Quiet Wing Technologies, Inc. has developed a new noise and performance kit for the 737-200 and 737-300/-400/-500 series. The new B737 kits consist of three parts; acoustic treatments to the JT8D engines, along with wing flap and aileron configuration changes, and an option to install winglets. Customers have the option of installing the wing configuration changes alone for added performance (performance kit) or the acoustic treatments and wing configuration changes (noise and performance kit) with the option of adding winglets to either configuration for additional performance and fuel savings and an improved look to the aircraft. The overall effect is improved operating performance and reduced fuel burn, a reduction in aircraft noise, with the ability to aid in the achievement of Stage 4 compliance.

Quiet Wing's design team has had more than 20 years of major modification experience on commercial transport aircraft. The modifications have covered a wide range of concepts including; reinforced cockpit doors, operating weight increases, cargo conversions, performance systems, and noise reduction systems, including the Quiet Wing System for B727 aircraft, which received its STC in 1996. The system meets or exceeds FAR Part 36 Stage 3 regulations up to a maximum weight of 210,000 lbs. The 737 noise and performance kits capitalize on the proven design and performance of Quiet Wing's already successful B727-100/-200 noise and performance kits. Similarly to the B727 Quiet Wing System, the B737 system design incorporates performance improvements to the aircraft in order to facilitate noise reduction, performance gains, and achieve payback revenue for operators.

Total list price for the noise, performance and winglet kit ranges between $295,000 - to $645,000; depending on options and the original configuration of the aircraft that is modified. An additional cost is that of installation. All elements can easily be completed during a C or D check. The performance kit alone requires about 1,200MH. This adds about $60,000 at a labour rate of $50 per MH. Installation of the winglets requires about a further 600MH adding another $30,000.

Technical details

Cruise Performance Improvements

The Quiet Wing System Kits change the wing configuration of the aircraft by drooping the neutral setting of the aft trailing edge flap and ailerons. The effect of this change on cruise performance is to reduce the compressibility drag, and thus contribute to a reduction in fuel burn. The principle effect is the increase in Mach number before the onset of a high rise in drag. That is, the drag divergence Mach number. This is at about Mach 0.76 in an unmodified 737-200, but the aerodynamic improvements offered by the performance kit raise this to about Mach 0.78-0.79, allowing a higher cruise speed without incurring the drag penalty.

In the case of the 727-200 Quiet Wing System, this Mach divergence number is raised from about 0.84 to 0.89, again allowing a higher cruise speed before high drag penalties are incurred. Besides reducing drag and fuel burn for a given cruise Mach number, the Quiet Wing System kits allow higher cruise speed and so reduce flight times by several minutes on short-haul missions. An additional cruise benefit of the wing configuration change is to increase the aircraft's buffet boundary, increasing its flight envelope. This allows the aircraft to operate at higher weights and altitudes.

Lower fuel burn

The reduction in drag provided by the Quiet Wing System kits directly relates to a reduction in fuel burn through all phases of flight. Savings in fuel burn are about 2-3% for modified aircraft without winglets and 5-6% for aircraft including the winglets option. These savings have to be considered in relation to fuel burn on unmodified aircraft on typical stage lengths and utilisations. The 727-100/200, 737-200 and 737-300/-400/-500 are all typically operated on short-haul operations and are here analysed in terms of a 750nm stage length. However, due to the performance gains achieved with the performance kit, operators are finding that modified aircraft are capable of operating at longer ranges and increasing the gross weight capability without having to up-grade the engines. As the stage length increases and/or aircraft utilization increases, the operating savings grow proportionally.

In the case of the 727-200, the aircraft burns approximatley 3,000-3,200USG on a typical 750nm mission length. A 3% savings derived from the performance kit alone (without winglets) reduces fuel consumed by about 90USG. This totals about 135,000USG over a year's utilisation of about 1,500FS (flight segment). At current fuel prices of about $1.60 this makes an annual saving of about $216,000.

This has to be considered against the price of the kit of about $400,000 and another $60,000 for installation. With winglets added to the modification, the fuel burn reduction will increase to about 6%, or 180USG. This will be about 270,000USG during a year's operation; equal to a saving of $432,000 at current fuel prices. This has to be considered against the price of the kit, which will be $500,000-600,000, plus the additional MH for installation.

The 737-200 has a fuel burn of about 1,850USG on a 600nm mission. Using about 1,500 flight segments per year, a fuel burn reduction of 3% will save about 55USG, or about 82,500USG over a year's operation; equating to a saving in the region of $132,000 at current fuel prices. For 737-200, the addition of winglets will raise the fuel burn saving to about 75USG, which will be a total of about 112,500USG and $180,000 during the course of a year.

In fuel savings alone, the payback period for the B727-200 kit without winglets is just slightly over two years and less than two years for the B727-200 with winglets, while the payback period for the B737-200 kit with winglets, based on list price and the immediate benefits of fuel savings alone, ranges from four to five years. The kits provide additional benefits, however, derived from improved low speed performance. These make significant contributions to the economics of installing the kit for hot and high operations and generate further savings or additional revenue by allowing the aircraft to operate at or close to maximum gross weight

A typical operator for the performance kit enhanced B727 is Asia Pacific Airlines. They operate three Boeing 727-200 Freighters with both wing flap configuration changes and winglets on cargo routes throughout the Pacific. According to Mike Quinn, who is both the president and an active flying pilot for Asia Pacific, they are achieving average fuel savings of 4.5% over a standard heavyweight -17 powered aircraft. Mike Quinn also commented that with their Re-Engined Super 27, which is also equipped with Quiet Wing's B727 Winglets and Performance Kit, "the fuel savings are phenomenal. We are getting more than 10 percent savings, which allows us to either carry about 10,000 lbs more in payload or save about 2,000 lbs. of fuel on our longest trips."

