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AEROMAGAZINE

# AERO



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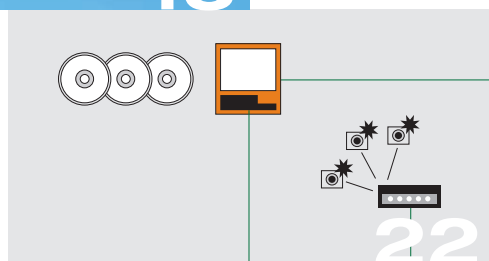
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# AERO

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The Boeing Company supports operators during the life of each Boeing commercial airplane. Support includes stationing Field Service representatives in more than 60 countries, furnishing spare parts and engineering support, training flight crews and maintenance personnel, and providing operations and maintenance publications.

Boeing continually communicates with operators through such vehicles as technical meetings, service letters, and service bulletins. This assists operators in addressing regulatory requirements and Air Transport Association specifications.

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# 2007 Customer Satisfaction Survey: What you told us



**LOU MANCINI**  
Vice President and General Manager  
Boeing Commercial Aviation Services

Our thanks to all of you – our valued airline customers – who participated in our 2007 customer satisfaction survey. The results showed a significant improvement in your rating of our customer support since our last survey in 2005. You told us that you had seen improvement in our overall support of currently produced airplanes; our working relationships and communication; our business-to-business Web site, MyBoeingFleet.com; and our maintenance documentation.



*The BCA Operations Center opened in December 2005 in response to the 2005 customer survey.*

Since the 2005 survey, we have:

- Opened the Boeing Commercial Airplanes Operations Center to improve our response time and communication with you in urgent situations.
- Expanded parts inventories at our distribution centers in Amsterdam, Beijing, Dubai, London, Singapore, and the United States.
- Placed our global training centers in locations to better meet local needs.
- Established a customer council with airline executives to review Material Management policies and practices.
- Revised our process metrics to better reflect how your business is affected by our day-to-day support operations.
- Embarked on an ambitious effort to improve our suppliers' on-time performance and support.
- Increased the finished quality of maintenance documentation.
- Reintroduced our technical customer publication, *AERO* magazine.

## Our goal is to improve our support to you year after year, so that you can operate your Boeing fleets as efficiently and safely as possible.

In addition to telling us where we are improving, you also told us where to put our efforts in the future. In response, we will continue our efforts in the areas listed on the previous page and also focus on improving our response time for:

- **Urgent airplane-on-ground (AOG) service requests.** Our on-time responsiveness to AOG requests has increased dramatically since the inception of the Operations Center — from 73 percent to 96 percent; however, we will continue to work to get our on-time performance even higher.
- **Approval of structural repairs.** We have a threefold approach to improving our response time on these requests: We are increasing capacity by adding stress analysts, service engineers, design engineers, and authorized representatives. We are streamlining our work flow using Lean principles and practices. And we are focusing our proactive efforts on increasing the availability of already-approved repairs in structural repair manuals, offering training on request quality and repair analysis, and providing guidance on major/minor repair classification. (This last topic is covered in detail in “Approved Versus Acceptable Repair Data,” *AERO* third-quarter 2007.)
- **Spare parts.** After two years of focus on Lean, our Material Management organization has been transformed. Customers are seeing us respond more quickly. We plan to publish more reliable lead times; do a better job of supporting all types of in- and out-of-production parts, as well as customers with small fleets; and provide more data on key performance associated with service bulletins, management control parts, and price escalation.

Our goal is to improve our support to you year after year, so that you can operate your Boeing fleets as efficiently and safely as possible.

Again, thank you for taking the time to give us formal feedback on our business. We always welcome your comments and ideas on how to serve you better.

LOU MANCINI

Vice President and General Manager  
Boeing Commercial Aviation Services



*The Spares Distribution Center in Seattle, Washington, is one of six serving customers worldwide. An advanced mainframe computer system links the centers in Amsterdam, Atlanta, Beijing, Dubai, London, Los Angeles, Seattle, and Singapore, providing up-to-the-minute inventory control.*





*DYNAMIC WIRING DIAGRAMS  
HELP ENSURE EFFICIENT,  
HIGH-QUALITY REPAIRS BY  
PROVIDING MAINTENANCE  
DATA ON A LAPTOP.*



# Dynamic Wiring Diagrams: Maintenance Efficiency on the 787

A special tool for the new Boeing 787 Dreamliner allows airline maintenance teams to access customizable wiring diagrams quickly and easily. This new approach is designed to help airlines increase safety, improve maintenance efficiency, and decrease maintenance costs.

By Dennis Dobrowski, Senior Project Manager, Commercial Airplane Services Information Technology; and Patrick Anderson, Manager, 787 Airplane Maintenance Engineering

For several years, Boeing has been working to develop a way to better communicate the configuration of the electrical systems on its airplanes. Wiring diagrams drawn by the electrical engineer responsible for the design of a specific airplane electrical system have traditionally been used to represent the system's configuration. While they provide an accurate view of the system, their usefulness is limited by their static nature.

Part of Boeing's objective in developing the 787 was to optimize revenue-generating flying time by increasing the efficiency of the airplane's maintenance. The primary interface for 787 support data is the Maintenance Performance Toolbox, which enables maintenance personnel to access maintenance procedures, fault isolation procedures, parts information, and other maintenance data in an electronic format on a laptop. (See "Maintenance Performance Toolbox," *AERO* first-quarter 2007.) The 787's new dynamic

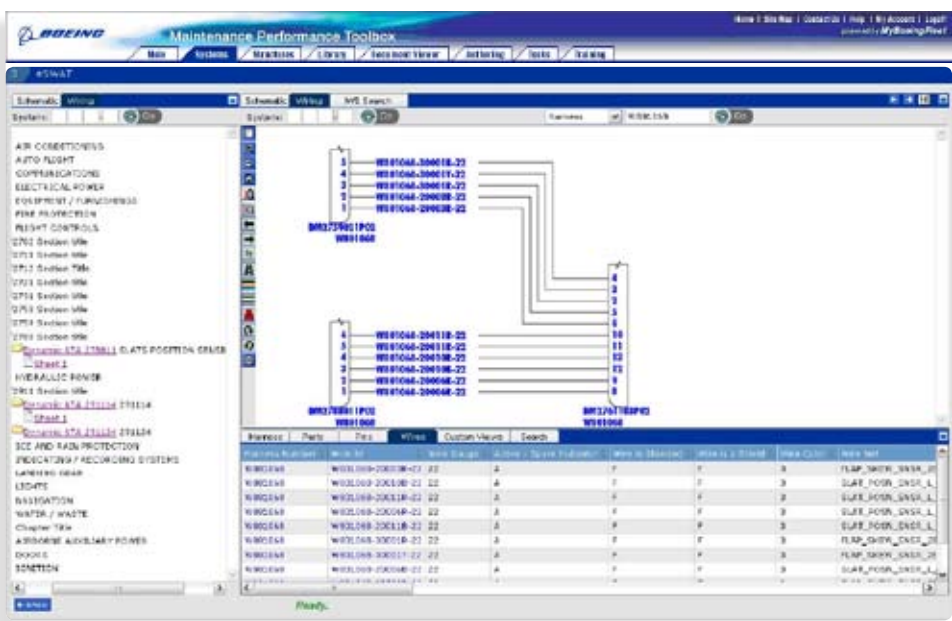
wiring diagrams are a complement to this e-enabled solution on the MyBoeingFleet.com online toolset.

#### LIMITATIONS WITH PRINTED DIAGRAMS

Traditional printed wiring diagrams were contained in a Wiring Diagram Manual (WDM) that provided airline maintenance teams with a precise representation of an airplane's wiring system. However, the process of locating the exact wiring harness, junction, wire, or other electrical component takes time away from the mechanic's real job: fixing a problem so the airplane can return to service. The data presented in the WDM was static and was not capable of data sorting or data linking.

It can also be a very time-consuming process — an electrical wiring manual may have 75 pages between a line replaceable unit and its associated

Table of Contents predefined view of a wiring harness

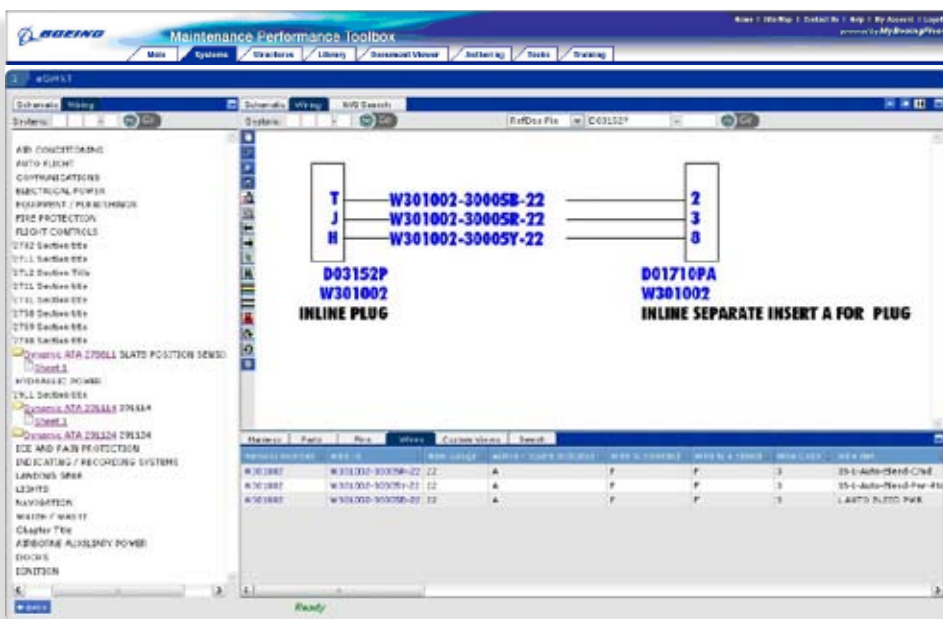


DYNAMIC DRAWINGS ENABLE USERS TO SELECT DESIRED DETAIL

Figure 1

This dynamic drawing of a subset of slat position sensor wiring creates a view of the harness W8001068. In a traditional wiring diagram manual, this small harness would have been part of a much larger engineering drawing. Reducing the scope of the drawing allows airline maintenance teams to quickly focus on the specific area they are interested in.

