Boeing Perspectives on ADS-B Surveillance

Considerations
&
Opportunities

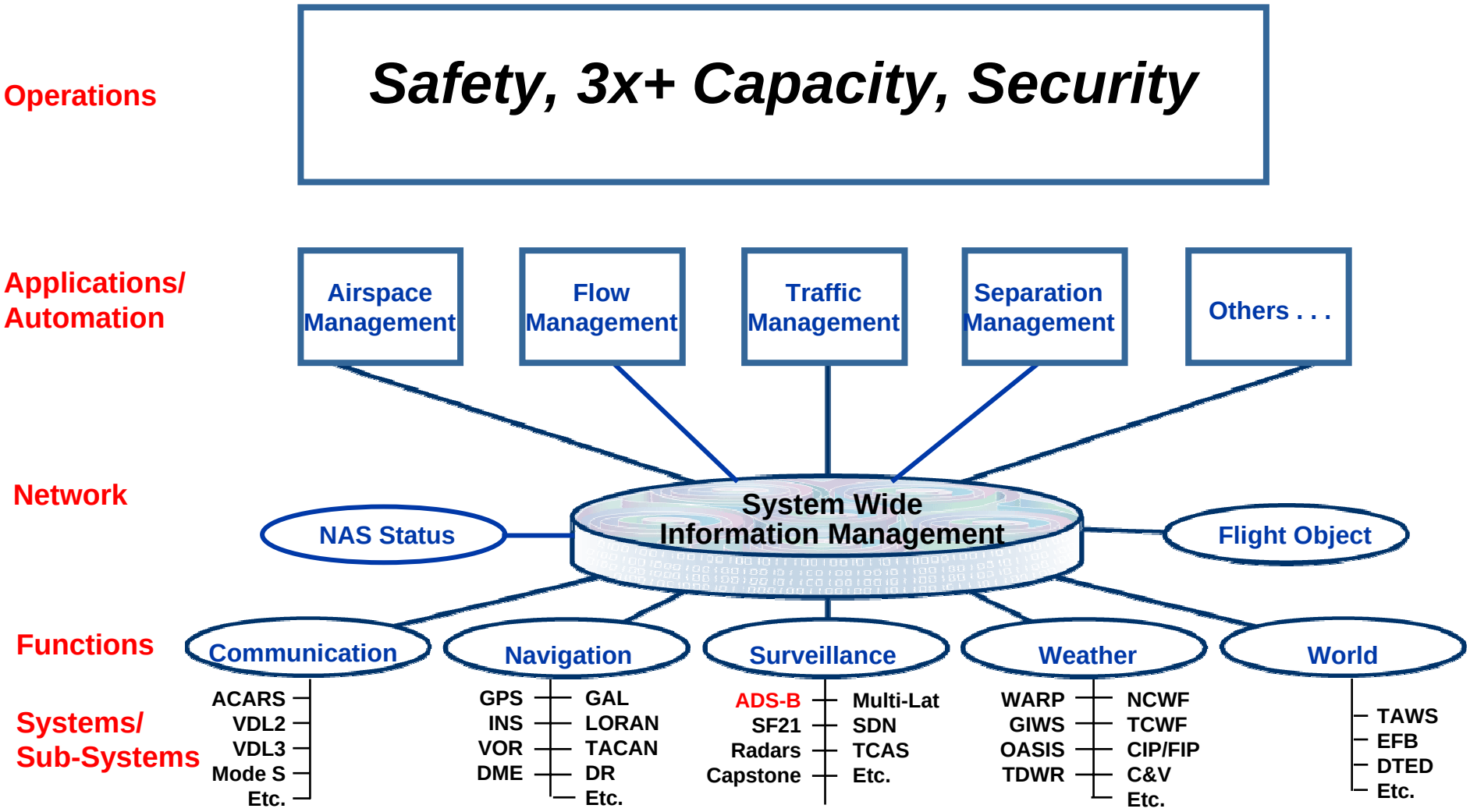
3 Messages

1. **ADS-B infrastructure deployment needs to be designed as one (key) component of a larger system transformation.**

2. **Operational applications are crucial to ADS-B success.**

3. **System applications/standards must integrate all users – GA and 121, U.S. and Global.**