<u>Takeoff and Landing Performance</u>

In addition to improved cruise performance and reduced fuel burn, the modification also provides a major improvement in low speed performance. The wing modifications provide an increase in the flap system efficiency, resulting in reduced flap drag. This directly leads to better performance leading to shorter take-off and landing runs. These can be traded for higher permitted take-off

weights at airports where aircraft with poorer performance often have limited take-off weight and therefore available payload. These are typically hot and high airports, or those with short runways. Mike Quinn confirms: "For those cargo operators whose flights are constrained by runway limits, the Quiet Wing Performance Kit creates an immediate revenue advantage by improving the Maximum Takeoff Gross Weight by 8,000 to 10,000 lbs through the use of 30-degree flap takeoffs."

The 727 and 737-200 are powered by several variants of the JT8D; starting with the low-powered -7 and going up to the highest powered -17 model. The effect of the Quiet Wing System kits is the same as changing engines to a higher thrust variant, which would increase the permitted take-off weight and provide the same effect as extending the aircraft's payload-range profile. Higher take-off weights are thus permitted at challenging airfields, and payload and range are both increased.

The increased payload capability is especially noticeable at hot and high airports. One example is Lloyd Aero Boliviano's (LAB) operation from La Paz, which is 13,000 feet above sea level. LAB's un-modified 727-200 with -17R engines had a permitted take-off weight of 145,000lbs. This was increased to 152,000lbs by the Quiet Wing modification, and potentially an equal increase in payload of 7,000lbs. This translates into about 30 additional passengers, depending on unit weight and baggage weight or additional freight. A passenger one-way fare of $100 would equal an increase in revenue of up to $3,000 per flight. This would equate to at least $1,000,000 additional revenue per year. The payback period on the installation of the kit would thus be reduced to less than one year. The kit would also defer the need to acquire a replacement aircraft with high capital cost and lease charges. Operation of the 727-200 as a freighter would increase revenue by up to $3,500 per flight. Even, at low rates of utilisation typical of freight operations, this would generate additional revenues equal to several hundred thousand dollars, and so realise a payback in a short period. The system has a similar effect of increasing permitted take-off and payload by more than 8,000lbs for a -9A powered 727-200 operating from Mexico City to Tijuana.

The 737-200 realises similar benefits. The aircraft's permissible take-off weight and payload is increased by 5,000lbs when operating from Mexico City. At typical freight yields this generates up to $2,500 additional revenue per flight, translating into several hundred thousand dollars per year. This effect thus shortens the payback period to just one or two years, depending on the actual additional payload carried, aircraft utilisation and freight or passenger yields.

A similar increase in operating performance is expected for the 737-300/-400/-500, and so realise a similar increase in revenues generated by higher permissible payloads, especially from hot and high airports.

Winglets Option

Quiet Wing's winglets have been in daily operation for more than nine years and have proven to be up to 7% more efficient than the standard wing. To further improve the performance of the older generation B737 aircraft, Quiet Wing is offering a New Contra-Vortex Tip Fairing (Mini Winglets) as an option for the B737 Classic Quiet Wing System. The design of this new winglet will be similar, but smaller in size, than that of the B727 winglet design and can be installed on all kit configurations. The winglets reduce wing tip vortices, further reducing drag in all phases of flight. In addition, the winglets option will further enhance the performance of the B737 by providing additional improvements in takeoff and landing performance, range, low speed handling and stall characteristics.

Quiet Wing's winglets on the FAA's B727 aircraft.

Technical support

The installation of the kit has no effect on aircraft maintenance costs. With the aircraft re-configured and performance affected, Quiet Wing provides documentation support for the flight manual supplement, weight and balance supplement, maintenance manual supplement, illustrated parts catalogue supplement, inspection manual supplement and the minimum equipment list. Quiet Wing also provides an installation supervisor to oversee and advise the customer's chosen installation facility during the installation process.

Noise Reduction

In addition to the savings provided by the kits, the installation of the modification reduces noise emissions of the 727-100/-200 and 737-200 to meet Stage III and aid in the achievement of Stage IV requirements for these aircraft and so permits the continued operation of the older aircraft. With respect to noise reduction on

the 727 and 737-200, the wing configuration change from the performance kits have the effect of reducing take-off, sideline and landing noise emissions by an aggregate five decibels. The engine treatment kits on the 727 and 737-200 reduce noise emissions by about an aggregate three decibels. This allows the aircraft to operate in and out of noise sensitive airports and will aid in complying with Stage 4 noise requirements.

Life Extension

The cost of installation can thus be viewed not only against savings from fuel burn, but also in relation to the life extension the kit allows. The acquisition or financing cost of a replacement aircraft, either a used 737-500 or new 717, 737-600 or A319 is high in relation to the amortisation of the $295,000-$600,000 installation cost of the kit. Moreover, the low capital or lease cost of the 737-200 means it is attractive to operators in regions such as Central and South America. The improved operating performance that results from the kit will enhance the aircraft's revenue generating capacity. Another direct benefit of the modification is to increase the aircraft's operational life and enhance its residual value retention. The modified 737-300 will have a fuel burn close to the same size 737-700, and so can defer replacement of the 737-300.

The cost of the kit also has to be considered in relation to the cost of swapping low thrust variants with higher thrust rated JT8D variants. In the case of the 727-200, Quiet Wing gives the example of a sector between Miami and Los Angeles, where payload is increased by about 4,200lbs when swapping -7 engines for -9 variants, while the increase from the performance kit instead is to increase the payload by about 7,900lbs.

Kit Availability

Quiet Wing is currently in the process of completing its FAA flight-testing. It expects to receive its STC for the B737 systems in the third quarter of 2004 and plans on having kits available as early as December 2004.