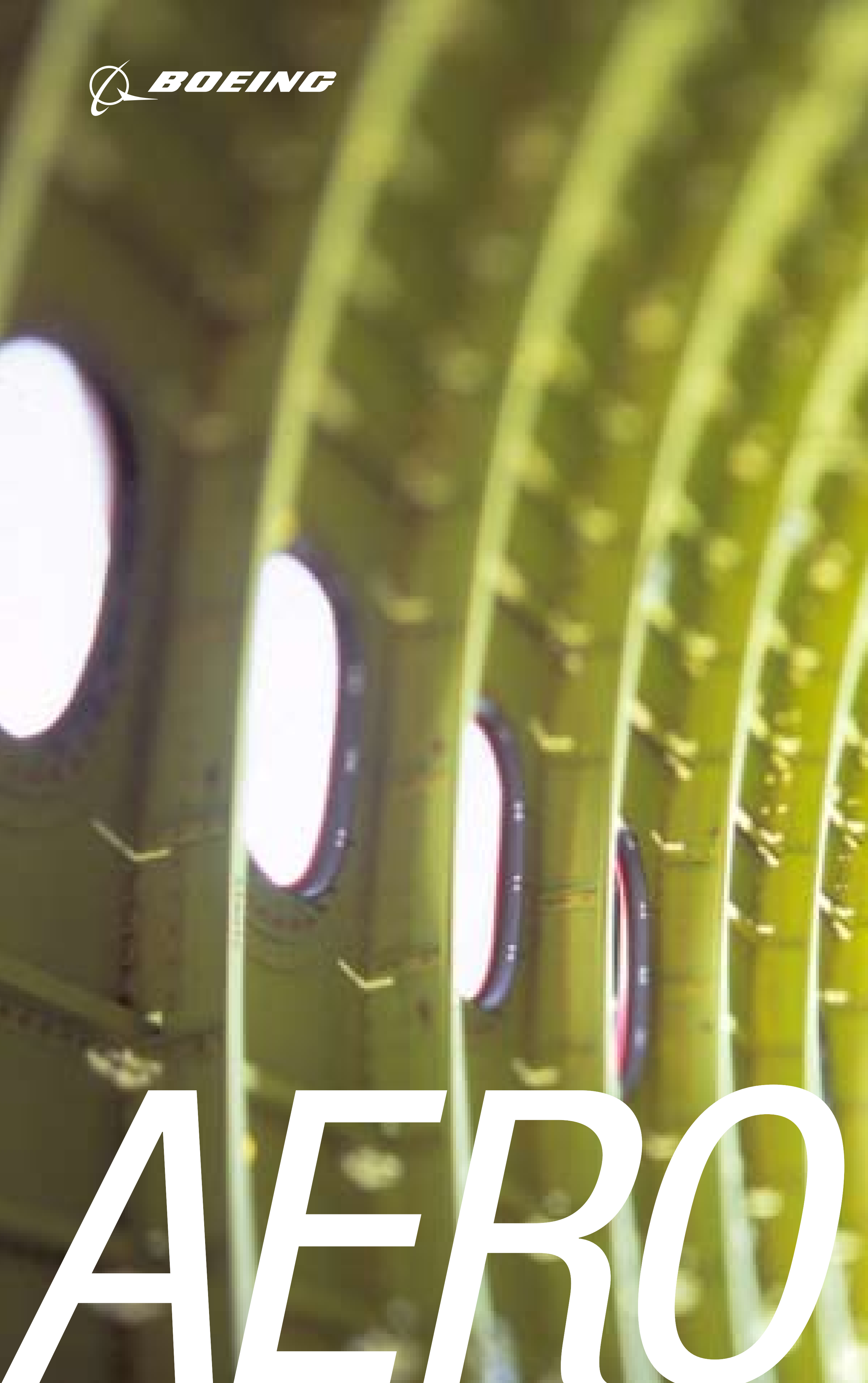

AERO

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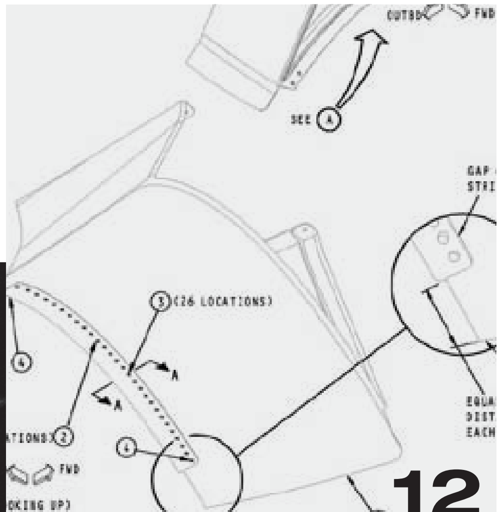
Cover photo: *777 fuselage interior*

AERO

contents



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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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welcome back

We're thrilled to be bringing back *AERO* magazine to you, our valued customers. Reintroducing *AERO* magazine is the direct result of a customer support survey conducted by Boeing last year. In that survey, you told us how much you valued information from and communication with Boeing.

We continually communicate with operators through such vehicles as technical meetings, service letters, and service bulletins. This assists you in addressing regulatory requirements and evolving industry specifications. Our goal for *AERO* magazine is to provide supplemental technical information that helps you operate your Boeing fleets efficiently and increases your awareness of Boeing products and services.

AERO magazine is being published quarterly and distributed at no cost to operators of Boeing commercial airplanes. It also is available on the World Wide Web at www.boeing.com/commercial/aeromagazine.

Each issue will offer articles that promote the continuous safe and efficient operation of the 12,000-plus Boeing airplanes currently in-service. Our first issue features articles on cruise performance monitoring, enhanced service bulletins, 787 maintenance by design, and maintenance program improvements.

We hope you enjoy *AERO* magazine and invite you to send us your comments or suggestions for future articles.

In addition to bringing back our customer publication, we also have been taking other actions in response to what you told us in the 2005 customer support survey. We have:

- Opened an Operations Center to improve our response time and communication with you in urgent situations.
- Expanded part inventories at our distribution centers in Dubai, London, Amsterdam, Beijing, Singapore, and the United States.
- Increased our global training center locations to better meet local needs.
- Established a customer council with airline executives to review Material Management practices.
- Created first-officer training solutions that help airlines meet the increasing demand for pilots.
- Revised our process metrics to better reflect how your business is affected by our day-to-day operations.
- Embarked on an ambitious effort to improve our suppliers' on-time performance and support.
- Increased the finished quality of maintenance documentation.

Our focus is on speed, ease, and attitude — responding quickly to your needs, making it easy for you to do business with Boeing, and having a "can-do" attitude when we resolve your issues.

We look forward to our continued partnership in flight.

LOU MANCINI
Vice President and General Manager
Boeing Commercial Aviation Services

*AIRLINES USE
CRUISE PERFORMANCE
MONITORING
TO DECREASE
OPERATING COSTS.*

Cruise Performance Monitoring

In addition to what might be considered its more common use of determining flight planning and FMC performance factors, cruise performance monitoring can help airlines identify and solve in-service performance problems. Often, performance monitoring will identify a need for Boeing to assist in determining the solution to a given in-service problem. However, with a good understanding of the monitoring process and the interactions among the variables involved, airlines can do a significant amount of their own problem diagnosing and solving.

by Dave Anderson,
Flight Operations Engineer,
and Carolyn Hanreiter,
Aerodynamics Engineer

Cruise performance monitoring has been used for many years by airlines that strive to operate their airplanes as efficiently as possible. These airlines know that continuous cruise performance monitoring of airplanes in their fleets can decrease operating costs relative to airlines that do not monitor airplane performance levels. Continuous cruise performance monitoring can give airlines the information they need to:

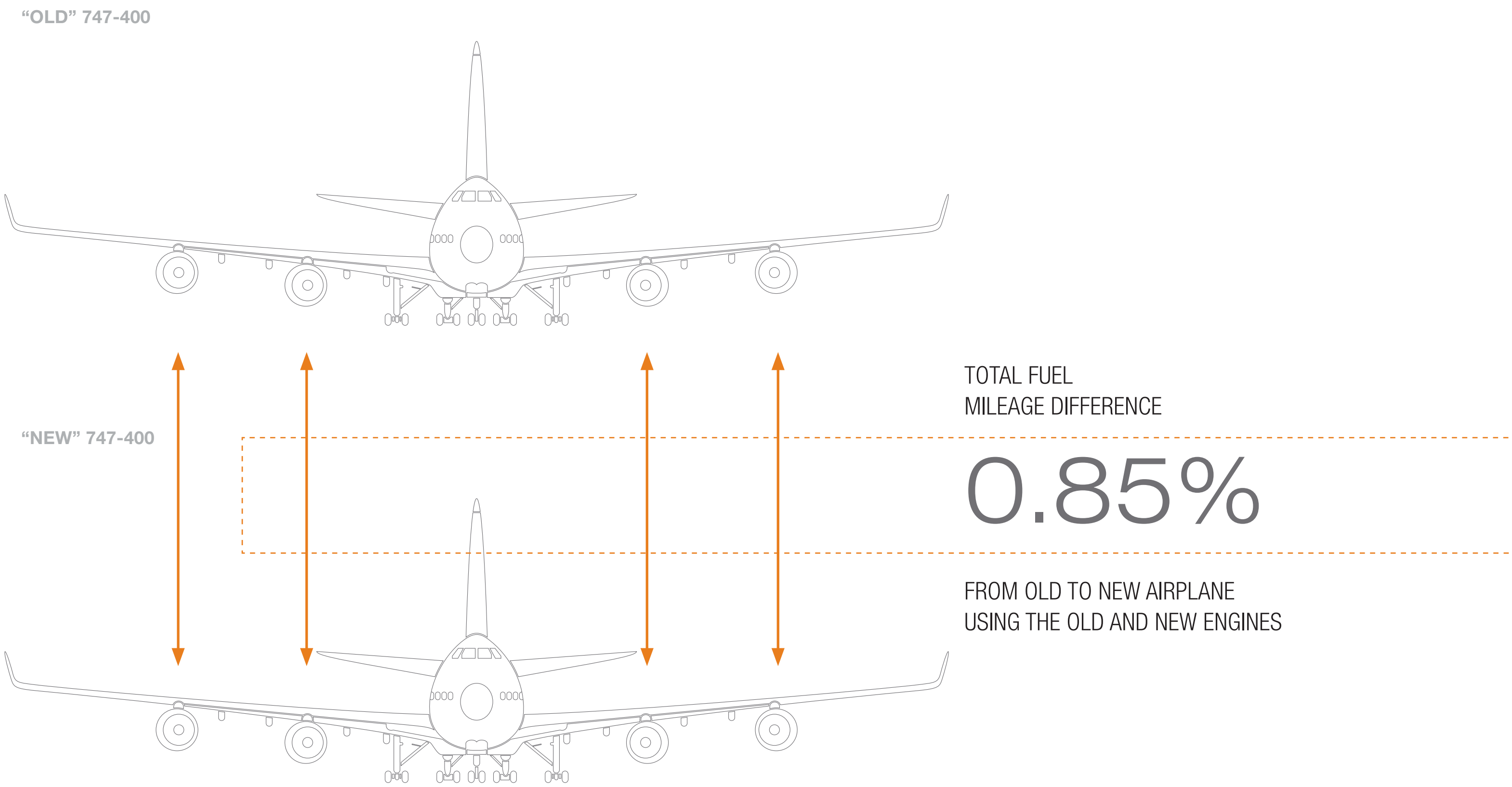
- Adjust the baseline performance levels they use for flight planning and flight management computer (FMC) fuel-required predictions so that the correct amount of fuel is loaded on each and every flight.
- Identify normal deterioration for a fleet of airplanes.
- Match the airplanes that perform best to their longest routes.
- Identify high fuel burning airplanes for possible maintenance.
- Validate performance degradation for extended twin-engine operations (ETOPS) critical fuel reserves planning (in lieu of the regulatory requirement of 5 percent fuel mileage deterioration allowance).
- Increase flight crew confidence in flight plans and possibly decrease the amount of discretionary fuel requested and loaded.

