AEROTEC AND AVIATION PARTNERS BOEING

EFFICIENCY & EXPERTISE ARE KEYS TO SPLIT SCIMITAR WINGLET CERTIFICATION

SUMMARY

Aviation Partners Boeing (APB) faced many technical challenges and a challenging timeline to certify its new Split Scimitar Winglets (SSW) for retrofit on 737NG aircraft with Blended Winglets.

BACKGROUND

Since they were introduced, more than 6,500 APB Blended Winglet Systems have saved over 8 billion gallons of fuel for hundreds of airlines worldwide. That's why, when testing showed that replacing the aluminum winglet tip cap with a new aerodynamically shaped scimitar and adding a new scimitar-tipped ventral strake promised to improve efficiency and performance further still, APB was keen to bring the new product to market. At the same time, APB wanted to back its program with high quality test data and analysis to ensure that the product would perform exactly as expected and as promised.

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CHALLENGE

AeroTEC was challenged to complete the Federal Aviation Administration (FAA) and European Aviation Safety Agency (EASA) Supplemental Type Certificate (STC) flight test process for three models of the new winglets (-700, -800, -900).

Like any certification process, it wasn't going to be easy. There were four primary requirements/challenges:

1. **Retain CAT III autoland capability.** Autoland certification is typically a time-consuming statistical analysis process involving months of computer simulations and a large number of landing demonstrations. Rather than proceeding with the status quo, AeroTEC instead completed a detailed engineering analysis and flight test demonstrations that focused only on the change imparted by the modification, resulting in a significantly shortened timeline.

2. **Retain original FAA certification rules (certification basis) in critical areas.** While the modification affected these areas of compliance in the eyes of the regulators, the most recent rules were not viable options for an older aircraft undergoing a modification of this scope. This required early identification of the issues at hand and extensive use of the FAA's potentially complex Issue Paper process to negotiate a viable certification basis in a timely fashion.

3. **Fleet complexity.** The fleet of 6,000 aircraft being modified was diverse, and a range of variants that were relevant to the modification had to be accounted for. This added complexity to many tests and engineering analysis.

4. **Compliance with new FAA Part 25, Amendment 121 rules for flight in icing conditions.** Testing an old aircraft to new rules adds risk because the original design did not account for current regulations. Compliance would require analytically determining expected ice accretion and performing extensive flight tests to produce a safe and compliant modification.

> We were able to successfully negotiate the minimum flight test program with the FAA, which is an art form," said AeroTEC President Lee Human. "Applying our experience to this program enabled a smooth and successful process."

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KEYS TO SUCCESS

AeroTEC knew it needed a flight test program as efficient as the distinctive winglets themselves. This was accomplished by combining AeroTEC's uniquely deep engineering expertise and its understanding of the entire certification process with a range of creative solutions that helped streamline the complex certification process.

Keys to success included:

- Identifying and mitigating all risks early.
- Following a comprehensive certification plan that encompassed DER services, test plan and execution, FAA coordination, analysis and aircraft operating manual updates.
- Showing the FAA that the modification did not significantly impact the autoland capability using "compliance by similarity," saving time and money on flight tests.
- Creating a turnkey solution for meeting the new FAA icing rules.
- Eliminating or minimizing multiple flight tests and multiple instrumentation requirements through engineering analysis.
- Getting the work done right the first time.

> As experts in the testing, engineering and certification process we had an airtight presentation with engineering justification and an answer for every question the FAA might throw at us."

*As a part of the testing and certification process, AeroTEC provides full service **ice shape design, analysis and testing**. Services include artificial ice shape development, ice shape testing, natural icing testing, and certification of de-icing systems.*

EFFICIENCY IN ACTION

Streamlining the certification process was one of the keys to AeroTEC's success. This was accomplished, in part, by replacing time-consuming tests with engineering analysis. Some of the test items eliminated through analysis included:

- **Autopilot hardover testing.** AeroTEC flight tested a small number of conditions on a comparison basis (SSWs vs. no SSWs) and applied that to an engineering analysis. This analysis eliminated over 80% of the traditional flight test points.
- **Minimum control speed (V_{MC}) analysis.** AeroTEC's in house stability analysis tools were used to avoid minimum control speed flight testing on the 737-900ER and 737-700 programs.
- **Heads-Up Guidance (HGS or HUD) compatibility.** AeroTEC was able to use the test data from the -800 to certify the -700 and -900ER. This system operates in similar manner to the autoland system, but is made by an independent manufacturer and therefore required an independent evaluation, analysis, and limited flight test demonstration. The certification approach taken was essentially identical to that done for autoland.
- **Takeoff Ice Shape testing on -900/900ER and -700.** AeroTEC was able to identify critical flight test conditions on the -800 and eliminate all flight testing for the -700 and -900/900ER.
- **-900 flight test.** AeroTEC identified the -900ER as the critical case for this modification and captured all the required test conditions to support the -900 program during the -900ER test conduct. As a result, all data needed for two minor models was captured during one program.

