all controllers, in both CMS and FIM format
  - GIM-S in Center, CMS in TRACON
  - FIM information may have to be relayed manually

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Summary

- Predicted increase in aviation operations
- Impact to high-density airports is significant
- ATD-1 ConOps integrates 3 NASA technologies to support high throughput, efficient arrival operations
  - TMA-TM: advanced scheduling, separation at all merge points, assigns runways
  - CMS: controller tool to achieve TMA-TM schedule
  - FIM: clearance based on TMA-TM schedule issued to pilots; they enter data into avionics, then fly FIM speed
- On-going work to address off-nominal procedures, technology integration, and operational implementation

Questions