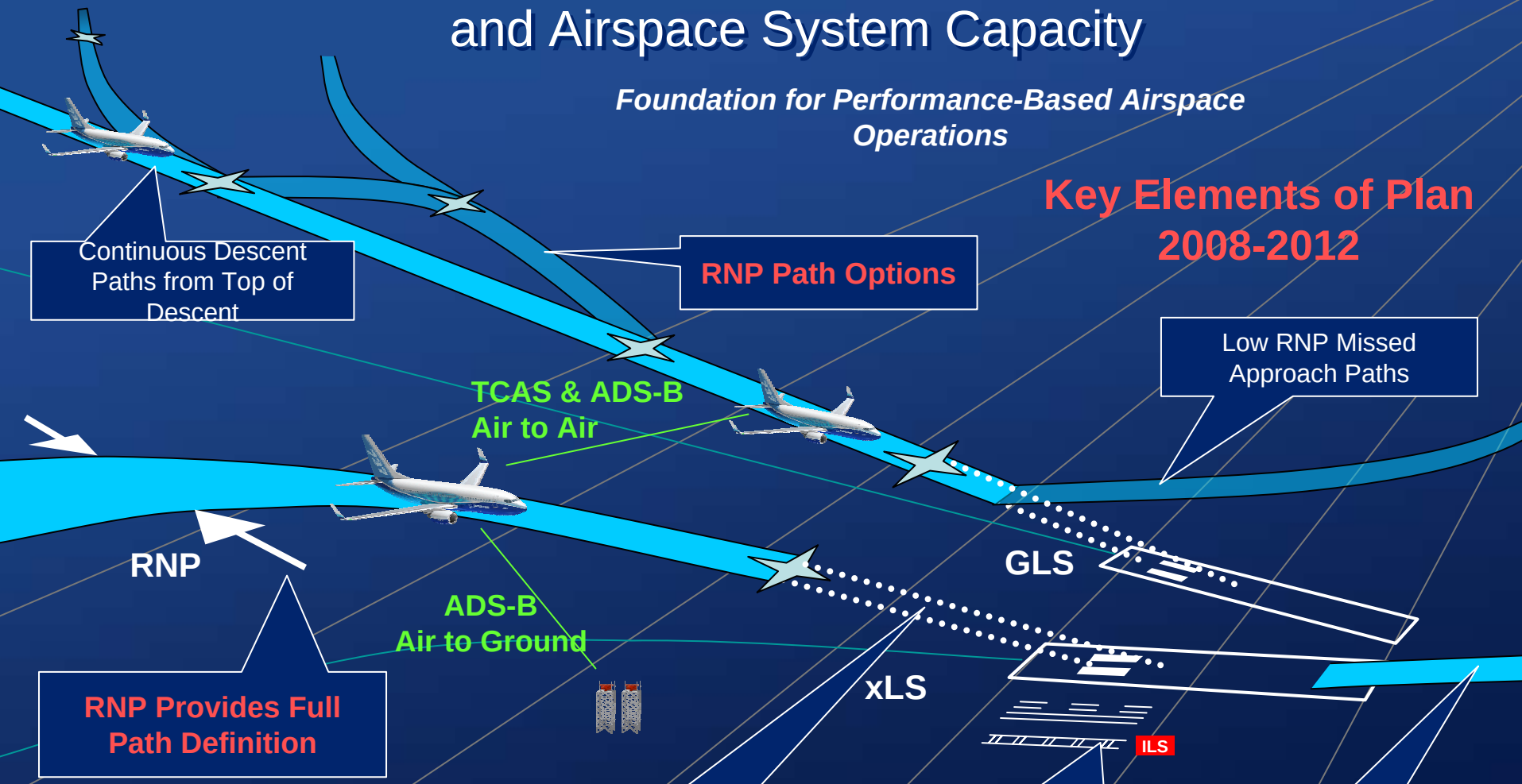
Network Centric ATM :
Exploiting Shared Precision Information



Reliable Precision Operations Improve Predictability, Safety and Airspace System Capacity

Foundation for Performance-Based Airspace Operations

Key Elements of Plan 2008-2012



Air Traffic Planning Tools

GBAS Based GLS

GLS Reduces / Eliminates ILS Critical Areas

Low RNP Departure Paths

Surveillance Applications - Surface

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Airport Surface Surveillance (ADS-B-APT): includes runway incursion alerting, could also enable low visibility surface ops	Safety (information provided to Tower controller, thus only incremental benefit)	2008	L	Multilateration	Surv. Data processing
Enhanced Traffic Sit. Awareness (ATSA-SURF): supplements out-the-window observations, includes runway occupancy alerting	Safety; research suggests increased surface efficiency	2008-2012	M (map takes larger part of the benefit); H for combined	Airport moving map display only; Synthetic vision	Airport moving map display

Includes surface traffic interacting with traffic on active runways and departure runways

Surveillance Applications - Departure

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Enhanced Traffic Sit. Awareness (ATSA-AIRB): Nearby traffic display with flight ID and position, general awareness, see and avoid. Augments out-the-window and enables crew to detect controller error.	Safety	2008-2012	L		CDTI
Enhanced Air-Ground Surveillance (ADS-B-ADD): provide aircraft-derived data (state data for short-term intent) to enhance ground ATC automation	Capacity, efficiency; controller productivity	2008-2012	M	CPDLC, ADS-C; ASPA-C&P	Advanced ATC automation
Enhanced Crossing and Passing (ASPA-C&P): controller identifies problem and delegates solution to aircraft. Primary use to separate from arrival traffic.	Capacity, efficiency; controller productivity	2012-2015	M	ADS-B-ADD	CPDLC, AC traffic automation

