

Maturing Airborne Precision Spacing through Field Testing

Efficiency

Airspace

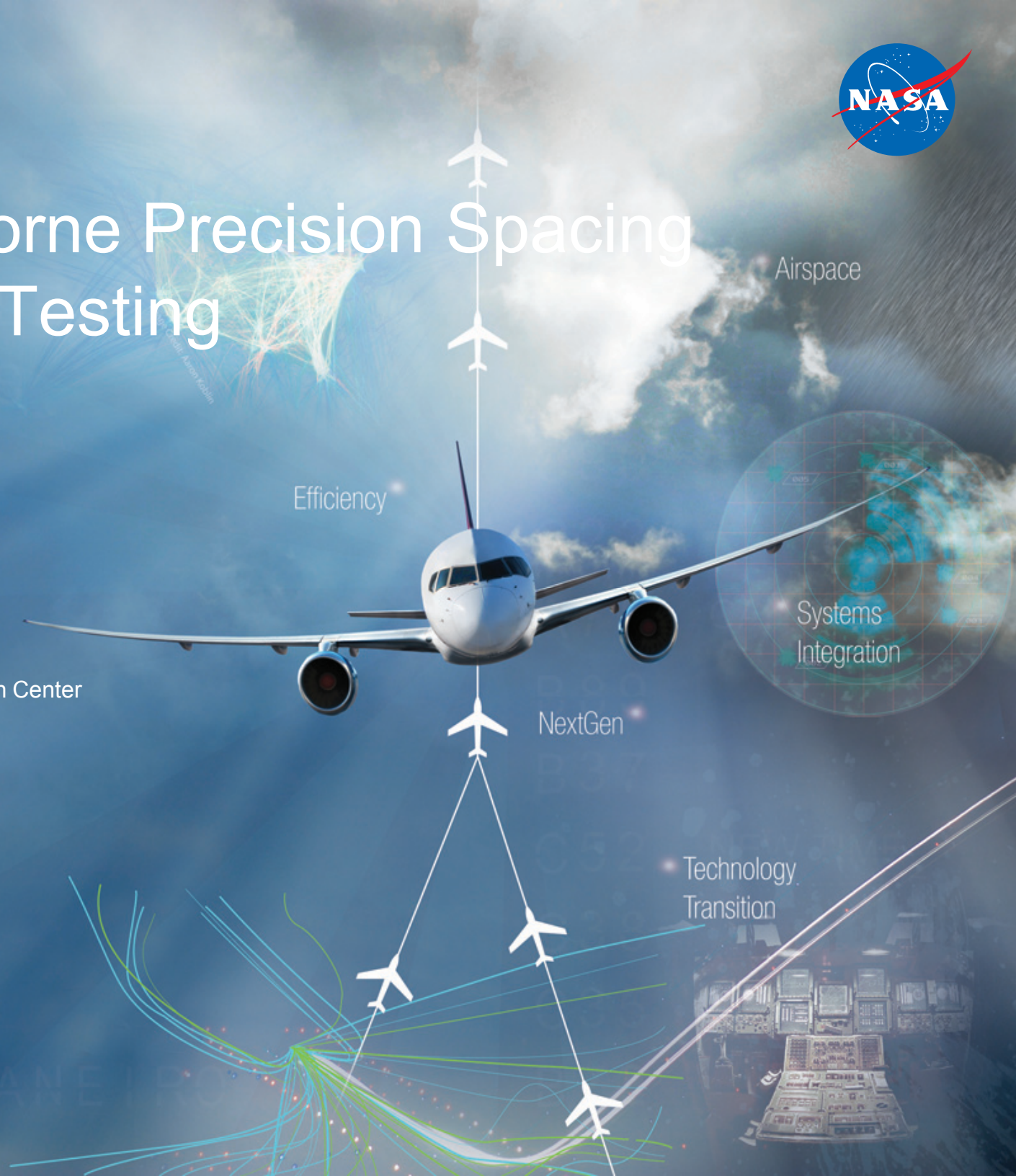
Systems
Integration

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NextGen

Airspace Systems Program
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San Diego, CA