An additional, less recognized benefit of cruise performance monitoring is diagnosing and solving various airplane performance problems or issues. These case studies show how cruise performance monitoring was used to determine solutions to three different problems.

CASE STUDY 1:
Airframe versus engine – causes of fuel mileage deterioration

An airline that operates a 747-400 airplane fleet was concerned about what it considered to be excessive fuel mileage deterioration relative to the fuel mileage levels its airplanes exhibited when they were new. The airline requested help from both Boeing and the engine manufacturer in determining what was causing this deterioration — the airframe, the engine, or both. Through a better understanding of the contributions that airframe and engine deterioration make to the overall fuel mileage deterioration, the airline could more efficiently focus its maintenance resources.

To help resolve this issue, the airline proposed an experiment involving an engine exchange



between an old and a new airplane. A six-year-old 747-400, which was operating about 4.1 percent below the flight planning database level of fuel mileage, represented the old airplane, while a soon-to-be-delivered 747-400 represented the new one. The airline requested assistance and support from Boeing and the engine manufacturer in carrying out the experiment, which would:

- Measure pre-exchange fuel mileage on both the new and the old airplane (pre-engine swap).
- Swap all four engines between the new and old airplane.
- Measure fuel mileage again on both the new and the old airplane (post-engine swap).

By using the same physical set of four engines on two different airframes, the airline, Boeing, and the engine manufacturer agreed that any measurable difference in fuel mileage for the same set of engines on two different airframes could be attributed to airframe effects alone — that is, drag deterioration.

Boeing's position was that proper maintenance of the exterior of an airplane would lead to minimal amounts of drag deterioration as an airplane ages. As a result, the experiment began by putting the old airplane through a complete D-check, including a configuration inspection, so that it would be considered as having a properly maintained exterior before the engine swap. Control surfaces were rerigged, seals were repaired, and one engine was replaced. A minor leak in the pneumatic system, discovered during the D-check, was not fixed by the airline (determined to cause about a 0.1 percent penalty in fuel mileage). Fuel mileage data was collected before and after the D-check to determine any change across the check, especially to quantify any changes resulting from rerigging the flight control surfaces and replacing any worn seals. Fuel mileage improved 0.7 percent after the D-check, with 0.3 percent attributed to proper rerigging of the flight controls and 0.4 percent attributed to the changing of one engine.

Fuel mileage data was then collected on both the old and new airplanes before and after the engine swap. The data collected was a combination of in-service data collected by the airplane condition monitoring system (ACMS) and hand-recorded data that was collected under more controlled test conditions.

Average results from all four sets of data were then compared to determine the differences in fuel mileage between the old and new airplanes with the same set of engines.

For both the old and new engines, the average improvement in fuel mileage for the new airframe relative to the old airframe was about 0.85 percent. The initial conclusion could be that the older

> The experiment began by putting the old airplane through a complete D-check, including a configuration inspection.

airframe must contribute about 0.85 percent toward the overall fuel mileage deterioration originally observed on the old airplane and engine combination. However, about 0.3 percent of that difference is explainable. Of the total calculated difference of 0.85 percent, the pneumatic duct leakage discovered on the old airplane during the D-check contributed about 0.1 percent. In addition, the old airplane did not have the same revised vertical fin fairing as the new 747-400. If the older airplane had had the newer vertical fin fairing, it is estimated that the fuel mileage would have improved about 0.2 percent.

After adjusting for the pneumatic system leak and the newer vertical fin fairing, for the same set of engines the old airplane's fuel mileage averaged about 0.5 percent worse than the new airplane.

The results are supportive of the position that the drag deterioration of a well-maintained airplane most likely will not exceed more than about 0.5 percent.

Case Study 1:
To help determine the primary cause of the fuel mileage deterioration, Boeing and the airline collected fuel mileage data on both a new and old 747-400 before and after an engine exchange.

NEW VERTICAL FIN FAIRING	PNEUMATIC LEAKAGE	ACTUAL UNEXPLAINABLE DIFFERENCE
– 0.2%	– 0.1%	= 0.55%

CASE STUDY 2:

Investigation of a cruise fuel mileage shortfall

An airline expressed concern to Boeing that its new 737-800/CFM56-7B airplanes equipped with Aviation Partners Boeing (APB) blended winglets were exhibiting fuel mileage performance more than 2 percent worse than the Boeing database level, while its older, nonwinglet 737-800s (all approximately two years old) displayed fuel mileage performance similar to the database level. The airline, which collects cruise fuel mileage data on an ongoing basis, based its analysis on ACMS-collected cruise fuel mileage data analyzed using the Boeing Airplane Performance Monitoring (APM) program.

In initial discussions between Boeing and the airline, it was explained that the database being used by the airline to represent the 737-800 with blended winglets was based on the original winglet flight test results completed in early 2000. This is the same database used in the Flight Crew Operations Manual, the FMC, and the operational flight planning database. Additional flight tests had led to Boeing's latest, best assessment of the delivered performance of the winglets, which showed slightly less improvement than the original testing. This revised database, based on several additional flight test programs conducted in 2000 and 2001, includes a different winglet drag increment (relative to a nonwinglet 737-800) and an aeroelastic correction absent in the earlier database.

At Mach 0.79, the difference between the two databases varies from 0.2 percent to 2.3 percent, depending on the exact conditions flown, with the airline's database predicting a better fuel mileage increment because of the winglets in all cases.

Upon request, the airline provided Boeing with ACMS data for two of its 737-800 airplanes with blended winglets. Boeing analyzed the data for each airplane using both the operational database and the revised database.

Boeing's analysis of the data using the revised database concluded that two of the airplanes appeared to display fuel mileage performance about 3 percent below the latest Boeing-assessed winglet level – even more than the 2 percent originally suggested by the airline.

While the data was, on average, about 0.5 percent closer to the newer database level than the operational database level, Boeing's analysis did not agree with the airline's analysis.

Boeing's analysis of the data using the revised database concluded that two of the airplanes appeared to display fuel mileage performance about 3 percent below the latest Boeing-assessed winglet level — even more than the 2 percent originally suggested by the airline.

Further discussions with the airline revealed that it had been using passenger weight allowances of 70 kg per passenger, including carry-on baggage, and 13 kg per checked bag for all of its flights. As of June 1, 2002, the airline changed to the higher passenger weight allowances recommended in the Joint Aviation Requirements – Operations (JAR-OPS) 1. Checked baggage would be weighed whenever possible; otherwise, JAR-OPS 1 checked baggage weight allowances would be used. The average passenger weight allowances are significantly higher than the 70 kg per passenger the airline had been using. Because the data sent to Boeing for the two winglet-equipped airplanes was collected prior to June 2002, it was based on the lighter weight allowance of 70 kg per passenger. The airline's analysis was based on data using a combination of the weight allowances.

As the investigation continued, the airline sent additional data to Boeing for the same two winglet-equipped airplanes — but only for conditions recorded after June 1, 2002, based on the higher JAR-OPS weight allowances. The airline also included data for one more winglet-equipped airplane, as well as for three nonwinglet airplanes. The data for the two winglet-equipped airplanes showed an immediate fuel mileage improvement of about 2.4 percent for each airplane, based on analyzing only the data from JAR-OPS weight allowances collected after June 1, 2002. This result led quickly to the belief that the previous 70 kg per passenger weight allowance was too light.

Although both the fuel mileage and thrust required changed significantly between data based on 70 kg per passenger and data based on JAR-OPS passenger weight allowances, the thrust-specific fuel consumption (TSFC) hardly changed. Errors in the estimated weight of an airplane present themselves as high or low drag but do not affect the fuel flow (i.e., TSFC) deviations calculated by APM.

Although a significant improvement was observed for both of the winglet-equipped airplanes originally analyzed with data recorded before June 1, 2002, the results for all six airplanes were still not as good as what Boeing experience indicated for this model. Further investigation determined that this airline operates its fleet of 737-800s in a mix of both scheduled and holiday charter flights, using the specific JAR-OPS weight allowances called out for each. The data sent to Boeing for the six airplanes included a mixture of data from both these types of flights. The average passenger weight allowance recommended for scheduled service is 84 kg per passenger and 76 kg per passenger for charter service (both are higher than the 70 kg per passenger originally used by the airline). At Boeing's request, the airline separated all of the post June 1, 2002, data into two groups: charter service and scheduled service. The data for each group was reanalyzed separately (see figs. 1 and 2).

The analysis revealed a significant discrepancy in demonstrated fuel mileage and thrust-required levels between the charter and scheduled flights. If airplane weight is underestimated, perceived airplane performance will be poorer than expected. Weight that is unaccounted for shows up as increased airplane drag and decreased fuel mileage. In this analysis, the TSFC deviations remained consistent between both sets of data, but the thrust-required (drag) deviations increased significantly for the charter flights — a strong indication of unaccounted-for airplane weight.

These results supported the conclusion that, for this airline, the JAR-OPS passenger weight allowances for scheduled flights more accurately reflect the true weight of the passengers plus carry-on baggage.

In this situation, Boeing proposed that the JAR-OPS passenger weight allowances as recommended for holiday charter flights were underestimating the airplane weight for this particular airline's charter operations. Although the airline was receptive to the possibility that the JAR-OPS passenger weight allowances might be too light for its holiday charter flights, it was not fully convinced. The airline believed that the JAR-OPS weight allowances for scheduled flights could just as easily be incorrect, in which case their airplanes were performing as poorly as the charter flight data indicated.

To determine which weight allowances were correct, the airline and Boeing agreed to collect delivery flight performance data on the airline's next new airplane delivery, a 737-800 with production blended winglets installed.

The advantages of collecting delivery flight data as opposed to in-service data are:

- The performance level of the airplane could be established at delivery.
- The airplane would be weighed at the Boeing factory with all the weight changes following weighing but preceding delivery accurately tracked and published in the Weight and Balance Manual. Therefore, the delivery flight empty weight could be considered accurate.
- Delivery flights are flown with minimum crew, so the issue of passenger weight allowances would not exist.

After collecting cruise performance data on the delivery flight, the airline would continue with its standard in-service data collection on both scheduled and charter flights. Comparing the results from the delivery flight with the results obtained in-service would help determine which JAR-OPS passenger weight allowances gave the airline more accurate airplane gross weights. If the weight allowances were too heavy (the airplane was actually lighter than estimated), then the in-service performance would appear to be better than the delivery flight performance. If the weight allowances were too light (the airplane was heavier than estimated), then the in-service performance would appear to be worse than the delivery flight level.