After liftoff

Surveillance Applications – Enroute

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Radar Airspace (ADS-B RAD): reduce cost of radar infrastructure by using ADS-B air-ground	Improved surveillance to reduce separation; reduce ATSP cost	FAA 2008	L (cap/eff) M (ATSP cost)	Radar	Surv. data processing
Enhanced Traffic Sit. Awareness (ATSA-AIRB): Nearby traffic display with flight ID and position, general awareness, see and avoid. Augments out-the-window and enables crew to detect controller error.	Safety, efficiency	2008-2012	L		CDTI
Enhanced Air-Ground Surveillance (ADS-B-ADD): provide ac-derived data to enhance ATC automation	Capacity, efficiency; controller productivity	2008-2012	M	CPDLC, ADS-C	Advanced ATC automation
Enhanced TCAS (Boeing): increase scope of TCAS	Safety	2012	L	Ground Short Term Conflict Alert	
Sequencing & Merging (ASPA-S&M)	Increased capacity; reduce fuel costs	2012+	M	ATC tools	CDTI, FMS integ, Aircraft traffic automation
Enhanced Crossing and Passing (ASPA-C&P): spacing application using lateral maneuvers	Efficiency; controller productivity	2012-2018	L	ATC conflict detection & resolution	CDTI, FMS integ, Aircraft traffic automation

Surveillance Applications – Enroute contd.

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Vertical Crossing and Passing (ASEP-VC&P): spacing application using vertical maneuvers	Efficiency; controller productivity	2012-2018	L	ATC conflict detection & resolution	CDTI, FMS integ, Aircraft traffic function
Lateral Crossing and Passing (ASEP-LC&P): separation responsibility transferred to crew for the specific identified problem	Efficiency; controller productivity	2018-2025	L	ATC conflict detection & resolution	CDTI, FMS integ, Aircraft traffic automation
Self-separation in segregated free flight airspace (SSEP-FFAS): aircraft fly user-preferred routings and provide self separation	Controller productivity; efficiency	2025	H (ATSP cost savings)	ATC tools	CDTI, AC traffic function
Self-separation in managed airspace	Controller productivity	2025	H (ATSP cost savings)	ATC tools	CDTI, AC traffic function
Airborne Short Term Conflict Alert (similar to RTCA ACM): safety backup for fully automated ATC	Safety, controller productivity	2025	H (ATSP cost savings)	Ground-based STCA	CDTI, AC traffic function
Airborne Autonomous Conflict Management (NASA ACM): ac detects and resolves conflicts by modifying its 4D trajectory (replaces sector ATC)	Capacity, efficiency; reduce ATSP cost	2025	L (airspace), H (ATSP cost)	Avionics cost to replace sector ATC function	Airborne Autonomous Operations Planner

Surveillance Applications – Arrival Management

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Enhanced Traffic Sit. Awareness (ATSA-AIRB)	Safety	2008-2012	L		CDTI
Enhanced Air-Ground Surveillance (ADS-B-ADD): provide ac-derived data to enhance advanced ATC automation	Capacity, efficiency; controller productivity	2008-2012	M	CPDLC, ADS-C	Advanced ATC automation
Merging and Spacing (UPS M&S): centralized metering by early speed control toward single merge point, aircraft self spacing during CDA descent	Efficiency, noise & emissions	2008+	M	Ground automation with FMS RNP 3D Path procedures; portability issue for high traffic	CDTI, Aircraft traffic function, Ground metering tool, RNAV
Sequencing & Merging (ASPA-S&M): maintain in-trail spacing, merge behind, can include path stretch by controller heading and CDA profiles	Capacity, reduced fuel costs; controller productivity	2012+	M	Ground automation with FMS RNP procedures	CDTI, Aircraft traffic function
Enhanced TCAS (Boeing): increase scope of TCAS	Safety	2012	L	Ground Short Term Conflict Alert	
Airborne Short Term Conflict Alert (similar to RTCA ACM): safety backup for fully automated ATC	Safety, controller productivity	2025	H (ATSP cost savings)	Ground-based STCA	CDTI, AC traffic function

