The faster you turnaround, the quicker you get to where you are going: solutions that improve airport ground efficiency and aircraft total ground time come in many forms. Some of these solutions use machine learning and video technology to visualise the perfect turn, while others use technology to lower taxiing time.

Solutions for improving ground operations

The aircraft turnaround process is a complex orchestration of several processes that are performed simultaneously. This creates several possibilities for things to go wrong. Many vendors and teams such as cleaning, catering and passenger service agents are all involved, and each have different priorities and time constraints. The finite amount of space around the aircraft adds to the complexity. Other factors like limited terminal area space and aircraft engines also play their part in increasing total ground time (TGT).

For the airline, a regularly achieved short turnaround allows the aircraft to complete more flight sectors, improving aircraft and fleet utilisation. Quicker aircraft turnarounds also mean airports can optimise their resources and utilisation of their capacity and facilities.

Several solutions are available for airlines and airports to improve operational efficiency on the ground.

London Gatwick (LGW) airport has invested in its infrastructure and IT systems to improve overall capacity and the efficiency of ground operations.

Speaking at the Future Travel Experience (FTE) event, Neil Harvey, head of airline performance at LGW, says: "Performance at the runway is not as good as I would like. I lose about 20% of my punctuality at the airfield due to ground operations.

"It is not the airlines' fault or the ground-handlers' fault. It is also not an airspace fault, but a collective one. We are all responsible for the entire journey when an aircraft comes in, turns around and goes back out," adds Harvey.

According to Harvey, LGW is particularly interested in stable operations. The best way to optimise its runway capacity is to get aircraft to arrive and depart on time. It is not necessarily by trying to make things faster.

To help drive punctuality and stabilise ground operations, LGW has created a 'resilience-cell' team that airlines can call on for assistance. The resilience-cell team can go to an aircraft and help in its turn-around and steady the core operation.

The specialist team is presented with a list of flights that are late. They look at the data and decide to accept or decline aircraft. "The team decides whether to decline or accept based on the likelihood of gaining punctuality," says Harvey. If it accepts, the resilience-cell team can provide extra assistance for that flight's ground operations to enable the aircraft to be turned around as quickly as possible.

LGW is implementing data analytics and machine learning technology to improve ground efficiencies. Typically, when an aircraft is late, airports work to a schedule based on an airline's pre-determined minimum turnaround time, which is not always reliable. With machine learning, it is possible to calculate a turnaround time and predict when the flightdeck will call up. "Using this data, we have become very accurate at predicting when the flight will call up for pushback, rather than just using the blanket minimum turn time," says Harvey.

The benefit is that the earlier that air traffic is informed of a departure time, the better able it is to schedule and optimise the runway. In addition, passengers can be called to the gate later, making the stands more efficient.

According to Harvey, a challenge is trying to find out the milestones that are happening on the aircraft from when it arrives to when it calls up to depart. "At the moment, I am reliant on many inputs from ground ops, the flightdeck or one of my team," says Harvey. "It is better to have real-time, sensor-fed information telling me what is happening with this aircraft."

Therefore, instead of responding to the aircraft, accurate data analytics can be used to predict how long the turnaround process will take, and when the aircraft will depart.

Lufthansa Systems

The aim of turnaround time management is to contribute to the aircraft's on-time performance by improving ground operations. The overall on-time performance is important because it is a value used to measure an airline's efficiency. In order to best improve on-time performance, airlines also need to visualise how a perfect turnaround will look, and make a plan.

According to Lufthansa Systems' senior product manager Michael Muzik: "If an airline specifies a turnaround time, it will need a real-time overview and basic transparency of all the different on-ground procedures. This is the key to optimising ground operations to improve on-time performance.

"You can compare aircraft ground operations to a Formula One race team's pit-stop," says Muzik. "All involved stakeholders and their actions are dependent on each other, and all have got to be in the right position at the right time. For example, catering cannot enter the aircraft until the passengers have disembarked and so on."

Therefore, if one turnaround process encounters a problem, the knock-on-effect could lead to the aircraft missing its departure slot and being delayed.

By capturing ground operations' process data, an airline can monitor its turnaround performance in real-time and

Southwest Airlines calculated three aircraft could do the work of four if they were in and out of the gate in 10 minutes. Sometimes flight attendants and pilots chipped in by cleaning to achieve this goal.

proactively manage it. Further performance analysis can determine why some flights are always delayed. It may be possible that an airline under certain circumstances may prefer to extend, rather than shorten, the aircraft's total ground time (TGT), because on-time performance has a higher value. But usually the set-up of a turnaround management is intended to improve and shorten turnaround times, while staying operationally stable.