The airline provided Boeing with the first 10 weeks of ACMS in-service data for the airplane following delivery, separating the data for charter flights and scheduled-service flights. For this analysis, the data was analyzed relative to the most recent 737-800 with winglets database. Although the delivery flight results showed the airplane to be slightly better than the demonstrated database level, the early in-service charter flight results show the airplane with an average perceived fuel mileage 3.3 percent worse than the demonstrated level (see fig. 3). Unaccounted-for weight shows up as airplane drag (thrust required). According to the charter flight data, the airplane experienced a 4.4 percent increase in thrust required on entering service, partially offset by a 0.7 percent drop in engine TSFC, for a 3.6 percent drop in fuel mileage from the delivery flight level. When the same airplane's scheduled service data for the same time period was analyzed, the fuel mileage was much closer to the delivery flight level. Average in-service fuel mileage for the first 10 weeks of operation deviated from the delivery level by only 0.8 percent (only 0.5 percent below the demonstrated level), which is within the ACMS's ability to determine fuel mileage over a given time period.

These results supported the conclusion that, for this airline, the JAR-OPS passenger weight allowances for scheduled flights more accurately reflect the true weight of the passengers plus carry-on baggage than the weight allowances recommended for the charter flights.

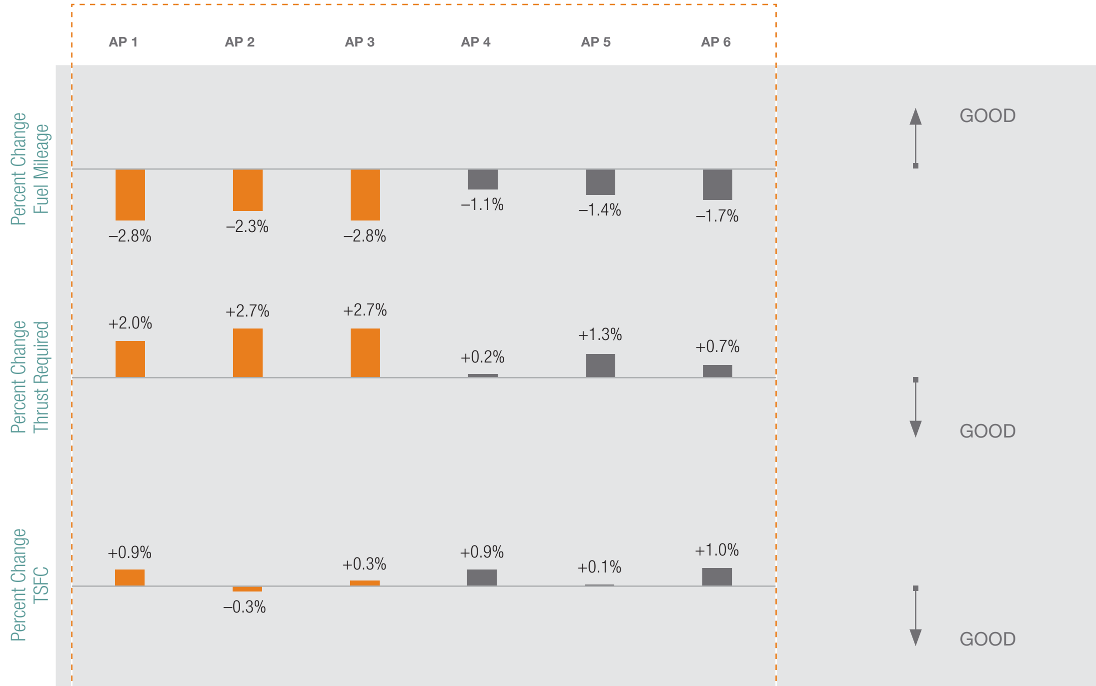
In addition, both are much more representative than the original 70 kg per passenger the airline had been using. The weight allowances for scheduled flights of 84 kg per passenger produce a more accurate zero fuel weight buildup and a truer representation of the actual performance of the airplane, with or without winglets.

The results of this case study identified a fleetwide airplane weight buildup issue for this particular airline. Boeing suggested that the JAR-OPS holiday charter passenger weight allowances appeared to be too light for this airline's operations, with unaccounted-for weight showing up as excess airplane thrust required (drag). Using the JAR-OPS-recommended passenger weight allowances for scheduled flights, the fuel mileage performance for its 737-800s — with and without winglets — is close to predicted and reflects Boeing expectations based on numerous flight tests and delivery flight results.

CHARTER SERVICE DATA ONLY
JAR-OPS 1 PASSENGER WEIGHT ALLOWANCES
Figure 1

■ =
Airplane with APB winglets relative to winglet database

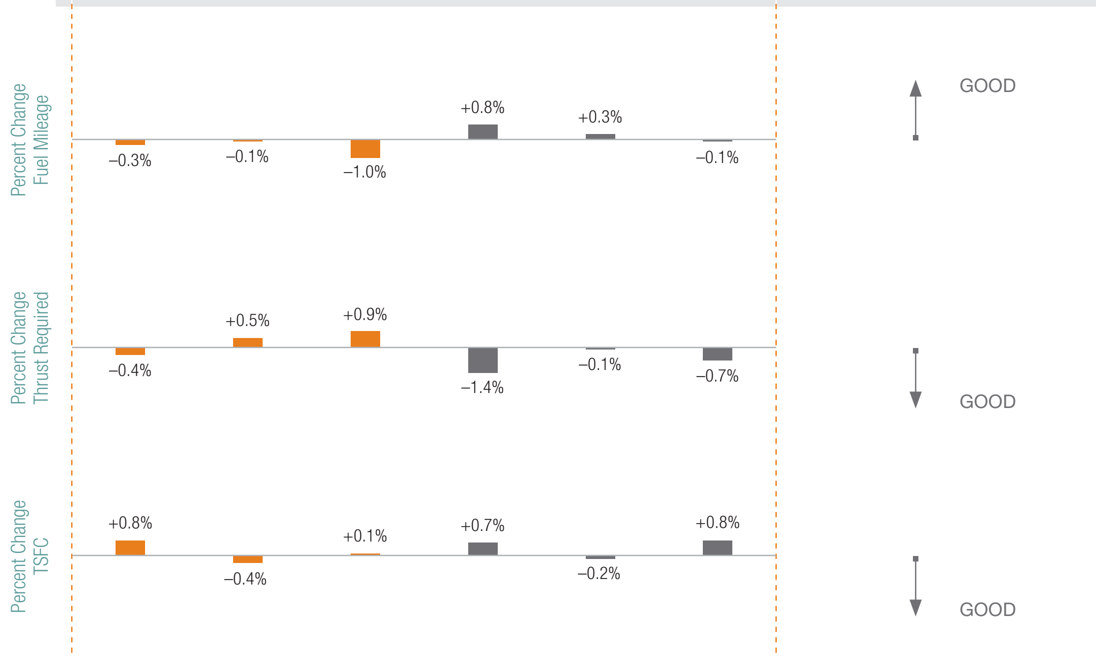
■ =
Nonwinglet relative to nonwinglet database



SCHEDULED SERVICE DATA ONLY
JAR-OPS 1 PASSENGER WEIGHT ALLOWANCES
Figure 2

■ =
Airplane with APB winglets relative to winglet database

■ =
Nonwinglet relative to nonwinglet database

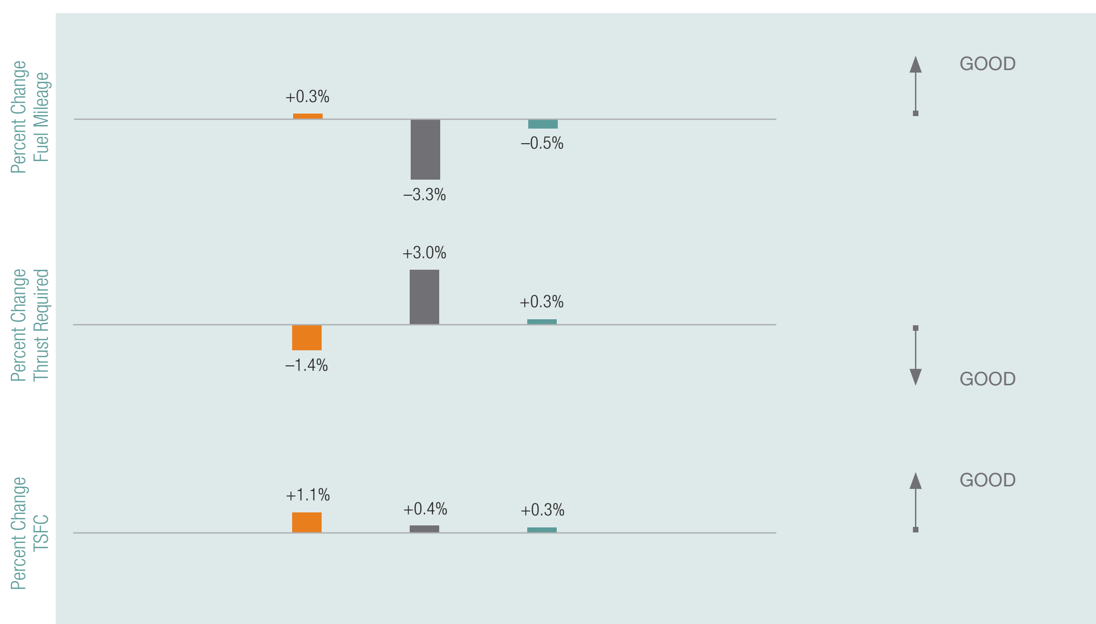


PERFORMANCE SUMMARY
DELIVERY FLIGHT VERSUS IN-SERVICE (ALL DEVIATIONS ARE RELATIVE TO THE WINGLET DATABASE)
Figure 3

■ =
Delivery flight

■ =
Post delivery charter service

■ =
Post delivery schedule service



CASE STUDY 3:
Performance improvement resulting from 737-800 winglet retrofit

An airline requested assistance from Boeing to determine the airplane cruise performance improvement resulting from the retrofit installation of blended winglets on 14 of its 737-800s. To determine the magnitude of this improvement, cruise fuel mileage data collected after the installation of the winglets would be compared to data collected before the installation. The airline provided ACMS-recorded data collected on each of the 14 airplanes, before and after the installation of the winglets, to Boeing for analysis and comment.

Retrofitting the winglets is a two-step process comprising a structural reinforcement of the wing followed by installation of the winglet. Eleven of the airplanes had the wing reinforcement completed many weeks before the winglets were installed, with the airplanes returning to service with the reinforced wings. For these 11 airplanes, the nonwinglet data was based on this reinforced wing configuration. Three of the airplanes had the wing reinforced and winglet installed at the same time. For these three airplanes, the nonwinglet data was based on the production nonreinforced wing. The two sets of data were analyzed separately in order to identify any differences in the improvement based on differences in the baseline before the winglets were installed.