Starts prior to TOD and ends around turn to base

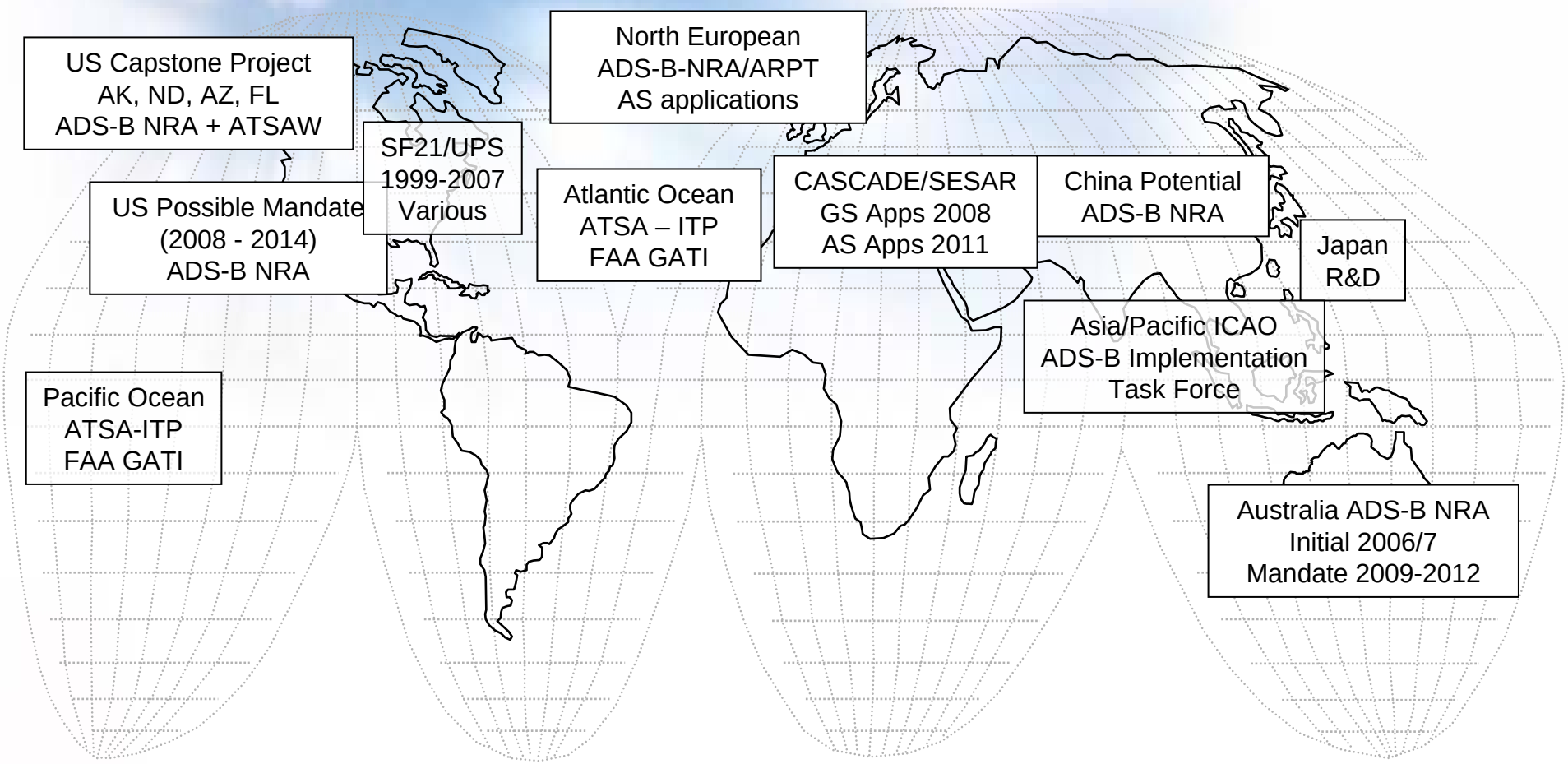
Surveillance Applications – Approach/Landing

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Precision Runway Monitoring (PRM) – Closely Spaced Parallel Runway Operations to 2500 ft (To be added to ASAS Package 1)	Capacity; allows approaches to closely spaced parallel runways w/o PRM radar	2008-2012	H	PRM	ATC display
Enhanced Visual Separation on the Approach (ATSA-VSA): to aid in acquiring and maintaining visual separation with lead ac on approach	Capacity	2008-2012	L	Eyes and window	CDTI
CAVS or CEFR (UPS): attain and maintain visual separations even when out-the-window visibility is lost	Capacity	2012-2018	M		CDTI
Enhanced Traffic Sit. Awareness (ATSA-SURF): supplements out-the-window observations, includes runway occupancy alerting	Safety; research suggests increased surface efficiency	2008-2012	M (map takes larger part of the benefit); H for combined	Airport moving map display only; Synthetic vision	Airport moving map display
Approach Spacing in Instrument Approaches (ASIA): In-trail spacing to visual minima in IMC and Independent parallel runway operations to 750 ft	Capacity	2018-2025	H	Wake Vortex Detection	TRACON automation?

