

Delivering the
Boeing Edge

**Why and When
to Perform a
Go-Around
Maneuver**

New Maintenance
Applications for
iPad

Planning Efficient
Airplane
Maintenance
Facilities

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The Boeing Edge 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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Delivering the Boeing Edge

Hello.

First, I want to say that I am deeply honored to lead Boeing's customer service organization. I am both thrilled by the new opportunity *and* humbled by the responsibility.

When you operate a Boeing airplane, you expect world-class services and innovative solutions to help your businesses grow. That's what sets Boeing apart. Frankly, you deserve nothing less.

We're focused on supporting the assets in your fleet so that Boeing is your preferred partner for maintenance and spares, engineering and modifications, training, navigation, and a wide range of technology solutions.

Yet, we know we have not always lived up to all of your expectations. There have been times when we have disappointed customers. We are committed to improving on that.

As you probably have heard, we are making changes to enhance our customer support. We are building a new customer support center in Southern California, bringing together all teams that work directly with airlines. Instead of devoting one center to airplanes currently in production and another to out-of-production models (as we do now), we are establishing a single facility dedicated to providing a superior customer experience. This will free up capacity for our Customer Support team in the Puget Sound area to focus exclusively on helping you successfully introduce the next generation of Boeing airplanes — the 787-8 and 787-9/-10 and all members of the 737 MAX and 777X families.

We also are expanding our flight and maintenance training options, redoubling our efforts to ensure critical parts are available around the clock and around the globe, and providing new analytical tools

to help you enhance operational efficiency and take advantage of market opportunities.

Our team is dedicated to making you successful, whether you are introducing the 787 Dreamliner into your fleet or operating MD-80s/-90s, 757s, Next-Generation 737s, 777s, or any other Boeing airplane.

As I take on my new role, I am excited about spending time with you, hearing about issues you face every day and solutions you expect from Boeing. I promise to be your champion for world-class customer support. And I expect the rest of the Boeing team to do the same.

We are part of an exciting industry. It is our job to give you every possible advantage to be successful — every day, wherever you fly, and with every airplane you operate.

STAN DEAL

Senior Vice President
Boeing Commercial Aviation Services



Flight crews should execute a go-around maneuver instead of continuing an unstabilized landing approach.

Why and When to Perform a Go-Around Maneuver

Industry statistics indicate that while only 3 percent of commercial-airplane-landing approaches meet the criteria for being unstabilized, 97 percent of these unstabilized approaches are continued to a landing, contrary to airline standard operating procedures. Most runway excursions can be attributed at least in part to unstabilized approaches, and runway excursions in several forms are the leading cause of accidents and incidents within the industry. Airlines should emphasize to flight crews the importance of making the proper go-around decision if their landing approach exhibits any element of an unstabilized approach.

By **Michael Coker**, Lead Safety Pilot, Flight Services

According to industry sources, no single decision has the potential impact on the overall aviation industry accident rate than the timely decision to execute a go-around maneuver. The reason is that runway excursions or overruns — which are typically the result of an unstabilized approach with a failure to perform a go-around — account for 33 percent of all commercial aviation accidents and are the primary cause of hull loss.

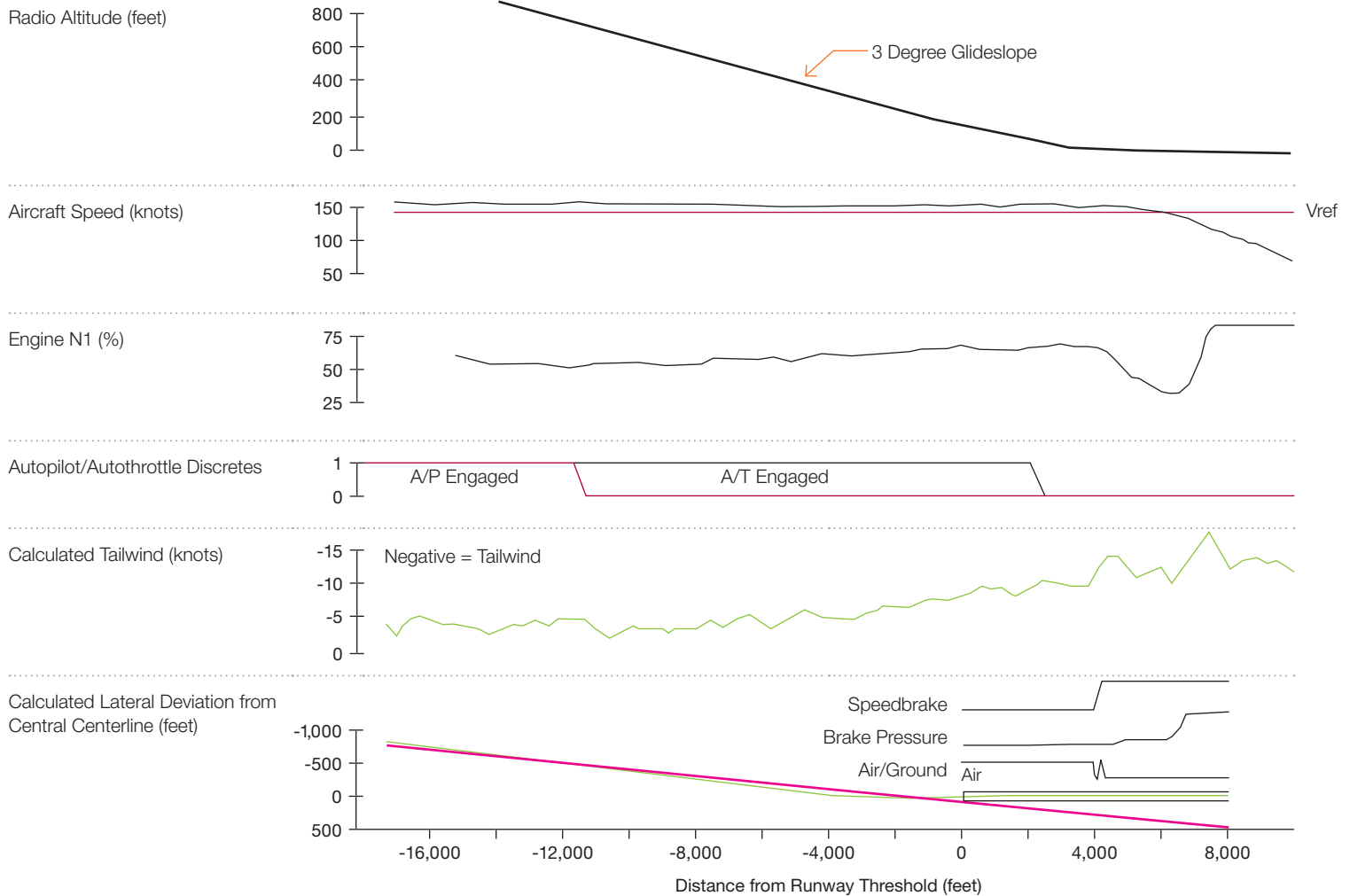
This article explains the relationship between unstabilized approaches and hull loss, why flight crews continue landing despite an unstabilized approach, the factors that govern landing outcomes, when flight crews should choose a go-around maneuver, and industry education efforts related to go-arounds.

THE RELATIONSHIP BETWEEN UNSTABILIZED APPROACHES AND HULL LOSS

Boeing developed an analysis to help visualize runway events. This Boeing Runway Track Analysis combines multiple sets of investigation data, including time-based flight-data-recorder data, distance-based ground-scar data, and the calculated track (see fig. 1).

Figure 1: Boeing Runway Track Analysis

Boeing Runway Track Analysis uses a variety of data to analyze runway events.



This analysis shows the relationship between unstabilized approaches and hull loss, due to runway excursion (see fig. 2). In every instance of hull loss, the outcome may have been very different if the flight crews involved had elected to perform a go-around instead of attempting a landing. According to a Flight Safety Foundation (FSF) study, more than half of all commercial airplane accidents in 2011 could have been prevented by a go-around decision. In fact, according to FSF's analysis 83 percent of approach-and-landing accidents could be prevented by a go-around decision.

The conclusion from this analysis is that flight crews need to know when to

abandon an approach to landing and perform a go-around maneuver because the decision to go around is an essential element of conducting a safe flight.