Technology
Transition

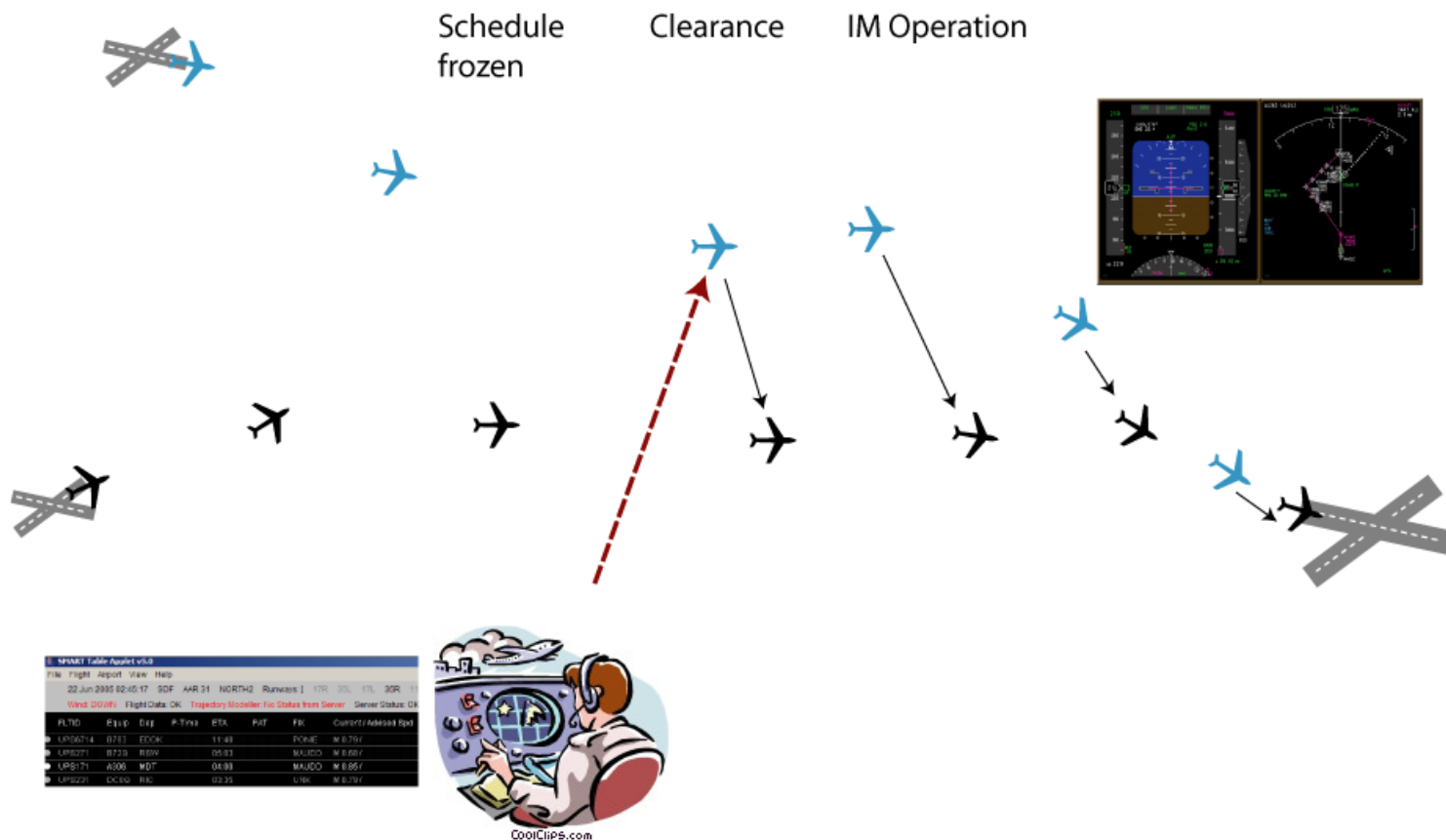


Presentation Agenda

- Overview of Interval Management concept
- Overview of Airborne Precision Spacing (APS) concept
- Significant APS research results
- Integration of Precision Scheduling with APS
- Overview of previous APS field testing
- Motivation for future APS field testing
- How field testing will mature APS
- Impact of successful field testing