User-defined custom view of a wire path



MAKING THE COMPLEX ACCESSIBLE SAVES TIME

Figure 2

Airline maintenance teams can use eSWAT to view a very small subset of a much larger drawing. This drawing displays only the connectivity between an inline plug and the three wires leading to an insert for a plug. This very basic view of a very small subset of a complex electrical system can dramatically reduce the team's research time while maintaining accuracy.

## The new electronic Schematic and Wiring Analysis Tool/Integrated Wiring Suite eliminates the production of a printed manual and enables airline maintenance teams to spend less time doing analysis and more time doing maintenance by providing flexible, dynamic wiring diagrams with customizable views.

connector. When assessing an electrical fault, the airline maintenance team must look through each of those pages to identify the WDM diagram pages that are applicable to the airplane tail number.

Additionally, when an airplane's electrical system has been modified, updated diagrams must be printed and distributed.

### MAKING WIRING DIAGRAMS DYNAMIC

The new electronic Schematic and Wiring Analysis Tool/Integrated Wiring Suite (eSWAT/IWS) that Boeing has developed for the 787 eliminates the production of a printed manual and enables airline maintenance teams to spend less time doing analysis and more time doing maintenance by providing flexible, dynamic wiring diagrams with customizable views. That, in turn, helps ensure efficient, high-quality repairs.

Users can adjust the view of the wiring diagram to see the entire airplane wiring system or a single wire path from power to ground (see fig. 1). Users can also adjust the view to better understand and orient the diagrams of the airplane's configuration and highlight any wire or harness in a specific color to make it easier to follow the wiring from source to termination. Other functionality includes links to other information as well as ties between visual wiring diagrams and wiring data reports. The application also allows for the linking of operator-specific supplemental data to the Boeing data structure. These features enable maintenance personnel to quickly understand and work with the electrical configurations in the 787.

### WORKING WITH ESWAT/IWS

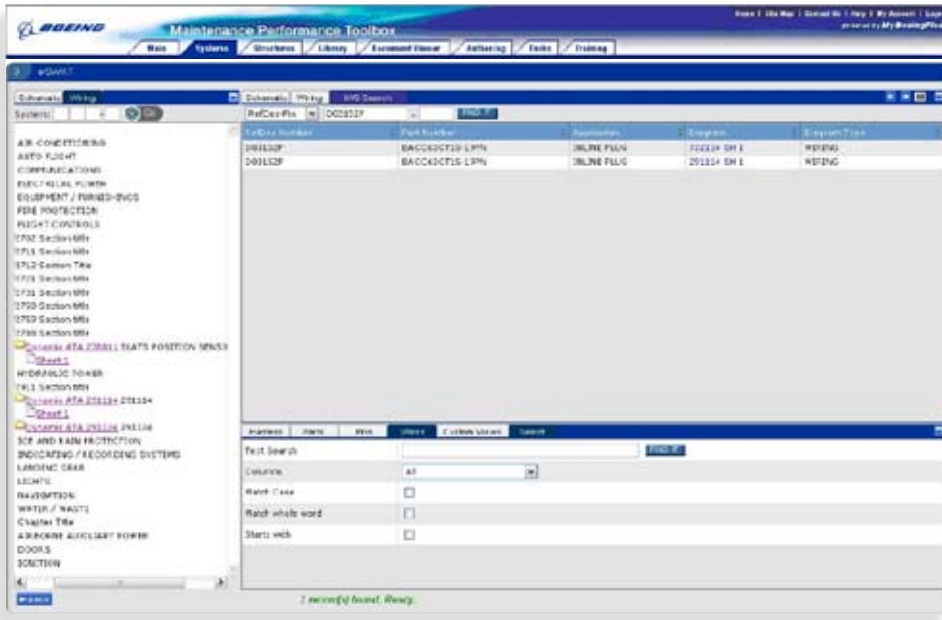
eSWAT/IWS dynamically displays system wiring information to the airline maintenance team.

Wiring information is stored in a database which can be accessed through MyBoeingFleet.com. The information can be retrieved as requested by the user and filtered to apply specifically to the airplane being serviced. The data is then formatted and displayed in any combination of wiring diagram, pin listing (within a connector), and/or wire listing (see fig. 2).

eSWAT/IWS eliminates the need to sort through multipage foldouts and interpret system configuration information. Locator graphics, connector pin arrangement graphics, parts listings, and drawing notes are always readily available.

To access the tool, the user enters the airline's airplane tail number and specifies through the table of contents which wiring system to display. The tool draws a wiring diagram and provides detailed report data. Graphical icons enable users to quickly locate key functions. While researching the wiring, harness, or electrical component to be studied, the user can zoom in or out, compare one

## Customizable views

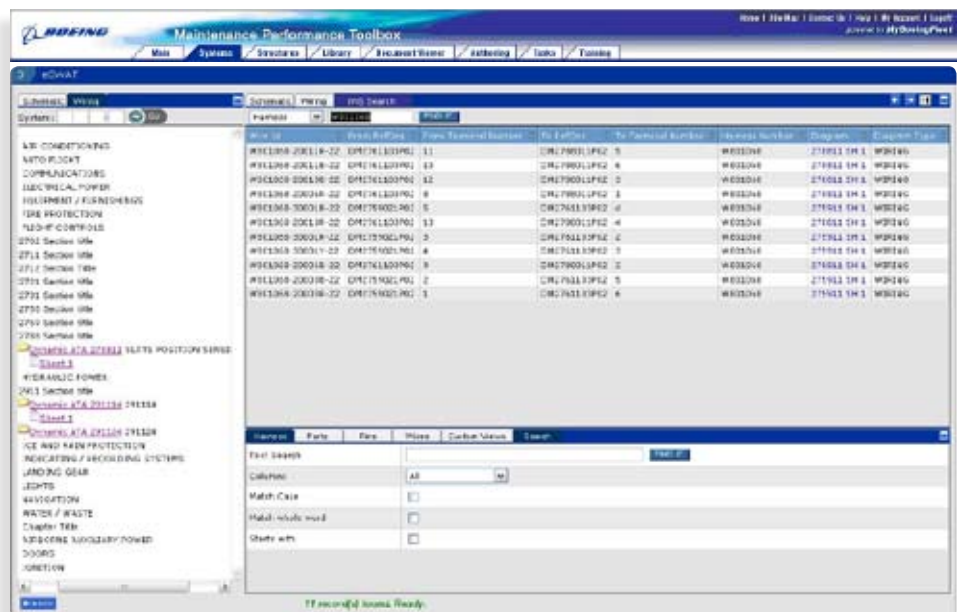


## CUSTOMIZABLE VIEWS AND SEARCH CAPABILITY ENHANCE EFFICIENCY

Figure 3

Users can customize the tabular view of the data and search on a specific item. In this example, the tabular view gives the airline maintenance team detailed information about a specific part and allows the user to draw a dynamic view of that data, or search repair practices or fault information based on this tabular data. This capability reduces the very large amount of data that would have been present in a traditional wiring data and wiring report to a very small amount of data, enabling the airline maintenance team to quickly isolate the area where work needs to be done and reducing the time required to service the airplane.

## Customizable tabular data columns

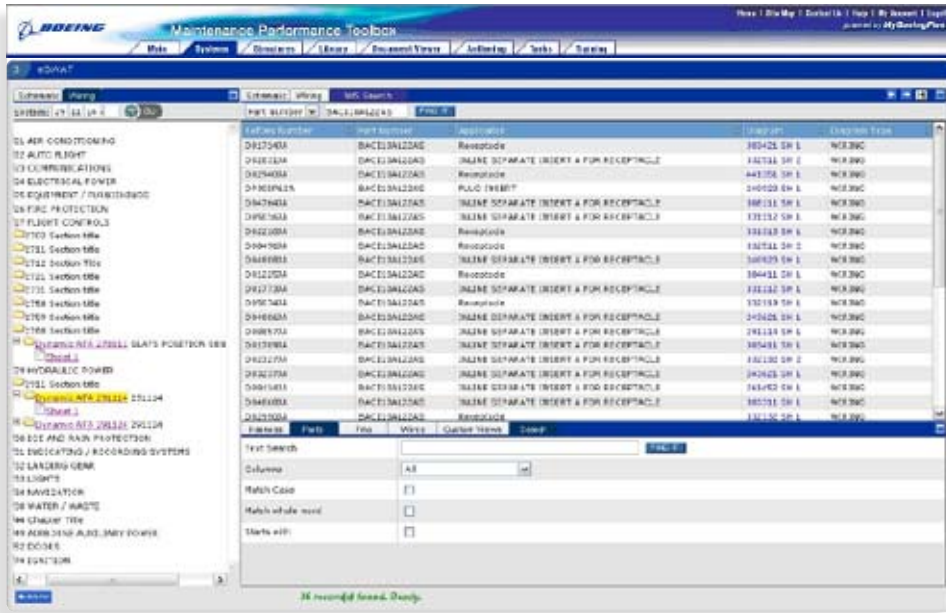


## SIMPLIFIED COLUMN VIEWS ELIMINATE UNNECESSARY DATA

Figure 4

Tabular data columns can be customized to match the set of data that is relevant to the type of work the user is doing. That allows the engineer or mechanic to eliminate unnecessary data and simplify the analysis needed to understand the airplane configuration. In this example, the columns have been set to "all," but they can be set to any subset of columns the user would like to focus on.

Comprehensive tabular search feature



LOCATE INFORMATION EASILY

Figure 5

eSWAT's tabular search can be used to locate all the instances of a specific part. This would be useful if, for example, a part had reached its end of life and needed to be replaced throughout the airplane. The tabular view provides the harness, wiring, part, and location information for each instance, allowing the engineering and repair teams to quickly assess the time and materials needed for the repair.

airplane configuration to another, and print any part, display, or information for use in troubleshooting or repairs. eSWAT/IWS is integrated into the rest of the 787 maintenance information.

Airline maintenance teams can use eSWAT to view a very small subset of a much larger drawing. This drawing displays only the connectivity between an inline plug and the three wires leading to an insert for a plug. This very basic view of a very small subset of a complex electrical system can dramatically reduce the team's research time while maintaining accuracy.