WHY FLIGHT CREWS CONTINUE LANDING WITH AN UNSTABILIZED APPROACH

According to the FSF, a number of factors contribute to a flight crew's decision to continue landing with an unstabilized approach, including:

- Fatigue.
- Pressure of flight schedule (e.g., making up for delays).

- Any crew-induced or air-traffic-control (ATC)-induced circumstances resulting in insufficient time to plan, prepare, and conduct a safe approach.
- ATC instructions that result in flight too high and/or too fast during the initial approach.
- Excessive altitude or excessive airspeed (e.g., inadequate energy management) during the initial approach.
- Late runway change.
- Excessive head-down work.
- Short outbound leg or short downwind leg (e.g., because of traffic in the area).
- Late takeover from automation.

Figure 2: Relationship between unstabilized approach and hull loss

This analysis shows that four out of seven unstabilized approaches in this study resulted in hull loss.

Approach	Touchdown Point (TD)		Touchdown Speed		Deceleration				Result		
	Point (feet)	Runway Used (% LDA)	Airspeed >Vref (knots)	Tail Wind (knots)	Speedbrake (SB)	Thrust Reversers (TR)		Runway	Overrun Speed (knots)	Hull Loss	
					When SB Deployed (sec)	When TR Deployed (sec)	When TR Reduced (feet)	Braking Action			
Long	Unstable	7,000	72%	23	0	TD	TD + 3	Departure	Good	81	Yes
	Unstable	6,200	70%	12	5	TD	Never		Dry	50	No
	Unstable	5,300	60%	16	3	TD	TD + 4	Departure	Good	35	No
	Unstable	5,150	48%	20	0	TD + 5	TD + 7	900	Med	70	No
	Unstable	4,700	52%	30	-1	TD	TD + 2	1,000	—	100	Yes
	Unstable	4,500	60%	-3	1	TD	TD + 2	Departure	Good	47	Yes
	Unstable	4,500	56%	6	3	TD	TD + 3	400	Dry	90	Yes
	Stable	3,950	44%	0	14	TD	TD + 3	Departure	Med	63	Yes
	Stable	3,260	41%	20	-1	TD	TD + 3	2,000	Med	40	No
	Stable	3,200	48%	-7	4	With TR	TD + 2	Departure	Good	30	No
	Stable	3,120	42%	10	10	TD	TD + 2	Departure	Good	50	No
	Stable	3,000	37%	-5	6	TD	TD + 2	Departure	Med	30	No
	Stable	3,000	34%	3	5	TD	TD + 3	Departure	Med	5	No
		13									
Fast	Stable	1,600	20%	12	10	TD	TD + 27	Departure	Good	25	No
	Stable	1,500	20%	20	10	TD	TD + 3	600	Med	5	No
	Stable	1,450	20%	11	15	TD	TD + 3	1,250	Med	20	No
	Stable	1,450	20%	6	9	TD	TD + 3	Departure	Med	0	No
	Stable	1,250	18%	4	11	TD	TD + 2	Departure	Poor	45	No
		5									
Deceleration	Stable	2,700	30%	0	0	Never	Never		Med	45	No
	Stable	400	6%	2	-6	Never	TD + 22	Departure	Med	48	No
	Stable	500	8%	3	4	With TR	TD + 20	Departure	Med	32	No
	Stable	1,250	21%	0	9	TD	TD + 16	Departure	Poor	42	No
	Unstable	1,720	27%	6	5	TD+9	TD + 13	Departure	Good	20	No
	Unstable	1,800	23%	10	2	With TR	TD + 11	Departure	Poor	28	No
	Stable	1,900	26%	6	-2	TD	TD + 8	Departure	Med	20	No
	Stable	1,150	24%	5	-5	TD	TD + 6	100	Med	12	No
	Stable	2,900	28%	0	-6	TD + 3	TD + 5	2,800	Poor	10	No
	Stable	2,600	31%	0	2	TD	TD + 2	2,250	Good	25	No
	Stable	2,200	27%	5	7	TD	TD + 2	2,000	Med	45	No
		11									



- Premature or late descent caused by failure to positively identify the final approach fix.
- Inadequate awareness of wind conditions.
- Incorrect anticipation of airplane deceleration characteristics in level flight or on a three-degree glide path.
- Excessive confidence by the pilot monitoring (PM) that the pilot flying (PF) will achieve a timely stabilization.
- PF and PM too reliant on each other to call excessive deviations or to call for a go-around.
- Visual illusions that cause a crew to misinterpret the airplane's position, such as a narrow runway that may give the impression that the airplane is higher than it actually is.
- Lack of airline policy, cultural norm, and training to direct pilots to perform a go-around instead of continuing an unstabilized approach.
- Lack of practice in performing a go-around maneuver.

FACTORS THAT GOVERN LANDING OUTCOMES

Three primary factors govern the outcome of every landing:

- **Touchdown point.** Defines runway remaining to dissipate energy. Having a stabilized approach contributes heavily to a proper touchdown point.
- **Touchdown speed.** Defines energy to be dissipated.

Recommended elements of a stabilized approach

All flights must be stabilized by 1,000 feet (305 meters) above airport elevation in instrument meteorological conditions (IMC) and by 500 feet (152 meters) above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:

1. The airplane is on the correct flight path.
2. Only small changes in heading/pitch are required to maintain the correct flight path.
3. The airplane speed is not more than $V_{ref} + 20$ knots indicated airspeed and not less than V_{ref} .
4. The airplane is in the correct landing configuration.

5. Sink rate is no greater than 1,000 feet per minute (FPM) or 305 meters per minute; if an approach requires a sink rate greater than 1,000 FPM, a special briefing should be conducted.
6. Power setting is appropriate for the airplane configuration and is not below the minimum power for approach as defined by the airplane operating manual.
7. All briefings and checklists have been conducted.
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glide scope and localizer; a Category II or Category III ILS approach must be flown within the

expanded localizer band; during a circling approach, wings should be level on final when the airplane reaches 300 feet (91 meters) above airport elevation.

9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 feet (305 meters) above airport elevation in IMC or below 500 feet (152 meters) above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-Landing Accident Reduction Task Force

- **Deceleration after touchdown.** Defines the effectiveness of dissipating the energy.

An analysis of overruns indicates that if two out of three conditions exist, an overrun is likely. But if one condition is removed, the overrun risk is reduced.

WHEN TO PERFORM A GO-AROUND MANEUVER

A go-around maneuver should be performed whenever the safety of a landing appears to be compromised (see fig. 3). Typically, this occurs for one of these reasons:

- **Requested by ATC.** ATC may request a go-around for a variety of reasons, including tight airplane spacing, an airplane on the runway, or an airplane too close on a parallel landing runway.
- **Unexpected events.** The flight crew may determine that something is not correct for landing — such as a flap gauge or gear indication — and that a checklist is needed to configure the airplane for landing. The presence of wind shear is another unexpected cause of go-arounds. These unexpected events may warrant initiation of a go-around even after the airplane has touched down following a

stable approach. Runway conditions, surface winds, friction coefficients, or unknown conflicts may be different than those reported to the crew during approach. A successful go-around may be possible after touchdown up to the point where the crew initiates the use of thrust reverse if conditions warrant. Because these types of go-arounds involve unexpected events, it is difficult to anticipate them.