RESULTS

Certification of three models covering a market of more than 6,000 airplanes was successfully completed, meeting objectives, and within two percent of proposal estimates.

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PROVING THE CONCEPT

Before investing in certification, Aviation Partners Boeing (APB) worked with AeroTEC to complete proof of concept flight testing on its Split Scimitar Winglets (SSW) and used the findings about reduced fuel burn to gauge the interest of Blended Winglet customers like Southwest Airlines.

These presentations were much more than promises of fuel savings to be delivered. They were in-depth technical briefings that walked customers through the proof of concept flight test program to show airlines exactly how the reduced fuel burn had been carefully calculated through professional flight test, data collection and analysis techniques.

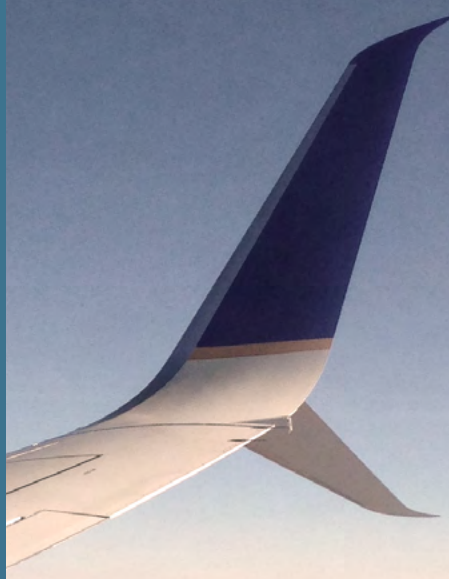
Airlines were provided a detailed breakdown of a 20-day, 17-flight, 102.2 flight-hour high-speed drag program that tested both the SSW and the baseline Blended Winglet. A total of 98 aerodynamic drag data points were specified—49 per configuration—at various altitudes, gross weight, and Mach numbers.

Customers were also shown the attention to detail required to accurately measure aerodynamic performance, including the aircraft configuration and aircraft weighing. Accurately measuring aircraft gross weight is critical to measuring performance increments. The same roll-on scales in the same locations were used for the duration of the test program, for example, and all weigh-ins were conducted in a closed hangar with circulation fans off. To ensure accuracy, airplanes were weighed multiple times on redundant sets of scales before and after each flight.

More information about aircraft weighing:

- Aircraft and test participants were weighed before and after each flight test. This established the absolute start-of-test aircraft weight of 185,000 lbs to within the accuracy of 100 lbs.
- Aircraft in-flight weight was determined by measuring engine and APU fuel consumption real-time throughout the mission.
- Post flight, the aircraft were weighed to validate and correct fuel consumption calculation if necessary. This process confirmed that aircraft gross weight was known throughout the entire mission.

...after customers were flying with SSW, APB and AeroTEC met with them again to further validate their fuel burn and show them the savings that were being realized.



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Customers were also briefed about the quality of flight test data, which is specified on years of experience and industry standards. AeroTEC tapped into its years of experience to find ideal test locations for preferred weather conditions and flew out of Sacramento, Calif., collecting data over the Pacific Ocean off the western coast of the U.S. Test tolerances for each three-minute minimum data point were as follows:

Mach:	**±0.004**
Heading:	**± 2°**
Drift Angle:	**<3° (minimize crosswind)**
Static Air Temperature:	**±0.5°C**
CG:	**±1.5% MAC**
W/d:	**±4000 lbs= ±.004 lbs E6**

Note: *W/d is a measure of wing lift. The end result of this parameter is that a typical data point must be flown within 125 feet of the reference altitude. Actual altitude variance during the data point will be much less.*

The fact that APB took the time to meet with these customers in person with the support of AeroTEC to demonstrate how the testing was conducted and to prove that the performance numbers were accurate speaks volumes about the integrity of the organizations and their willingness to stand behind a new product to ensure customer satisfaction. They didn't go to customers with a promise, they went to customers with data.

