Increasing oil & fuel prices are pushing airlines to find new ways of cutting costs. The development of self-taxi equipment promises to dramatically reduce taxi fuel margins. This article analyses how, why and where these fuel burn reductions are achieved, as well as the other benefits self-taxi equipment can provide.

Fuel burn reductions & savings through the use of self-taxi equipment

With the ever-increasing price of fuel, airlines are continually looking for ways to reduce fuel consumption. Techniques available to them include optimising flight plans, reducing weight carried, or single-engine taxiing, among many others.

The development of self-taxi equipment provides another fuel-saving opportunity for airlines. Self-taxi equipment involves the use of induction or permanent magnetic motors to taxi the aircraft, instead of the traditional method of taxiing under main engine power (either all- or single-engine power).

At its simplest level, the implementation of self-taxi equipment will allow airlines to cut the amount of fuel carried for taxiing, which can potentially save an airline many thousands, if not millions, of dollars per year. This article examines the potential fuel and other savings.

System development

There are several self-taxi systems currently in development: WheelTug; Lufthansa Technik (LHT) and L-3 Communications; Safran and Honeywell; and DLR.

WheelTug is the self-taxi system that is closest to entry into service, which is forecast to be the third quarter of 2013, with launch customer El Al Israel Airlines.

The WheelTug system uses power from the auxiliary power unit (APU) to drive electric motors built into the nosegear wheels. These motors have enough torque to taxi the aircraft in both a forward and reverse direction, without using power from the main engines.

"Taxiing using power from the APU and electric motors to drive the aircraft forward and reverse replaces forward-only taxi, which uses the constant 'engines-versus-brakes' method of controlling aircraft motion (also known as 'riding the brakes')," says Isaiah Cox, chief executive officer at WheelTug. "The motive force constantly supplied by the engines and opposed by the wheel brakes is wasted. In comparison, WheelTug applies motive force upon demand, and can also move the plane in reverse." This method allows pilots to control the entire taxi process from being parked at the gate to take-off, and to the gate after landing.

This means that self-taxi systems will fundamentally change the traditional pushback procedure. Currently, an aircraft must be pushed back with a ground tug vehicle, accompanied by a ground marshal, while engines are started and other controls tested. The tug vehicle must then be disconnected after pushback and driven away while the engine start-up procedure continues. As Brian Davis, vice president of electrical sales, air transport and regional at Honeywell Aerospace, explains, "The Safran/Honeywell electric green taxiing system (EGTS) has the potential to dramatically reduce or eliminate the need for traditional push-back equipment."

It is important to note that aircraft engines usually need a three to five minute 'warm-up' period before the take-off roll. Self-taxi systems will allow pilots to reverse the aircraft from the gate themselves, and immediately begin taxi out for take-off. The time it takes to taxi from the gate to the runway is usually sufficient for the engines to warm up for take-off. At airports with longer taxi times, engines need only be started three to five minutes before take-off time.

WheelTug

Current ground-handling procedures for pushback will also be changed through the use of self-taxi equipment. With WheelTug, the gate crew can be reduced from three to two people. There will be one marshaller, who will be able to see the pilot and one wing. The marshaller will communicate with the pilot through visual signals, as opposed to voice commands. There will also be one wingwalker, who will help ensure that the aircraft stays clear of all obstacles during pushback. "Aircraft can reverse from the gate, or from a standstill, and can even 'rotate/pivot' using the nose wheel as the driving force. Situational awareness is provided by a marshaller and wingman," says Cox.

"In terms of installation, the WheelTug system will involve twin electric motors installed within the nose

The wheelTug system uses two electric motors in the nosewheel. These are electrically powered, deriving power generated by the aircraft's APU.

wheels, as well as an inverter/controller in the electronic and equipment (E & E) bay, and a cockpit control interface," Cox explains. "The cockpit control connects to the inverter/controller in the E & E bay, which communicates to the motors in the nose gear. It does not interact with the aircraft's databus, and it receives power directly from the APU."