ADVANTAGES OF DIGITAL WIRING DIAGRAMS

This new system provides an integrated view of flexible wiring diagrams and the data contained in

traditional wiring reports. Data is provided in a format that is specific to a single airplane and can be updated more frequently than paper-based diagrams.

The wiring data is linked electronically to the 787 Fault Isolation Manual and 787 Airplane Maintenance Manual. Additional links to the Standard Wiring Practices Manual are planned.

eSWAT/IWS can also enhance productivity by providing users with customizable views of information. For example, airline maintenance teams can view a wiring diagram in one window and a list of parts associated with that view of the diagram in another window (see fig. 3). That enables the team to quickly locate required parts, facilitating faster maintenance turnarounds.

By streamlining access to a vast array of wiring information, this new tool has the potential to dramatically increase knowledge transfer while decreasing the possibility of maintenance errors.

SUMMARY

The new Boeing eSWAT/IWS is designed to improve the flow time and quality of electrical system maintenance by enabling maintenance personnel to focus their efforts on making repairs, not searching for information. The system provides virtually instant access through MyBoeingFleet.com to detailed information about any copper or fiber-optic wiring on the 787, all in context to the specific airplane being repaired. This new approach to wiring diagrams is designed to increase the efficiency of maintenance and decrease maintenance costs for 787 operators.

For more information, please contact Dennis Dobrowski at [dennis.e.dobrowski@boeing.com](mailto:dennis.e.dobrowski@boeing.com).



PERFORMANCE-BASED  
NAVIGATION WILL  
ENABLE EFFICIENCY-  
ENHANCING OPERATIONS  
IN THE FUTURE.

# Operational Benefits of Performance-Based Navigation

By David Nakamura, Senior Technical Fellow, Airplane Systems; and William Royce, Chief Pilot — Research, Flight Operations

Global airspace and airline operations are moving to performance-based navigation (PBN), which provides a basis for designing and implementing automated flight paths that will facilitate airspace design, traffic flow, and improved access to runways. This change offers a number of operational benefits, including enhanced safety, increased efficiency, reduced carbon footprint, and reduced costs. To fully realize these benefits, operators may need to make changes to their airplanes and operations.

Operators have already begun to experience the benefits of area navigation (RNAV) and required navigation performance (RNP). These benefits include safer, more efficient operations; greater capacity; and improved access. For instance, freeing airplanes from reliance on ground-based navigational aids (navaids) and allowing flexible and optimum routing with satellite navigation can create more direct routes, saving fuel and reducing CO<sub>2</sub> emissions and enroute flight time.

However, the definitions and concepts associated with RNAV and RNP, as well as some RNP naming conventions, are inconsistent both in the United States and in various regions of the world. The result has been confusion among operators, manufacturers, regulators, and air navigation service providers (such as the U.S. Federal Aviation Administration [FAA], United Kingdom National Air Traffic Services [NATS], and NavCanada) in the implementation of RNAV and RNP applications in different areas in the world.

PBN is the result of recent collaboration between industry, states, regulators, and service providers to understand the issues leading to this confusion, and to clarify and update the definitions and explanatory material about RNAV and RNP concepts and applications. To ensure harmonization and consistency, this effort was applied to all areas of flight, from oceanic/remote to terminal area and approach.

This article provides background about RNAV and RNP, reasons for the move to PBN, benefits of PBN, the industry's PBN strategy, and keys for airlines to move successfully to PBN.

RNAV AND RNP: GOOD CONCEPTS  
IN NEED OF STREAMLINING

Historically, commercial airplanes have navigated from a position relative to one ground-based navaid — such as very-high-frequency (VHF)

omni-directional range (VOR), distance measurement equipment (DME), or non-directional beacon (NDB) — to a position relative to another navaid. Because airplanes are inhibited from flying the most direct possible routes, this method leads to inefficient routes and procedures. Adding to this inefficiency are large airspace separation buffers that commercial airplanes must use because of both the inherent inaccuracies of conventional navigation methods and the need to protect against operational errors.

RNAV began as a means of navigation on a flight path from any point, or fix, to another. These fixes could be defined by a latitude and longitude, and an airplane's position relative to them could be established using a variety of navaids. RNAV facilitated a type of flight operation and navigation in which the flight path no longer had to be tied directly to overflight of ground navigation stations.

RNP is built on RNAV. The International Civil Aviation Organization (ICAO) recognized that global navigation satellite systems, the navigation infrastructure, airline operations, and airplane systems were undergoing change faster than traditional processes for equipment, including RNAV, could support. RNP was developed to allow airspace designers to specify airspace and operation requirements without relying on specific equipment or systems. The original RNP concept was oriented toward enroute, remote, and oceanic airspace, and was primarily concerned with precise navigation and safe separation of routes. Both RNAV and RNP offer a number of advantages over conventional, ground-based navigation systems, including greater safety and efficiency (see fig. 1).

However, as RNP has evolved, some of its elements have been implemented inconsistently. Additionally, RNP applications lacked a common basis for interoperability, creating confusion and hampering adoption. At the same time, work had

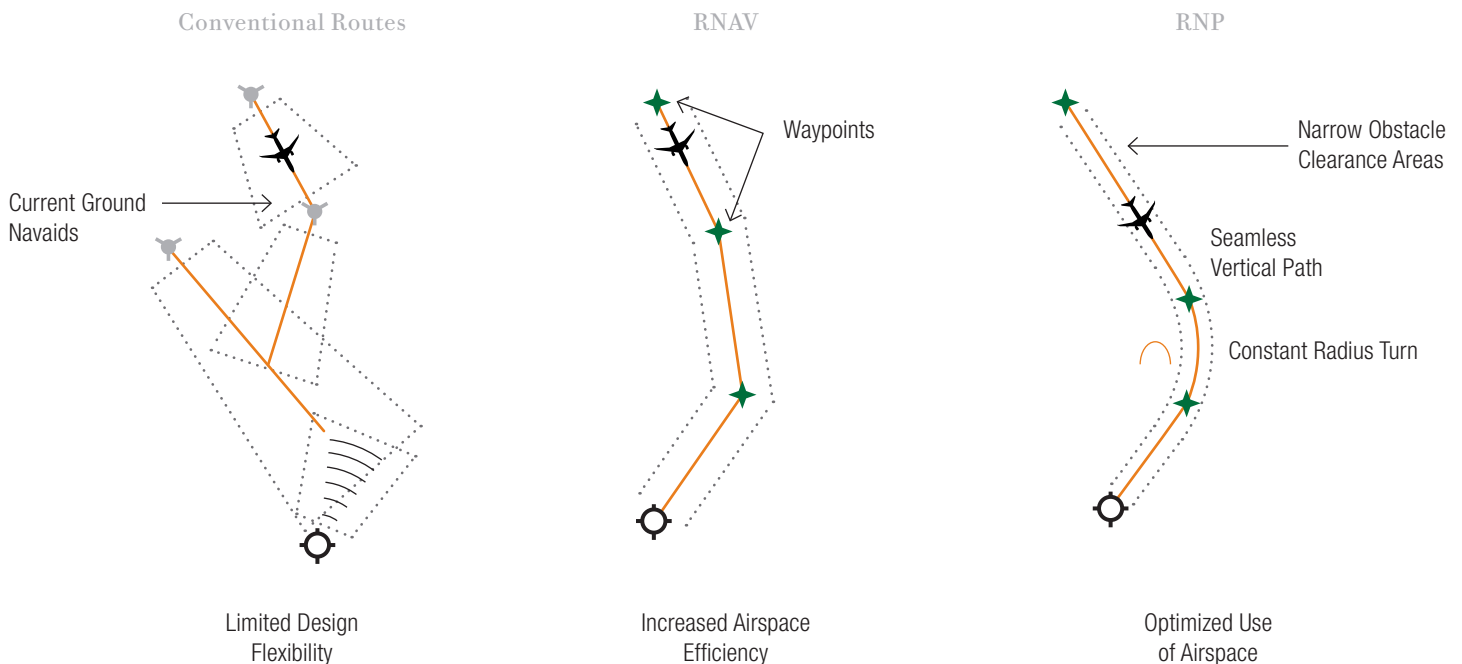
begun both within and outside ICAO to develop guidance for other phases of flight and operational environments. This work led to the understanding that it would be impossible to achieve global interoperability with these new concepts unless the assumptions on which they are based, such as RNP, were consistently applied. PBN is seen as the solution that will enable future efficiency-enhancing operations concepts.

**THE MOVE TO PBN**

The FAA defines PBN as “a framework for defining navigation performance requirements that can be applied to an air traffic route, instrument procedure, or defined airspace.” PBN, which comprises both RNAV and RNP specifications, provides a basis for the design and implementation of automated flight paths that will facilitate airspace design, traffic flow, and improved access to runways.

The PBN concept began with an assessment of all current and near-term implementations of RNAV and RNP, including basic RNAV (BRNAV) standards, precision RNAV (PRNAV), RNAV 1, RNAV 2, RNP < 1, RNP 1, RNP 2, RNP 4, and RNP 10. Part of the goal of PBN is to consolidate these various implementations to alleviate confusion and streamline operations (see fig. 2). RNAV now includes BRNAV, PRNAV, RNAV 1, RNAV 2 and RNP 10 (now RNAV 10), and RNP now includes RNP < 1, RNP 1, RNP 2, and RNP 4. This consolidation provides better guidance on how to apply RNAV and RNP and what it means to airspace, traffic management, air traffic control, and the commercial air service infrastructure.