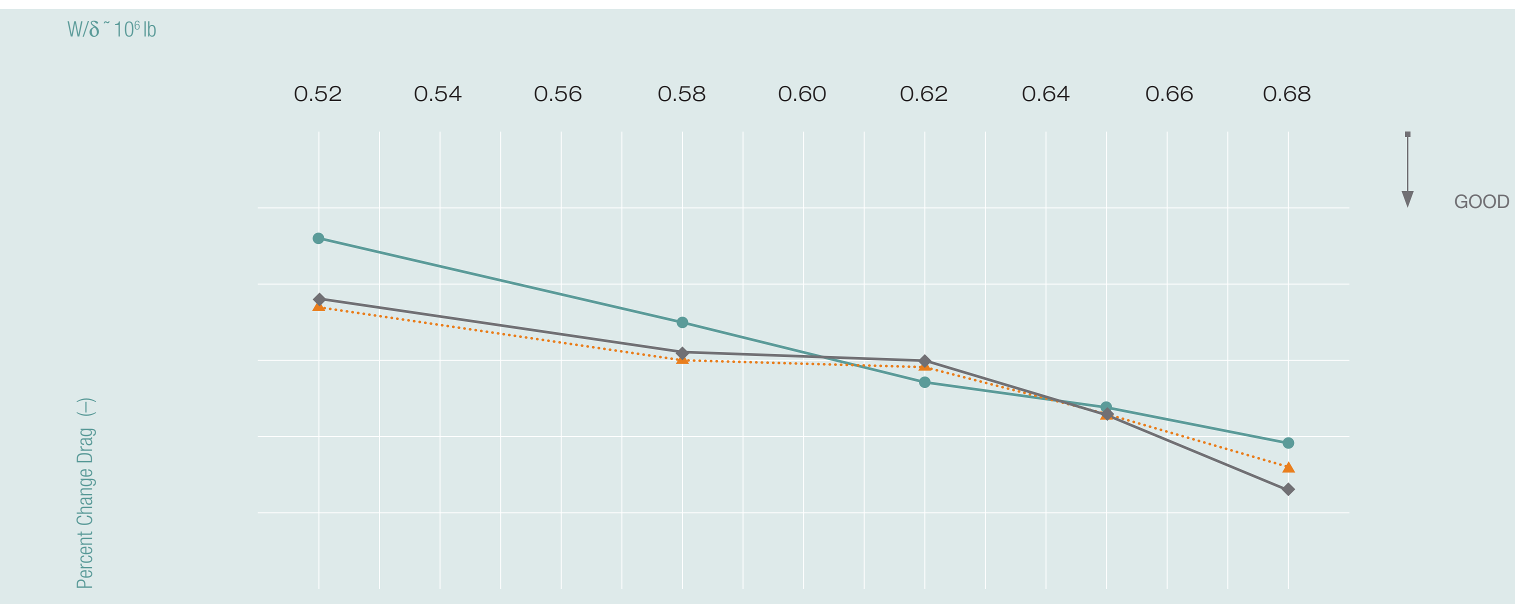
Boeing analyzed the data for all 14 airplanes using the same in-house software tools used to analyze Boeing flight-test data. These software tools are different from the APM software provided to airline customers, but the analysis produces basically the same results. The main difference is that the Boeing in-house software normalizes the data points to nominal weight to pressure ratios (W/δ) chosen by Boeing while the APM software does not.

The improvements were plotted versus W/δ in order to illustrate that the magnitude of the improvement depends on W/δ for a given Mach number. This dependency on W/δ is because the winglet improvement is a function of airplane lift coefficient, which in turn is a function of weight, altitude, and speed. The improvements were determined by comparing both the nonwinglet and winglet fuel mileage results to the nonwinglet 737-800 database. The performance improvement because of the winglet is not the average winglet deviation from the nonwinglet database; rather, it

Boeing's analysis of the data indicated a slight improvement in drag and fuel mileage (at a fixed weight) that resulted from the reinforcement of the wing structure.

DRAG IMPROVEMENT RESULTING FROM RETROFITTING 737-800 AIRPLANES WITH APB BLENDED WINGLETS

Figure 4



▲ = Winglet installation plus wing reinforcement relative to baseline wing

(based on in-service cruise fuel mileage measurements of three retrofit airplanes)

● = Winglet installation relative to reinforced wing

(based on in-service cruise fuel mileage measurements of eleven retrofit airplanes)

◆ = Predicted drag improvement

(based on Boeing flight-test results)

is the difference between the average deviations for the winglet and nonwinglet, both measured relative to the nonwinglet database. This same process was followed for each W/δ, and for the various sets of data (see figs. 4 and 5).

Boeing's analysis of the data indicated a slight improvement in drag and fuel mileage (at a fixed weight) that resulted from the reinforcement of the wing structure. The results indicated this improvement to be relatively small but still worth an average of a few tenths of a percentage at normal cruise weights and altitudes. Including the effects of both the wing strengthening and the addition of the winglets, the fuel mileage and drag improvements closely matched their predicted levels.

Because the improvement in drag is a function of W/δ for a given cruise speed, the actual improvement in fuel mileage that the airline would experience for any given flight conditions depends on the W/δs flown during that airline's operations. The change in total fuel required to fly a given route is determined by a combination of the improvement in fuel mileage offset by any increase in airplane weight. Retrofitting the winglets to the 737-800, including wing reinforcement, currently adds about 218 kg to the empty weight of the airplane, and this additional weight alone would increase fuel burn approximately 0.2 percent to 0.3 percent for an average 737-800 flight leg.

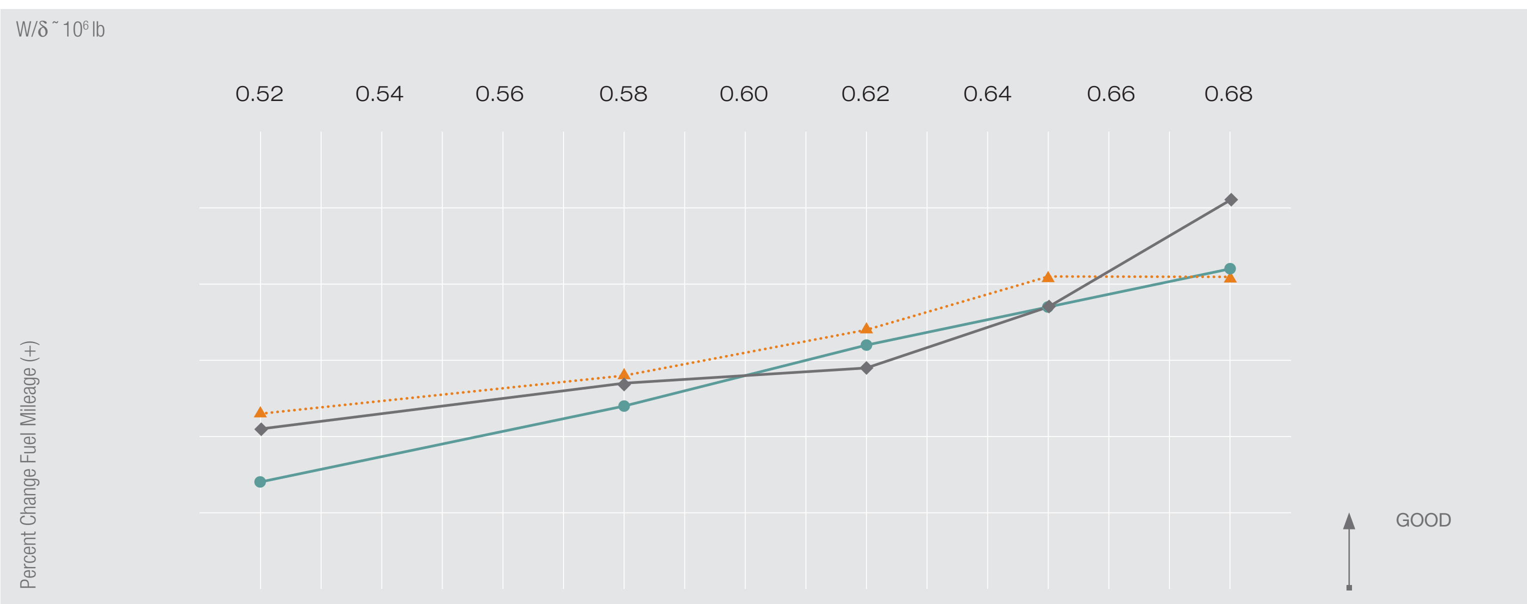
An analysis similar to the Boeing analysis could have been carried out by the airline itself using the spreadsheet output option from the APM software program. The results of analyzing the data in this manner would differ by only a relatively small amount from the analysis carried out using the Boeing in-house software. This same method of analysis could be used to investigate any type of modification to an airplane. Data collected before and after a modification would be compared to a reference database and the difference between the two sets of data would reflect the effect of the modification.

SUMMARY

The benefits of cruise performance monitoring are well known by many airlines that include the practice as part of their toolbox of practices aimed at efficient operation of their airplanes. The three case studies in this article illustrate the use of cruise performance monitoring to solve various cruise performance issues. Performance monitoring can also be used to identify flight planning and FMC performance factors and to monitor performance deterioration trends. Boeing has the resources to assist airlines with cruise performance monitoring analyses and to help them interpret results. For more information, contact David Anderson at david.j.anderson@boeing.com.

FUEL MILEAGE IMPROVEMENT RESULTING FROM RETROFITTING 737-800 AIRPLANES WITH APB BLENDED WINGLETS

Figure 5



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(based on in-service cruise fuel mileage measurements of three retrofit airplanes)

● = Winglet installation relative to reinforced wing

(based on in-service cruise fuel mileage measurements of eleven retrofit airplanes)

◆ = Predicted fuel mileage improvement

(based on Boeing flight-test results)

New Enhanced Service Bulletins

by Mark Baker, Tim Dowling, Willard Martinez, Tom Medejski, Dan Pedersen and Don Rockwell, Service Bulletin Engineering

Increasing economic and regulatory pressures make it imperative for airlines to find opportunities to reduce costs and show conformance to manufacturer's data. Because airline maintenance operations represent a significant cost, airlines have asked Boeing for help in reducing this cost. Recent results show that changing the way service bulletins are prepared and delivered – combined with airline process improvements – can reduce maintenance cost significantly and improve the ability to show conformance.

Boeing has continually made enhancements to the content, format, and delivery of its service bulletins. Past enhancements include digital delivery, simplified English, and tabular work instructions.

Boeing has been working directly with airlines to reduce end-to-end costs for service bulletin incorporation. During this process, it was observed that when airlines create their engineering orders, they rewrite or reengineer service bulletins and rekit or repackage the kit of parts to match their own engineering orders. This reengineering causes unnecessary delays and expense for the airlines in implementing service bulletins.

Boeing developed the "Enhanced Service Bulletin," also known as the "Next Generation Service Bulletin," to minimize this reengineering effort while making it easier and less expensive to implement service bulletins. The enhanced service bulletin, in conjunction with airline process improvements, will enable a smooth workflow ensuring that information, parts, and tools are staged in a coordinated manner to support the mechanic during service bulletin incorporation.

Boeing's enhanced service bulletins incorporate four key features: lean work instructions, faster access to essential information, improved kit packaging, and selective information extraction. These features have been incrementally introduced into Boeing service bulletins as they became available beginning in mid 2003. Today, Boeing develops all new service bulletins to encompass all four features whenever possible.

FOUR KEY FEATURES REDUCE AIRLINE ENGINEERING, PLANNING, AND OPERATIONS COSTS ASSOCIATED WITH SERVICE BULLETIN INCORPORATION.

01.

Lean work instructions

One of the most apparent changes in the enhanced service bulletin is that figure instructions are provided in a work breakdown of four hours or fewer. This makes it possible for airlines to schedule mechanics' time more efficiently and reduces the coordination difficulties associated with work shift changeover.

Each figure in the enhanced service bulletin is a single configuration. Previously, multiple configurations were typically shown in a figure. This required the airline engineer, planner, or mechanic to extract the steps applicable to the specific airplane. One configuration per figure simplifies extraction of the applicable data and can prevent accomplishment of the wrong steps. Additionally, separate left and right side figures are now provided, which further facilitates extraction of the applicable data.

02.