The cockpit control interface will be a small addition with simple buttons and switches, including master power and control of the system. In all, this equipment will add about 300lbs of weight to the aircraft. It will take two shifts to install, meaning that aircraft will not have to spend much, if any, time out of service for WheelTug installation.

Lufthansa Technik & L3

Lufthansa Technik and L-3 Communications, in cooperation with Airbus and Fraport, trialled a self-taxi system, labelled GreenTaxi by L-3, on an A320 in December 2011. The purpose of this was to demonstrate that it is technically feasible to taxi an aircraft solely using electric/magnetic motors. Analysis of the operational procedures and economic benefit is currently being carried out on the data generated from this trial. "Nothing has been validated yet, but we believe there is a lot of potential behind this," says Christian Mutz, eTaxi project manager at Lufthansa Technik.

The applied demonstrator system uses power from the APU to drive permanent magnet motors installed into the main landing gear, one in the left and one in the right. For the trial, these were connected to a controller housed in the cargo load compartment inside an LD3 unit. Inside this unit were located the power controller, the cooling system and the AC/DC filter units. This was connected by cable to the cockpit and a man-machine interface, with power and torque controls for the pilots. Also used in the trial were cameras facing the landing gear to help the pilots.

"The system was tested for four days and involved about 40 test steps. These simulated full taxi tests and included pushback, forward taxi, and reverse taxi. Also included was drive with a single wheel, and tests without the cooling system," says Mutz. "These tests will tell us a lot about the technical feasibility of the technology and, along with the pilots' feedback, will help us to specify a prototype."

The LHT and L-3 motors were specified to 11,000 Newton-metres of torque, which provided sufficient power. To put this into perspective, a powerful automobile may have about 300 Newton-metres of torque. "The tests showed that manoeuvring the aircraft required less than the available torque," continues Mutz. "We also conducted tests by adding to the aircraft's weight, and by lowering the tyre pressures."

LHT and L-3 are now analysing operational and economic data before a decision can be made on whether to push ahead with a prototype. "Trade studies and demonstration data evaluations are in process to compare two-wheel drive, or four-wheel drive systems," says Manfred Heeg, president at L-3 magnet motors. "In terms of the added weight of the LHT and L-3 system, our target design is for it to weigh less than 300kg (660lbs)."

If a prototype is built, it will have several differences to the testing system used for the trial. "The prototype is likely to be different to the trial system. For example, two brakes were removed for the trial, but this cannot be repeated for the prototype," explains Mutz.

In terms of implementation, no system is likely to be in operation before 2016. "The realistic goal for entry into service is on the A320neo in 2016," says Mutz, "but we are looking to verify the potential for all customers and aircraft models."

Safran & Honeywell

An alternative to WheelTug or the LHT and L-3 system is the self-taxi system currently being developed by Safran and Honeywell. "By using the APU generator to power motors in the main wheels, the EGTS allows aircraft to taxi without relying on its main propulsion engines," says Davis. "Each of the outboard main wheels is equipped with an electric motor, reduction gearbox and clutch assembly to drive the aircraft. The utilisation of unique power electronics and system controllers gives pilots total control of the aircraft's speed, direction and braking during taxi operations."

Similarly to the LHT and L-3 system, the Safran/Honeywell EGTS will use electric motors in the main landing gear, as opposed to the nose-gear-powered WheelTug system. "This is because our analysis shows that aircraft weight distribution and traction available at the nose wheel do not support the required performance," says Davis.

Safran and Honeywell recently began testing the EGTS in November 2011, but do not expect the system to be entering service before 2016. "Safran has begun an initial series of tests, on a recently acquired A320, which will serve to evaluate runway conditions and calculate the necessary loads needed for moving the aircraft on the ground," says Davis. The EGTS development, however, will not just be limited to the A320. "Honeywell and Safran intend to focus on a wide range of narrowbody aircraft," added Davis. easyJet announced that it will be the first airline to support the development and trial of the Safran/Honeywell EGTS, with the first operational trials scheduled to begin in 2013.