- **Unstabilized approach.** An unstabilized approach occurs when an airplane fails to keep one or more of these variables stable: speed, descent rate, vertical/

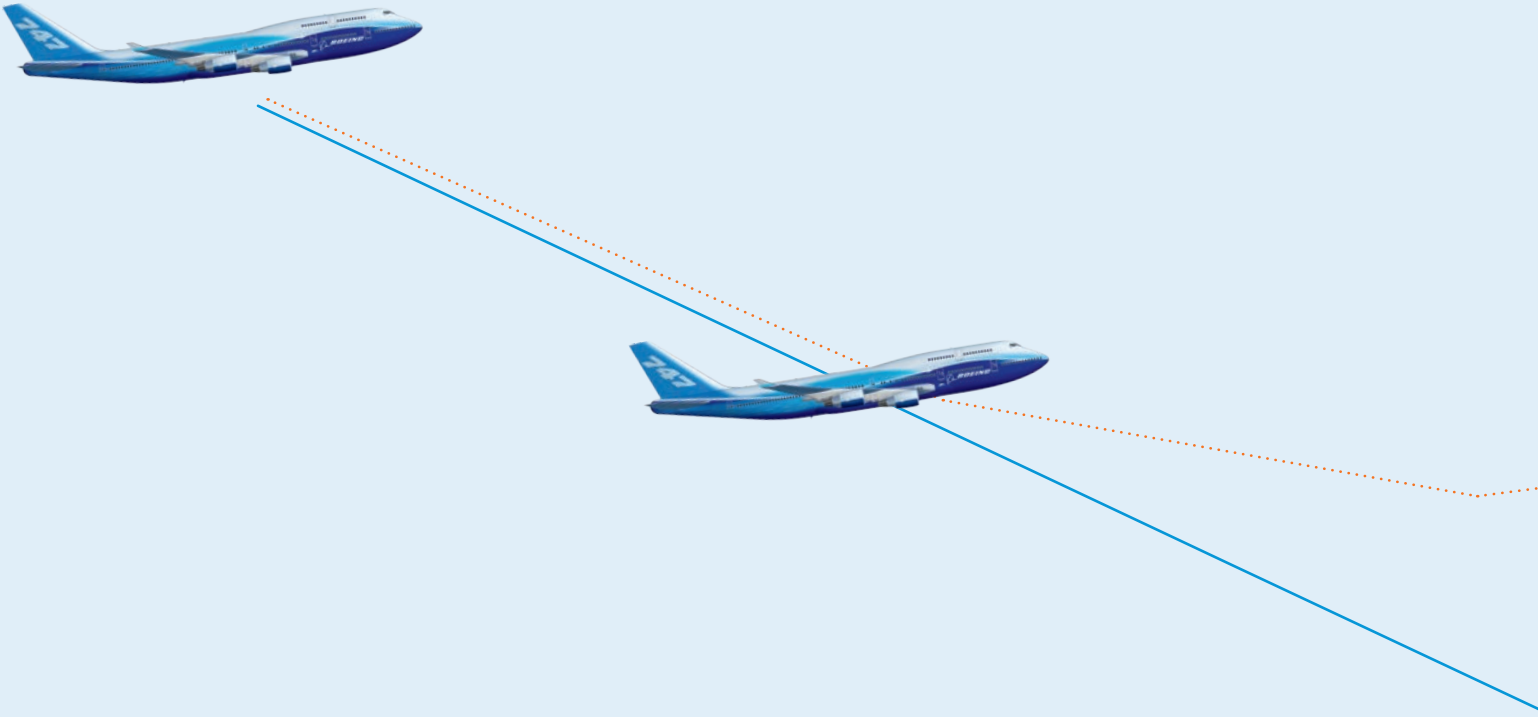


Figure 3: When to perform a go-around

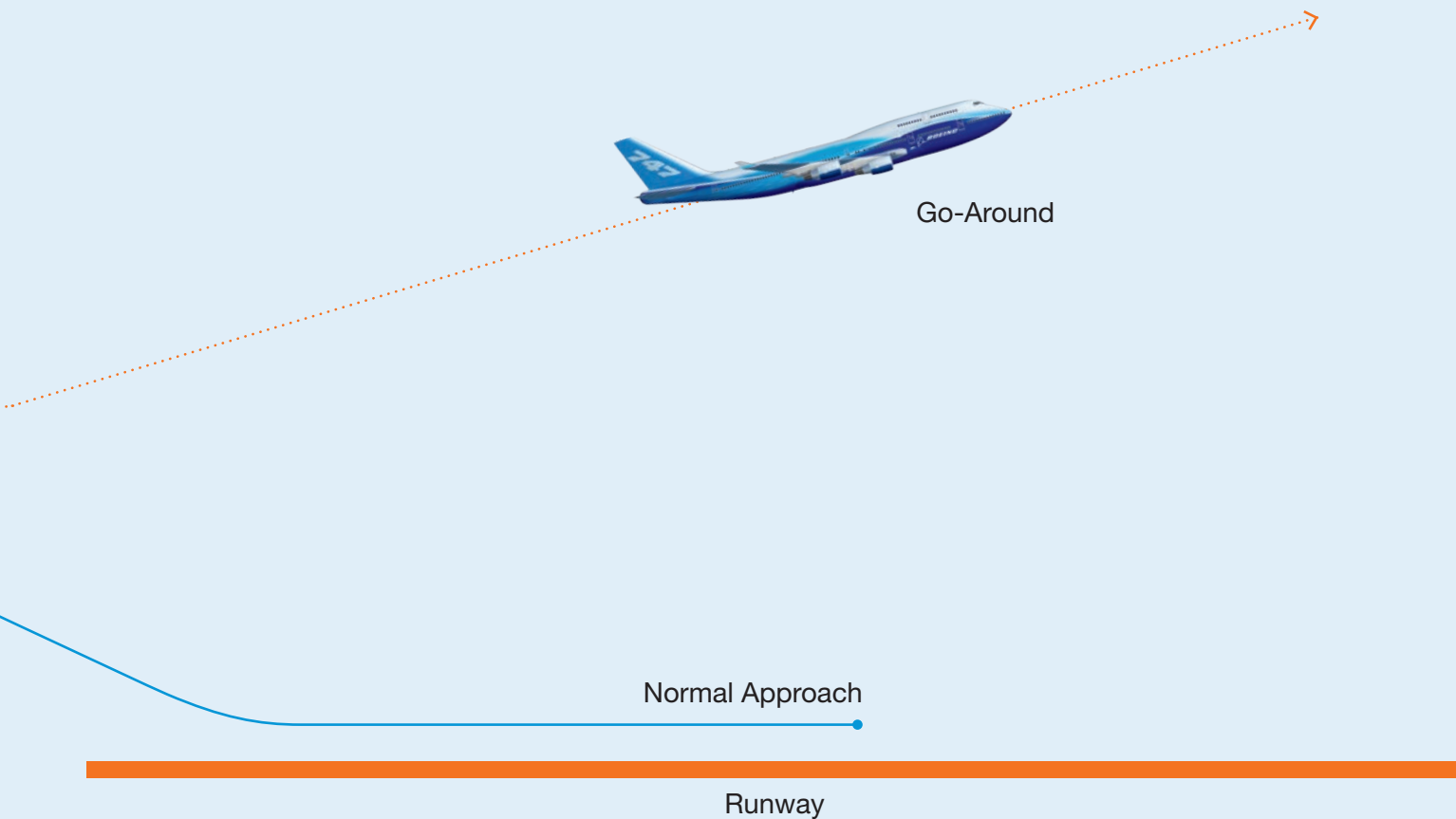
The timely decision to initiate a go-around if the approach is unstable or conditions have changed, such that a safe landing is at risk, allows the crew to safely conduct a follow-on approach. There are several reasons to perform a go-around maneuver, including a request by ATC, an unexpected event (such as wind shear), an unstabilized approach, or the determination that the landing cannot be made within the touchdown zone.

lateral flight path, and configuration for landing. It is important to understand that the stabilized approach recommendations do not apply only to the “gates” of 1,000-foot (305-meter) instrument meteorological conditions (IMC) and 500-foot (152-meter) visual meteorological conditions (VMC). Those altitudes are merely a snapshot analysis of the approach, and the elements need to be maintained throughout the landing. (See “Recommended elements of a stabilized approach” on page 9.)

- **Landing cannot be made within the touchdown zone.** This is defined as the first 3,000 feet (915 meters) or first third of the runway, whichever is shorter. Crews should calculate a landing distance based on current conditions and compare that distance to the runway available for every landing. Touchdown at the far end of the accepted first 3,000 feet (915 meters) or first third of the runway may not be appropriate if conditions change at the last moment during the flare or touchdown.

INDUSTRY EDUCATION EFFORTS

Numerous airline pilot associations and regulatory authorities have efforts under way to educate flight crews about go-arounds. These include the FSF, International Civil Aviation Organization (ICAO), International Air Transport Association, Commercial Aviation Safety Team (CAST), and European Commercial Aviation Safety Team.