Faster access to essential information

When viewed online, Boeing's enhanced service bulletins include hotlinks within their text that provide direct access to referenced documents, making it easier and faster to find the information needed. For example, hotlinks provide quick access to relevant information in the Airplane Maintenance Manual (AMM), Structural Repair Manual (SRM), and other documents available on the Web portal MyBoeingFleet.com.

03.

Improved kit packaging

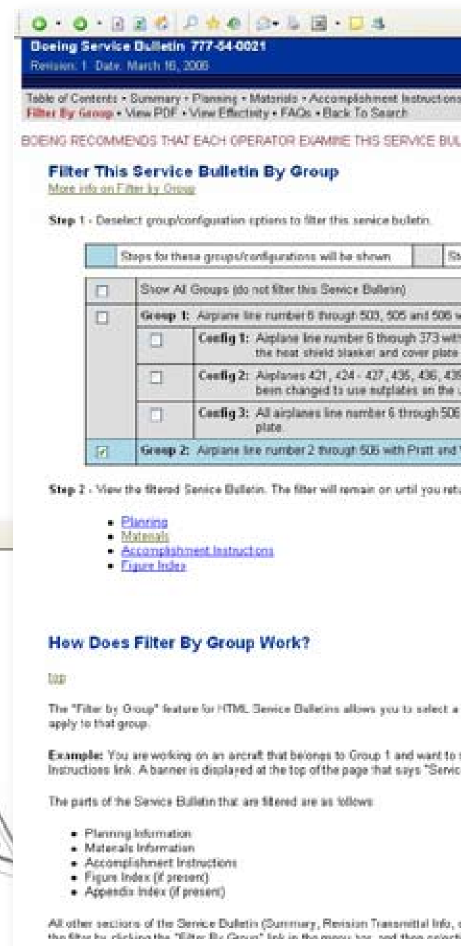
Enhanced service bulletin kits are packaged to match the figure instructions. If operators use the service bulletin instructions as written, this new packaging eliminates additional repackaging or sorting through parts. This change alone can result in a significant time savings in both the operations and maintenance arenas.

04.

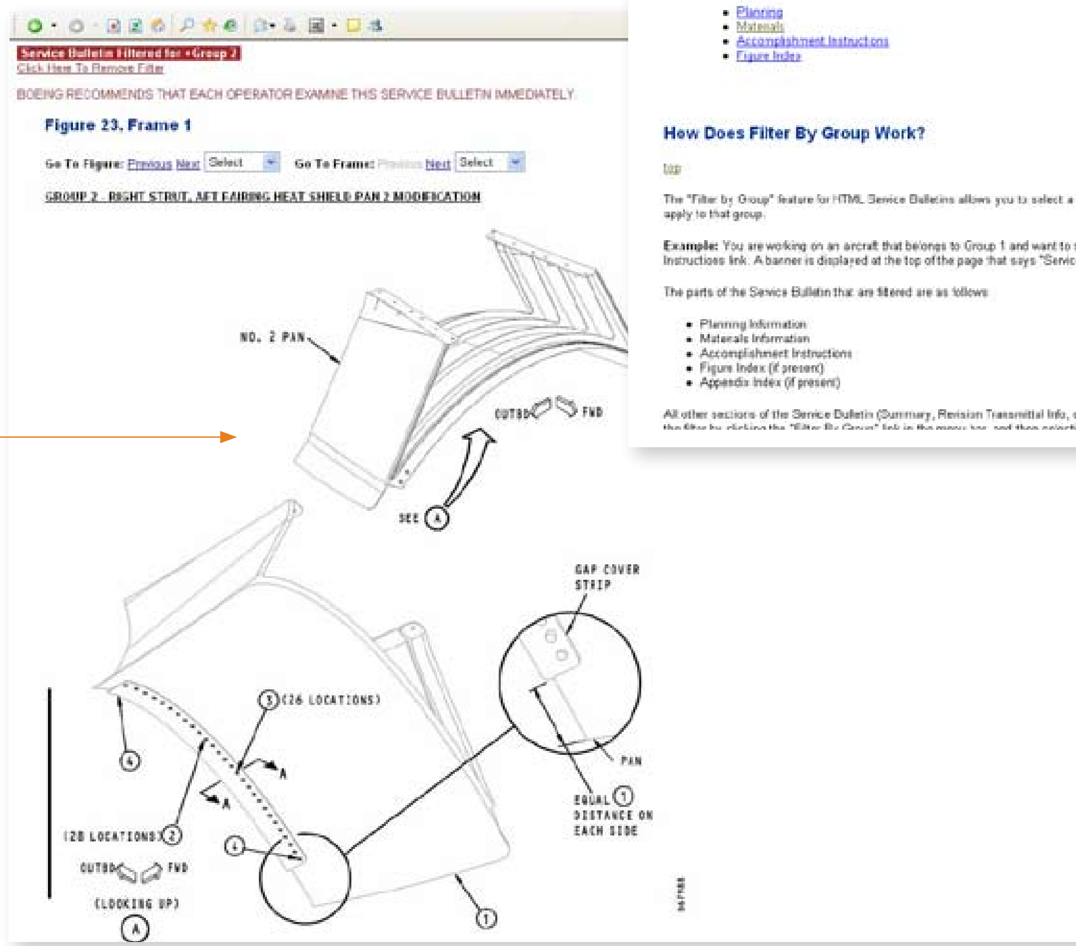
Selective information extraction

Enhanced service bulletins enable airline personnel to extract information specific to selected airplane configurations. This allows an airline to more quickly identify and extract service bulletin information specific to its airplane configuration. Once the data is extracted, it can easily be copied into an airline's own document management system.

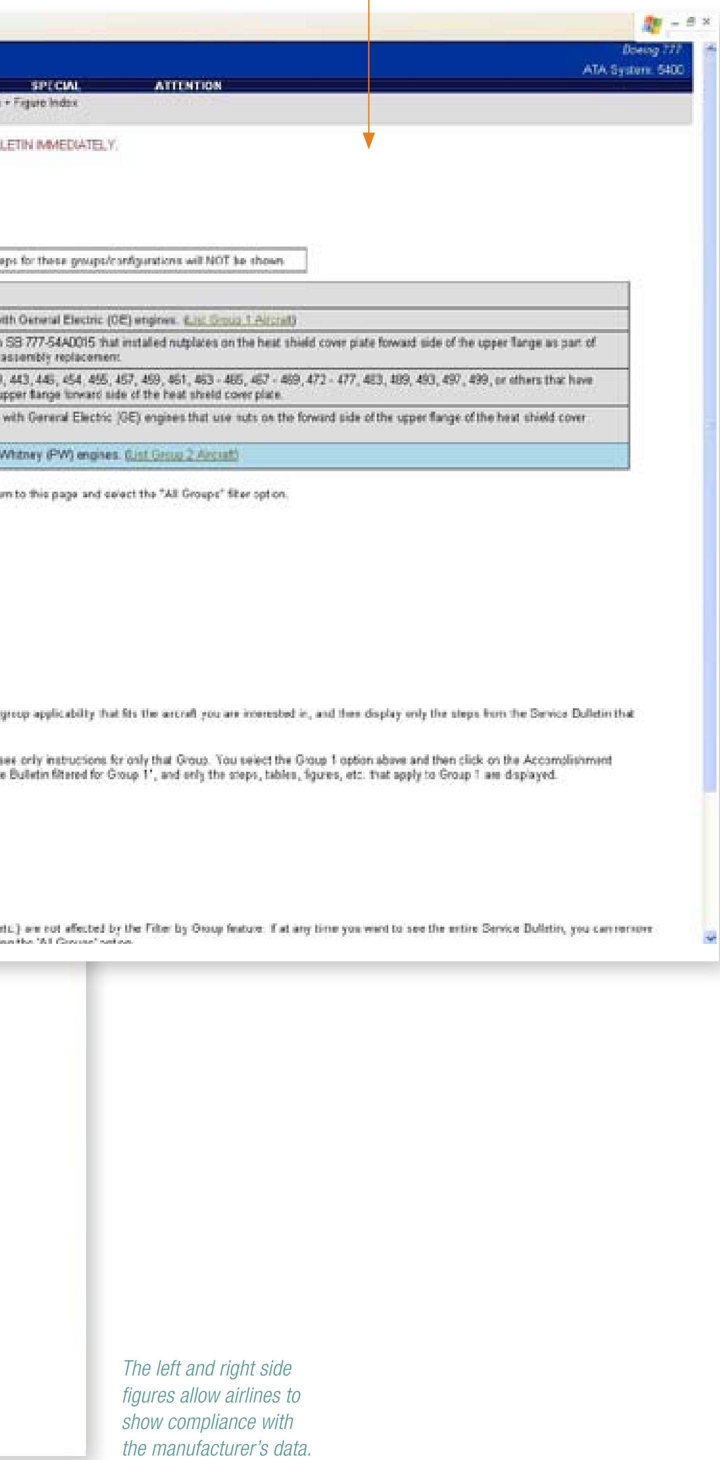
The HTML file provides hotlinks to maintenance documentation referenced in the service bulletin and the ability to quickly extract data.



ONE CONFIGURATION PER FIGURE PROVIDES DIRECT ACCESS TO APPLICABLE DATA.



THE “FILTER” FUNCTION ALLOWS AIRLINES TO EXTRACT DATA BY INDIVIDUAL AIRPLANE GROUP AND CONFIGURATION.



The left and right side figures allow airlines to show compliance with the manufacturer’s data.

BENEFITS OF THE BOEING ENHANCED SERVICE BULLETIN

Boeing worked with airlines to validate the benefits of the enhanced service bulletin. As part of that effort, Boeing coordinated closely with one airline to study the predicted benefits of the enhanced service bulletin. Study data from the airline showed these predicted benefits:

- A potential 60 percent reduction in defects attributed to the rewriting or reengineering of the service bulletin data into the airline’s document management system.
- A potential 77 percent reduction in labor hours to develop and release the service bulletin data into the airline’s document management system.

Based on the positive results of the study data, Boeing continued to work closely with the same airline to collect actual labor hour benefits. The actual data was obtained by comparing airline incorporation of a conventional service bulletin on part of its fleet and an enhanced version of the same service bulletin on the remainder of its fleet. Data from the airline showed these actual results:

- A reduction in nonrecurring engineering labor hours to develop the airline’s own engineering and job cards from 143 labor hours to 87 labor hours.
- A reduction in recurring kit packaging labor hours from 24 hours to 6 hours per airplane.

ENHANCEMENTS CONTINUE

To date, Boeing has issued more than 1,300 service bulletins across all Boeing model airplanes with one or more of the four key features described above. Boeing has been working with a number of airlines to assist in the adoption and implementation of enhanced service bulletins into their operations as well as to obtain airline user feedback. Such feedback is key to adding improvements to the enhanced service bulletins.

SUMMARY

Boeing understands that each airline’s maintenance operation is unique and is willing to work with individual airlines to ensure that each leverages all of the benefits possible from enhanced service bulletins and that the bulletins fit well with existing airline operations. Airlines may contact their Boeing Field Service Representative for assistance in adopting enhanced service bulletins. For more information, contact Dan Pedersen at dan.w.pedersen@boeing.com.

THE 787 DREAMLINER
TAKES ADVANTAGE
OF NEW TECHNOLOGIES
TO INCREASE RELIABILITY AND
IMPROVE MAINTAINABILITY.