DLR

The final self-taxi system under development is that by DLR, again in co-operation with Lufthansa Technik, and also Airbus. "DLR has developed an emission-free electrical nosewheel taxi system as a technology prototype," says Dr Josef Kallo, project manager of electric taxiing at the DLR Institute of Technical Thermodynamics. "DLR will not produce or further qualify this system, and this should be done by an industrial partner."

Again, the objective of the exercise was to prove the technical feasibility of DLR's self-taxi system. "Airbus had the major task in system integration and safety calculations and Lufthansa Technik made the nose-wheel drive integration," adds Kallo.

The DLR self-taxi system is, therefore, a nose-gear driven system, like WheelTug. The system was tested on an A320 in June/July 2011 at Airbus's Finkenwerder facility in Hamburg.

The DLR self-taxi system differs from the others, because it uses power from fuel cells, and not the APU or the main engines. The fuel cell utilises hydrogen as the power source. "The hydrogen is directly used in an electrochemical reaction at low temperatures (80°C), without burning fuel. The reaction is totally emission-free. No NOx or CO2 is emitted, and only water vapour is produced," says Kallo. "The oxygen from the air is used for the reaction."

The utilisation of the fuel cell is not confined to powering the nose wheel for self-taxiing. "As a multi-functional fuel cell, providing electrical energy, it produces water and inert gas. Inert gas can be used as a fire-suppressing medium in kerosene tanks or cargo areas on the aircraft," explains Kallo. "The water can be utilised for the aircraft's lavatories. The electrical energy can be used for the energy net in aircraft, but also for an emergency power system to replace the ram air turbine."

After proving the success of this technology, DLR hopes that an industrial partner can take development further towards certification, and then entry into service. "We demonstrated the functionality and the possibility to apply high torques on the nose wheel and move the aircraft emission-free on the ground by using a fuel cell," says Kallo.

Fuel savings

The main benefit of all of the self-taxi systems being developed is the potential fuel savings generated by not using the main engines during taxi. For example, using a conservative estimate of five minutes' engine warm-up time, and the US average of 25 minutes' taxi per flight, an airline will save 20 minutes of taxiing fuel.

For those systems powered by the APU, such as WheelTug and the LHT and L-3 self-taxi system, taxi fuel will still be required to run the APU. "The ratio of fuel burn for dual engine taxi on an A320 to APU fuel burn is about 8:1," says Mutz. "This means that taxiing fuel required for a self-taxi system can be one-eighth of current levels for dual-engine taxi, or one-quarter for single-engine taxi. Heeg adds that: "Up to 4% of total mission fuel can be saved by using self-taxi equipment."

According to Cox, while dual-engine taxi for a 737 is 24-26lbs per minute, the APU burns only 4lbs per minute.

This is a saving of about 20lbs of fuel per minute. Using the previous example, 25 minutes of taxiing will burn only 100lbs of fuel with the APU, as opposed to 600-650lbs burnt under dual engine taxi. For those airlines that have currently adopted single-engine taxi to save fuel,

The GreenTaxi system has been developed by Lufthansa Technik and L-3 Communications in cooperation with Airbus and Fraport. The system works by magnet motors power the wheels on each of the main landing gears. The power to drive these motors is derived from the APU.

adoption of self-taxiing systems will still bring significant savings: single-engine taxiing burns 300-350lbs of fuel for 25 minutes' taxiing, still significantly higher than the 100lbs of APU fuel burn in the same period.

When this fuel saving is extrapolated out over a year, the potential saving in fuel burn is great. Using the US average of 4.5 flight cycles (FC) per day for a narrowbody aircraft, and 25 minutes' taxiing per cycle, the fuel savings against dual engine taxi are 2,250-2,475lbs per day. This is equal to 821,250-903,375lbs or 122,000-135,000 US Gallons (USG) per year. With fuel prices ever increasing, this represents thousands of dollars per aircraft in potential savings for airlines. Savings against single-engine taxi operations in this scenario are 900-1,125lbs per day, equal to 328,500-410,625lbs or 49,000-61,000USG per year.