Because RNAV and RNP are part of PBN, lateral navigation standards for performance, functionality, and capability are intrinsic to it. PBN has the potential to provide operators with more efficient airspace and instrument procedures that can improve safety, access, capacity, and efficiency, while minimizing environmental impacts. With PBN,

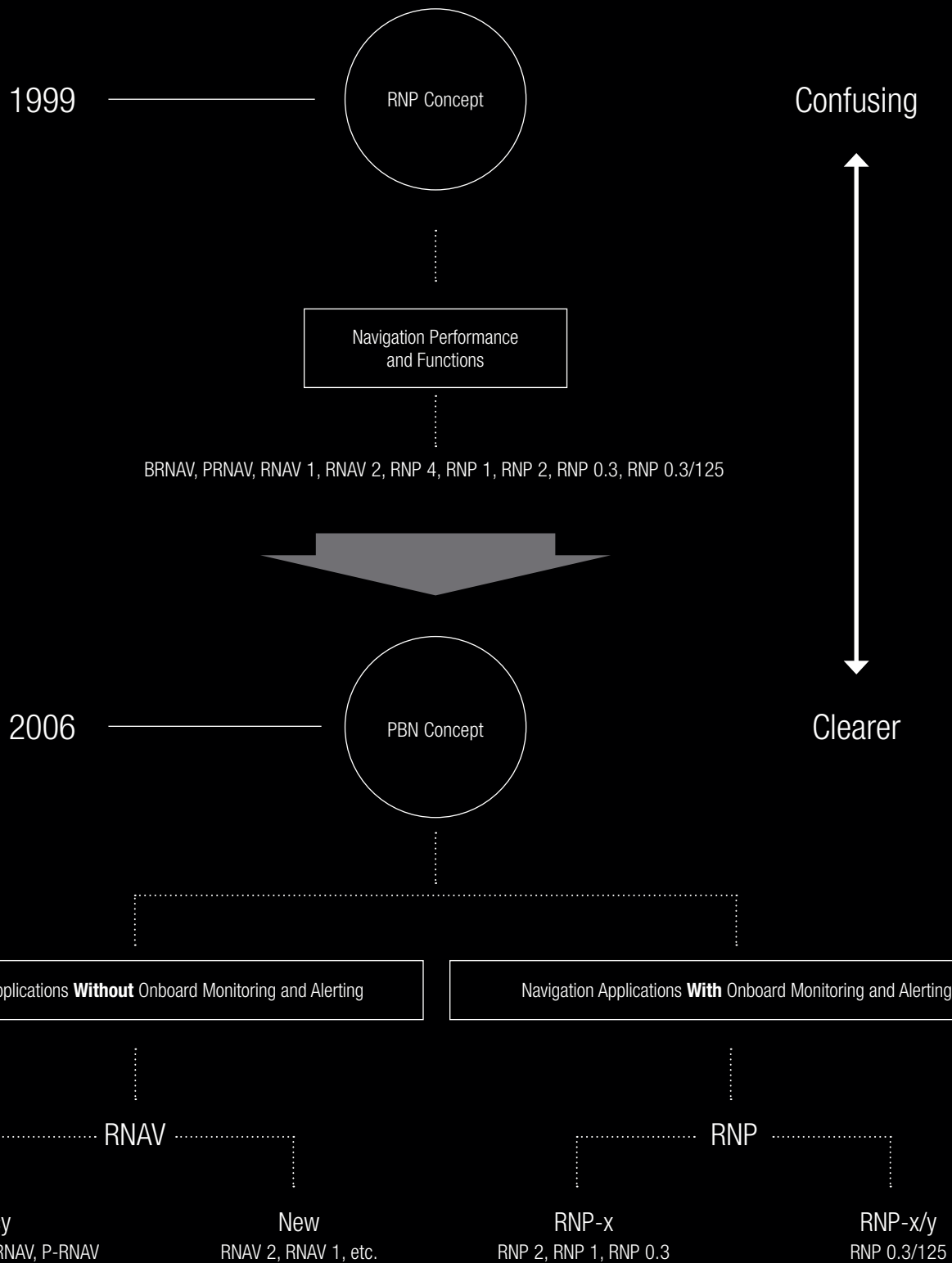


**CONVENTIONAL ROUTES COMPARED TO PBN-BASED ROUTES**

Figure 1

*PBN comprises RNAV and RNP specifications to enable airspace designers to develop and implement new automated flight paths that increase airspace efficiency and optimize airspace use.*

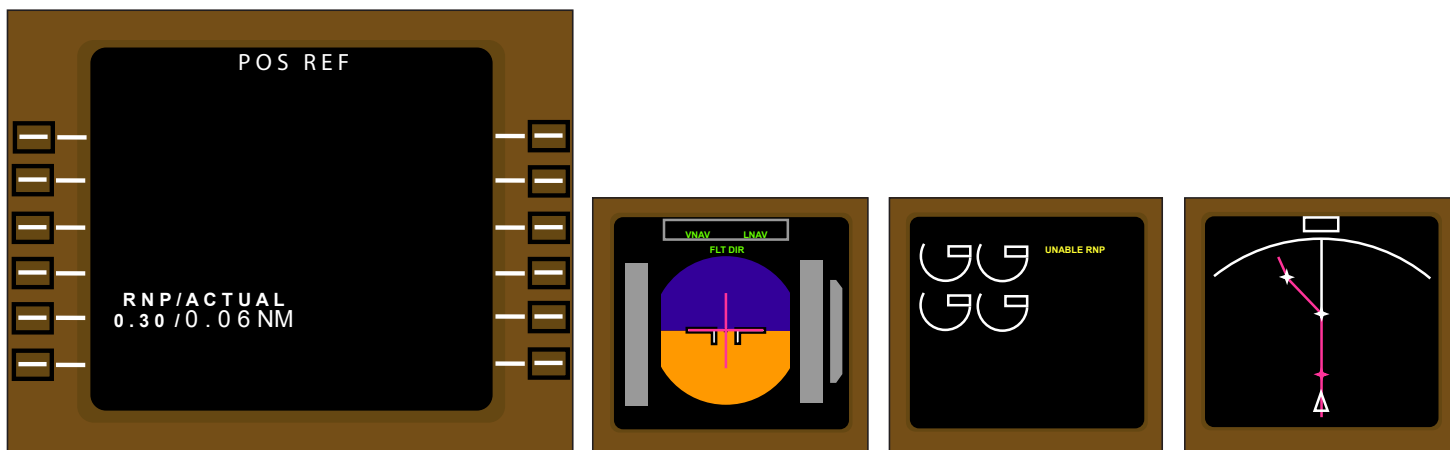




**EVOLUTION OF PERFORMANCE-BASED NAVIGATION CONCEPT**

Figure 2

PBN is an attempt to reduce confusion and streamline RNAV and RNP specifications and standards.



**INCREASED OPERATIONAL SAFETY**

Figure 3

*PBN provides flight crews with an enhanced new interface designed to minimize manual insertion and control errors, enhanced situation awareness, better monitoring and RNP alerting, and improved indication of equipment failure.*

all navigation aspects of operations — including terminal airspace — will be defined, developed, and implemented on the basis of operational requirements and the associated required performance.

More detailed information is provided in the PBN Manual, which is available on the ICAO Web site ([www.icao.int](http://www.icao.int)). It will be issued as a major revision and replacement to the existing RNP Manual, Document 9613.

**BENEFITS OF PBN**

Aviation authorities anticipate a number of benefits when PBN becomes widely implemented. These benefits include:

**Safety:** Lateral and vertical track-keeping is much more accurate and reliable due to new three-dimensional guided arrival, approach, and departure procedures that cannot be defined by conventional nav aids. No accidents have been

reported to date associated with the use of RNP/RNAV procedures. In contrast, for all controlled-flight-into-terrain accidents, 60 percent occur on non-precision approaches using conventional nav aids. PBN also reduces the flight crew's exposure to operational errors (see fig. 3).

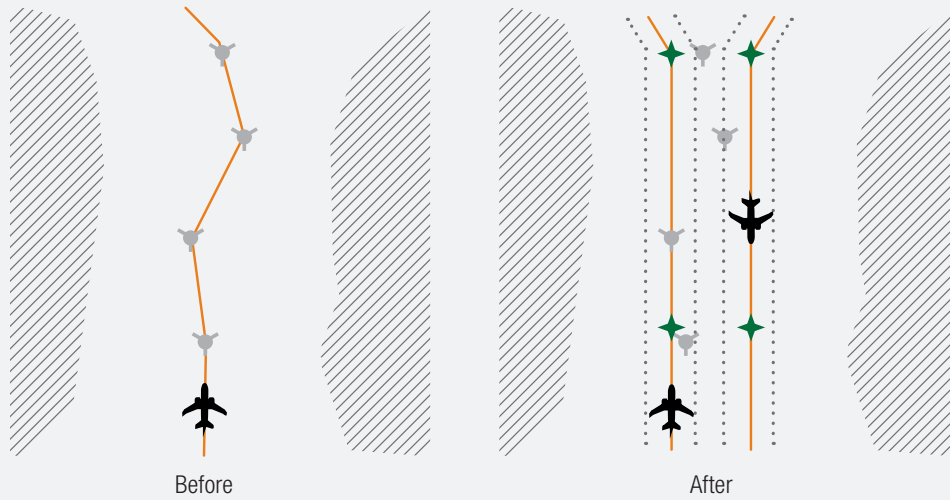
**Capacity:** Delays, congestion, and choke points at airports and in crowded airspace may be reduced because of new and parallel offset routes through terminal airspace, additional ingress/egress points around busy terminal areas, more closely spaced procedures for better use of airspace, and reduced or eliminated conflict in adjacent airport flows (see fig. 4).

**Efficiency:** Enhanced reliability, repeatability, and predictability of operations lead to increased air traffic throughput and smoother traffic flow.

**Access:** Obstacle clearance and environmental constraints can be better accommodated by applying optimized PBN tracks.

PBN promises economic benefits as well. For example, Hartsfield-Jackson Atlanta International Airport has streamlined operations by implementing 16 RNAV departures and three RNAV arrivals. The resulting earlier climb to enroute altitudes reduces fuel burn, and the reduced track distances enable fuel savings. For 2007, Hartsfield-Jackson Atlanta International Airport authorities are estimating \$34 million in annual fuel savings for airlines as a result of RNAV. The airport is also reporting an additional 10 departures per hour. At Dallas-Fort Worth International Airport, RNAV departures are allowing between 11 and 20 additional operations per hour.