Surveillance Applications – Oceanic/Remote

Operational Enhancements	Benefit Mechanism	Time Frame	Benefit Level	CNS/ATM Trade	Other Enablers Required
Non-Radar Airspace (ADS-B-NRA): Provide air-ground surveillance instead of radar: providing separation services where there currently are only procedural	Capacity - reduced separation minima	4Q/06 (Australia) GOM Mediterranean N-Scand China	M	Radar; ADS-C	Communication, Surv Data Proc
Enhanced Traffic Sit. Awareness (ATSA-AIRB): Traffic information Broadcast (TIBA) – remote crossing route safety	Safety	2008-2012	L	Voice; Radar	CDTI
Oceanic In-Trail Procedures (ATSA-ITP): ac climbs through lead ac FL, behind lead and closer than oceanic in-trail min, to reach more efficient FL	Efficiency - reduce fuel burn or flying time	2008-2012	L	Satellite CPDLC and ADS-C	CDTI
Oceanic In-Trail Follow (ATSA-ITF): ac to maintain time or distance behind lead ac (replaces Mach rule)	Possible controller workload	2008-2012	L	Mach Rule; Satellite CPDLC and ADS-C	CDTI, AC traffic automation
Self-Separation in Organized Track System (SSEP-FFT): crew can choose alt and speed freely	Possible controller workload	2008-2012	L	Remove track system	CDTI, AC traffic automation

Worldwide Surveillance Activity



Lots of diverse world-wide activity going on!

Key Surveillance Issues

1. **Surveillance standards need revision and extension – both TCAS and ADS-B**

2. **Existing ADS-B-Out Equipment potential for operational use**

3. **Surveillance enhancements must be driven by comprehensive operational benefits**

4. **We need a transition strategy for surveillance – including operational incentives, mandates, etc.**

Issue #1: Surveillance Standards need revision and extension – both TCAS and ADS-B

- Operational Criteria must drive all surveillance standards
  - This is currently in work by the Requirements Focus Group
- Airplane level criteria for installation and capability, in the form of FAA ACs / EASA TGLs are not yet available
- Equipment standards also evolving:
  - DO-260 vs. DO-260A vs. DO-260A-CHANGE-1, Updated TSO-C166a, ADS-B MOPS, CDTI MOPS
- Boeing strongly urges that industry focus on:
  - Understanding sufficiently both ADS-B-out/in requirements
    - ADS-B-in must not “re-do” ADS-B-out
  - Developing cert standards that address both requirements

Issue #2: Existing ADS-B-Out Equipment potential for operational use

- ADS-B-Out was only partially implemented (non-interference basis)
  - ADS-B-Out standards were limited in scope at the time of criteria publication
- Use of existing ADS-B-Out equipment requires safety assessment and additional operational considerations
  - Regulatory basis for airplane level performance of existing equipment is needed
  - Part number roll for XPDR may be needed
- Boeing advocates for a stable ADS-B-out standard that:
  - Meets ADS-B-out mandates
  - Will not be changed for ADS-B-in

Issue #3: Surveillance enhancements must be driven by comprehensive operational benefits

- Implemented applications need to have a positive benefit for <u>all stakeholders</u> in the value stream
  - ADS-B-Out is a logical first step for airplanes with GPS
  - Consider a package of applications to be implemented together
  - Significant user benefits are likely enabled by ADS-B-In
- Airline-centric business cases need stronger consideration
- Early trials are subject to different criteria for closure than global implementations, but provide a good opportunity for advancing standards and understanding benefit mechanisms
- Boeing will work with all stakeholders in sharpening the technical effort on comprehensive operational benefits

Issue #4: We need a transition strategy for surveillance

- Regulators should coordinate credits (operational incentives) permitted, and if used, any mandates
  - Avoid multiple or conflicting mandates for the same functions
- Ground infrastructure requirements and implementation must be coordinated with airplane functionality and implementation
- All transition activity should be scheduled and phased for industry efficiency
  - Development, testing, and certification (e.g. for TSO)
  - Airplane production certification
  - Airplane fleet deployment for retrofit installation
  - Ground infrastructure deployment
- Credits or mandates should account for varying capability of aircraft (e.g. GPS v. non-GPS) and establish requirements accordingly
  - Current production configuration: LRU upgrade only
  - Retrofit Configuration: TBD/Variable

- ADS-B infrastructure deployment is part of a larger system transformation
- Near-term operational applications/risk reducing trials are crucial to ADS-B success
- System must integrate all users