These savings have been calculated against the US averages, but for those airlines operating from more congested airports, or which utilise their aircraft at a higher rate than 4.5FC per day, the savings potential is still greater. For example, for flights operating to/from highly congested airports such as London Heathrow (LHR), taxi times can be as high as 60 minutes. This means that even greater fuel savings can be achieved by using a self-taxi system from these airports, since close to an hour of main engine taxiing fuel can be saved. Aircraft with high utilisation rates will also spend more time taxiing, regardless of airport congestion. This means that higher fuel savings can be realised by their operators.

Safran and Honeywell are similarly optimistic about these potential fuel savings. "Current industry analysis indicates that the world's short-haul aircraft consume 5 million tons of fuel per year during taxi operations. Honeywell and Safran estimate that EGTS will save customers a significant portion of the up to 4% of the total flight fuel currently consumed during taxi operations," says Davis.

DLR echoes this optimism on fuel savings. "An A320 operating at 5-7FC per day can save up to 300-700kg (100-230USG) of kerosene per day, depending on airport taxi times," says Kallo.

It is important to note, however, that each self-taxi system will add a certain amount of weight to the aircraft, which will increase fuel burn in flight.

The WheelTug system, for example, adds about 300lbs to an aircraft. When considered against the potential fuel savings, however, because there is no taxi fuel uncertainty, meaning no extra taxi fuel needs to be carried, self-taxi systems can be weight-neutral, or can save weight on current procedures. A self-taxi system will be weight-neutral when the weight of fuel burnt by the APU added to the physical weight of the self-taxi system is equal to the amount of taxi fuel saved from not using either single- or dual-engine taxi.

"For dual-engine taxi, the WheelTug system is flight weight-neutral when there is 14 minutes of taxi fuel margin on-board. At less than 14 minutes, WheelTug overall adds weight; while at longer than 14 minutes, WheelTug overall reduces weight," explains Cox. "At hub airports like LHR or Newark, aircraft often carry 60 minutes of taxi fuel margin. This means that WheelTug would reduce the flight weight of a dual-engine taxi aircraft by as much as 1,000lbs." The same theory can be applied for single-engine taxiing, whereby the self-taxi system would be weight-neutral when taxi times are a little longer. The WheelTug system will be weight-neutral with 23 minutes of taxi fuel margin carried for single-engine taxi.

Maintenance savings

Another key area for savings from a self-taxi system is through a reduction in maintenance costs of an aircraft installed with self-taxi equipment. This is achieved by reductions in three areas: engine use; foreign object damage (FOD) in the engines; and wheel brake usage.

First, self-taxi equipment will reduce the total number of hours of engine operation. This is because the aircraft will not be using the engines to taxi. The aircraft will only have to start its engines three to five minutes before take-off, and can shut them down after the aircraft has landed and has had time for its engines to cool down, which is typically three minutes depending on the use of reverse thrust.

This is a benefit being analysed by all of the self-taxi developers. "As part of the overall project, we are evaluating the concepts of operation with the use of Lufthansa's test crew and technical pilots to develop the engine warm-up and cool-down procedures and timing," says Heeg. "As no stopping will be required after landing, the GreenTaxi system will be able to engage the wheel at low speed, thereby enabling engine shut down while moving."

Using the previous example, with the US average of a 25-minute taxi per FC, a conservative average of 20 minutes of engine operation can be cut per FC in the US. With the US narrowbody average of 4.5FC per day, engine usage is cut by 90 minutes per day. Over a year this adds up to 547.5 engine flight hours (EFH) saved. Again, the number of saved EFH will be higher for those airlines with higher rates of aircraft utilisation and/or which operate from congested airports with longer taxi times. DLR estimates that reductions in engine usage could be even higher. "600-1,200EFH per aircraft could be saved each year," says Kallo.

Less engine usage means longer removal intervals can be achieved for

The ability to self-reverse without the use of a pushback tug not only saves time, but also avoids the costs associated with using a pushback tug. These are estimated to be as high as $100 per pushback.

engines, providing savings for an airline if they adopt self-taxi equipment. This is particularly true for airlines with power-by-the-hour (PBH) engine maintenance contracts.