Resources include:

- FSF Approach-and-Landing Accident Reduction Tool Kit Briefing Note, *Being Prepared to Go Around* (http://flightsafety.org/files/alar_bn6-1-goaroundprep.pdf).
- ICAO Working Paper, *Measures for Preventing Runway Excursion Caused by Unstabilized Approach* (http://www.icao.int/Meetings/a38/Documents/WP/wp302_en.pdf).

- CAST Go-Around Safety (http://www.skybrary.aero/index.php/Portal:Go-Around_Safety).

SUMMARY

Runway excursions are the leading cause of accidents and incidents within the industry. Airlines can avoid most runway excursions if flight crews choose to execute

a go-around maneuver instead of continuing an unstabilized approach to a landing. Flight crews should understand the importance of making a go-around decision if they experience an unstabilized approach or conditions change during the flare or touchdown up to the point of initiating thrust reverse during the landing rollout. **A**



Boeing's new mobile maintenance application suite helps airlines improve their operational efficiency.

Part No.	Part Name	Location	Part Number	Availability
1000	Engine	Engine	1000-001	Available
2000	Wing	Wing	2000-001	Available
3000	Fuselage	Fuselage	3000-001	Available
4000	Landing Gear	Landing Gear	4000-001	Available
5000	Avionics	Avionics	5000-001	Available
6000	Interior	Interior	6000-001	Available
7000	Exterior	Exterior	7000-001	Available
8000	Electrical	Electrical	8000-001	Available
9000	Hydraulic	Hydraulic	9000-001	Available
0000	Other	Other	0000-001	Available

New Maintenance Applications for iPad

As part of the overall commercial aviation industry trend of using mobile devices to increase operational efficiency, Boeing has developed a number of mobile applications designed specifically to speed and streamline airplane maintenance tasks. Airlines are now using these applications to improve operations efficiency and productivity, lower costs, and reduce flight delays.

By Rex Douglas, Product Manager, Toolbox Mobile Library/Parts, and **Stephen P. Miller**, Product Manager, Maintenance Turn Time

As more airlines discover the efficiencies of using electronic flight bags (EFBs) to store flight manuals and other data, they are seeking ways to extend these efficiencies to other aspects of their operations. Maintenance is a logical area to target. Even if an airline is using digital manuals, it typically prints hard copies of the procedures needed when maintenance personnel work on the airplane.

With the emergence of tablets as viable tools for business, Boeing has worked with several airlines to develop a suite of maintenance applications.

This article provides a brief history of Boeing's technological innovations that led to the development of the mobile maintenance application suite and describes the individual applications that comprise the suite.

A HISTORY OF INNOVATION

Boeing began offering EFBs to operators in 2003 and now offers a common application suite and ground infrastructure for use across all categories of EFBs (i.e., Class 1, Class 2, and Class 3). (See *AERO* second-quarter 2008 and *AERO* first-quarter 2010.)

In 2007, Boeing introduced Maintenance Performance Toolbox, an online system that provides operators with up-to-date fleet maintenance information using intelligent documents and visual navigation methods. (See *AERO* first-quarter 2007.)

As the iPad emerged as a viable tool for the flight deck, Boeing began developing applications for it, the first of which was an electronic iPad-based version of the quick reference handbook (QRH) used by flight crews. (See *AERO* first-quarter 2013.)

More recently, Boeing worked with several airlines to develop a suite of maintenance applications to enable airline

Figure 1: Toolbox Mobile Library

Toolbox Mobile Library gives technicians access to maintenance documents to perform routine maintenance tasks and diagnose airplane issues more quickly and easily.

FIG ITEM	PART NUMBER	NOMENCLATURE	EFFECT FROM TO	UNITS PER ASSY	TOTAL QTY PER AIR
01		WIPER INSTL-WSHLD (WINDSHIELD WIPER ARMS ONLY)	001-999		
-1	MODREF:143643	WIPER INSTL - WSHLD (WINDSHIELD WIPER ARMS ONLY)	001-999	RF	AR
		MODULE NUMBER: 232W6100-7 REV A			
		POSITION DATA: LH			
		FOR ADDITIONAL DETAILS SEE: 30-42-01-02 30-42-03-01			
-5	MODREF:143644	WIPER INSTL - WSHLD (WINDSHIELD WIPER ARMS ONLY)	001-999	RF	AR
		MODULE NUMBER: 232W6100-8 REV A			
		POSITION DATA: RH			
		FOR ADDITIONAL DETAILS SEE: 30-42-01-02 30-42-03-01			
10	90-0216-1	ARM ASSY	001-999	1	AR
		Supplier Code: V72914			
		SPECIFICATION NUMBER: S232T601-63			
		COMPONENT MAINT MANUAL REF: 30-42-12			
		POSITION DATA: LH SIDE			
		FUNCTIONAL DESCRIPTION: THIS ARM HOLDS THE WIPER BLADE.			
		MAINTENANCE MANUAL REF: 30-42-02			
10	90-0216-7	ARM ASSY	001-999	1	AR
		Supplier Code: V72914			
		SPECIFICATION NUMBER: S232T601-63			
		COMPONENT MAINT MANUAL REF: 30-42-12			
		POSITION DATA: LH SIDE			

Figure 3 (Sheet 001)

technicians to perform routine maintenance tasks and diagnose airplane issues more quickly and easily. Boeing has used input from these airlines to optimize the user interface and maximize utility for airline technicians.

As an example of the efficiency and cost-savings improvements airlines are experiencing, technicians from one of the participating airline development partners recently estimated that by using these iPad applications, the airline will reduce the volume of printed paper by as much as 4,000 pages per day.

SUITE OF MAINTENANCE APPLICATIONS IMPROVES EFFICIENCY

Boeing's maintenance applications give technicians real-time access to manuals, parts availability, the maintenance history of an airplane, and other critical information needed to resolve maintenance issues at the airplane and collaborate with coworkers located elsewhere.

The mobile maintenance applications include Toolbox Mobile Library, Toolbox Mobile Parts, and Maintenance Turn Time. These advanced tools can enhance

regulatory compliance, reduce flight delays, and lower operational costs.

TOOLBOX MOBILE LIBRARY

Toolbox Mobile Library gives technicians access to Boeing maintenance documents and internal company manuals on a mobile device (see fig. 1). Available maintenance documents include the aircraft maintenance manual, fault isolation manual, illustrated parts catalog, structural repair manual, wiring diagram manual, and system schematics manual. Operators can

Figure 2: How Toolbox Mobile Library saves time

A typical line maintenance scenario can involve multiple trips to the line maintenance office to locate and print required information. Toolbox Mobile Library enables technicians to find and use the information they need without leaving the airplane.