Boeing 787 from the Ground Up

by Justin Hale,
787 Deputy Chief Mechanic

With the 787 Dreamliner, Boeing is using a new approach to design which takes into greater account the cost to maintain airplane structure and systems over their lifetimes. As a result of this approach, the basic 787-8 airplane will have 30 percent lower airframe maintenance costs than any comparable product and will be available for revenue service more often than any other commercial airplane.

The Boeing 787 program has consciously designed in new, state-of-the-art features and performance that reduce cost and increase airplane availability. These features will lead to additional savings and greater revenue for Boeing customers. The 787 reflects a new life-cycle design philosophy that has dictated some significant changes in the way the airplane will be built. These changes include extensive use of composites in the airframe and primary structure, an electric systems architecture, a reliable and maintainable design, and an improved maintenance program. Taken together, these changes will offer customers a guaranteed reduction in maintenance costs.

LIFE-CYCLE COST DESIGN PHILOSOPHY

The life-cycle cost approach to design looks at the total cost picture for design options by examining all of the factors that affect an airplane over its lifetime. Traditionally, the value of a given design solution has been measured using factors such as:

- Drag
- Weight
- Noise (cabin and community)
- Schedule reliability
- Development cost
- Build cost

Using these measures to compare design options helps determine the optimum choice.

With the 787, Boeing has expanded the life-cycle design approach by adding two unique performance measures: maintenance cost and airplane availability. Clearly, looking at the cost to maintain systems over their lifetimes becomes a significant factor when attempting to understand the total effect of a design decision on an operator's cost structure. Airplane availability includes not only schedule reliability but also other factors such as the length of time an airplane must be out-of-service when maintenance is required. Obviously, taking an airplane out of service for two days has a much bigger effect on operator revenue than taking it out of service for two hours.

COMPOSITES IN THE AIRFRAME AND PRIMARY STRUCTURE

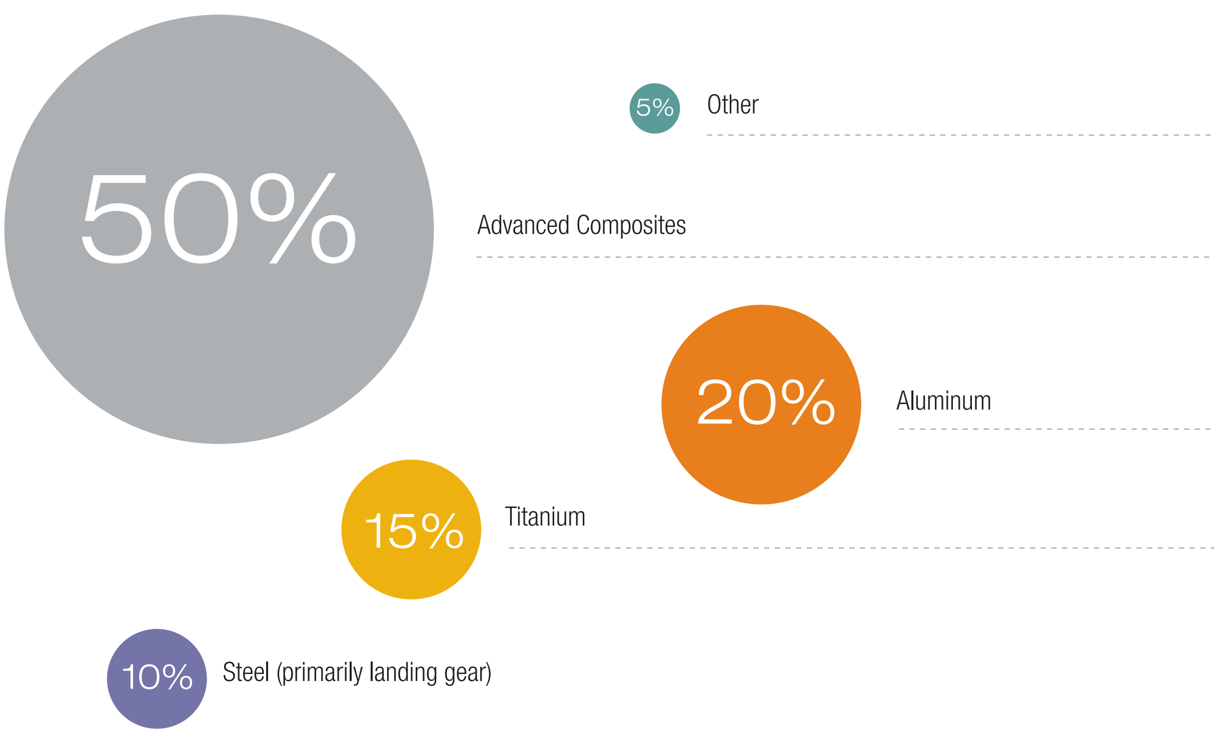
The Boeing 787 makes greater use of composite materials in its airframe and primary structure than any previous Boeing commercial airplane. Undertaking the design process without preconceived ideas enabled Boeing engineers to specify the optimum material for specific applications throughout the airframe.

The result is an airframe comprising nearly half carbon fiber reinforced plastic and other composites. This approach offers weight savings on average of 20 percent compared to more conventional aluminum designs.

Selecting the optimum material for a specific application meant analyzing every area of the airframe to determine the best material, given the operating environment and loads that a component experiences over the life of the airframe. For example, aluminum is sensitive to tension loads but handles compression very well. On the other hand, composites are not as efficient in dealing with compression loads but are excellent at handling tension. The expanded use of composites, especially in the highly tension-loaded environment of the fuselage, greatly reduces maintenance due to fatigue when compared with an aluminum structure. This type of analysis has resulted in an increased use of titanium as well. Where loading indicates metal is a preferred material system but environmental considerations indicate aluminum is a poor choice, titanium is an excellent low-maintenance design solution. Titanium can withstand comparable loads better than aluminum, has minimal fatigue concerns, and is highly resistant to corrosion. Titanium use has been expanded on the 787 to roughly 14 percent of the total airframe. Every structural element of the 787 has undergone this type of life-cycle analysis and material types are based on a thorough and disciplined selection process.

In addition to using a robust structural design in damage-prone areas, the 787 has been designed with the capability to be repaired in exactly the same manner that airlines would repair an airplane today – with bolted repairs. These can be just as permanent and damage tolerant as they are on a metal structure.

HOW COMPOSITE SOLUTIONS ARE APPLIED THROUGHOUT THE 787



In addition to lowering the overall airplane weight, moving to a composite primary structure promises to reduce both the scheduled and nonroutine maintenance burden on the airlines.

Reduced scheduled maintenance. Experience with the Boeing 777 proves that composite structures require less scheduled maintenance than noncomposite structures. For example, the 777 composite tail is 25 percent larger than the 767's aluminum tail, yet requires 35 percent fewer scheduled maintenance labor hours. This labor hour reduction is due to the result of a reduced risk of corrosion and fatigue of composites compared with metal.

Reduced nonroutine maintenance. A composite structure also results in less nonroutine maintenance. The 777 floor structure is all composite and highlights the advantages of this material when applied in a harsh environment. Airline operators are aware of the fatigue cracking and corrosion difficulties experienced with traditional aluminum floor beams. The 777 model has been flying for more than 10 years with more than 565 airplanes in the fleet and to date has not replaced a single composite floor beam.

Boeing has also implemented a rigorous process for evaluating the use of aluminum that combines likelihood of corrosion with consequence of corrosion. This scoring system provides a definitive measure for establishing acceptable application of aluminum in the design with full understanding of the maintenance implications.

Corrosion and fatigue in a structure add significantly to the nonroutine maintenance burden on an operator. Nonroutine maintenance frequently doubles or even triples the total labor hours expended during a maintenance check. With the expanded use of composites and titanium combined with greater discipline in usage of aluminum, Boeing expects the 787 to have much lower nonroutine labor costs than a more conventional metallic airframe.

In addition to using a robust structural design in damage-prone areas, such as passenger and cargo doors, the 787 has been designed from the start with the capability to be repaired in exactly the same manner that airlines would repair an airplane today — with bolted repairs. The ability to perform bolted repairs in composite structure is service-proven on the 777 and offers comparable repair times and skills as employed on metallic airplanes. (By design, bolted repairs in composite structure can be permanent and damage tolerant, just as they can be on a metal structure.)

In addition, airlines have the option to perform bonded composite repairs, which offer improved aerodynamic and aesthetic finish. These repairs are permanent, damage tolerant, and do not require an autoclave. While a typical bonded repair may require 24 or more hours of airplane downtime, Boeing has taken advantage of the properties of composites to develop a new line of maintenance repair capability that requires less

The right material for the right application. Without preconceived ideas, Boeing engineers were able to specify the optimum material for specific applications throughout the airframe.

BLEED-AIR POWERED

NO BLEED / MORE ELECTRIC ARCHITECTURE

UNAFFECTED SYSTEMS:	PNEUMATIC COMPONENTS REMOVED FROM THE ENGINE AND APU:
Engine anti-ice system	Precooler Pneumatic starter Valves Ducts APU load compressor

The transition from bleed-air power to an electric architecture reduces the mechanical complexity of the 787.

than an hour to apply. This rapid composite repair technique offers temporary repair capability to get an airplane flying again quickly, despite minor damage that might ground an aluminum airplane.

In total, the reduced risk of corrosion and fatigue associated with composites combined with the composite repair techniques described will lower overall maintenance costs and maximize airline revenue by keeping airplanes flying as much as possible.

One innovative application is the move from hydraulically actuated brakes to electric. Electric brakes significantly reduce the mechanical complexity of the braking system and eliminate the potential for delays associated with leaking brake hydraulic fluid, leaking valves, and other hydraulic failures.

NO-BLEED, MORE ELECTRIC SYSTEMS ARCHITECTURE

The Boeing 787 reflects a completely new approach to onboard systems. Virtually everything that has traditionally been powered by bleed-air from the engines has been transitioned to an electric architecture. The affected systems include:

- Engine start
- Auxiliary power unit (APU) start
- Wing ice protection
- Cabin pressurization
- Hydraulic pumps

The only remaining bleed system on the 787 is the anti-ice system for the engine inlets.

While much can be said regarding the efficiency gains achieved by changing the means of extracting power for airplane systems from the engines, the 787's no-bleed architecture brings with it some significant maintenance cost and reliability advantages as well. By eliminating the pneumatic systems from the airplane, the 787 will realize a notable reduction in the mechanical complexity of airplane systems. The list below highlights just a few of the components eliminated as a result of this systems change:

- Pneumatic engine and APU start motors
- APU load compressor
- Precoolers
- Various ducts, valves, and air control systems
- Leak and overheat detection systems

Auxiliary power unit. The APU provides an excellent illustration of the benefits of the more-electric architecture. One of the primary functions of a conventional APU is driving a large pneumatic load compressor. Replacing the pneumatic load compressor with starter generators results in significantly improved start reliability and power availability. The use of starter generators reduces maintenance requirements and increases reliability due to the simpler design and lower parts count. In terms of inflight start reliability, the 787 APU is expected to be approximately four times more reliable than conventional APUs with a pneumatic load compressor.

Electrical power generation. Another fundamental architectural change on the 787 is the use of variable frequency electrical power and the integration of the engine generator and starter functions into a single unit. This change enables elimination of the constant speed drive (also known as the integrated drive generator, IDG), greatly reducing the complexity of the generator. In addition, by using the engine generator as the starter motor (an approach used with great success on the Next-Generation 737 APU), the 787 has been able to eliminate the pneumatic starter from the engine.