"WheelTug can drastically reduce EFH, sometimes even by as much as half," claims Cox. "Aircraft used in regional service, especially to/from congested hubs, often run the engines more on the ground than they spend flying."

The second type of maintenance savings that self-taxi equipment can provide is through reduction in FOD in the engines. The intake of FOD damages engine parts and results in expensive repairs and shop visits. With self-taxi equipment, the engines only operate on the ground near the runway. This means there is less likelihood of FOD intake and damage on the ground, thereby reducing engine maintenance and its cost.

"By drastically reducing FOD where it occurs most frequently (near the stand), the turbine blades sustain less damage and so generally achieve longer intervals between blending repairs and replacement," says Cox. "The lower use of blending repairs has an added benefit of increased engine efficiency on a self-taxi-equipped aircraft.

"WheelTug reduces the degradation of engine efficiency from FOD damage; and the aircraft will also be more efficient in flight than the same aircraft without WheelTug on-board," adds Cox. This further adds to the savings gained through the use of self-taxi equipment.

Reduction in wheel brake usage is the third maintenance saving an airline can achieve from self-taxi equipment. "Brake life could be increased by up to 20%," says Heeg.

Using the main engines in conventional taxi causes pilots to 'ride' the brakes to control aircraft speed. This is because even when the engines are idle, they are providing a forward driving force, which needs to be countered by the wheel brakes to keep the aircraft at a standstill and then to control aircraft speed on the ground. This means that on taxi-out, the brakes are used almost constantly while the engines are running. With traditional taxiing methods, this will be from the gate area to the runway, which can be up to 60 minutes at congested airports.

Using self-taxi equipment, pilots only use the brakes to slow down/stop, and not to counter the engines. This reduces brake wear, and increases the intervals between brake removals and so reduces maintenance costs relating to brakes. "Carbon brake units are overhauled about once every 2,000 flight cycles (FC). Total cost for a shipset of four brakes is about $144,000," explains Cox.

This is equal to a cost of $72 per FC. A 20% reduction in brake wear means a saving of about $14 per FC. Most of this saving is incurred on taxi-out, as carbon brakes wear poorly when cold. "The industry estimates that 30% of brake wear occurs in taxi-out, but only 5% in taxi-in," says Cox.

Time savings

Time savings are another key benefit that can be derived from the use of self-taxi equipment. As discussed, there will be no need for a tug vehicle, nor waiting time in the gate area or apron for the engine(s) to warm up before commencing taxi. This means aircraft can taxi immediately after backing from the gate and proceed immediately to the runway for take-off, with no waiting time. "Aircraft equipped with the EGTS will be able to 'pushback and go' more quickly," Davis explains, "reducing gate and tarmac congestion, improving on time departure performance and saving valuable time on the ground. "

WheelTug anticipates that average total time savings of self-taxiing against traditional taxiing are about 2.50 minutes per FC. "On a per-gate basis, pushback is delayed by 130 seconds for a lift-tug, 150 seconds for a tow bar tug, and 210 seconds for a drive-through stand," explains Cox.

Using the US average of 4.5FC per day, this means a time saving of 11.25 minutes per day, and 68.44 hours per year. This will be even higher for those aircraft with higher utilisation levels than this.

Once self-taxi equipped aircraft are in service, therefore, scheduling tweaks could be made to improve their utilisation. This is because they currently have the time available in their schedules to make these savings. This is supported by Davis, who states, "Aircraft equipped with the EGTS will be able to pushback and go up to two minutes sooner, reducing gate and apron congestion."

A further benefit is that nearby aircraft on the apron can pushback at the same time as self-taxi-equipped aircraft, since there is no disruptive jet engine blast to endanger ground staff. This means that apron congestion can be reduced, and on-time departure performances improved.

Tug-related delays are also completely eliminated through the use of self-taxi equipment. Tug-related availability issues and hook-up problems are not common but can happen from time to time, creating extra cost for an airline.

Other savings

There are several other savings to be gained through the use of self-taxi equipment aside from the fuel, maintenance and time savings possible. The first of these is reduced noise. As self-taxi-equipped aircraft will only have to start their engines near the runway, jet engine noise will be reduced around the

The GreenTaxi system provides 11,000 Newton-metres of torque power. Test data is being evaluated prior to deciding whether or not to develop a prototype.

terminal area, benefiting airport ground staff and local residents.

