

Ground operations can be a major contributor to flight delays, which can lead to dissatisfied passengers and additional costs for airlines. A number of technological solutions have been developed to improve the efficiency of ground operations and minimise delays. Some of these solutions are summarised here. Nick Preston investigates.

Solutions for improving ground operations efficiency

Airlines are constantly striving to improve operational efficiencies, often by focusing on methods for reducing in-flight fuel burn and related costs. Another area that can optimise operations is on the ground, between flight sectors.

Typical ground operations and turnaround processes are discussed here. Some of the solutions and strategies available for optimising ground operations processes, thereby improving rates of aircraft utilisation, are identified.

Aircraft turnaround process

WheelTug defines the time an aircraft spends on the ground between an arrival and its next departure, in terms of two sub-categories: total ground time (TGT) and turnaround time (TAT). TGT covers the entire period from touchdown to the next take-off, including the time required to taxi-in and out. TAT covers the on-block, off-block period, or the time taken between parking on the stand and starting pushback for the next departure.

“There are five main categories of tasks in the turnaround process,” says Martin Harrison, global managing director, airlines, aerospace and MRO at ICE. “These are: disembarkation; servicing; security checks; boarding; and pushback/air traffic control (ATC) clearance. Each category features multiple sub-tasks. For example, servicing includes cleaning, catering and refuelling.”

easyJet lists its main turnaround functions as: customer disembarkation; baggage unloading; cabin tidy and security check; customer boarding; baggage loading; refuelling; water and waste servicing; baggage and customer reconciliation; and flightcrew preparation. It says that these task groups are broken down into 360 different sub-tasks. According to easyJet’s procedures, the turnaround period finishes once all doors and holds are closed, the parking brake is off and the aircraft is moving at

more than three kilometres per hour (kmph), either under its own power, or by being pushed back by a tug. In common with some operators, easyJet does not consider the pushback process as part of the turnaround, but efficiency gains in this area can still bring benefits since they could reduce TGT. WheelTug suggests that airlines have not previously focused on improving pushback efficiencies due to a reliance on ground-handlers.

Influencing factors

A number of factors can influence an airline’s turnaround processes and TATs, including the airline business model, on-board service, aircraft size, and the airports and routes being served.

Delta Air Lines says variables such as aircraft size, hub versus spoke airports, and international versus domestic routes all influence the length of a turnaround.

Low-cost carriers (LCCs) and those operating mainly point-to-point networks are likely to have shorter average TATs than full-service airlines operating hub-and-spoke systems. Short TATs are a principal strategy of the low-cost business model and are designed to maximise aircraft utilisation. Full-service operators may have longer TATs, since their schedules are often designed around providing connections at a hub airport. The turnaround process may therefore be governed more by schedule requirements, than by a desire to minimise TAT.

Harrison points out that full-service airlines are more likely to need a heavier catering service than LCCs, which could add to their TATs.

A widebody’s extra capacity means that it will require a longer TAT than a narrowbody. For example, many of the standard turnaround processes, such as disembarkation and loading tasks, and servicing functions, like cleaning and catering, will take longer on a widebody, while its longer range and fuel capacity mean that refuelling will also take longer.

“Widebody ground times for full-service carriers are often driven by commercial scheduling requirements, rather than the turnaround process,” says Harrison. “Widebodies operating long-haul sectors can be on the ground for six to eight hours, simply because of an airline’s preferred departure time. The growing number of low-cost, long-haul carriers may choose instead to minimise ground time and maximise utilisation.”

Turnaround procedures and TAT can also be influenced by an airport’s infrastructure, operating procedures and how busy it is in terms of commercial aircraft movements and passengers.

“Airport infrastructure and curfews can affect time on the ground,” says Michael Muzik, senior product manager of the weight and balance solution NetLine/Load, at Lufthansa Systems. “Turnarounds take longer at major hubs than at smaller regional airports, due to the higher complexity of hub airports. A typical LCC TAT might be 20-25 minutes at a provincial regional airport, but could take 40-45 minutes at a major hub.”

“Large airports operating near capacity might request standardised TATs from operators for gate allocation and planning purposes,” says Harrison. “At busy airports, TATs can be defined by slot availability.”

easyJet says its TATs vary by airport according to the stand infrastructure. “Our standard TAT for an A319 or A320 is 25 minutes when both the forward and aft doors can be used for disembarkation and loading,” says Philip Harbidge, operations performance manager at easyJet. “We use two doors when the parking stand allows passengers to walk to and from the aircraft; be bussed to and from the aircraft; or when a jet bridge is used for the forward door, but steps can also be used for the aft door. On stands where only one door can be used, the standard TAT increases to 30 minutes. More time is also scheduled when an airport does not allow passengers to be



on the aircraft while it is being refuelled.”