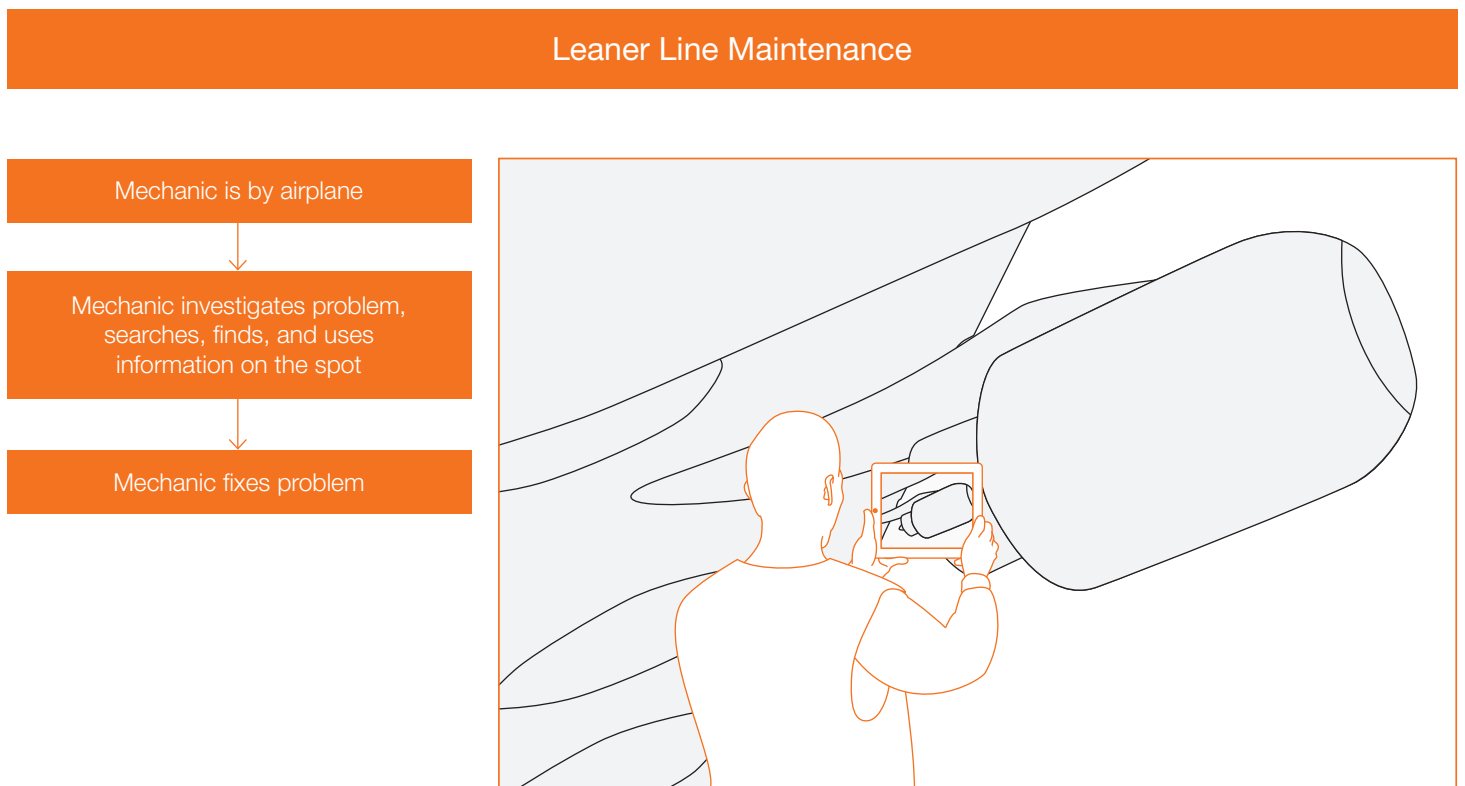
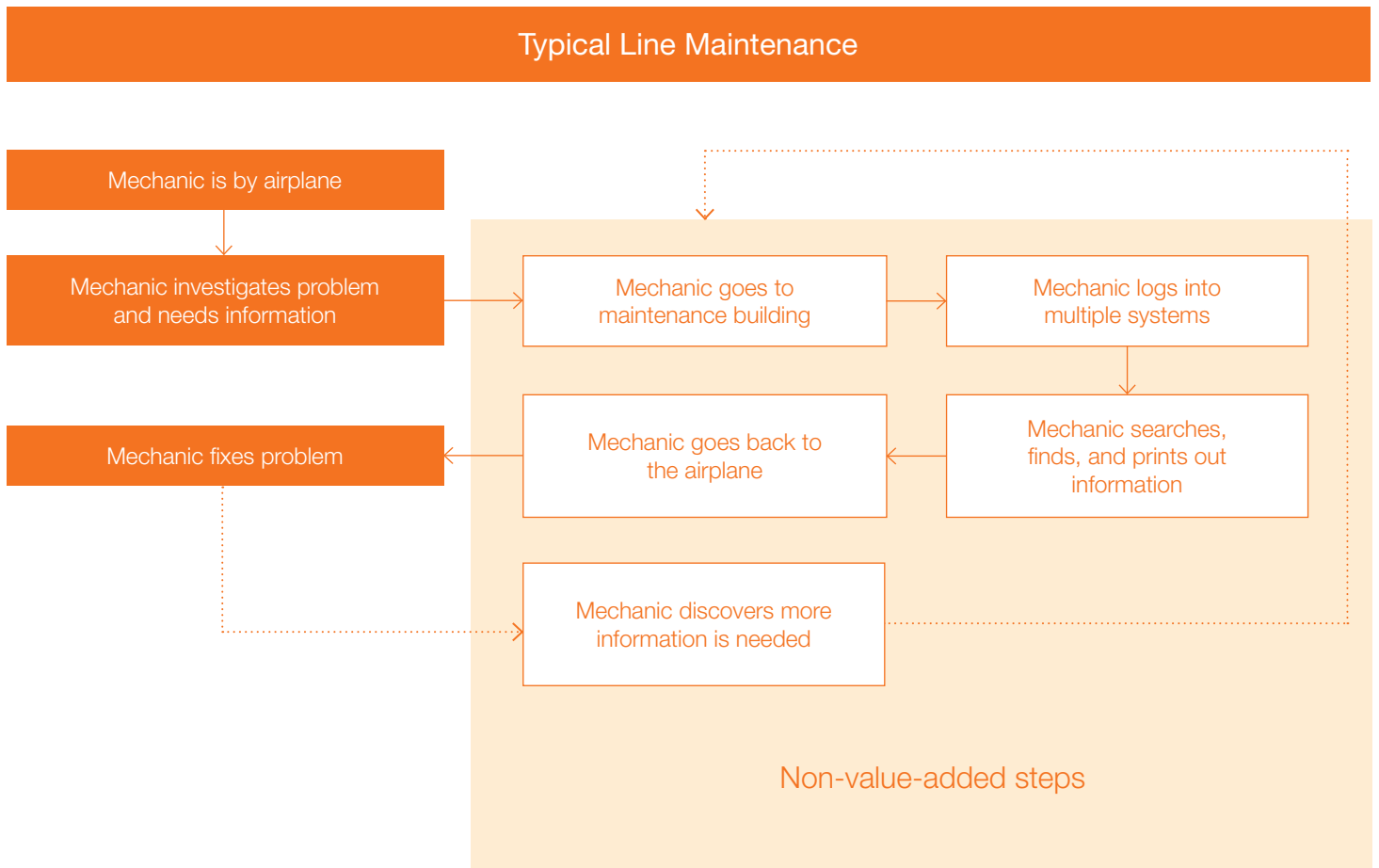
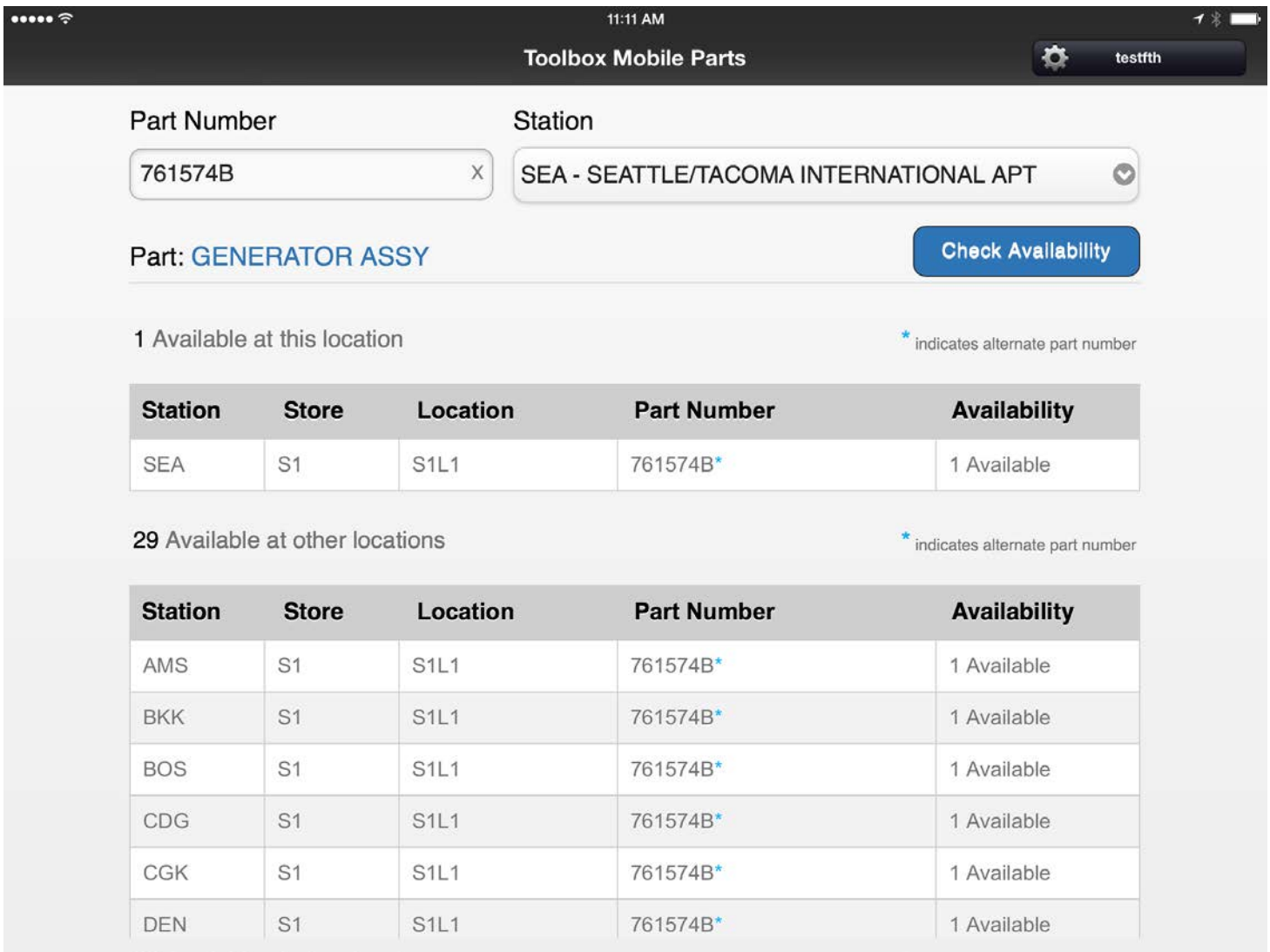