"Airlines that I speak to usually like to focus on the day of operations, which is important," says Muzik. "So, if there is a delay at one airport it becomes necessary to speed up ground operations at the next to catch up. But if the airline has got to do this every day for the same flight, there is clearly a problem. Long-term performance monitoring of ground operations therefore allows the root cause of the problem to be determined."

According to Muzik, the implementation of day-of-operations monitoring is to design a plan for each aircraft type, and, reference each individual task to visualise the turnaround process. As an example, the airline has to decide how much time the cleaning of a A330 should take, and the number of staff required. This also includes the definition of the dependencies, such as 'cleaning starts one minute after the last passenger de-boards'.

Then the provider's service levels on the day of operations need to be monitored. Are the cleaners on time at their position? Do they start punctually? Do they finish in time? These three measuring points have to be monitored for identifying areas of improvement.

Monitoring service levels requires two data sets. The first is the time the cleaners are scheduled to start and finish their task. The second is the actual time the cleaners start and finish their task. These two data sets have to be matched in real time to make the airline aware of possible turnaround process delays on the day of operations.

The benefit for the airline is that it can penalise a provider if it is not reaching an agreed service level. Alternatively, if the provider is exceeding service levels then the airline can credit or reward it. Steering providers to exceed agreed service levels is also part of how an airline can optimise its turnarounds.

The biggest challenge in turnaround management is collecting the actual time stamps, which can be recorded autonomously and/or be manually entered by the ramp agent, or individual providers. The manual time-stamping process is vulnerable to erroneous timings being entered.

"For our turnaround management solution, we currently use a mix of information that is gathered both manually and automatically. Ramp agents and/or providers, like caterers and cleaners, may use mobile devices to time-stamp their start and finish time," says Muzik adding, "Yet some data is recorded autonomously, so when an aircraft door opens, the aircraft will automatically send a message to the system telling it boarding has started."

Manual data-gathering is problematic for airlines, since they may involve many service providers. Additionally, human touchpoints are less accurate. "So an alternative way to fully manually input data is the use of artificial intelligence," says Muzik.

This new solution using deep machine learning is called Deep Turnaround. Employing artificial intelligence (AI), Deep Turnaround has the capability to learn by itself. If a provider's truck is always late for a particular flight, then the system will account for this delay and redefine the turnaround parameters for that particular stopover.

This new method relies on video cameras installed at the gate to enable the system to recognise which truck is arriving and when. This means Deep Turnaround can accurately timestamp individual providers' physical presence, and start and finish times automatically.

Video-streaming the turnaround process is very objective because it makes it possible to timestamp the process exactly when it happens, and not when a ramp agent or provider manually set this timestamp (based on their observations). Using cameras makes it possible to know if the fuelling truck is in position and to differentiate if somebody has started their tasks. Additionally, if five cleaners are contracted for an A350 turnaround and the provider sends four, Muzik says it will be possible to see this.

It is predicted that in future all the individual elements that make up an aircraft turnaround will be able to identify themselves and their position. It will be possible for AI to count and categorise individual providers, as well as stairways and other generic ground equipment. In future if four cleaners turn up to complete a job that is scheduled for five, the system can automatically send an alert.

"Using video means it is also possible to use big data to monitor, analyse and optimise the boarding process," says Muzik. "A camera for the jetway can count the number of passengers to determine when boarding is complete. You might want to ask about the issue of data security, but the system does not recognise a person's individual identity. It just counts the number of anonymous people boarding the aircraft."

Installing a camera at the airport gate also enables the analysis of boarding procedures, for evaluation of the most effective ones. Using this methodology, it might show that flights carrying passengers with special needs are delayed because of longer boarding times. The outcome might be to give such passengers an extra five minutes ahead of the official boarding time.

It has been discovered that the high volume of hand luggage that passengers bring on flights is also causing delays. The result is to try to influence them to check their carry-on luggage into the hold.

According to Muzik, a real improvement of the turnarounds lies with long- and mid-term perspectives. Using and analysing performance data, it is possible to determine the root cause of some process delays. Once the cause of ground delays has been identified, aircraft ground operations, and therefore overall on-time performance, can be optimised.

Honeywell Forge

Honeywell Forge for the ramp is a software system that provides a complete view of all services and their status throughout the turn. Utilising comprehensive software, Honeywell Forge can manage and optimise all aspects of ramp operations.

According to Fadi Ghourani, director of connectivity sales at Honeywell Aerospace: "Forge for the ramp provides real-time data-sharing capability between all stakeholders in the turn process, including the airline, airport and ground handlers."

The software ensures there is no wasted time or effort during the turn, and everyone can carry out their tasks as efficiently and effectively as possible, without any service conflicts or delays.