Certain route types can also influence turnaround times. There may be differences between domestic and international services, for example, related to different fuel, catering or baggage demands. “We adjust scheduled TATs according to the quantity of cabin baggage that is typically brought to the gate,” says Harbidge. “We allow more time for turnarounds on domestic Italian routes, for example, because this market tends to see high cabin bag numbers and few bags checked into the hold. A high number of cabin bags increases the time taken for boarding.”

Why efficiency matters

Ground-handling and turnaround operations can be responsible for flight delays, which result in additional costs for an airline.

“An efficient turnaround is crucial to our operation because punctuality is important to our customers,” says Harbidge at easyJet. “It also allows us to maximise aircraft utilisation which keeps costs and fares low.”

Delta says that operational reliability is a key focus across the business and a smooth, safe turnaround is at the heart of that. It adds that many aircraft fly multiple sectors in a given day, so a delay could have a compounding effect on subsequent flights. Delta claims to have demonstrated a much improved flight completion factor and delay performance in recent years, and says this has helped to drive its strong revenue performance.

“An efficient turnaround is very important for maintaining network schedules,” says Stephan Ellenberger, head of ground operations, Switzerland,

at SWISS.

“Flight delays are a serious challenge,” says Altay Fellah, vice president, business development, Aviation Division at INFORM. “According to the US Bureau of Transportation (BTS), external factors such as severe weather conditions have been the main cause of late arrivals since it started collecting data in 2003, but weather delays are now being surpassed by other factors. In more than 50% of cases, the leading reason for a delayed flight can now be traced to circumstances within the airline’s control, such as refuelling, cleaning, maintenance and crew scheduling.

“From 2005 to 2015, 28-45 million delay minutes per year were attributed to factors that were under the direct control of US airlines,” continues Fellah. “This results in billions of dollars of delay costs. In 2016 the average cost of block time for US airlines was \$62.55 per minute. A small setback in one of the turnaround processes can result in delays that are almost impossible to make up, if the problem is not identified, rectified, or at least limited early enough. The knock-on effect can lead to delays on other flights operated by the airline.”

If an aircraft is scheduled to operate multiple sectors in a single day, but is delayed on one of its first flights, the remaining flight sectors could also be affected, and the extent of the delay could get worse throughout the day, if air traffic slots are missed. Delays to one aircraft can also affect other parts of an airline’s network, especially in a hub model where an aircraft may be forced to wait for large numbers of delayed connecting passengers. “If one aircraft is delayed on the stand, the next arriving flight may be unable to enter the gate at the allocated

Turnaround time (TAT) is the time taken between parking on a stand and commencing pushback for the next departure. The turnaround process can involve hundreds of sub-tasks performed by internal staff or external service providers. Co-ordinating the various stakeholders is one of the main challenges faced by airlines.

time,” says Jan Willem Kappes, business development manager at INFORM. “It may also have to wait for ground service providers which have been delayed due to previous flights.”

Airlines incur costs as a result of flight delays, including the provision of food and refreshments, hotel accommodation or alternative flights on other carriers for delayed passengers or those that have missed connections. Airlines may also be obliged to pay compensation to delayed passengers. European Union (EU) regulation EC 261/2004 dictates the levels of compensation that should be paid to delayed passengers travelling to or from an EU member state, depending on the extent of the delay.

It is difficult to determine a global average for the delay-related costs incurred by airlines, due to the many potential variables and scenarios. “A number of studies have tried to identify the costs associated with delays, but the results have been varied,” says Harbidge.

“Airlines also need to consider customer dissatisfaction levels when evaluating the impact of delays,” says Harrison. “Customer satisfaction is one element that can influence loyalty levels and the potential for repeat business.”