This noise reduction will be of particular benefit to those airlines operating at curfew-controlled airports. About 70% of airports in the European Union (EU) are curfew-controlled, as well as key airports in the US such as New York LaGuardia and Washington National. If the curfew time is 6:30AM for example, jet engines cannot be started until that time. Under current taxiing methods, this means that aircraft can only leave the gate area at this time, and will not get to the runway for take-off for several minutes after this, say at 6:45AM. Self-taxi-equipped aircraft can taxi to the runway before the curfew time, start their engines at curfew time, at the runway, and take off soon after. "This effectively adds 5-10 slots per runway, and is only available to airlines operating WheelTug," says Cox. The same will be true of operators of other types of self-taxi equipment.

This adds significant value to the self-taxi equipment for those airlines regularly operating from curfew-constrained hubs and airports. Slots at premium hubs can be worth $3 million or more, so the ability to add these slots through the use of self-taxi equipment represents a significant benefit to those airlines that are first to make use of this. "The creation of take-off slots at curfew controlled airports is a benefit we are particularly proud of," adds Cox.

A reduction in carbon emissions is another benefit of self-taxi equipment. This is directly related to the fuel savings: less fuel will be burnt using self-taxi equipment, and fewer emissions will be created. The environmental benefit is important from a moral and ethical point of view, but a reduction in emissions can also benefit an airline financially. With the EU emissions trading scheme (ETS) affecting commercial aviation from 2012, airlines flying to, from or within the EU will be forced to pay for their carbon emissions. Using self-taxi equipment will reduce fuel burn, thus reducing carbon emissions and ETS payments.

Insurance costs can also be reduced through the use of self-taxi equipment. "Since no person will have reason to go near the nose gear with a large piece of heavy equipment, and because there will be no pins to get stuck and no use of fingers to try and 'unstick' the pins, both insurance for the plane and for workers will go down," explains Cox. "Furthermore, nothing can get sucked into an engine that is not running, or blown over by an engine that is not running. These dangers are eliminated and risk is reduced by using WheelTug." It can be expected that other self-taxi systems will provide similar benefits.

The ability to reverse with self-taxi equipment has an additional safety benefit. "If an aircraft's 'nose' is too far onto a runway path, the pilot doesn't have to race across the path to get out of the way, he can simply 'back up' with WheelTug," explains Cox. This will increase safety because in this situation, the aircraft will no longer have to rush across the runway to get out of the way, which may cause a go-around for another landing aircraft. This reversing can even decrease fuel burn in these situations. "This sort of 'expedite' situation requires less fuel by the aircraft if it moves with WheelTug compared to the amount used with a hard thrust of its engines," says Cox.

Airline suitability

As has been discussed, the majority of benefits from the use of self-taxi equipment is realised for aircraft when they are on the ground. Logically, therefore, this means that self-taxi equipment will be of highest benefit for aircraft that spend significant time taxiing. This means that two particular types of airline operation will gain most by implementing self-taxi equipment.

The first of these are airlines that have high utilisation combined with a higher number of cycles. Although the US average is 4.5FC per day, many airlines achieve more than this, particularly low-cost carriers (LCCs). Some LCCs might be operating 7-8FC per day, meaning seven or eight taxi-outs and taxi-ins. This adds up to a significant amount of taxi time, and therefore fuel. Self-taxi equipment would provide the greatest savings for airlines using this kind of operation. "As taxiing makes up a greater percentage of total aircraft use for short-haul flights, taxiing costs become more of a concern for operators. Honeywell and Safran will focus on the use of EGTS primarily for short-range flights," says Davis.