"The ramp is continually learning from the data gathered during each turn, and adjusts the requirements and plans for future turns based on its prior knowledge," says Ghourani. "Over time the system will compare performance data based on many factors."

These factors include, but are not limited, to aircraft type, passenger load, destination, airport stand location and weather. Further integration across all ground support services, as well as aircraft electronic flight bags, will allow a deeper sharing of data in real time across all stakeholders from curb to gate.

Aircraft Towing System

Aircraft Towing Systems (ATS) is an automated system that will pull aircraft to and from the runway to the airport terminal. It does this by using an ATS pull cart with an underground rail network of built-in channels beneath the taxiway.

The system's fully integrated software can control all aircraft movements between the runway and the terminal. It is forecasted that the ATS system will increase airport throughput and capacity by 30%. This is achievable because ATS has the capability to stack aircraft much closer together during taxi.

Once an aircraft has landed, it will enter the ATS system by rolling its nosewheel onto a small above-ground tow dolly. The tow dolly is powered by a 400 horsepower (HP) oil-cooled electric motorised pull cart. This is situated directly beneath the taxiway with steel plates covering the 2.6 ft deep and 4ft wide trench. The pull cart then drives along a monorail installed in the base of the trench.

Vince Howie, vice president and chief executive officer of Aircraft Towing Systems, says: "We call it a monorail system that works underground. So, the tow dolly runs above the taxiway and the pull cart pulls itself and the dolly along the underground monorail, while the aircraft is attached. The electric motor turns two hydraulic motors that drive two sets of steel wheels which are locked onto the monorail for guidance and traction."

Increasing passenger throughput is one way the WheelTug system improves ground operational efficiency. The WheelTug self-taxi system will make it permissible for narrowbodies to utilise two or more jet bridges simultaneously.

The electric motor is very efficient and powerful, and can reliably work in a compact space. The tow dolly is designed to work with aircraft ranging from small regional jets to an A380 or 747. The system has the capability to pull an aircraft weighing up to 1 million pounds. According to Howie, it is expected to have two pull cars coupled together to pull an ultra aircraft.

Hydraulic ramps lock the nosewheel into place, leaving pilots to then shut the main engines down, saving fuel and reducing emissions while leaving the auxiliary power unit (APU) running for aircraft power. "Yet the crew still maintains control of the aircraft. At any time during the taxi they can overpower the system by applying the aircraft brakes if needed," says Howie.

The system will automatically drive the aircraft to the correct gate. Once the pilots have connected the aircraft to the ATS, they will have no further actions to complete. Integrated software means that the ATS will monitor and manage all other aircraft ground movements. The system's elimination of human touch points reduces the risk of collisions with other aircraft. According to Howie, this equates to cost savings in manpower, equipment and insurance.

"At airports today, airlines sometimes have to wait for tugs, and wasted time waiting at the gate leads to aircraft missing their departure slot," says Howie. "ATS will eliminate this problem by holistically controlling all pushback and taxiing operations. As far as movements go, we have conducted research of the speeds for aircraft at different phases of the on-ground operations. We have designed the system to pull aircraft at a maximum of 20 miles-per-hour, which is the speed at which they currently taxi."

ATS will be able to push an aircraft backwards from the gate. It can do this because of the installation of a straight section of track, followed by a 90-degree turn and another straight section. The straight sections are long enough to ensure the aircraft's nosewheel is perfectly aligned. This allows the aircraft to be pushed back, starting the turn to face the aircraft the opposite direction for departure every time. It is expected that the system will be able to compensate for anomalies, such as a difference in aircraft tyre pressures and the unequal drag this creates.

Installation is broken down into two components. First is the pushback component, and the second is the airport taxiway component. "We believe that we can begin selling the pushback component in early 2020," says Howie.

For the past two years ATS has contracted Oklahoma State University to do the design and development work for the prototype. "We recently signed another contract with the Ardmore Air Park, allowing us to install the working prototype. We are aiming to get a pushback component installed by November," says Howie. "We have a company in Wichita Falls, Texas, called Precision Manufacturing and Tooling (PMT), which is building the prototype pull cart and tow dolly."

Ardmore Air Park is contracting with ATS to install the prototype and conduct testing. Since Ardmore Air Park is equipped with a 9,000 feet long runway, potential customers can fly in their own aircraft in and see the system in action. "Once we begin to get sales for the pushback portion, we can complete the entire system," says Howie.

It is expected that the pushback system will take about 30 days to install, depending on the number of gates and the amount of uninterrupted access the installers have at the airport. Working at night and covering the channel in the day will mean the airport gates will remain operational during peak periods. It is estimated it will take a year to install a full system at large airports.