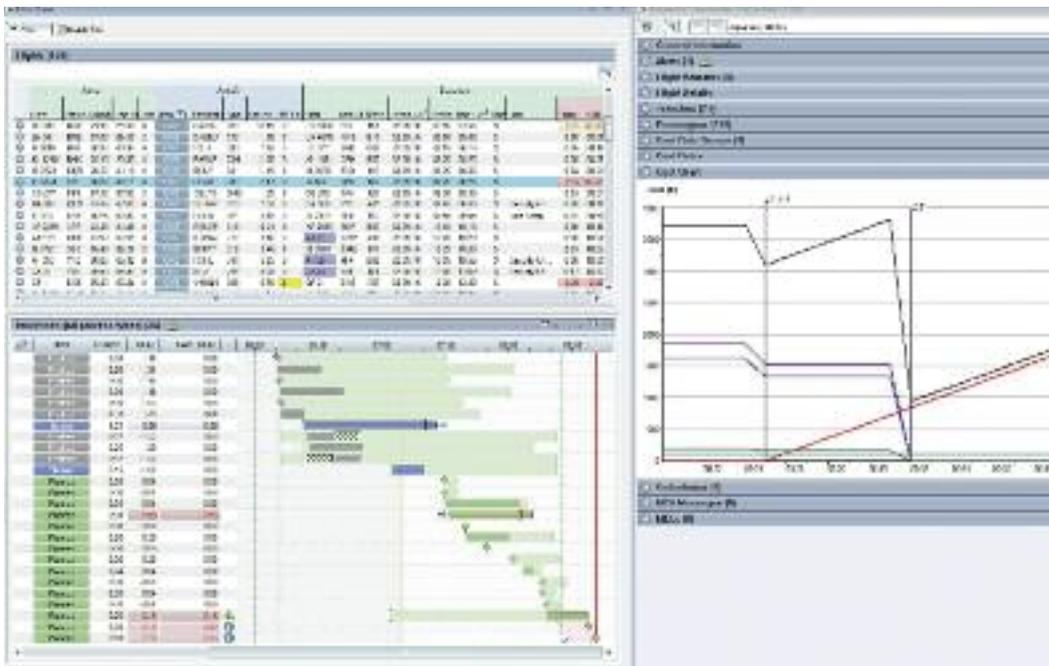
Technology solutions for improving efficiency

Some of the technology solutions available for improving efficiencies in ground operations, and reducing the potential for delays, are identified here: turnaround management software, which is designed to optimise TATs; and E-Taxi solutions, which can increase efficiency in the period from off-blocks to take-off.

This summary is not intended as a comprehensive survey of suppliers, and other solutions may be available.

Turnaround management software

“Managing an aircraft turnaround is complex,” says Harrison. “There are many functions in the turnaround process, some of which may be carried out internally by the airline, while others are outsourced to third-party ground-handling or ramp-service agents. A large number of stakeholders are involved, such as pilots, cabin crew, customer service personnel, cleaners, security



INFORM's GroundStar software suite helps airlines improve their turnaround efficiencies. The GroundStar has various modules. This includes GS HubControl, which has screens that enable an overview of the entire real-time ground operation at a single airport. The user can drill down into an individual turnaround to monitor the status of individual tasks.

agents and ramp personnel. Coordinating these functions and stakeholders is one of the main challenges of a turnaround.”

“Ideally, every turnaround needs proactive management and monitoring and I.T. solutions can be used to achieve this,” says Muzik. In a Lufthansa Systems white paper called ‘Airline Turnaround Management’, Muzik argues that many airlines are still not actively controlling their ground processes. He suggests that by implementing a turnaround management strategy, airlines could improve on-time performance and passenger satisfaction, and reduce delay costs.

Muzik recommends setting up a reference model to plan and define the main turnaround processes and process points for measuring the performance of the turnaround. Some of the central turnaround processes are defined as: de-boarding, de-loading, cleaning, catering, fuelling, boarding and loading. Each single turnaround process can be broken down into process points. For example, process points for disembarkation might include identifying the time when doors are opened and when the first and last passengers leave the aircraft. For fuelling they might include identifying when the refuelling truck arrives, when fuelling commences and when it is complete. Target times need to be defined for when each process point should begin, and dependencies between the different turnaround processes need to be identified. For instance, catering and cleaning can only start after de-boarding has finished. It is recommended that target times be clearly allocated among stakeholders for each turnaround task. Muzik also suggests that airlines should apply rules to allow for differences between individual turnaround scenarios. This might include different TAT and

process assumptions depending on the aircraft type, route and airport.

“The key to coordinating a turnaround is to identify the critical path,” says Harrison. “This involves defining the desired processes and sub-tasks, when they should start and stop, and how long each stakeholder has to perform a task. Dependencies between tasks should also be identified, which means processes that cannot be started until another has been completed.”

Muzik suggests airlines should establish service level agreements (SLAs) with third-party ground-service providers, once turnaround processes, any related rules and target completion times have been defined. The SLA might include a requirement for service providers to complete turnaround tasks within a specific time frame. “Airlines should monitor the performance of their providers, but also implement an SLA which includes financial rewards or penalties depending on whether the service provider meets their agreed performance targets,” says Muzik.

“Visible key performance indicators (KPIs) can be a useful tool for internal and third-party staff involved in the turnaround process,” says Harrison. “For third-party providers these may be based on SLAs.”