PNEUMATIC COMPONENTS REMOVED FROM THE AIRFRAME:

Ducts
Valves
Heat shields
Overheat monitoring systems
Duct burst protection systems

AFFECTED SYSTEMS:

APU start
Brakes
Cabin pressurization
Engine start
Hydraulic pumps
Wing ice protection

When compared to the more complex 767 IDG, the 787 starter generator is predicted to have a mean time between faults (MTBF) of 30,000 flight hours — a 300 percent reliability improvement compared to its in-service counterpart.

Brakes. One innovative application of the more-electric systems architecture on the 787 is the move from hydraulically actuated brakes to electric. Electric brakes significantly reduce the mechanical complexity of the braking system and eliminate the potential for delays associated with leaking brake hydraulic fluid, leaking valves, and other hydraulic failures. Because its electric brake systems are modular (four independent brake actuators per wheel), the 787 will be able to dispatch with one electric brake actuator (EBA) inoperative per wheel and will have significantly reduced performance penalties compared with dispatch of a hydraulic brake system with a failure present. The EBA is line-replaceable enabling in-situ maintenance of the brakes.

In general, electric systems are much easier to monitor for health and system status than hydraulic or pneumatic systems; the brakes take full advantage of this. Continuous onboard monitoring of the brakes provides airlines with a number of advantages, such as:

- Fault detection and isolation
- Electrical monitoring of brake wear
- Ability to eliminate scheduled visual brake wear inspections
- Extended parking times

Because the 787 brakes can monitor the braking force applied even while parked, the electric brakes enable extended parking brake times by monitoring and automatically adjusting its parking brakes as the brakes cool.

At an airplane level, the reduction in systems parts by moving to a primarily electric architecture is significant. Overall, the 787 will reduce mechanical systems complexity by more than 50 percent compared to a 767; elimination of pneumatic systems is a major contributor. As a consequence of this reduction in complexity, airlines will experience reduced airplane-level maintenance costs and improved airplane-level dispatch reliability.

In fact, the move to electric systems is expected to cut about a third of the schedule interrupts compared to a 767 for the systems affected by the no-bleed/more-electric architecture. Other benefits include improved health monitoring, greater fault tolerance, and better potential for future technology improvements.

Overall, the 787 will reduce mechanical systems complexity by more than 50 percent compared to a 767; the elimination of pneumatic systems is a major contributor.

RELIABLE AND MAINTAINABLE BY DESIGN

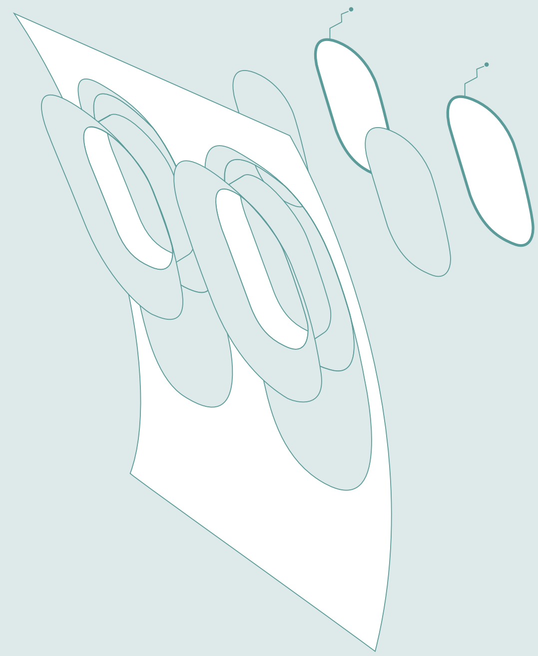
In addition to major changes such as use of composites and the elimination of pneumatic systems, the 787 takes advantage of new technologies to increase reliability and improve maintainability. Boeing has looked for opportunities large and small to reduce maintenance costs while making the 787 highly available for revenue service.

Here are some wide-ranging examples that illustrate the extent of these improvements.

Advanced maintainability analysis. A new generation of digital analysis tools is enabling Boeing to better understand future maintenance issues during the design process. Through

ELECTRO-CHROMATIC DIMMABLE WINDOWS:

Eliminated mechanical window shades
High reliability – 70,000 cycles / 20 years
Operational temperature range -40C – +60C
Installed between the dust cover and outside window
Easily replaced by removing window reveal



animated simulations, designers ensure mechanics can perform various procedures effectively and efficiently, resulting in a more maintainable airplane and higher quality maintenance procedures. Boeing has already identified about 4,000 areas of maintenance on the airplane and will both digitally and physically validate 100 percent of 787 maintenance procedures prior to entry into service (EIS).

Advanced maintenance computing systems. The 787 features greatly expanded and improved systems monitoring capability coupled with an advanced onboard maintenance computing system. This capability combined with e-enabling technologies, which make real-time ground-based monitoring possible, will significantly aid in rapid, accurate troubleshooting of the 787. Airplane systems information used in conjunction with fully integrated support products will help maintenance and engineering organizations quickly isolate failed components and reduce return-to-service times. Boeing expects the 787 to show a reduction in no-fault-found (NFF) removals of 58 percent compared to the 767, reducing yet another major cost driver for 787 operators.

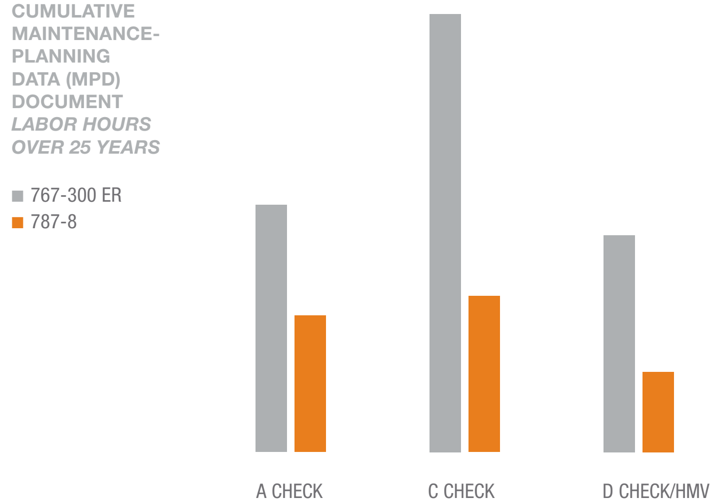
Selective paint stripping. Boeing is pioneering a new paint stripping technique that makes it possible to chemically strip the paint on the airplane's composite airframe. A three-hour chemical strip removes decorative paint. This eliminates the hand-sanding requirement for paint removal on composite structure and puts the 787 on par with a metal airplane in terms of repaint times.

Electro-chromatic dimmable windows. The 787 replaces mechanical window shades with highly reliable electro-chromatic dimmable windows with a projected life of more than 20 years. In addition to eliminating the maintenance associated with light-leaking or inoperable window shades, electro-chromatic dimmable windows give cabin crews the ability to dim or brighten an entire cabin at the press of a single button.

Propulsion structure and airplane interface. The 787 marks the first time Boeing has made the engine type interchangeable at the wings. That allows a 787 owner to quickly and easily convert an airplane to a different engine brand in order to place it into a fleet. The 787 engine cowlings have a quick composite repair capability, enabling small damages to be repaired in one hour at the gate, maximizing the airplane's availability.

High-intensity discharge (HID) and light emitting diode (LED) lighting. The 787 has replaced virtually all cabin, flight deck and exterior lighting with HID and LED lighting technologies. Because these light types have no filament, the operational life of the lights is dramatically longer than that of an incandescent bulb. For example, HID landing lights will last an order of

CUMULATIVE MAINTENANCE-PLANNING DATA (MPD) DOCUMENT *LABOR HOURS OVER 25 YEARS*



44% reduction

65% reduction

63% reduction

Improved and expanded monitoring, advanced onboard maintenance systems, and e-enabling technologies make real-time ground-based monitoring possible. This will aid in troubleshooting the 787. Airplane systems information and fully integrated support products will help maintenance and engineering organizations quickly isolate failed components and reduce return-to-service times. Boeing expects the 787 to show a reduction in NFF removals of 58 percent compared to the 767, reducing yet another major cost driver for 787 operators.

magnitude longer than the lights in service today. LED cabin lights will last 50,000 operational hours and LED aircraft position lights 20,000 operational hours. Overall, 787 lights will last ten to twenty times longer than their in-service counterparts.

Improved dispatch reliability. In the 787, Boeing is demonstrating that generational improvements in systems technology result in airplane-wide reliability improvements. At an airplane level, component reliability is improved by more than 15 percent when compared to the 767. That translates into improved schedule reliability. The 787 program is targeting a mature schedule reliability of more than 99 percent.

MAINTENANCE PROGRAM DEVELOPMENT

By working closely with airlines, major partners and suppliers, and regulatory agencies, Boeing plans to deliver a scheduled maintenance program approved by the U.S. Federal Aviation Administration and European Aviation Safety Agency before taking the 787 into flight testing. The 787 program has set target intervals for EIS that exceed those of any other commercial airplane. These target intervals include a first external visual inspection of the structure at 6 years and the first internal visual inspection of the structure (heavy check) at 12 years. The 787 maintenance program is on track to deliver the target intervals at EIS.

In addition to longer intervals between scheduled maintenance checks, the 787 program projects labor hours content will be reduced by 20 percent on a per-check basis and total scheduled labor hours will be reduced by 60 percent over the life of the airplane.

This reduction in required scheduled maintenance is another significant contributor to the overall 30 percent airframe and systems maintenance cost reduction guaranteed by the 787.

SUMMARY

By designing the 787 with features and performance that reduce cost and increase airplane availability, Boeing is developing an airplane that promises to offer Boeing customers significant savings and greater revenue. For more information, contact Justin Hale at justin.e.hale@boeing.com.

Maintenance Program Enhancements

by Brian McLoughlin,
Maintenance Engineering Technical Services Manager,
and Jane Beck, 777 ISC Co-Chair

BOEING WORKS WITH THE INDUSTRY TO ENSURE THAT SCHEDULED MAINTENANCE PROGRAMS MEET THE HIGHEST STANDARDS.

Boeing regularly works with an Industry Steering Committee to improve the efficiency of the maintenance tasks that operators use to create their scheduled maintenance programs for their commercial airplane models. These improvements optimize the content and interval of maintenance tasks to maintain safety and reliability and achieve cost efficiencies. Improvements are based on Boeing analysis of in-service data collected from the worldwide fleet. All improvements are reviewed and approved through an industry process involving Boeing, operators, and regulatory agencies.

Over the decades, Boeing has worked closely with the aviation industry to develop robust processes that ensure scheduled maintenance programs adhere to the highest safety and operational reliability levels. In creating and updating its scheduled maintenance programs, Boeing uses a process as outlined in Federal Aviation Administration Advisory Circular 121-22A (Maintenance Review Board Procedures) that involves the establishment of an Industry Steering Committee (ISC), in-service data collection and analysis, and a recommendation from Boeing for each individual task under review.

INDUSTRY STEERING COMMITTEE

An ISC comprises operators, manufacturers, and regulators who follow the guidance outlined in Advisory Circular AC 121-22A to develop the scheduled maintenance program for an airplane model and the resulting Maintenance Review Board Report (MRBR). It is the function of the ISC, under the direction of a chairperson (an operator selected by its peer operators), to develop and establish policy for the development of the MRBR proposal and participate in the review and approval process of the ISC.