Since the vast majority of short-haul, high-utilisation airlines use narrowbody jets, it is no surprise that the initial developments and tests of self-taxi equipment have been on these aircraft

The combined savings of lower fuel, reduced engine maintenance & brake wear, and zero pushback tug charges are claimed to be as high as $800,000 per year.

types, such as the A320 and 737. The LHT and L-3 system and Safran/Honeywell's EGTS were tested on A320s, while WheelTug will be first certified on the 737NG. Having said this, however, none of these developers are ruling out other types of operation or aircraft types. "The savings are greatest for aircraft that spend more time on the ground, engines running," says Cox. "Typically these are narrowbodies, but it would include A330s in Asia, for example, where A330s are used for short-haul operations, and even larger widebodies flying between congested hubs."

In fact, WheelTug predicts that by 2020 the potential market size will be 26,000-plus aircraft. This comprises 7,000 or more 737NGs, 9,000-plus A320s, 5,000-plus regional jets, and 5,000 or more older aircraft, such as 737 classics and 757s. Widebodied aircraft are predicted to follow, but WheelTug advises this will be customer-driven.

The second type of airline operation that self-taxi equipment will particularly benefit is those airlines that operate from highly congested airports. Here, taxi times may be longer due to waiting times to take-off, runway constraints and the physical size of large airports. This mostly affects legacy carriers operating from large, congested hubs such as London Heathrow or New York JFK. Airlines that combine both high-utilisation, short-haul operations and who pass through congested airports will therefore gain most from the use of self-taxi equipment.

Costs

Despite all the various benefits that self-taxi equipment can provide for an airline, there are associated costs, starting with acquisition costs.

The LHT and L-3, Safran/Honeywell, and DLR systems are too early in their development to be able to detail acquisition costs.

However, WheelTug, which expects to have entry into service within 18 months, says that WheelTug will require no capital expenditure upfront. The equipment will be leased to the customer. It will also be installed free of charge.

As the customer begins using the WheelTug product, and begins to make savings, WheelTug charges the customer an amount equal to half of the savings it realises. Both parties, therefore, stand to make revenue from the WheelTug product. This shows significant confidence by WheelTug in the product to deliver the savings discussed in this article. WheelTug offers a guarantee that if a customer is unhappy with the product, it can be quickly removed and taken back by WheelTug. Removal can be done overnight and the customer simply goes back to conventional taxiing.

WheelTug is also be prepared to offer a PBH, or power-by-cycle contract, in a similar manner to engine contracts.

On-going maintenance costs are the second type of cost that may rise, as a result of adding a new system to an aircraft. All the self-taxi systems are relatively simple sets of equipment, however, and are not expected to add much to an aircraft's overall maintenance requirements. WheelTug, as part of its lease agreement with airlines will cover the on-going maintenance costs of the system and so will not be an added cost to the customer.

Increased APU maintenance, however, may be more costly. "It is expected that WheelTug will double the number of cycles that the APU currently undergoes, because the APU would run on taxi-in, as well as during taxi-out. This is one of the few 'costs' of using WheelTug," explains Cox. This is likely to be the case for all APU based self-taxi systems.

Summary

In summary, therefore, significant savings can be achieved through the use of self-taxi equipment. These will be from fuel reductions, savings in engine and wheel brake maintenance, shorter taxi times and improved aircraft maintenance, reduced noise reductions, cuts in carbon and other gaseous emissions, the creation of slots at curfew-controlled airports, and insurance savings.

Airlines that have high utilisations and operate a high number of FC, or that operate from congested airports, or a combination of the two, are likely to benefit most.

"Overall, EGTS has projected typical savings of up to $200,000 per aircraft per year on fuel and other operating costs," says Davis. "The system will also eliminate the need for pushback tugs and associated equipment costs for ground operations, and taxes related to on-ground carbon emissions."

The cost of a pushback tug can be in the region of $100 per FC, and so the savings for each aircraft can be $150,000-200,000 per year.

WheelTug feels the combined savings could be even higher than this. "Over $500,000 per aircraft per year in savings can be achieved through the use of WheelTug. In some cases the savings can be as high as $800,000 per plane per year," says Cox.

This means that there is a compelling case for airlines to adopt self-taxi systems. With many things in aviation, however, adoption of new technologies does take time, but with so many potential savings on offer, self-taxi systems will become increasingly hard to ignore. AC