There are software solutions on the market that help airlines and ground-handling companies coordinate the turnaround process and reduce the potential for ground-handling-related delays. These solutions permit users to establish and measure bespoke turnaround processes, executed by third-party ground-handlers or airline personnel. They provide users with a real-time picture of turnaround status and the ability to compare this against set target times and SLAs. This can allow users to

intervene proactively and reallocate resources where available, to try and prevent certain tasks falling behind schedule, which, in turn could lead to delays. An example of an intervention might be to request a quick cleaning from the relevant supplier. In addition to monitoring real-time operations, turnaround management software might also include tools for identifying longer terms trends in turnaround performance.

“ICF has worked with airlines to help redesign their turnaround processes. This can also be part of a turnaround management software implementation project,” says Harrison.

INFORM – GroundStar

INFORM offers its GroundStar software solution for coordinating aircraft turnarounds. “The GroundStar suite is designed to be used by airlines, airports and ground-handling companies,” says Kappes. “It is the most comprehensive I.T. solution for optimised airline and ground-handling processes and resource management. GroundStar supports the planning, day-to-day and administrative functions of all sectors of airport ground handling, including individual and fully integrated turnaround processes, both in the terminal, and on the ramp. The software’s sophisticated algorithms help ground-handlers and airlines to optimise their operations.”

“Most of the delays to turnaround tasks are only detected after they have occurred, leading to frustration in the departure lounge, and significant expenses,” says Kappes. The GroundStar platform can resolve this by providing a real-time overview of every turnaround. “The GroundStar platform’s core operational functionality is the creation

The WheelTug solution is based on electric motors installed in each of the aircraft's nose wheels and powered by the APU. WheelTug claims its solution could save between seven and 20 minutes in total ground time between each arrival and departure.

of turnaround tasks according to constantly changing flight schedules, and the allocation of resources to carry them out," says Kappes. "The system integrates with multiple sources of information to ensure that full details of the operation are available. Its optimisation algorithms provide the most efficient deployment of resources and guarantee that contractual commitments are met and completed services recorded.

The GroundStar Suite features different software modules to support airlines, ground handlers and airports, in their strategic, tactical and operational planning and management.

GS HubControl provides the default visual displays and overviews for an airline operations control manager. "GS HubControl provides business rules and dedicated screens to enable a hub or operations controller to easily view the entire ground operation at one airport," says Kappes. The Hub View screen gives a general overview of all turnarounds taking place at a single airport. The user drills down into more detail by clicking on one of the flights to open a new display, which lists the status of each individual turnaround task. It includes a Gantt chart, showing the planned and actual durations of each task. The status of each task is indicated by a colour code, which can be defined by the user. Most users feature 'planned', 'started' and 'finished' as their task status options.

"GS HubControl constantly compares the actual task duration to a pre-defined target time," says Kappes. "Customers decide how many sub-tasks they want to define and which business rules they want to apply. Together with GS RealTime, which provides the real-time allocation of staff and equipment to turnaround tasks, GS HubControl can automatically move certain tasks along a pre-defined timeline, following a critical path. Real-time, mobile interaction between GS HubControl and staff in the field is made possible by mobility functions, which allow staff to automatically receive allocated tasks on their mobile devices and to update the status of the current tasks they are performing. "This real-time communication means that the GS HubControl user is always up to date and can react immediately if a task is not evolving as planned," says Kappes. Another source of live data is provided by GS GroundFleet, which feeds automated



timestamps and location data from ground support equipment (GSE) into GS HubControl, by tracking GPS signals.

GS BIS provides business intelligence tools for a more in-depth analysis of turnaround trends to help airlines identify and amend any tasks that are causing regular delays. Key functions of GS BIS include collecting and analysing operational data and presenting KPI data in real time to dedicated target groups.

"The GroundStar suite is 100% customisable and scalable," says Kappes. "New customers often start with only one part of the suite and add additional modules later." The GroundStar suite is installed on a user's server and can be accessed via a desktop application. There are also apps available and a web portal for staff to use on their mobile devices.

Several airlines are using the GroundStar HubControl product. These include operators in the US, Netherlands, Portugal and Scandinavia. According to INFORM, one airline reduced its ground-handling-related delay costs at a European airport by 42% within four years of implementing the GroundStar software, while a major US carrier using it improved punctuality by 9%.

Lufthansa Systems

Lufthansa Systems also offers a software solution for the real-time monitoring of aircraft turnarounds. This capability is provided by its NetLine/Hub *TurnaroundManager* solution, which is one module of the NetLine/Hub suite. NetLine/Hub is a tool for managing and optimising passenger connections. In the future, Lufthansa Systems plans to offer the *TurnaroundManager* solution as a module in its Operations Control System,

NetLine/Ops ++.