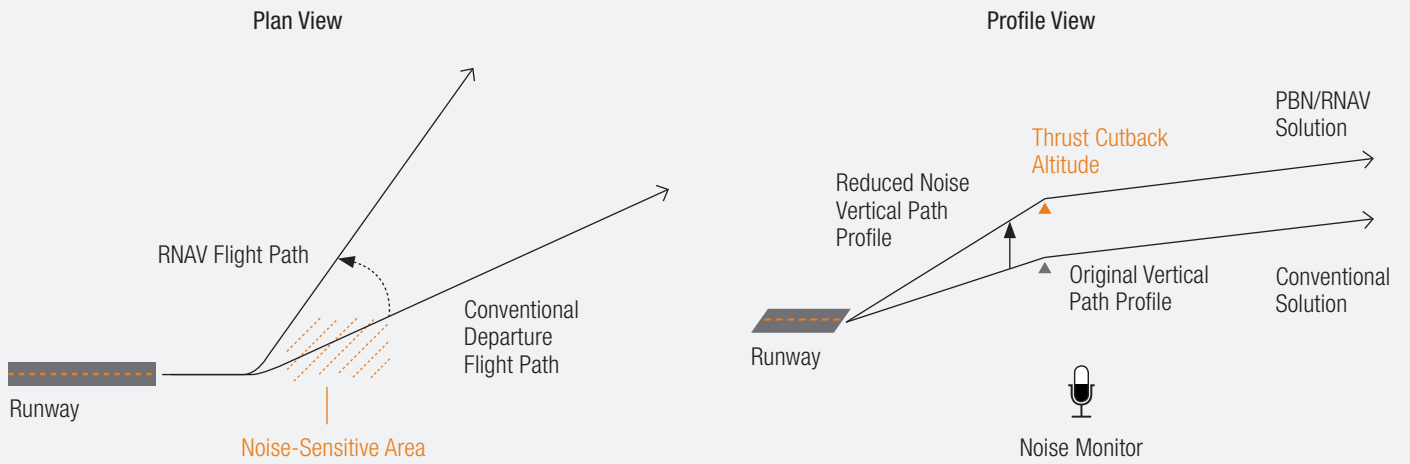
PBN also offers environmental benefits by saving fuel, reducing CO<sub>2</sub> emissions, and eliminating high-thrust go-arounds. Flying down the middle of a defined flight path means less throttle activity and better avoidance of noise-sensitive areas, so people on the ground perceive less jet noise and are exposed to fewer engine emissions (see fig. 5).



**INCREASED CAPACITY**

Figure 4

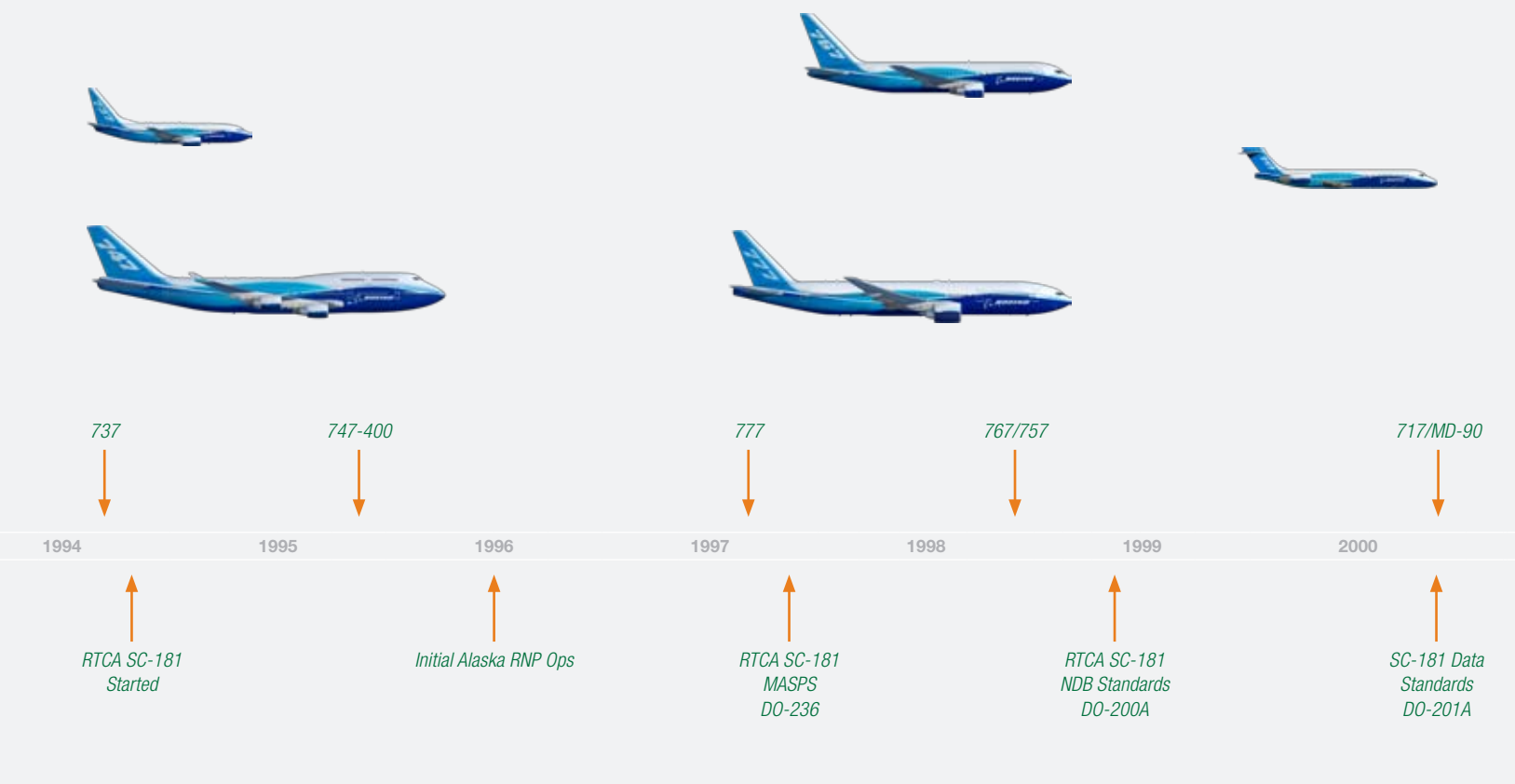
Conventional routes (left) have limited development and flexibility due to vertical separation requirements and implementation of routes based on ground nav aids. RNAV and RNP routes (right) offer design flexibility and capacity from additional flight levels and parallel routes using latitude- and longitude-based fixes.



**REDUCED ENVIRONMENTAL IMPACTS**

Figure 5

Moving from ground-based flight procedures to RNAV latitude/longitude fix-referenced and performance-based procedures leads to flexibility in the specified location and profile of the flight path, making it easier to accommodate noise-sensitive areas.



#### INDUSTRY'S PBN STRATEGY

Boeing has helped shape the evolving PBN standards through close and ongoing involvement with the FAA and ICAO. Boeing has also worked with the Air Traffic Alliance with a goal of developing a strategy that a large number of industry participants can support to establish a clear, focused direction for the future.

In developing a strategy for PBN, Boeing started by observing industry developments, taking into account the trends and constraints of the various regions and technologies, and accommodating the business realities of the airlines and service providers.

All Boeing commercial airplanes manufactured since the 1980s include RNAV capabilities. Boeing

began implementing RNP on airplanes in 1994. As of 2000, every Boeing commercial airplane included RNP capability (see fig. 6).

#### CONSIDERATIONS FOR AIRLINE OPERATIONS

PBN is expected to be the foundation for a number of operational changes, including additional point-to-point routes, independent parallel runway operations, and coordinated departures and arrivals for adjacent airports. The degree of impact to requirements for crews, flight operations, maintenance, and dispatch could range from minimal to significant, depending on the current state of airports serviced and associated operating requirements.

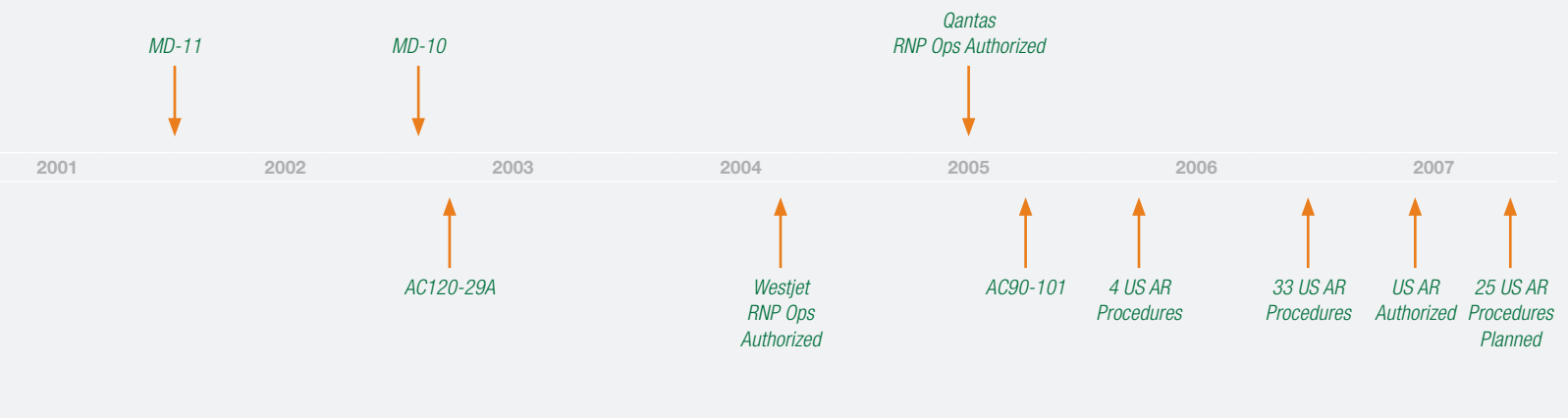
Operators moving to PBN should begin coordination with their regulatory agency as soon as possible. When planning additions or modifications to a fleet, operators should carefully consider including RNP-related features such as navigation performance scales, a display feature that integrates lateral navigation and vertical navigation with actual navigation performance and RNP. Operators should also provide as much information as possible about PBN to their operations departments and crews, develop training curriculum and scenarios, and review standard crew procedures.