Interval Management Overview

- Controller uses scheduling tool to set up traffic flow.
- Flight crew is provided with guidance, mainly speed, to achieve precise and consistent inter-aircraft spacing
- Improved surveillance and tighter control loop allows better balancing of spacing with efficient flight profiles

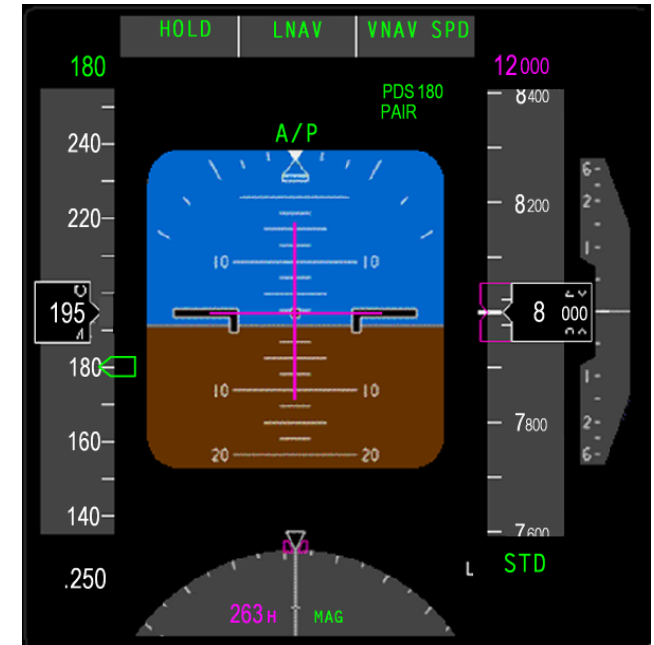


Airborne Precision Spacing (APS) Overview

- Precise spacing at a specific point to achieve high throughput when needed
 - Aircraft is a resource for accomplishing airline and ATM goals
 - Each flight crew achieves assigned spacing interval behind lead aircraft
 - Flight crew follows guidance from onboard software (using ADS-B information)
 - Additional benefit of reduced need for vectors and speed instructions to maintain separation
- Smaller deviations from aircraft optimized trajectory for less fuel consumption and noise
- Compatible with and able to enhance Current-Day Operations
- Enables the extended use of flight path optimization based procedures such as Optimized Profile Descents, Tailored Arrivals, 3D PAM, Green Skies, RNAV & RNAV/RNP routes
- Spacing possible for low-density airspace without advanced ground scheduler
- Workload and acceptability
 - Flight crew: not a significant change -- they fly arrival and approach as usual, speed from spacing algorithm on aircraft instead of speeds and headings from controller
 - Controller: ground software devises schedule and spacing between aircraft; workload for tactical tasks is reduced

Airborne Spacing: Algorithm

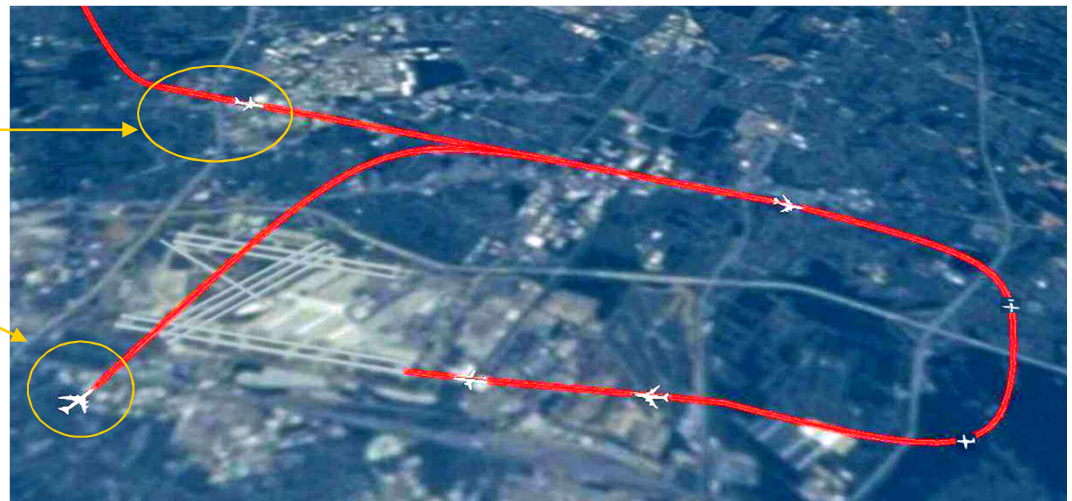
- Trajectory based, allows for aircraft on different RNAV routes with altitude and speed constraints
- Computes lead & ownship ETA at threshold
- Calculates speed guidance to achieve desired ETA over remainder of the route
- Corrects speed if necessary to prevent separation violations (delegated separation)
- Relative spacing enables smaller spacing buffer, increasing throughput during high-density ops