Lufthansa Systems' *TurnaroundManager* module allows users to monitor tasks in real-time and compare performance to targets established in SLAs. Users are alerted if delays occur, allowing a proactive response if they see that a task is taking longer than it should, or that it has not started on time.

"The Station Control View is the central display in *TurnaroundManager*," explains Muzik. "It provides a graphical overview of all the turnarounds taking place at a particular station or hub in the form of a Gantt chart. Every aircraft is represented by a single bar with three different segments to show the inbound, ground and outbound events.

"Users can drill down into an individual turnaround by clicking on the ground event segment in the Station Control View," continues Muzik. "This opens the Workbench which provides detailed information about each of the main turnaround tasks. The Workbench comprises different tabs, each of which is dedicated to a specific topic, including passenger connection information, crew connection information, ATC/de-icing, and ground services. Users can monitor the processes in text or graphical form. The Graphical display is a Gantt chart, which can be colour-coded to visually emphasise whether processes are on time.

"To provide real-time monitoring, *TurnaroundManager* collects data from existing automated data flows such as Aircraft Crewing and Reporting System (ACARS) messages," explains Muzik. This data is enhanced with measurements captured by handheld mobile devices used on the ramp, either by the ramp agent, or the ground-handler. Integration



WheelTug has produced a pyramid diagram to demonstrate how the use of its system could reduce the time used for pushback. The use of WheelTug with TaxiCam removes the need for ground equipment and reduces personnel required during pushback.

and information-gathering are the most challenging aspect of implementing a turnaround management project. It requires negotiation with ground-handlers, service providers and the airline's own ground-handling staff."

"It is not enough to just monitor real-time turnarounds on the day of operation," says Muzik. "While this may address an issue on the day, it will not identify the cause of a recurring problem. To achieve longer-term improvements to regular delays, business intelligence tools should be used to identify any trends, such as the fact that a certain flight or aircraft type is suffering regular turnaround delays. Business intelligence tools can be used to identify specific fields of improvement to stabilise the whole turnaround system." Lufthansa Systems also offers a business intelligence tool for monitoring turnarounds.

E-Taxi solutions

In this analysis, E-Taxi systems are categorised as providing an alternative approach to traditional driver-operated tractor tugs. The E-Taxi solution may be controlled by the flight crew or from the ground. Most E-Taxi solutions use electric rather than diesel motors.

E-Taxi systems can potentially reduce an aircraft's TGT, and provide benefits by reducing fuel burn, environmental impact and maintenance costs. E-Taxi systems can be sub-categorised into installed and non-installed solutions.

Installed solutions

There are two, installed E-Taxi programmes in development: the WheelTug solution; and the eTaxi system, which is being marketed via a collaboration between Airbus and Safran. Both solutions involve installing electric motors in an aircraft's wheels or landing

gear, so that it can taxi without using engine power, or relying on a tug vehicle.

Installed E-Taxi systems manoeuvre aircraft away from the ramp area without using main engines. Operators will, however, need to leave enough time for the engines to warm up before take-off, and to commence engine start procedures accordingly.

The WheelTug and Airbus/Safran programmes have adopted different approaches to installed E-Taxi solutions.

WheelTug

The WheelTug E-Taxi solution is based on two electric motors, with one installed in each of the aircraft's two nose wheels. Power for these motors is supplied from the aircraft's auxiliary power unit (APU). The WheelTug system can move an aircraft backward and forward, without using the aircraft's engines. An aircraft with the WheelTug solution installed will, therefore, be able to enter a stand, push back and taxi without using the aircraft's engines or a tractor tug. The main aim of the system is to optimise TGT.

The complete WheelTug system comprises a nose wheel assembly containing the electric motors, several avionics boxes and a dedicated flight deck control panel. The control panel is used to turn the system on and off, and to apply the desired forward or reverse movement. Steering is controlled using the aircraft's steering tiller. There is an optional feature called TaxiCam, which has a set of cameras to provide the pilot with exterior situational awareness for taxiing purposes, via a live feed to a cockpit display or electronic flight bag (EFB).

"The on-board system can be retrofitted, and easily installed and removed in one overnight maintenance visit," says Isaiah Cox, chief executive

officer at WheelTug.

The WheelTug solution has been in development for more than a decade. "We have used this time to modify and refine the design," continues Cox. "One change we have made is to reduce the size of the wheel assembly by reducing the width. In late 2016 the Federal Aviation Administration (FAA) accepted our certification plan for the 737NG family. Recertifying part of the landing gear takes time, but we expect the system to be approved for operation on the 737NG family by 2019." Once WheelTug receives its first supplementary type certificate (STC), it expects to develop further STCs for the A320 family and potentially regional aircraft. Widebodies are not currently a priority, but WheelTug says it will evaluate all options.