Operators should fully understand the capabilities of each airplane and match present and future capabilities to what they hope to achieve with PBN operations. For example, one

## RNP-CERTIFIED BOEING AIRPLANES

Figure 6

Boeing has been steadily increasing the RNAV and RNP capabilities of its commercial airplane fleet. Every Boeing commercial airplane currently produced, including the 787, incorporates RNP capability. This figure illustrates when RNP capability was introduced in the fleet.



airline took advantage of the improved access afforded by RNP to avoid more than 980 diversions at one airport in 2006. Another airline replaced a non-precision approach into a valley surrounded by mountainous terrain with an RNP “Special Aircraft and Aircrew Authorization Required” (SAAAR) approach. The new approach enhanced safety with a guided, stabilized three-dimensional path to the runway, lowering the landing minima by 1,600 feet and two miles visibility (see fig. 7).

Boeing provides service letters, airplane flight manuals, and other documentation to assist operators in implementing PBN operations. Boeing also offers support information for PBN operations to assist operators seeking approvals by regulators or air navigation service providers, as well as

implementation guidance (see sidebar). Also, Boeing subsidiary Jeppesen has begun to expand its RNP services to include FAA AC90-101 Readiness and Application Consulting Services, RNP NavData and Charting, RNP Training, and RNP Monitoring Tools in addition to its current offering of RNP Procedure Development.

Operators should be aware that the operational approvals can range from requiring relatively little effort (i.e., RNAV) to demanding a great deal of time and extremely complex information (i.e., RNP SAAAR).

As PBN continues to evolve, operators have the opportunity to provide input and raise issues and concerns to ICAO and other governing bodies.

### LOOKING AHEAD

Airspace designers envision airplanes flying on defined RNP paths from takeoff to touchdown and using RNP path options in combination with time-of-arrival management and speed control for sequencing, separation, and weather rerouting. Improved air traffic control planning tools are being developed to optimize controller performance in such an “RNP path” world. It is also expected that RNP may eventually make a transition to an integration with global navigation satellite landing systems, which ensure reliable, predictable takeoff and touchdown in all visibility conditions.

# Glossary of terms

## RNAV

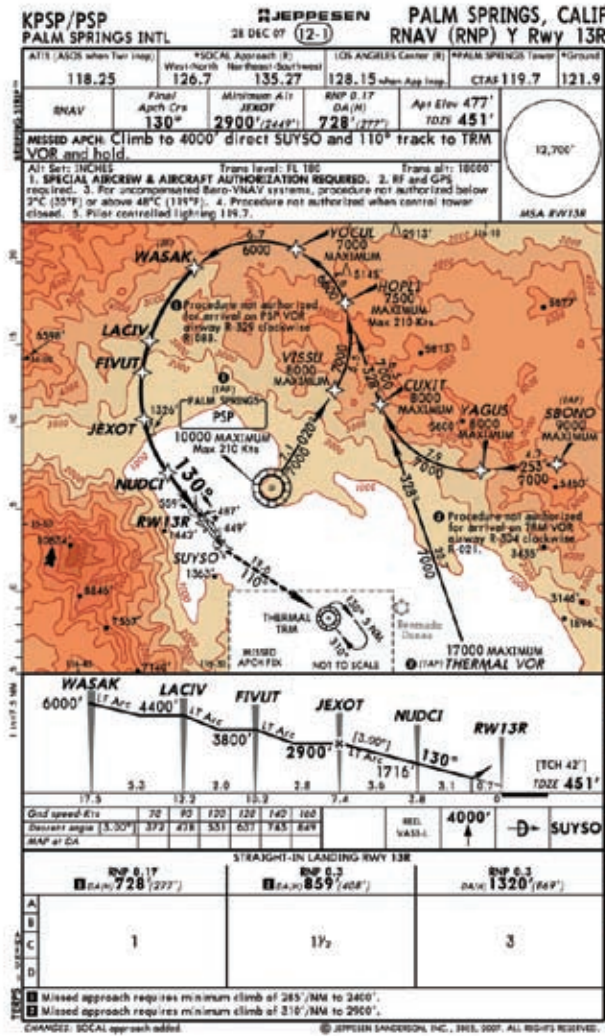
Area navigation (RNAV) enables airplanes to fly on any desired flight path within the coverage of ground-based navigation aids, within the limits of the capability of the self-contained systems, or a combination of both capabilities. As such, RNAV airplanes have better access and flexibility for point-to-point operations. When values are specified, they indicate the required performance level for the operation.

## RNP

Required navigation performance (RNP) is RNAV with the addition of a number of functional enhancements, including onboard performance monitoring and alerting capability. A defining characteristic of RNP operations is the ability of the airplane navigation system to provide improved performance information, monitor the navigation performance it achieves and inform the crew if the requirement is not met during an operation. This onboard monitoring and alerting capability enhances the pilot's situational awareness and can enable reduced obstacle clearance or closer route spacing without intervention by air traffic control. When values are specified, they indicate the required performance level for the operation.

## PBN

Performance-based navigation (PBN) is a framework for defining navigation performance requirements that can be applied to an air traffic route, instrument procedure, or defined airspace. PBN includes both RNAV and RNP specifications. PBN provides a basis for the design and implementation of automated flight paths as well as for airspace design and obstacle clearance. Once the required performance level is established, the airplane's own capability determines whether it can safely achieve the specified performance and qualify for the operation.



APPROACH PLATE USING RNP SAAAR  
Figure 7

This approach plate shows an RNP SAAAR approach for Palm Springs International Airport in Palm Springs, California.

### SUMMARY

Using PBN also could help prepare operators for advanced navigation concepts, such as trajectory-based operations (TBO). TBO creates lateral and vertical flight profiles for airplanes that are very specific while being highly flexible and adaptable to operational needs. These profiles can be visualized as tunnels in space. The profiles would change depending on the navigation accuracy required, the climb and descent points, and time of arrival to satisfy traffic flow requirements. TBO encompasses what many call “three- and four-dimensional operations.” The relationship to PBN is that the core airplane capability from takeoff to landing is to navigate accurately along a defined flight path both laterally and vertically, and to be at the correct points along that path at precise times.

PBN represents an evolution of aviation navigation away from ground-based nav aids. This offers a number of tangible benefits to operators, from greater safety and more reliable airport access to more efficient operations. Some operators are already realizing these benefits. Others are taking advantage of the opportunity to develop a PBN-compatible fleet in anticipation of continued adoption of PBN-based approaches and departures at airports around the world. Boeing provides implementation services to operators considering a move to PBN systems.

For more information, please contact David Nakamura at [dave.nakamura@boeing.com](mailto:dave.nakamura@boeing.com). **A**

# Implementation Guidance

Boeing has identified three main processes that are part of the successful implementation of a PBN operation. These processes require the combined efforts of regulators, air navigation service providers (such as the Federal Aviation Administration, National Air Traffic Services, and NAV CANADA), and users to be effective. Contact Boeing at [jeff.s.roberts@boeing.com](mailto:jeff.s.roberts@boeing.com) for details about these implementation processes, or for assistance in implementing PBN.

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Determine Requirements

Formulate airspace concept.

Assess fleet capability and navaid infrastructure.

Identify performance and functional requirements.

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Identify ICAO Navigation Specification(s) for Implementation

Review ICAO *Navigation Specifications* (Volume II), or appropriate airworthiness circulars and procedure design guidance material.

Identify the appropriate ICAO navigation specification to apply in the specific communication navigation surveillance/air traffic management environment.

Identify tradeoffs with airspace concept and/or functional requirements.

Select ICAO navigation specification(s), or appropriate airworthiness circulars and procedure design guidance material.

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Plan and Implement

1. Formulate safety plan.
2. Validate airspace concept for safety.
3. Design procedure.
4. Perform procedure ground validation.
5. Make implementation decision.
6. Conduct flight inspection and validation.
7. Account for air traffic control (ATC) system considerations.
8. Provide awareness and training for ATC and flight crews.
9. Establish operational implementation date.
10. Conduct a post-implementation review.

# *Electronic Flight Bag:* Real-Time Information Across an Airline's Enterprise

By David Allen  
Chief Engineer, Crew Information Services

The Boeing Electronic Flight Bag (EFB) system has been expanded to include ground software components that enable airlines to turn airplanes into nodes on their information network. This expansion allows airlines to implement a Boeing Electronic Logbook (ELB) application that resides both on the airplane and on multiple ground components. It also allows the future implementation of airborne and ground applications that will enable the airline to operate more efficiently as a business. This new application will be implemented first on the 777 and will be available for the Next-Generation 737, 747-400, 757, 767, and 747-8. It will be basic on the 787.

An airplane in the air is an asset. An airplane that cannot meet its next departure cannot generate revenue. That reality was the impetus behind the Boeing ELB application. Because airplanes can only produce revenue when they are flying, the aviation infrastructure exists to keep them operating safely and efficiently. When an airline is forced to cancel a flight, the revenue from that flight may be lost and the disruption costs affect the airline bottom line. Yet airplanes are basically out of touch with the airline operations (except for some system messages and voice reports) most of the time. The system-generated failure messages many times do not provide enough information for airline maintenance to provide a solution in the time necessary to support the next dispatch. Pilot workload many times precludes using voice to communicate problems. As airlines increase airplane utilization and reduce airplane turn time, information to resolve issues becomes more important.

The Boeing ELB connects the airplane systems to the airline information technology infrastructure, providing data to the appropriate departments that allows them to strategically react to airplane problems. This knowledge helps the airline schedule the airplane operation so that all deferred faults can be resolved during a time when the airplane is available, thereby reducing costs.

This article discusses the evolution of the Boeing EFB, the definition and benefits of a Boeing ELB, the advantages of connecting airplanes in flight with ground systems, and the infrastructure required to support this kind of connected system.