Lead ETA = 14:22:15

Ownship ETA = 14:23:30

- **assigned spacing interval: 90 sec**
- **15 seconds early at threshold**
- **Slow down 5 knots**



Airborne Spacing: Pilot Cueing

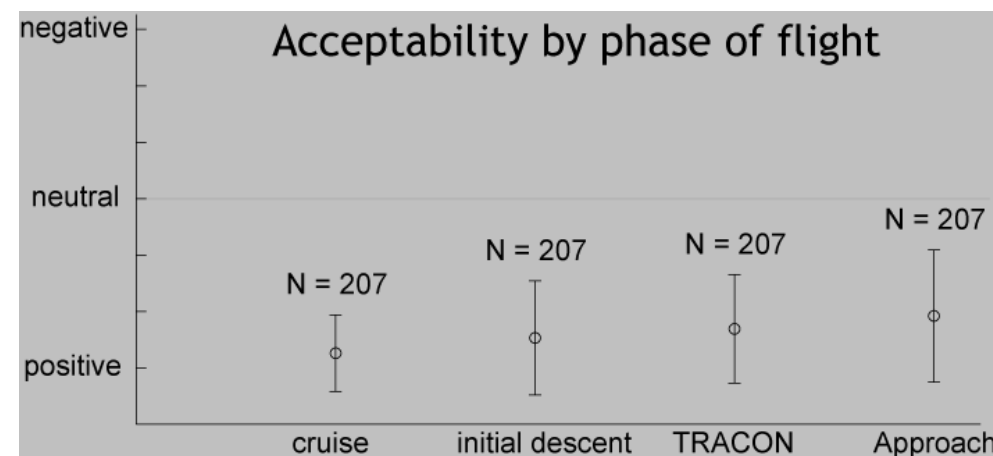
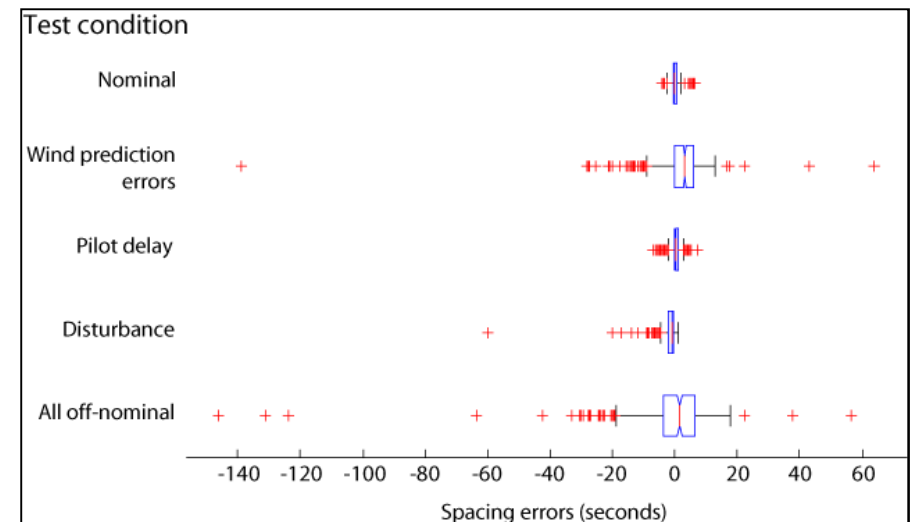
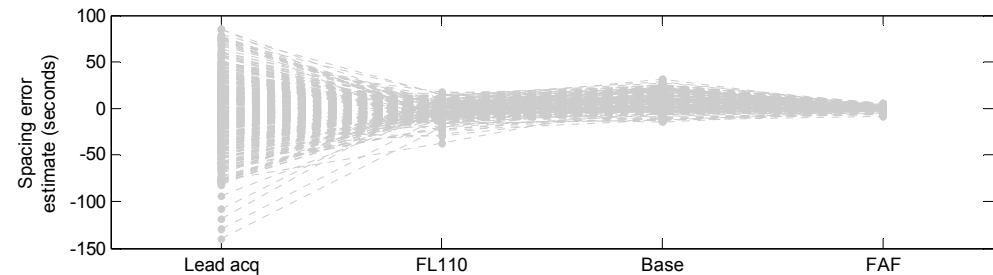
IM Commanded Speed
FMS Commanded Speed