WheelTug identifies a number of potential cost benefits that its system could provide. "The main benefit is the potential to reduce TGT," says Cox. "Others include a reduction in pushback charges, fuel expenses, insurance premiums and engine-related maintenance costs."

"We have analysed data from thousands of narrowbody flights and established that there is a correlation between TGT and an airline's operating margin," claims Cox. "Airlines with shorter TGTs tend to have higher operating margins. Reducing ground time will increase aircraft utilisation. Our analysis shows that the average pushback time for a narrowbody is eight minutes from the point at which the aircraft is ready to push back, to the moment it actually starts to taxi forward under engine power. For a typical nose-in parking scenario, we estimate that an aircraft with the WheelTug system could complete the same manoeuvre in one minute, providing a TGT saving of seven minutes per flight."

WheelTug has produced a chart comparing the traditional pushback process with proposed operations using its own system. The chart shows that an aircraft with the WheelTug system would have no need for GSE, would require fewer personnel and processes than the traditional approach, and that it would have fewer safety factors to consider. An aircraft with the WheelTug system would not have to wait for a tug to become available or for the coupling and uncoupling processes to take place. It would also not be necessary to go



through the engine start-up procedures during the pushback, with engines started while the aircraft is taxiing out instead. The engine start process would still need to begin at least three to five minutes before take-off, since engines need this long to warm up.

WheelTug adds that its solution could allow aircraft to turn 90 degrees on a stand and park side-on at the gate to allow front and rear doors to be used for disembarkation and loading. This is made possible by the lack of jet blast while manoeuvring, but depends on airport stand infrastructure. Cox claims that, in addition to the seven-minute pushback time saving, this strategy could reduce TAT by 13 minutes, providing a TGT saving of up to 20 minutes. This claim is based on evidence from a trial by United Airlines' LCC subsidiary TED at Denver (DEN) in 2006. The trial involved using a Y-shaped air bridge which was connected to both the front and rear doors of the LCC's A320s to allow two-door disembarkation and loading.

Cox suggests that each minute of TGT saved, could save airlines \$50-200 per minute depending on a variety of factors, including whether passengers are flying for business or leisure, and how critical the flight is, in terms of the rest of the network. Flights that would cause more knock-on effects when delayed, would be considered more critical. TGT savings on critical flights would therefore be more valuable.

Using the WheelTug system for taxiing, rather than the aircraft's engines, could reduce costs associated with engine maintenance, foreign object debris (FOD), and brake wear. It will also reduce fuel burn during taxi. WheelTug believes its solution will reduce a 737's

taxi fuel burn by about 21lbs per minute or by up to 84% per minute, compared to a typical dual-engine taxi scenario. The WheelTug system will add about 300lbs to an aircraft's operating empty weight, but Cox suggests the lower fuel burn during taxi reduces the marginal fuel required. "An aircraft with the WheelTug system installed would be weight-neutral at take-off due to the reduced marginal fuel requirement, so it would not burn any additional fuel in flight," he claims.

WheelTug says that operators using its systems could see first-year savings of up to \$2.00 million per aircraft, rising to \$4.00 million per aircraft after five years as airlines become used to the system's benefits and begin making greater procedural changes.

WheelTug says it has received letters of intent (LOIs) from 22 airlines. It plans to lease its system to airlines under an operating lease, or a power-by-the-hour (PBH) model that includes maintenance reserves. Lease rates will be based on an airline's expected cost savings.

Airbus/Safran

Airbus and Safran announced plans to market their proposed 'eTaxi' solution in June 2017, following completion of a research and testing phase. A decision on whether to proceed with an official launch of the eTaxi system could be taken in the near future depending on airline feedback.

eTaxi uses electric motors installed in each main landing gear leg. The motors are powered by the APU, which allows an aircraft to push back and taxi without using its engines or tractor tugs.

At this stage, the eTaxi system is designed for the A320 family only,

IAI has developed the TaxiBot solution in association with TLD. There are two models of TaxiBot; the TaxiBot NB for narrowbodies and the TaxiBot WB for widebodies. IAI claims the TaxiBot can reduce pushback times, and provide, fuel and maintenance cost savings.

including classic engine option (ceo) and new engine option (neo) variants. It is proposed that the solution would be available for line fit and retrofit. There are no plans to develop the eTaxi system for widebody aircraft.