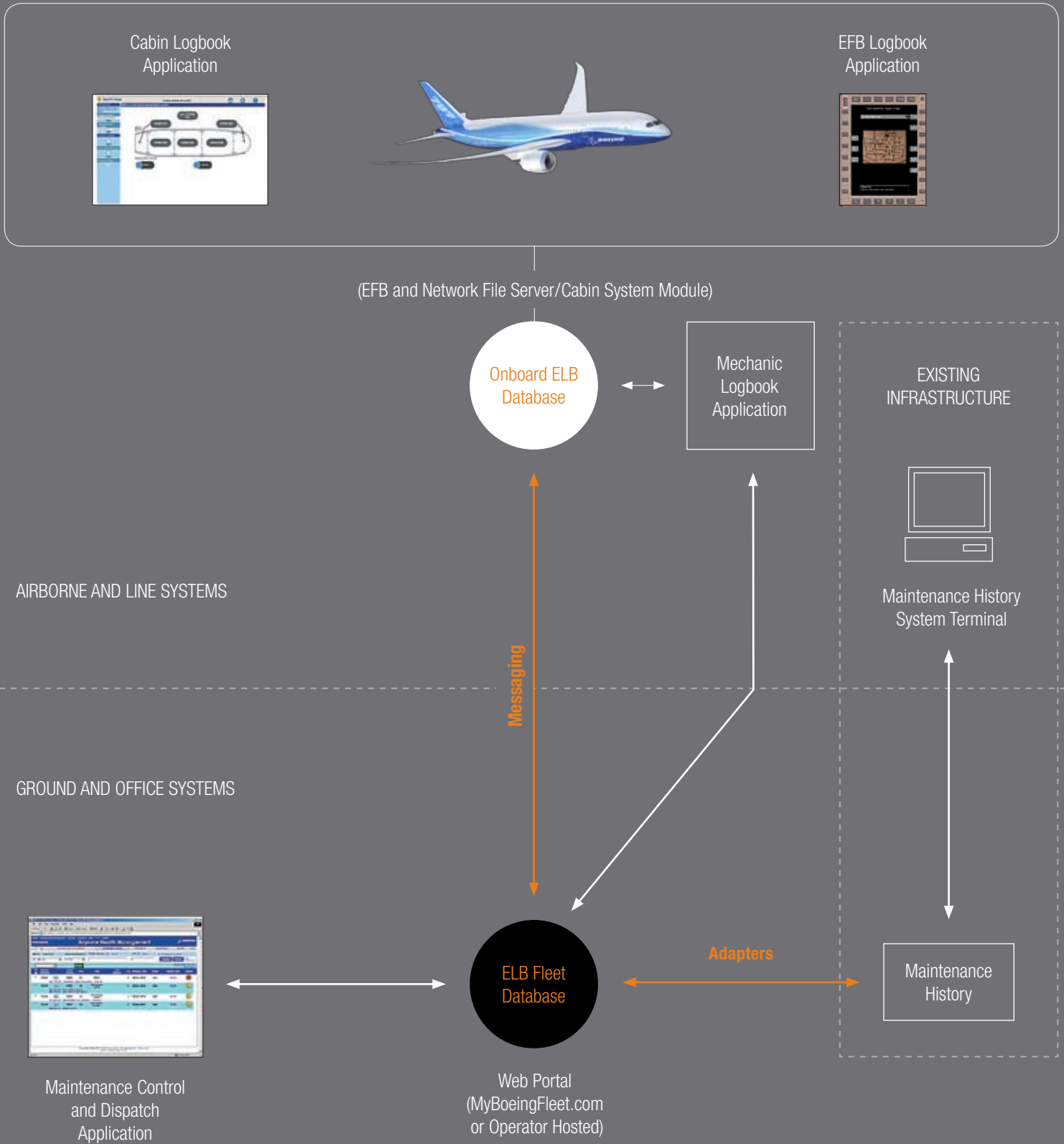
#### THE EVOLUTION OF THE BOEING EFB

When first introduced in 2003, the Boeing EFB was seen as a major step toward e-enabling the entire air transport system — from the flight deck to the cabin, maintenance, and the airport.

(See "Electronic Flight Bag," *AERO* third-quarter 2003.) EFB benefits included reduced fuel and maintenance costs through precise, accurate takeoff speed calculations; improved taxiway safety; flight-deck entry surveillance; and elimination of paper from the flight deck and access to digital documents.

Nearly five years later, the Boeing Class 3 EFB has evolved from a simple flight bag replacement to a generalized computer system that can link information provided by airplane systems, flight crews, and cabin crews to the airline when the airplane is remote from the airline home base. Integrated with the Boeing ELB, it provides real-time administrative information from the airplanes to the airline so that the airline can make high-value operational decisions. Administrative information is that information which helps the airline manage its business and is not associated with the flight currently in progress. For example,





**ELECTRONIC LOGBOOK SYSTEM OVERVIEW**

Figure 1

By connecting airplanes in flight with ground systems, an electronic logbook provides continual, real-time communication about the airplane's status and possible maintenance requirements, making possible new levels of maintenance efficiency and airplane availability.

# Boeing ELBs

## EFB Technical Electronic Logbook

Includes fault reporting and logbook database containing flight log, fault reports, maintenance actions, deferrals, release and servicing records — all synchronized with a ground database.

## EFB Cabin Electronic Logbook

Includes cabin crew fault reporting form for cabin and in-flight entertainment faults, which are synchronized with the EFB Technical Electronic Logbook. These critical faults (such as an inoperable cabin public address system) are flagged to the flight crew, which does not see all of the other cabin faults.

## EFB Ground Module

Consists of a database hosted locally by the airline and/or by Boeing that contains fleet logbook history. An interface is provided into the database for use by ground personnel, such as maintenance control and dispatch. This function allows the entry of maintenance action and release information remotely from the airplane.

## Mechanic ELB Application

Provides visibility of new faults to be worked and allows entry of maintenance action and release information on the airplane itself.

Boeing EFB and ELB products are available to operators of most Boeing models as options. An EFB and the ELB application will be standard on all Boeing 787 Dreamliner models. The standard 787 implementation will include the Technical Logbook, Cabin Logbook, MyBoeingFleet.com-hosted ground application, and the Mechanic ELB Application.

if an airplane has a deferred fault that needs to be resolved, but the required downtime exceeds the current turn time on the schedule, the airline can use this information to swap airplane route assignments to ensure that it has the time necessary to resolve the issue before the airplane needs to dispatch again.

### DEFINITION AND BENEFITS OF AN ELB

Airlines use a number of paper-based logbooks, including flight, technical, airplane maintenance, cabin, ground, and system-specific logs. These logs are used to record technical problems and maintenance resolution, provide flight crews with airplane status, and comply with regulatory recordkeeping requirements. But paper logbooks have a number of limitations. The paper logbook entries record the flight crew interpretation of the problem. These can vary widely depending on the

flight crew. There is often no correlation to the fault code identification, and entries can be difficult to match with the system-generated fault messages. The Boeing ELB correlates entries automatically and provides standard nomenclature for problems.

An ELB system replaces paper logbooks with computer-based logs that can be easily stored and shared — even if users are thousands of miles apart (see fig. 1). At a minimum, an electronic logbook should do everything paper logbooks do today while making pilots' logging tasks simpler and faster by providing easy-to-use, standardized fault-reporting tools. Regulatory and legal requirements mandate signoff of the log by the flight and maintenance crews. The Boeing ELB provides a U.S. Federal Aviation Administration (FAA)-approved method for this signoff, which does not require processes that might include a universal serial bus (USB) token or real-time validation.

An electronic logbook also may enhance an operator's ability to plan unscheduled maintenance before the airplane arrives, coordinate logbook data with airplane-generated maintenance messages, and extend Airplane Health Management (AHM) capabilities beyond the central maintenance communication function to other types of faults. While AHM is not required for the ELB implementation, the combination of AHM and the ELB increases the value to the airline. (See "Remote Management of Real-Time Airplane Data," *AERO* third-quarter 2007.) The system should enhance flight crew and mechanic work management and reduce the impact of nonroutine maintenance needs and the resulting schedule delays.

Boeing's objective in developing electronic logbooks is to ensure coordinated data between flight and ground staff and increase maintenance efficiency. The integration of the system-generated



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**ELECTRONIC LOGBOOK ACCESSED THROUGH ELECTRONIC FLIGHT BAG**

Figure 2

The flight crew uses the Boeing EFB to access the Boeing ELB. A touch screen and graphical user interface enable crews to enter information quickly and accurately. The ELB can minimize ground delays by providing flight crews with instant access to airplane status, deferred maintenance items, information on recurring faults (i.e., fault history), and other vital information.

faults with the pilot-reported faults could also reduce the no-fault-found (NFF) removals by providing additional information necessary to isolate the actual problem.

**REGULATORY APPROVAL**

The introduction of an electronic replacement for the paper logbook is a significant change. Boeing has been working closely with the FAA and the European Aviation Safety Agency (EASA) during development. While FAA and EASA guidance on approval of EFB applications include the ELB (Advisory Circular 120-76A/TGL36A), many of the details (such as revisions, signatures, and data retention) are not specifically covered. Boeing provides support for the operational approval of the ELB application. This includes the airborne- and ground-provided components.

**THE ADVANTAGES OF CONNECTING AIRPLANES IN FLIGHT WITH GROUND SYSTEMS**

Traditionally, maintenance teams have had to wait for the airplane to land to gather enough information to begin their “parts and planning” to make repairs. Today, by integrating ground-based and airplane-based systems, information can be received and decisions made in real time.

For example, if a flight deck effect fault occurs in flight, the pilot enters the fault information into the Boeing ELB, which then automatically enters the fault code into the fault recording form (see fig. 2). The system is designed to allow the pilot to easily enter the initial fault; additional information can be added during a low workload phase of flight. As soon as the captain electronically signs the fault, the ELB transmits an accurate fault description to the ELB ground control system in the maintenance center and to any other airline

organizations that need the information. (Because the fault is automatically correlated to the fault code, the deferral status is automatically available.) Even though the airplane might still be several hours from landing, the airline can have people, parts, and equipment prepositioned and ready to make any needed repairs when the airplane arrives.

This system offers operators a number of additional advantages, including:

**Maintenance efficiency.** The ELB system allows the pilot to choose faults from a codified list of fault descriptions without typing or writing. Due to flight crew workload, many times the standard fault code is not entered into the paper flight log. The automatic inclusion of standard faults and their fault codes will reduce the rate of NFF removals. The accurate and immediate data the ELB provides can reduce troubleshooting and improve communication throughout the enterprise, helping optimize the maintenance operation.

Additionally, by providing a history of Fault Reports and Maintenance Actions, the Boeing ELB allows airlines to analyze fleet trends to proactively address system or component issues.

**Operational efficiency.** An ELB system can reduce downstream delays through fault forwarding of pilot eLogbook reports, translating into a reduction of maintenance delays and missed air traffic control slots.

**Reduction or elimination of paper documents.** Boeing estimates that a Boeing EFB/ELB system can reduce labor costs associated with gathering and maintaining paper forms, as well as data entry costs associated with typing logbook entries into airline maintenance planning or history systems.