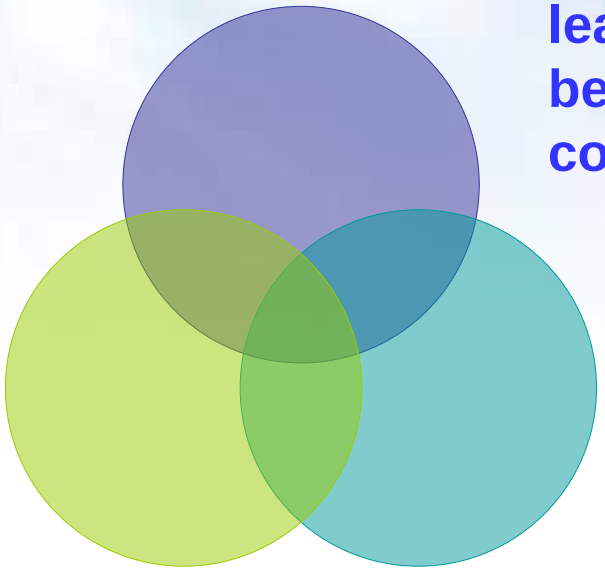
BOEING

Selected Surveillance Applications of Interest, 2006-2012

Operational Enhancements	Benefit Mechanism	Benefit Level	CNS/ATM Trade	Other Enablers Required
Airport Area (Surface) Enhanced Traffic Sit. Awareness: supplements out-the-window observations; runway occupancy alerting	Safety; increased efficiency	M; H if combined w/map	Airport moving map display; Synthetic vision	Airport moving map display
Non-Radar Airspace: Provide air-ground surveillance instead of radar, providing separation services where there currently are only procedural. Australia, GOM, Mediterranean, N-Scand, China.	Capacity - reduced separation minima	M	Radar; ADS-C	Communication, Surveillance data processing
En-Route Radar Airspace: reduce cost of radar infrastructure by using ADS-B air-ground. FAA plan for mandate.	Reduced ATSP cost; reduced separation	L (cap/eff); M (ATSP cost)	Radar	Surveillance data processing
Oceanic In-Trail Procedures: aircraft climbs through lead's FL, behind and closer than oceanic minima, to reach more efficient flight level	Efficiency - reduced fuel burn or flying time	L	Satellite CPDLC and ADS-C	CDTI
Arrival Management Merging and Spacing (UPS M&S): centralized metering by early speed control toward single merge point, aircraft self spacing during CDA descent	Efficiency, noise & emissions	M	ATC automation with FMS 3D paths; issues w/high traffic	CDTI, Aircraft traffic function, Ground metering tool, RNAV
Arrival Management Sequencing & Merging (ASPA-S&M): maintain in-trail spacing, merge behind; can include path stretch by controller heading and CDA profiles	Capacity, reduced fuel burn; controller productivity	M	ATC automation with FMS 3D paths	CDTI, Aircraft traffic function
Approach Precision Runway Monitoring: Closely Spaced Parallel Runway Operations to 2500 ft without PRM radar	Capacity	H	PRM	ATC display

Strategy Objectives

Surveillance upgrades target three key components:



ADS-B should have at least a positive benefit on each component, and...

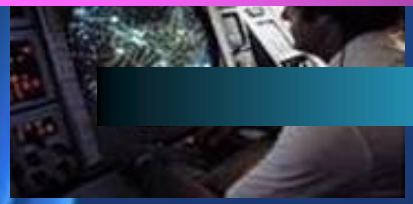
ADS-B <u>cannot</u> have a negative safety impact.

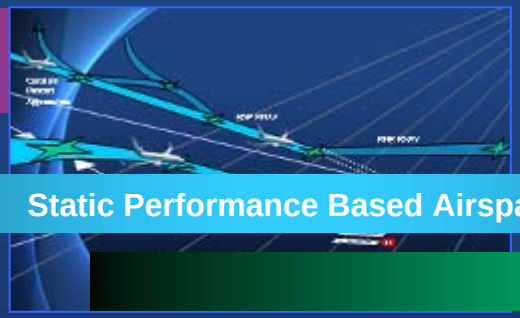
Air Transportation System Landscape

2005 | 2010 | 2015 | 2020 | 2025 | 2030

Airspace Design

Manual ATC Intervention & Navaid-based





Static Performance Based Airspace

Dynamic Performance Based Airspace

Key Capabilities

Communication

AOC ATS
- Voice
- Oceanic Datalink (FANS)
- ACARS
- IP Comm
- Datalink for Congested Airspace
- IP Comm

Navigation

RNP Applications at Secondary Airports

GLS - GBAS

Broad RNP Use at Primary Airports

Comprehensive Global Use of Satellite-based Navigation

Surveillance

Primary / Secondary Radar

TCAS ADS-A

Dependent Surveillance (ADS-B)