IM Commanded Speed
(Green Indicator)



APS: Significant Research Results

- Decades of research by Langley, Ames, MITRE
- Recent Langley research results:
 - 2006 batch study:
 - arrival stream stable
 - gradual reduction of spacing error
 - 2008 batch study & Human-In-The-Loop (HITL) experiment:
 - high precision crossing runway with wind error, pilot delay, schedule disturbance, and off nominal events
 - pilots rated procedure as very acceptable and with low work load
 - 2009 batch study:
 - RTA and airborne spacing possible in same arrival stream
 - airborne spacing very robust to schedule deviations
 - 2011 IMSPiDR HITL this summer



Integrating Precision Scheduling with APS

- Precision Scheduling provides a pre-conditioned traffic flow that allows aircraft to execute APS
- APS research to date has assumed a pre-conditioned flow (built into the simulation scenario)
- Integration of precision scheduling into APS operations needs to be explored in simulation (dynamic scheduling to replace static traffic flow scenario) as build up to field test
- Field test should incorporate both precision scheduling and APS in order to be realistic and relevant

Motivation for Future APS Field Testing

- NASA's precision scheduling and spacing research has matured to show the high potential of merging efficient flows in high density operations
 - Precision scheduling and efficient delay distribution to minimize early descent from enroute altitude and low-altitude vectoring – not a part of the previous field testing
 - APS for aircraft on different arrival routes has been demonstrated in simulation, but not in an operational environment
 - Trajectory-based algorithm improves stream stability – has not been evaluated in an operational environment
- FAA/NASA/Industry collaboration will accelerate implementation of ADS-B applications in a way that delivers the full benefit of NextGen operations to those that equip in high density airspace
- Integrated precision scheduling and spacing will offer immediate and systematic benefits to users in a wide variety of operational environments, even with different equipage levels and traffic densities

How Field Testing Will Mature APS

- NASA
 - Mature APS technology with Interval Management capabilities to a level that allows for a smooth hand-off to avionics manufacturers
 - Higher TRL level achievable with partnering
- FAA and Industry Partners
 - Participate in precision scheduling and spacing evaluation; use experience to develop international harmonized procedures and set avionic standards
 - Ensure relevance of combined procedures and technologies for NAS-wide application (arrival, departure, enroute, oceanic)
 - Enable broad airspace user and operator collaboration
- Characterize the behavior of precision scheduling and spacing in an operational environment
- Users/Manufacturers conduct cost benefit analyses for broad NAS application with highly relevant operational data

Impact of Successful Field Testing

- Higher throughput and more fuel efficient/reduced noise impact operations
 - Reduced vectoring to ensure safe separation (fuel saving)
 - Throughput increase during high-density operations possible by reduced excess separation buffer at runway threshold (extrapolated from inter-arrival spacing performance)
 - Compatibility with OPDs, Tailored Arrivals, etc.
- Accelerated technology demonstration of a major NextGen capability for high density operations
- Reduced ATC-pilot communication required, especially during busy or complex operations
- Motivate ADS-B IN equipage, which enables other operational benefits (e.g. In Trail Procedures, runway incursion warning, CDTI Assisted Visual Separation, Traffic Awareness with Alerts)

Discussion/Questions