Figure 3: Toolbox Mobile Parts

Toolbox Mobile Parts enables technicians to instantly retrieve information about part availability, according to the airline's most current inventory information.



use the Maintenance Performance Toolbox Authoring module to add customized content, including internal company manuals.

Toolbox Mobile Library enables operators to reduce airplane turn times by giving them instant access to maintenance documents. With access to the procedures they need readily available on their tablets, maintenance technicians don't need to leave the airplane to go to the maintenance building and retrieve documents (see fig. 2). Toolbox Mobile Library supports full search

capabilities and hyperlinking between documents — the same features as in the online Maintenance Performance Toolbox, but with the portability of a tablet.

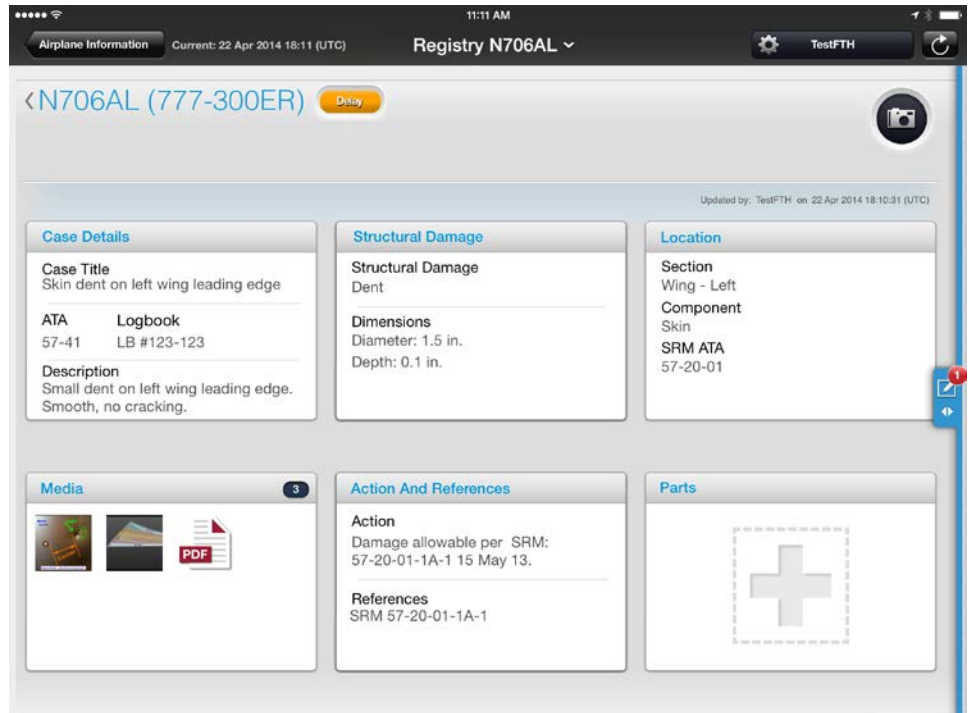
TOOLBOX MOBILE PARTS

The Toolbox Mobile Parts module enables technicians to use an iPad to check on the availability of required parts, reducing the need for trips to the line maintenance office.

The application gives maintenance and engineering personnel access to the most current parts inventory information (see fig. 3). Direct linking from part numbers in the illustrated parts catalog to the airline's local parts inventory database eliminates part number rekeying errors and allows the technician to make an immediate decision as to whether or not the necessary parts are available to perform maintenance and release the airplane on time.

Figure 4: Maintenance Turn Time

Maintenance Turn Time gives technicians a secure connection to collaborate with their colleagues when troubleshooting a maintenance issue. A technician can take a photo of a damaged part, upload it for others to see, and annotate and share information about maintenance issues with peers in real time.




MAINTENANCE TURN TIME

The Maintenance Turn Time application allows airlines to quickly identify and resolve nonroutine defects, reducing delays and cancellations while improving productivity. Technicians can access Maintenance Turn Time from a mobile device at the airplane to quickly troubleshoot defects. Technicians can also share information securely in real time to collaborate with their colleagues in the airline's maintenance and engineering organizations (see fig. 4).

Through integration with the airline's systems, the application enables technicians to access airplane maintenance history at the gate, eliminating the need to go to the line maintenance office to view this information. Technicians can add photos to a case using a mobile device to record any physical damage to an airplane, and they can also view a three-dimensional image of the damaged section.

SUMMARY

Boeing's new mobile maintenance application suite helps airlines improve their operational efficiency by delivering real-time, critical digital maintenance information to technicians at the point of use.

For more information, e-mail theboeingedge@boeing.com. 



Boeing offers maintenance-facilities planning services to help airlines be more successful.

Planning Efficient Airplane Maintenance Facilities

Boeing can assist airlines with their planning and preliminary layouts of hangar and maintenance facilities.

By **Gerald Paluszek**, Lead Principal Engineer, Maintenance and Ground Operations Systems

The planning and construction of airplane hangars and maintenance facilities require a unique skill set and extensive knowledge of airplane maintenance and component repair and overhaul. This type of expertise is beyond that of conventional design firms. In addition to the actual physical structure, the facility design should incorporate workflow analysis for airplane maintenance and component repair. Examples of workflow analysis include procedures for cleaning, repairing, testing, and inventorying parts. The facility design also should reflect the operator's fleet growth and maintenance

plans for five to 15 years into the future and incorporate the latest lean-manufacturing principles.

This article explains the benefits of well-planned maintenance facilities and the fee-based planning services offered by Boeing.

THE CRITICAL ROLE OF MAINTENANCE FACILITIES IN AIRLINE OPERATIONS

Properly planned and constructed, an airline's maintenance facilities can contribute

to operational safety, efficiency, and cost control. (See *AERO* first-quarter 2001.)

Effective project planning will help ensure that a new maintenance facility will meet an airline's present and future business objectives. For this reason, a number of factors should be considered in planning the facility.

The facility must be tailored to the site. In order to achieve maximum site utilization, planners should gather as much information as possible about the existing site and its planned uses before beginning a



preliminary layout (see fig. 1). These are some examples of what to consider when performing an initial site survey:

- **Existing and planned runway construction.** There are specific formulas per International Civil Aviation Organization regulations that determine the position and height of buildings with relationship to runways. This is critical to the location of the hangar and facilities on the site.
- **The number, type, and size of airplanes that will use the facility.** Entering, exiting, and turning radii must be planned into the layout along with adequate parking for the number of expected airplanes.
- **Dedicated engine run-up area.** If a run-up area is to be included at the site, the plan must provide adequate space, an access road, and a determination of the prevailing wind direction so the run-up area is positioned properly. Future space requirements may include an engine overhaul and test facility.