ISC meetings for all models, which are held on an as-needed basis, take place in Seattle, Wash., or Long Beach, Calif., and generally last one week. Meetings are open to all operators and typically cover a specific Boeing airplane model or defined set of models.

The airframe manufacturer serves as an ISC co-chairperson and has the duties of receiving in-service data to be analyzed for proposed MRBR changes, providing the ISC with sufficient technical data to base decisions on proposed changes, providing relevant training to the ISC as needed, and coordinating and participating in ISC and working group activities.

The Federal Aviation Agency (FAA) and European Aviation Safety Agency (EASA) have Maintenance Review Board (MRB) chairperson duties, which consist of inviting other regulatory authorities, in coordination with the manufacturer, to participate in the MRB process; reviewing and accepting or rejecting the policy and procedures used throughout the process; and providing final acceptance of the MRBR.

The ISC makes ongoing improvements to the scheduled maintenance program using the most current maintenance philosophy (see "History of Maintenance" on p. 28). These improvements not only maintain the inherent safety and reliability of the airplane but can also produce substantial savings for the operators. Any operator may become a representative voting member of an ISC.

IN-SERVICE DATA COLLECTION AND ANALYSIS

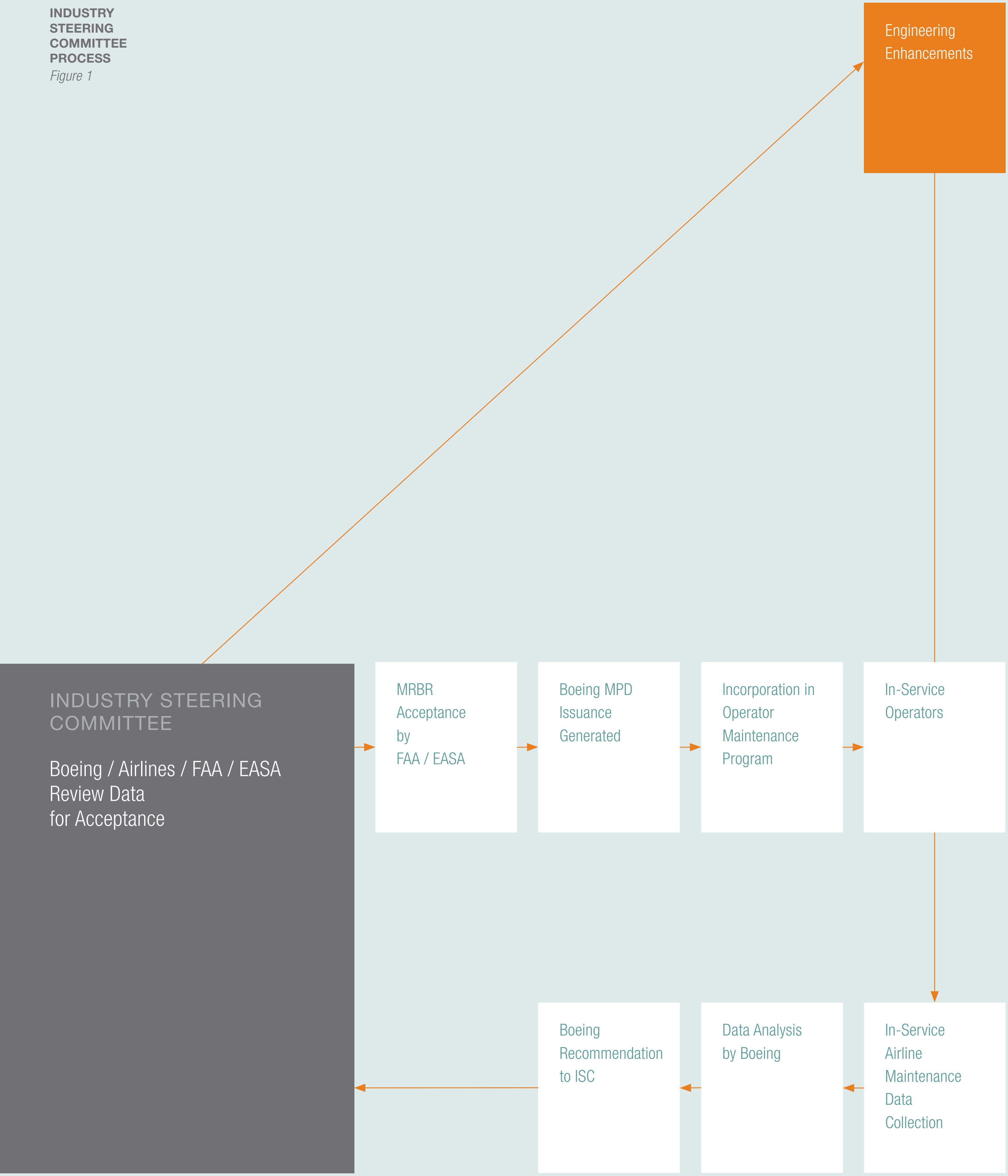
Operators strongly influence the success of a scheduled maintenance program revision by providing in-service data. Boeing analyzes the fleetwide data provided by the operators to identify important trends for incorporation into the scheduled maintenance programs through the ISC process.

The operators and Boeing work together to identify areas within the scheduled maintenance program to review for optimization. In-service data is collected by the operators and sent to Boeing for review and analysis. For each identified maintenance task, Boeing reviews the data and analyzes the positive and negative in-service results. Boeing also reviews service bulletins, reliability data, service letters, airworthiness directives and any other pertinent documents, and coordinates proposed changes with other Boeing or supplier engineering groups.

Once the analysis is complete, Boeing makes a recommendation for each individual task under review and presents it to the ISC-participating operators and the regulatory agencies. Each operator is entitled to one vote on the Boeing proposal. The entire process is observed by the regulatory agencies, which ultimately can approve or reject any proposed changes. Accepted changes are incorporated into the MRBR, requiring acceptance from the MRB chairperson (the FAA and EASA). The changes are also incorporated into the Boeing Maintenance Planning Data (MPD) document and Boeing-configured task cards, which are issued to the operators for inclusion in their own scheduled maintenance programs.

The ISC process (see fig. 1) ensures that operators have efficient scheduled maintenance programs with the highest possible levels of safety and reliability. The combination of operators' experience and Boeing's design-based analysis ensures that all safety items on the airplane are supported by scheduled maintenance tasks with appropriate intervals. The result is increased reliability with decreased labor hours and maintenance costs (see fig. 2). Boeing engineering design groups can develop resolutions to technical issues arising from the in-service data. The new design or process changes can improve reliability and result in maintenance cost avoidance for the entire fleet.

INDUSTRY STEERING COMMITTEE PROCESS
Figure 1



777 TECHNICAL DISPATCH RELIABILITY AND SCHEDULED MAINTENANCE LABOR HOURS
Figure 2

Reduction in scheduled maintenance cost has had no adverse effect on technical dispatch reliability.

777 SCHEDULED MAINTENANCE PROGRAM IMPROVEMENTS

A recent evaluation of the scheduled maintenance program for the 777 illustrates the ISC process. This evaluation included a review of approximately 400 777 maintenance tasks.

The new program extends the maintenance inspection interval for zonal and structural tasks, involving such areas as doors, fuselage compartments, struts, and flight controls, from 25 to 37 months. Under the previous MRBR, an airplane was pulled out of service for approximately 5 days to perform required maintenance checks every 25 months. The addition of 12 months to this maintenance interval provides significant financial and scheduling opportunities to 777 operators. Other tasks that have been escalated in the new maintenance program include many general inspections, which have increased from 100 to 125 days.

The result saves more than 400 labor-hours per airplane per year and increases airplane availability by providing airlines with one additional day of revenue operation annually for each 777 in their fleet. Using industry averages, the reduced maintenance costs and increased revenue opportunities added more than $100,000 USD in annual value to each 777 in operation.

In total, the evaluation resulted in an escalation (i.e., lengthening of the interval between maintenance task accomplishment) of approximately 100 line maintenance phase check tasks (similar in content to the block program A-check) and approximately 250 hangar-level-check tasks (similar in content to the block program C-check). The ISC, however, did not escalate approximately 12 percent of the tasks reviewed and de-escalated (i.e., shortened the interval between maintenance task accomplishment) one task based on the findings from the in-service data.

For example, one task that was escalated on the 777 was "operationally check flight deck indicator lights in dim and bright mode," which is considered an economic, not a safety, task. Operators provided 1,500 test results for this task with no adverse findings, and the ISC determined that the interval for this task could be extended from 1,200 to 1,500 flight hours. As with the other tasks that were escalated, this change enables operators to arrange their maintenance programs in a more efficient manner without compromising safety.

FUTURE DATA COLLECTION

Boeing continues to seek optimization of its maintenance requirements using improved data collection and the ISC processes. Boeing is currently developing a program that collects and stores real-time in-service data from scheduled maintenance visits in a line and hangar environment and associates this data with the scheduled maintenance task. The program enables data to be gathered and analyzed centrally for use by the industry in adjusting current scheduled maintenance tasks or check intervals based on in-service findings.

This will allow ISCs to be more proactive in managing scheduled maintenance programs. It also will allow operators to benchmark against other participating operators, expedite ground times for line and hangar maintenance visits, and plan spares and consumables using worldwide averages for scheduled maintenance.

SUMMARY

The ISC process maintains safety and reliability standards and reduces waste by ensuring maintenance tasks are performed at the proper level of intensity and interval, based on industry in-service flight data and each airplane model's inherent design characteristics.

Data collection and operator participation in the ISC process remain key factors in future scheduled maintenance program improvements. For more information, contact Brian McLoughlin at MaintenanceEngineering@boeing.com.

history of maintenance

AERO

In the early days of aviation, maintenance programs were developed by mechanics. The programs were simple and without analytical basis. The formation of airlines created the need for new regulations and broader regulatory involvement in maintenance requirements.

With the entry of large jet airplanes into the commercial market in the 1950s, the airplane manufacturer became the source of maintenance program development. The underlying concept was to overhaul every component at a given time.

In 1960, the industry formed a task force to investigate the capabilities of preventive maintenance. The findings of the task force led to a new type of maintenance called "on-condition" maintenance.

The handbook "Maintenance Evaluation and Program Development," also referred to as "MSG-1," was developed in 1968 for the 747 by the Air Transport Association (ATA) Maintenance Steering Group (MSG), a group of airframe manufacturers, airlines, U.S. Federal Aviation Administration (FAA) representatives, and suppliers. MSG-1 used decision logic to develop scheduled maintenance.

For aircraft in the 1970s, the document "Airline/Manufacturer Maintenance Program Planning," or "MSG-2," was developed. It was process oriented and analyzed failure modes from the part level up. The MSG-2 philosophy was based on the theory that all airplanes and their components reach a period when they should be "zero timed" or "overhauled" and restored to new condition.

In 1978, United Airlines, commissioned by the Department of Defense, developed a methodology for designing maintenance programs based on tested and proven airline practices. This new methodology was the basis for MSG-3, the current industry standard.

This methodology has a task-oriented approach to maintenance that analyzes system failure modes from a system level, or top down. Maintenance tasks are performed for safety, operational, or economic reasons. They involve both preventive maintenance and failure finding tasks.

Revisions to the MSG-3 philosophy have provided added methodology for improving coverage of all modes of failure, such as inclusion of the Corrosion Prevention and Control Program, Enhanced Zonal Analysis, and Lightning/High Intensity Radiated Fields.

Boeing continues to work with airplane operators, regulators, and the ATA to update MSG-3 to enhance the methodology. A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