Airbus claims the eTaxi system could provide time savings of up to three minutes per pushback, since it avoids issues associated with coupling and uncoupling tow bars. It adds that users would be less exposed to ground-handling delays, such as the late arrival of a tug vehicle. Airbus also claims that the eTaxi system could reduce block fuel burn on shorter sectors by up to 4%, since aircraft will not use their engines for most of the taxi-in or out. It claims that the equivalent annual saving could be up to several hundred thousand dollars per aircraft. The installed electric motors would add weight to the aircraft, but Airbus says that this would be less than 400kg, and that the effect on in-flight fuel burn performance would be minor compared to the savings achieved on the ground. Using electric motors for taxiing, rather than aircraft engines, is also expected to reduce nitrogen oxide (NOx) and carbon monoxide (CO) emissions. Airbus adds that an additional environmental benefit would be a reduction in noise during taxiing. The eTaxi system allows engines to start up away from the ramp area, reducing the risk of engine damage from FOD.

Non-installed solutions

Non-installed solutions involve some form of ground-based pushback vehicle. They may not involve any modifications to aircraft systems. Several different designs have been developed, including tractor tugs that can be controlled from the flightdeck, and wireless remote-control vehicles that are operated by ramp personnel.

TaxiBot

TaxiBot is a series of semi-robotic, tractor tugs developed by Israel Aerospace Industries (IAI) in association with GSE manufacturer TLD. When a TaxiBot is used, the pushback operation is performed by a human operator in the cab of the tractor vehicle, although IAI is planning to automate this process. Once the pushback is complete, control of the TaxiBot vehicle is passed to the pilots

who then use the tractor vehicle, rather than the aircraft's engines, to taxi out. This is referred to as pilot control mode (PCM).

"A TaxiBot can also be used for taxiing after landing, although it is more likely to be needed for dispatch," says Eran Tamir, business development, IAI Lahav. "There are two main reasons for this. First, the taxi-out process usually takes longer, so there are more savings to be realised there. Second, it is logistically easier to connect a TaxiBot at the gate than on the taxiway after landing. Even so, there are likely to be scenarios with lengthy taxi-in times where TaxiBots will be used." With a fully loaded aircraft, a TaxiBot can achieve taxiing speeds of up to 23 knots.

A TaxiBot does not have a tow bar. "The nose landing gear is clamped on a rotatable turret at the centre of the tractor vehicle," says Tamir. "Pilots then control the taxiing process using the aircraft's steering tiller and brakes. The aircraft's brakes are used to control the speed of taxi. The pilot's braking command is transferred directly to the TaxiBot via sensors, thereby reducing the speed. Acceleration is achieved by releasing the brakes. Acceleration rates adapt to the pilot's braking pattern and the location of the aircraft. There is no need for a dedicated flightdeck interface,"

continues Tamir. "No modifications are required for 737 Classics or NGs. For the A320 family, a switch must be installed on the flightdeck, which mimics an 'engines-on' status for the aircraft's hydraulic systems."

There are two models of TaxiBot: the TaxiBot NB for narrowbodies, and the TaxiBot WB for widebodies. IAI has already received FAA and European Aviation Safety Agency (EASA) certification for the use of its TaxiBot NB with A320 family aircraft. It has also received EASA approval for the 737 Classic and NG, and expects to receive approval from the FAA in the near future. IAI is considering certifying the TaxiBot NB for 757s, subject to customer demand. "The TaxiBot NB was operated in a trial with Lufthansa's 737 fleet, and we are in discussion with other airlines, airports and ground-handlers," says Tamir. "Certification of the TaxiBot WB is expected in 2019."

Tamir claims a TaxiBot will provide reductions in turnaround time, fuel burn, noxious gas emissions and maintenance costs. "A TaxiBot can reduce block time and improve airport efficiency at the gate area," says Tamir. "With a TaxiBot, the aircraft does not need to be pushed back all the way to the pushback line. At many airports, aircraft are pushed to a designated 'pushback' line, where the

engine-start process is completed. This is to minimise disruption for other aircraft entering or leaving the ramp area. TaxiBot users can be pushed back a minimum distance, since they will not need to wait for engine-start, with the pilots clearing the gate area immediately in PCM mode. This could shorten the regular apron clearance time by two to three minutes for a twin-engine narrowbody, thereby reducing congestion in the gate area and delays and increasing efficiency for other aircraft as well." IAI believes that apron clearance time-savings will be bigger for a four-engine widebody.

Tamir claims that using a TaxiBot can reduce taxi-out fuel burn by 85%. He adds that CO₂ and other noxious gas emissions are reduced by 85% when compared to normal taxi-out procedures, and that noise levels are reduced by 50%. "It is expected that engine and brake wear will be reduced by using a TaxiBot, and that FOD incidents will decline by 50%," adds Tamir. "A TaxiBot can also provide more traction than an aircraft under its own power on slippery or icy surfaces, since it has eight wheels in contact with the ground, rather than the aircraft's two nose wheels."