- **Warehouse.** If the overall plan needs to accommodate a warehouse, access within the grounds and adequate road access outside the facility should be included because large semitrailers will use this warehouse. Access roads and loading areas need to be planned into the facility.
- **Site services.** These include the incoming water supply, the type and capacity of waste treatment, and the availability of the electrical supply. These also include the heating and air-conditioning requirements of the facility depending on the regional climate.
- **Local building codes.** These include local laws for building design and construction.

Incorporating lean-production principles saves money during both the development and the use of a facility. The term “lean production” refers to the efficient design, manufacture, delivery, and support of products through the systematic identification and elimination of waste.

In maintenance facility planning, lean construction processes start with the selection of a contractor that uses methods and systems that not only monitor progress and costs but can also contribute to selecting systems that will produce operational efficiencies. Evaluating contractor proposals and their individual approach to managing the entire project provides insight to the methods and efficiencies that each prospective contracting company is using, well before construction begins.

An efficient layout produces operational cost efficiency. After choosing the facility’s location and tailoring the facility to the site, the next stage in maintenance facility planning is to design the most efficient physical layout for the facility. Workshop positioning, shop equipment, and tooling should be arranged with an objective of optimizing the workflow with a minimum of disruptions.

The workflow should reflect the level and quantity of airplane maintenance to be accomplished in the facilities. This helps determine the size and layout of the workshops needed for component repair and refurbishment. For example, the design should take into consideration the parts, materials, equipment, processes, and workforce skill set required to perform airplane maintenance, and modification, and component repair and overhaul.

Aspects that should be considered in creating an efficient layout include:

- **Work flow.** The flow should reflect the level and quantity of airplane maintenance to be accomplished in the facilities. This helps determine the size and layout of the workshops needed for component repair and refurbishment. For example, the design should take into consideration the parts, materials, equipment, processes, and workforce skill set required to perform airplane maintenance, and modification, and component repair and overhaul.

In some cases, maintenance docking systems should be included to perform heavy maintenance more efficiently.

- **Materials handling.** The layout must accommodate the handling of all types of airplane components, engines, and materials, from small parts to large jet engines. Special consideration should be given to the location of specialized

material handling equipment, such as overhead cranes.

- **Parts and components.** Adequate space should be provided on the hangar floor and within each component repair overhaul shop.
- **Safety and environmental.** The facility should be laid out to ensure that it can operate in accordance with applicable safety and environmental regulations and requirements.
- **Security.** Design and layout of the maintenance complex should incorporate all aspects of exterior and interior security monitoring and management. This may include appropriate perimeter fencing and guard access control and monitoring, vehicle and truck inspections when necessary, and lighted and monitored parking and warehouse access.

COMPREHENSIVE PLANNING PROCESS

Comprehensive planning for a maintenance facility project encompasses these steps:

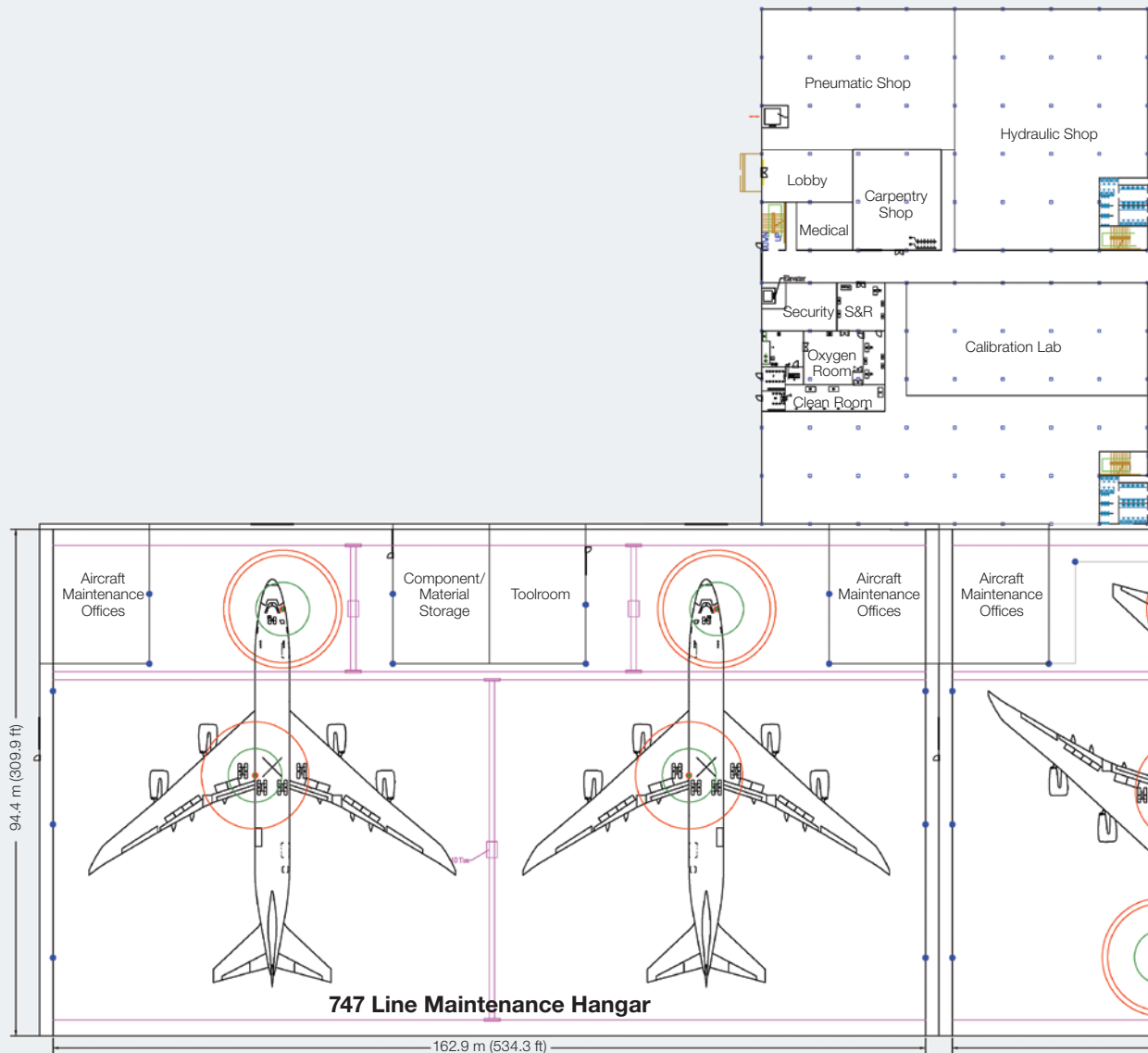
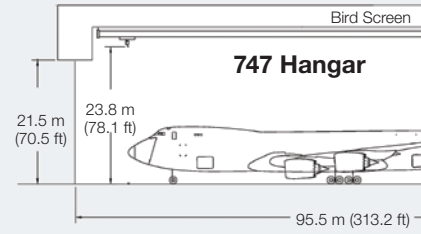
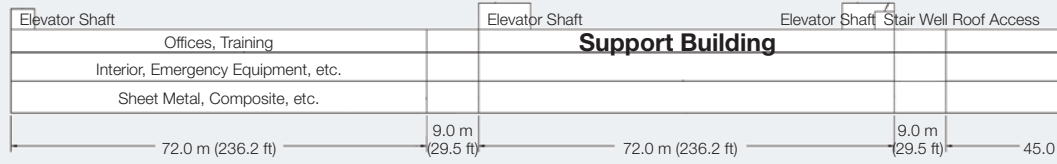
Research. This involves studying the types of required maintenance, support functions, facility specifications, site development, site utilities, and building requirements. The overall objective is to optimize an airline's investment by developing design criteria documentation and conceptual layouts for fully functional and lean maintenance facilities.