"Before APB showed the product to customers they hired AeroTEC to prove the concept with high quality flight test data, and we were able to deliver," said AeroTEC President Lee Human. "There were no shortcuts. Just real fuel savings backed up by high quality data collection that was done with integrity, care, and the most advanced methods."

> Before we certified the SSW, APB made a promise to customers about the fuel savings they would experience. We backed that promise with data," said AeroTEC President Lee Human.

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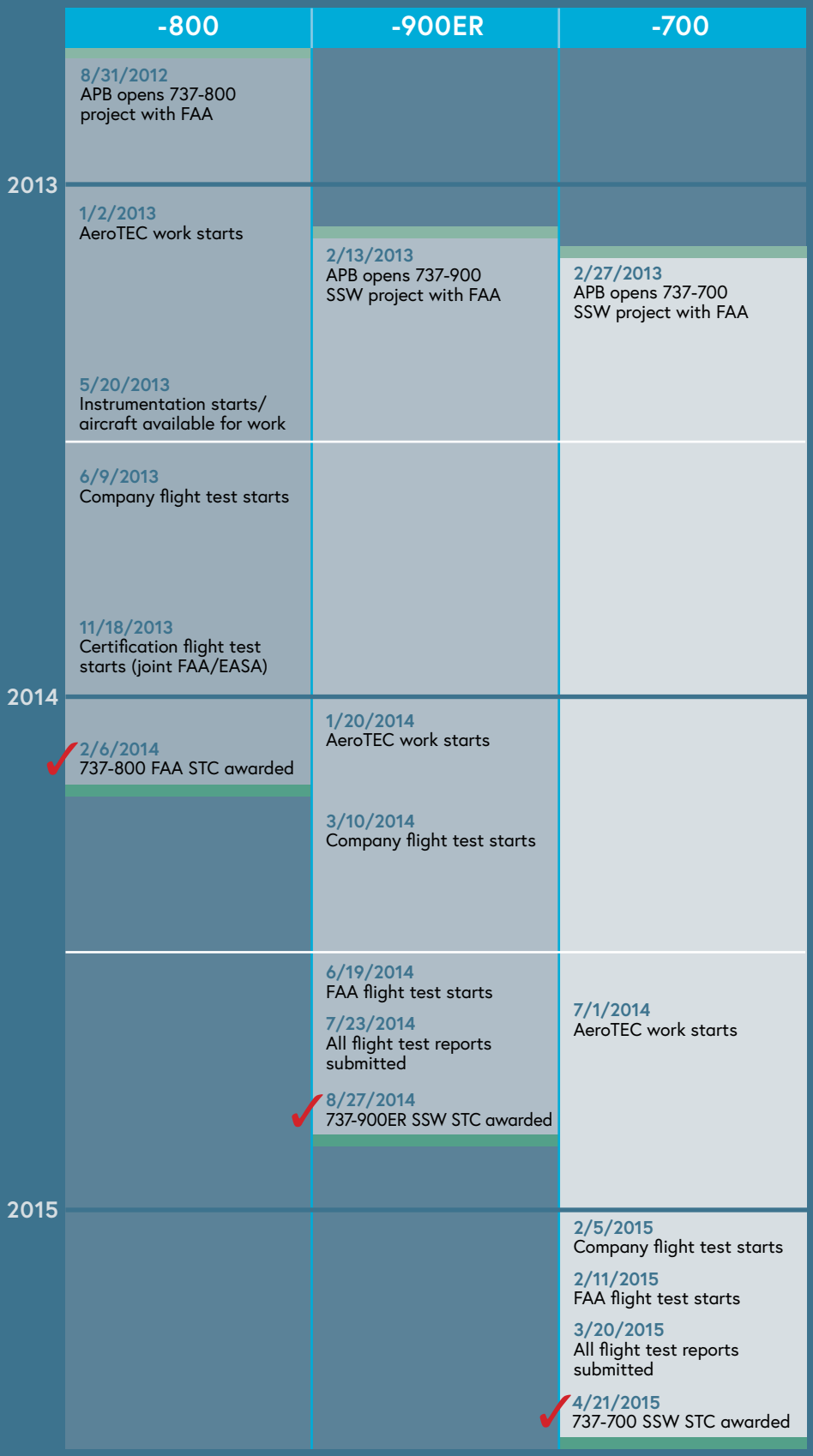
At right is the timeline for the 737 SSW certification process.

737 SSW CERTIFICATION



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