Air to Air

Air to Ground

Evolving Applications

ATM Automation

Arrival Scheduling

Conflict Probe

3D-Paths for Arrival Planning and Conflict Resolution

4D Trajectory-Based Air-Ground Integration

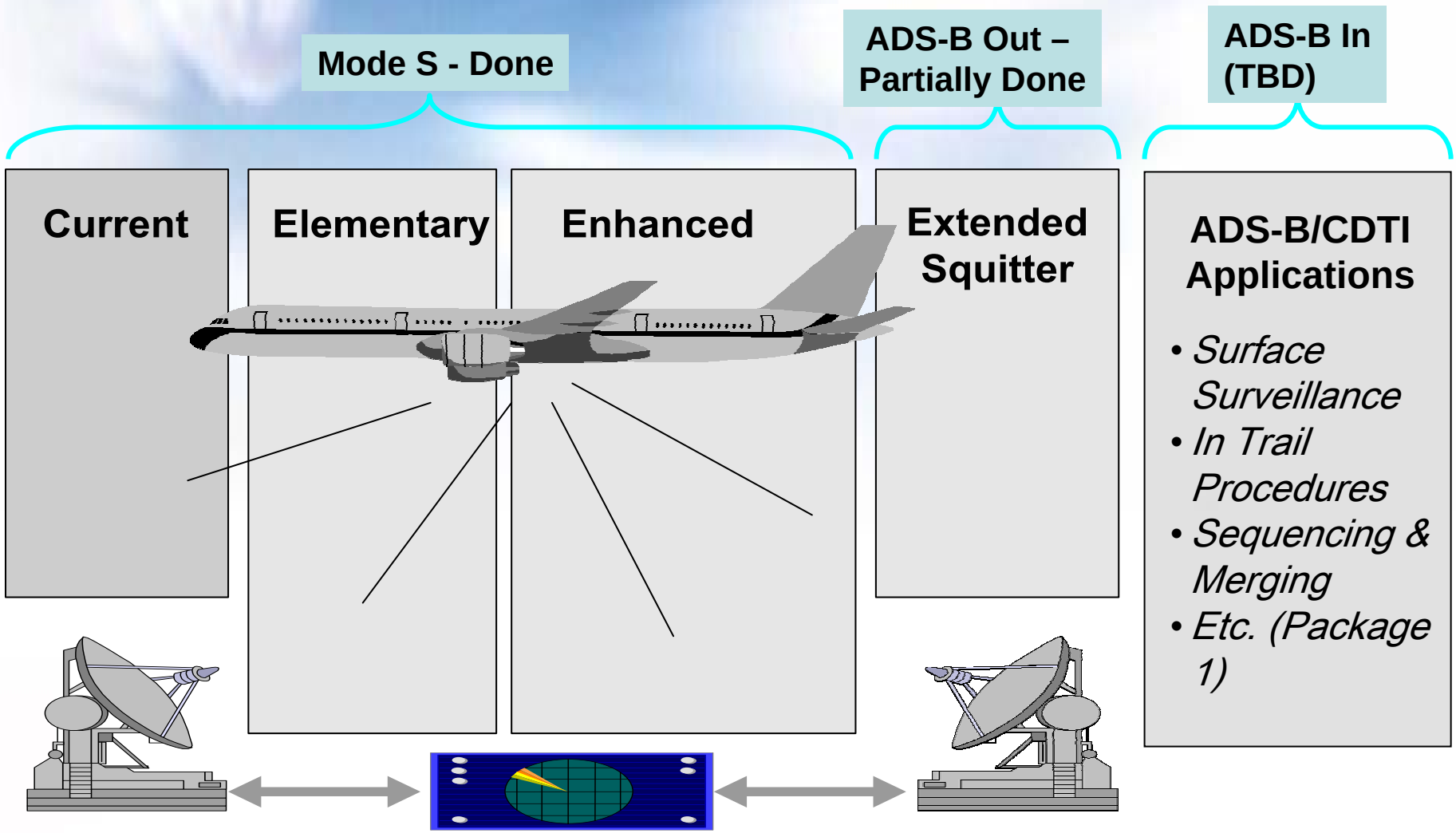
Additional capabilities in support of…

Required Total

ce

Surveillance Applications

A Synopsis of Surveillance Upgrades

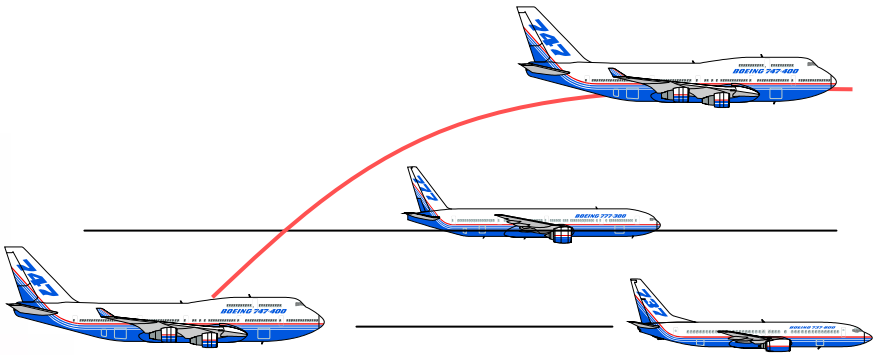


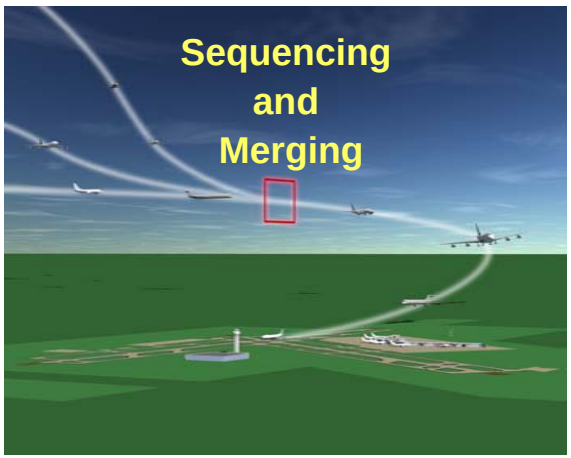
ADS-B Airplane Applications

Airport Surface