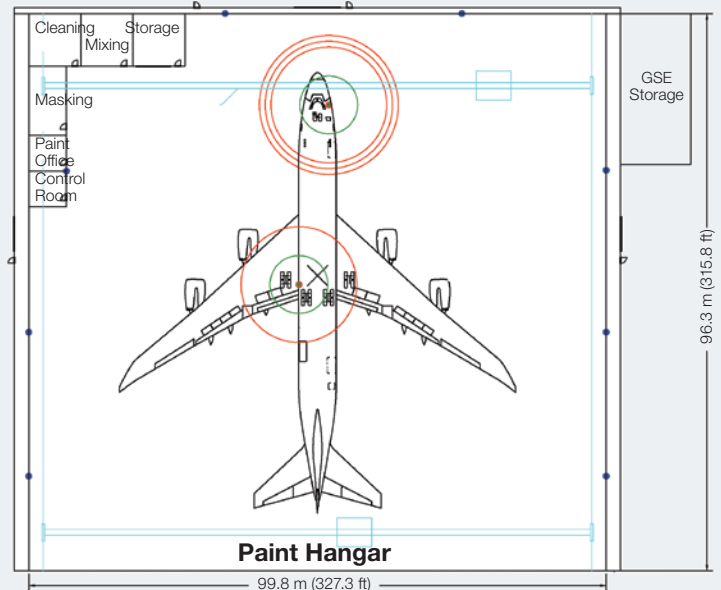
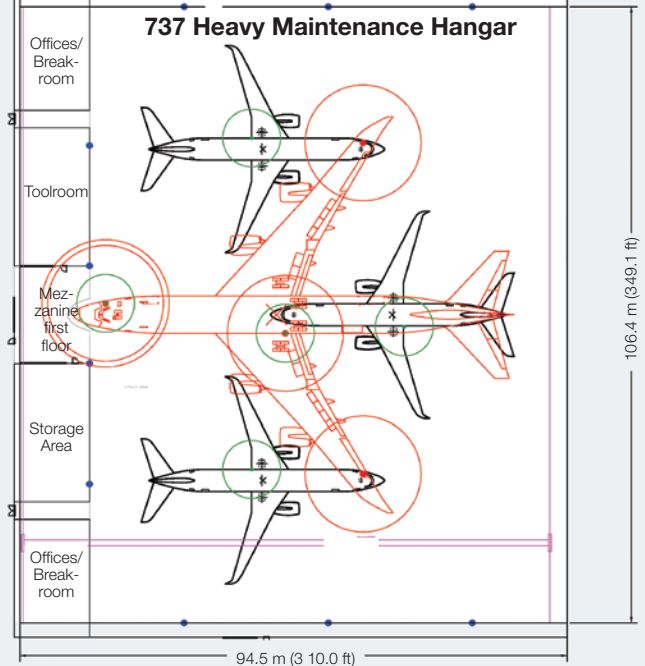
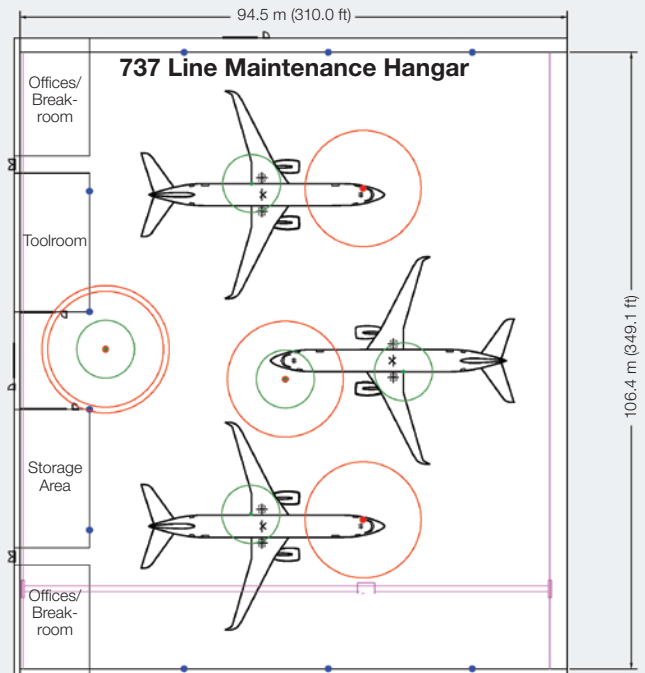
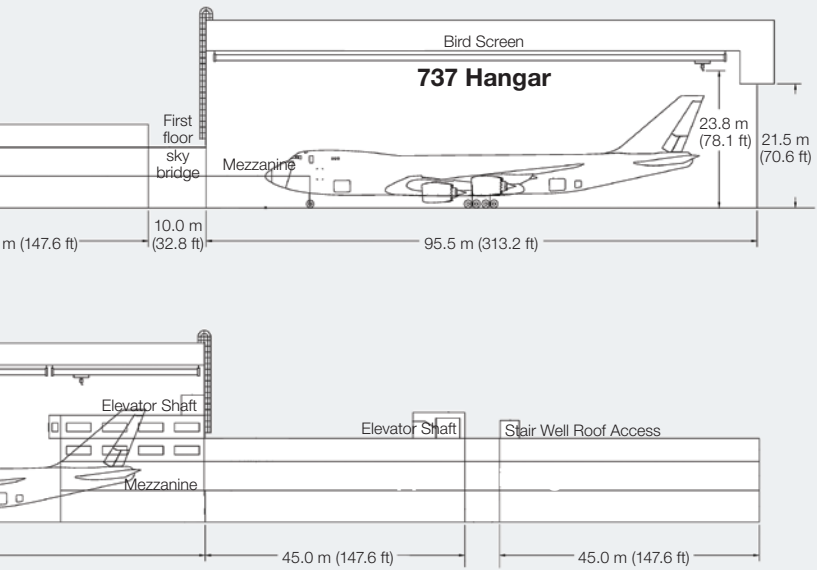
Development of a criteria document.

A comprehensive criteria document for a maintenance facility project specifies all aspects of the planning process, taking into account the most efficient layouts and land utilization. This can include workshop designs that contribute to a lean-production facility.

Figure 1: Maintenance facility site plan

All aspects of the maintenance facility site must be considered to obtain optimum use of the available space.





Boeing maintenance facility planning services

When providing maintenance facility planning services, Boeing's goal is to meet the strategic goals of the airline and keep an operator's fleet in the air by reducing repair time.

To this end, Boeing provides operators with various degrees of requested assistance, from developing a facility

criteria document to reviewing construction documents to planning lean and efficient maintenance facilities.

Boeing assistance of planned facilities can range from a single component workshop — such as a wheel, tire, and brake shop — to full maintenance facilities.

Boeing's access to airplane maintenance data and component maintenance manuals helps ensure that facilities utilize the latest technology, the appropriate equipment, and the proper procedures. Boeing's experience and knowledge of worldwide maintenance facilities can help to ensure the application of the latest concepts for a maintenance facility design.

Although the criteria document is tailored for each project, it may include:

- **Project approach**, including purpose and scope, design phases and reviews, building codes and regulations, and drawings and specifications.
- **Facilities**, such as hangar, component repair, warehousing, ground-service equipment repair, guard houses, line maintenance, and hazardous materials storage facilities.
- **Site requirements**, such as geotechnical investigation, parking, aprons and taxiways, site utilities, security, and landscaping.
- **Special considerations**, such as applicable airplane weights and special concrete requirements where these airplanes will park, taxi, and be positioned within the hangar.
- **General building information**, including building materials, mechanical and electrical space requirements, building finishes, elevator requirements, foundations, mechanical systems, fire protection, and information technology.
- **Data access**, which includes how personnel will access maintenance and repair data for the specific airplane model type.
- **Descriptions of specific spaces**, such as hangar bays, shops, offices, and support spaces.
- **Plan review**, which may include suggested revisions based on data about the airline, its fleet size, and the types of maintenance it wants to perform in-house, both initially and in the future.

For example, during the planning process, Boeing can review the plans for a facility and provide the customer with a summary of items that it should

consider changing, along with reasons for each change. Boeing can also perform a major redesign of a customer's plans. In one case, this resulted in retaining the outer facility and hangar dimensions but making significant changes to the shop layout to improve efficiency.

SUMMARY

Adept maintenance-facilities planning can help airlines develop facilities that enable efficient and cost-effective airplane maintenance, thereby improving the airlines' operations and overall competitiveness. Boeing offers fee-based maintenance-facilities planning services to help airlines be successful.

For more information, e-mail mgos@boeing.com. 