Although the TaxiBot will not require power from the aircraft, the APU will still need to be run to provide lights and air conditioning for the cabin.

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Mototok

Mototok International GmbH has developed a series of remote, radio-controlled tug vehicles, powered by electric motors. It offers vehicles suitable for all aircraft sizes, including commercial airliners.

The SPACER 8600 is suitable for aircraft with a maximum taxi weight (MTW) of up to 95 tonnes. This covers all regional and most narrowbody aircraft. It is already certified for the 737 Classic and NG, and A320 families, and is approved for the latest generation 737 MAX and A320neo families. “British Airways has ordered 28 SPACER 8600s for its operation at London Heathrow Terminal 5,” says Marc Hemery, sales, EMEA at Mototok.

A larger vehicle, the SPACER 195, will be capable of pushback operations on larger aircraft with an MTW of up to 195 tonnes. Mototok expects this variant to be certified for ramp operations in the near future.

Mototok’s SPACER vehicles are operated by a single ramp agent with a remote control. No wing walkers are required. “The operator does not require a special licence,” says Hemery. “Anyone can use a Mototok tug after a half-day training session.”

Mototok SPACER vehicles can be connected from the front or rear of the aircraft’s nose wheel. They feature a one-click loading system, which secures a hydraulic door and clamps around the nose wheel before raising it on a platform.

Hemery says that a Mototok vehicle can provide a quicker and more manoeuvrable pushback than conventional tugs. The Mototok loading

process is quicker than connecting a tow bar, taking 10-15 seconds. The SPACER vehicle’s ability to turn an aircraft’s nose wheel on the spot also allows it to perform more precise manoeuvres.

TowFLEXX

TNA Aviation technologies has developed the TowFLEXX series of wireless, remote-controlled tug vehicles, which are powered by electric motors.

“The TowFLEXX 5-series can be used on any Bombardier, Embraer, ATR, Saab or other regional aircraft with a maximum take-off weight (MTOW) of up to 120,000lbs,” explains Michael Turwitt, co-owner and managing partner of TNA Aviation technologies. “A new TowFLEXX vehicle is being developed for larger aircraft.”

TowFLEXX vehicles are in use with a wide variety of customers including airport authorities, fixed-base operators (FBOs) general aviation flight departments and hangar owners. TNA also has five airline clients.

TowFLEXX vehicles do not use tow bars. “We use quick, soft-capture coupling technology,” explains Turwitt. “After the tug has been steered into place under the nose gear of the aircraft, the wheel cradle is closed and the entire nose gear is lifted off the ground.”

Turwitt says a TowFLEXX vehicle will provide pushback time-savings compared to traditional tractor tugs. “Docking and undocking is faster and requires less personnel, resulting in time and labour savings.” He also emphasises the added flexibility: “The equipment needs less space and can move aircraft into tight areas that are impossible to reach with traditional tow tugs.”

easyJet says that airport stand and gate infrastructure is the biggest cause of turnaround inefficiencies. Where infrastructure allows, easyJet performs disembarkation and boarding using both the front and rear doors of the aircraft. It claims that using both doors can reduce TAT by five minutes.

Other airline strategies

Airlines have been using other strategies to optimise their ground operations.

“Our turnaround process is already very efficient, but we are always looking for ways to improve by using innovative equipment, changing turnaround processes, or removing waste,” says Harbidge at easyJet. “Airport stand and gate infrastructure is the biggest driver of inefficiency. We are working with airports to ensure the necessary infrastructure is in place to permit boarding via both front and rear doors, since using two doors saves about five minutes per turn.

“We have implemented a number of processes to improve turnaround efficiency in recent years,” continues Harbidge. “These include the removal of the on-board headcount, unless this is requested by the ground or air crew. This can save three minutes and offsets the additional time required by allocated seating. We have also introduced the use of powered aircraft steps and flexible baggage belts which reduces the number of ground agents required.”

Delta says it continues to look for ways to improve the efficiency of the boarding process and the overall turnaround. It has recently implemented measures to close the boarding process five minutes before the scheduled departure time, to improve overall on-time performance. Delta is also testing biometric boarding pass technology.

It has worked with frontline teams to implement better time management strategies during the turnaround process to ensure aircraft leave on time. During pushback at hub airports like Atlanta, Delta’s ground crews now push aircraft out of the gate at a 45-degree angle, rather than completing the full 90-degree turn. It says this has reduced pushback times and improved the taxi-out.

“SWISS conducts regular continuous improvement workshops to maintain a high level of performance for turnaround activities,” says Ellenberger. “At our Zurich hub we have introduced a minimum ground time process with enlarged cleaning crews.” **AC**

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