Situational Awareness

In-Trail Procedures

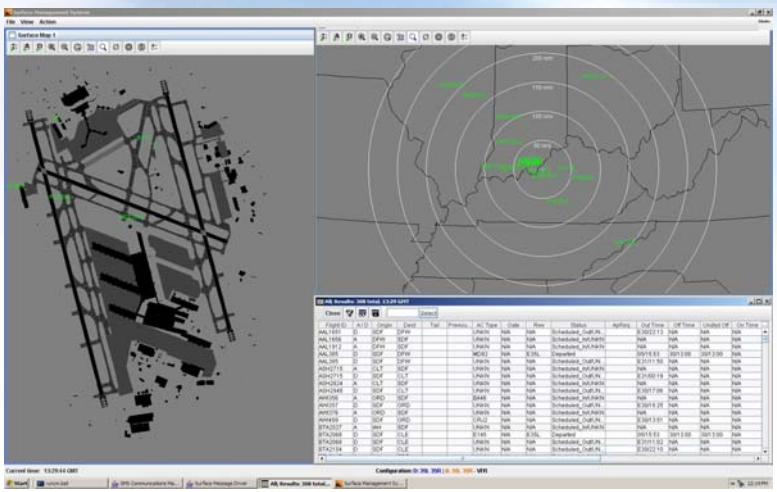




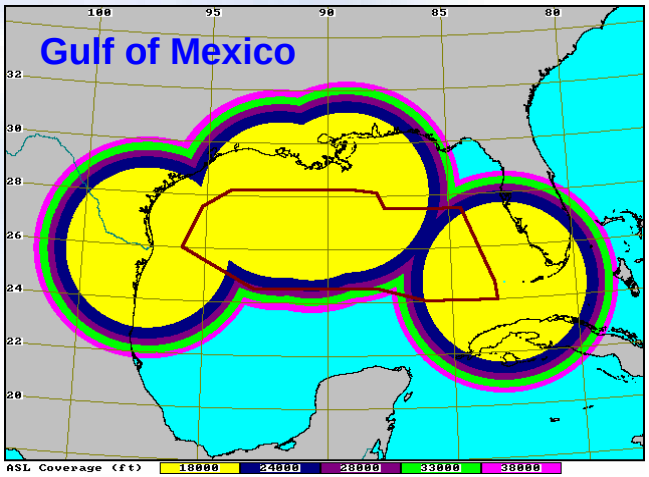
Graphics: Compiled from Boeing and other Industry Participants

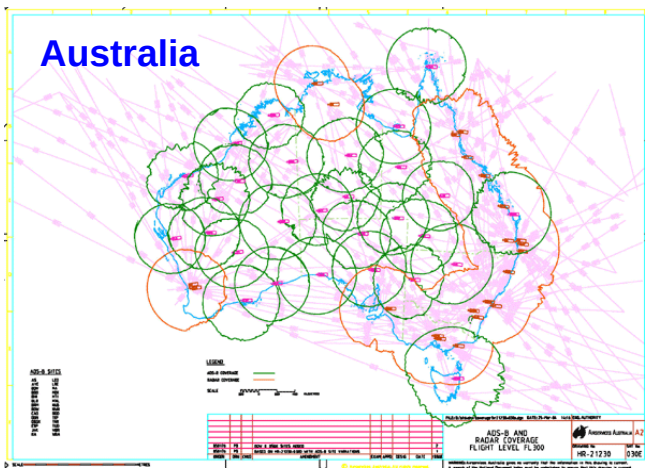
ADS-B Air Traffic Service Provider Applications

Airport Surface Surveillance



Non-Radar Areas Surveillance





Graphics: Compiled from Boeing and other Industry Participants

Detailed Analysis of Surveillance Operational Enhancements

Top Surveillance Issues