#### AN E-ENABLED INFRASTRUCTURE


The Boeing ELB offers the most value when it is part of an overall e-enabled infrastructure. The ELB application links flight crew fault reporting to Boeing-provided ground applications (such as AHM), an airline ground-hosted logbook application, and airline ground systems, such as Maintenance Control.

This type of system provides the airline with a solution that can transform its maintenance operation. It also provides the framework for future implementations that can support other cost-reducing functions leading to a paperless dispatch of an airplane.

A comprehensive e-enabled infrastructure is complex (see fig. 3), and airlines may need to develop new resources to support it. But it provides a framework that can readily integrate future productivity improvements. Boeing offers a variety of implementation and support services. Figure 3 depicts a full installation, which includes a locally hosted ELB Fleet Database and connection to airline back-office systems. Boeing offers a scaled implementation that uses MyBoeingFleet.com for the primary fleet database for airlines that do not require back-office integration.

#### SUMMARY

The efficient operation of an airline's fleet depends on reliable technical communication between the airplane and airline ground stations. The Boeing EFB/ELB system provides real-time administrative information from air to ground, allowing airlines to make high-value operational decisions.

For more information, please contact David Allen at david.l.allen@boeing.com. 

## E-Enabling Interfaces

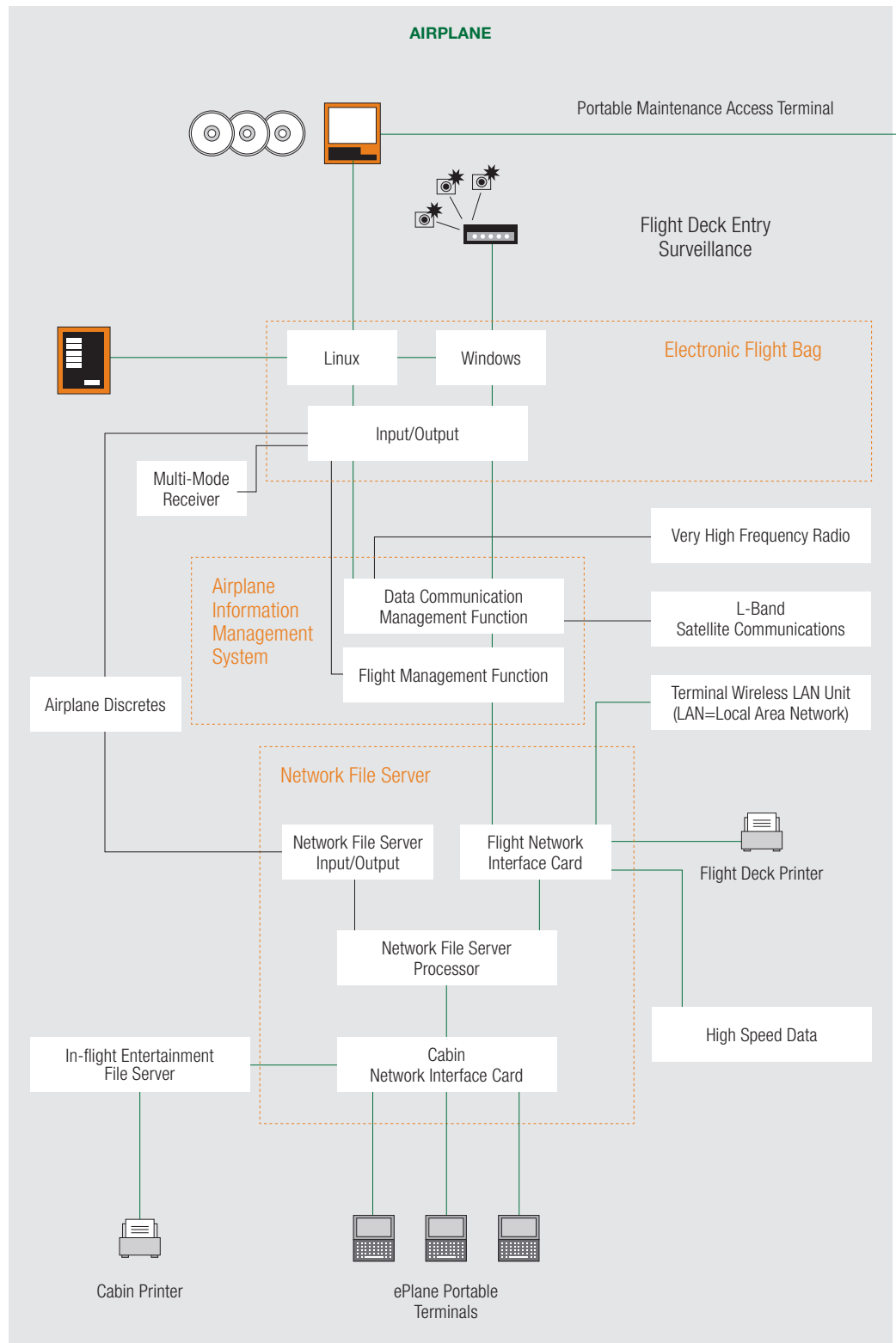
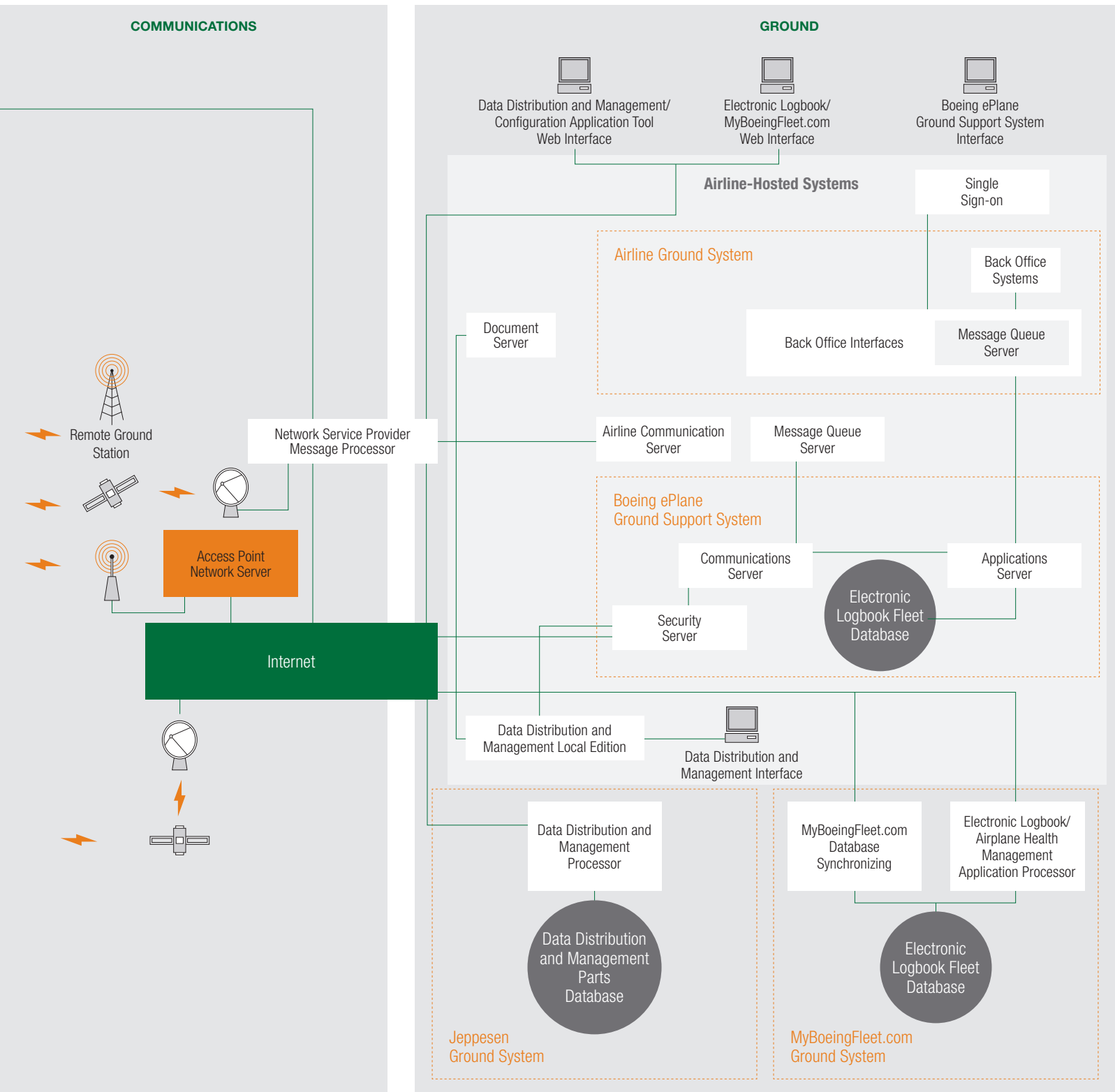


Figure 3

*In a network-centric, e-enabled airline, airplanes are always connected, sending and receiving valuable information. This real-time monitoring allows the airline to be predictive rather than reactive, which can increase revenues by improving overall operating efficiency.*



## Class 2 EFB

In addition to its Class 3 EFB, Boeing offers Class 1 and 2 EFB support through its subsidiary Jeppesen. A Class 2 EFB is generally a commercial off-the-shelf computer that has been optimized for airborne use (i.e., made more rugged, featuring sunlight-readable screens, and having touch screens). In some cases, the screen is connected to a remotely mounted computer; in other cases, the computer and screen are combined into one unit.

Class 2 EFBs are mounted on the flight deck and approved for use during all phases of flight and ground operations. They use ship's power and can receive inputs from the airplane's systems, such as position data to drive moving maps; however, they cannot send data to the airplane.

Class 2 EFBs are less integrated with the airplane than Class 3s, and therefore their functionality is more restricted. Class 2 EFBs offer a retrofit option for airlines with large fleets of existing airplanes, in which a fully integrated Class 3 system may not be viable. The market continues to evolve with some airlines moving toward a mix of Class 3 EFBs that are forward-fit as part of a new airplane order, and a combination of Class 2 and Class 3 EFBs that are installed in phases as a retrofit solution.





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