To begin with, pushback will be initiated by a ramp manager or ground controller who will activate the system after receiving a signal from the aircraft's crew. The system will eventually become fully automated as ATS develops additional software upgrades. It is expected that the ATS software will fully integrate with current air traffic control (ATC) software.

According to Howie, pilots' feedback is positive because they can perform their post-flight procedures and paperwork, while the aircraft is taxiing to the gate.

WheelTug

WheelTug is a taxi system that uses an electrically-powered nosewheel which allows pilots to reverse and manoeuvre their aircraft between the airport gate and the runway. It can therefore do this without using ground-based towing equipment or running its engines. WheelTug is forecasted to reduce operational costs and improve on-time performance (OTP) by streamlining aircraft ground procedures.

The nosewheel electric motors can move the aircraft forwards or backwards at speeds up to eight mph.

An optional camera and sensor system means pilots will have enough situational awareness to allow them to perform the pushback procedure without the need for wing-walkers or a pushback tug.

The system draws its power from the aircraft's APU, so WheelTug does not require power from a ground power unit, nor does it need additional batteries on board the aircraft.

Using WheelTug for pushback and taxi will save about seven minutes from pushback to the runway. A WheelTug-equipped aircraft can park parallel to the terminal without its engines running. This will allow a narrowbody to access multiple jet-bridges, because the aircraft can safely approach gates without causing damage from jet blast.

"Our goal is to challenge the widebodied domestic market by replacing it with narrowbodies that will use multiple jet-bridges," says Cox. "Many new airport gates in the Asia Pacific have been designed for widebodies. So, a lot of these airports already have second and third jet bridges per gate waiting, which could be used by narrowbodies."

According to Cox, parallel parking and using two jet bridges will reduce turnaround time by 13 minutes and improve TGT by 20-28 minutes. Cox forecasts that passenger throughput per gate using two jet bridges will more than double the rate embarkation and disembarkation.

At some airports, a single taxiway the width of one aircraft can provision up to 20 gates. An aircraft stopped on the taxiway during pushback will block all traffic. These delays greatly affect overall airport efficiency and OTP.

"LaGuardia in New York has more than twice as many gates as Chicago Midway, but Midway handles 60% more passengers per gate," says Cox. "With two operational runways, LaGuardia Airport is taxiway- not runway-constrained."

According to Cox adding more gates or runways will not increase throughput. The source of the delay is the taxiway restrictions that only allow for one aircraft at a time. WheelTug developed a metric based on TGT. "The data that we share relating to TGT is publicly sourced," says Cox.

Information like aircraft speed and airport ground position are transmitted from the aircraft every second, so it is possible to track individual aircraft and know what speed they are travelling. This information can sometimes help to explain why a flight has missed its departure slot.

"When people talk about taxi time there is a lot of bad data within the industry. Typically, when crews close the doors and remove the parking brake, the taxi has officially started. But often the aircraft is not moving," says Cox. "Maybe the aircraft is waiting for ATC clearance or for the tug to connect or for the pushback staff to get into position. Even though the aircraft is not moving, it can still be classed as taxi-out time.

WheelTug uses three different timestamps to delineate two periods and forecast system benefits.

The first period is doors closed to starting the backward roll. "We can help improve some parts of this time, but not all of it. The main benefit is that WheelTug reduces time that is lost due to waiting for a tug or wing walker," says Cox. "From getting ATC clearance, it takes WheelTug 60 seconds to reverse and start moving forward."

The second period is backward roll to taxi forward under engine power. "Depending on the airport, you could be pushed back between 50 feet or a quarter of a mile before you can start your engines," says Cox. "With WheelTug, you can pushback, turn and taxi out, then start your engines when your jet blast is clear of the terminal area and aircraft apron.

WheelTug has looked at the numbers. "From the beginning of backward roll to the beginning of forward roll takes on average 5.5 minutes. Doors closed to backward roll, can be several more minutes. Or even longer," says Cox.

"I am asked how far you can taxi on the system. The main goal for WheelTug is to get the aircraft rolling to break away from the terminal area, then to a point where pilots can begin running the engines up," says Cox.

Along with a small control panel in the cockpit, pilots use existing aircraft controls to taxi the aircraft by WheelTug, and can learn to operate the system by a 60-minute computer-based training

IAI TaxiBot can reduce taxi out time by seven minutes for some aircraft types. By using intelligent adaptive algorithms, TaxiBot learns how to manoeuvre the aircraft at particular speeds.

course. The system can be retrofitted in the space of two overnight shop visits totalling about 150 man-hours.

When should people look for WheelTug? "We are planning on entering service in 2020. We are scheduling a full-size demonstration at Memphis Airport later in November 2019. This is so airline operators and airport representatives can see the system in action. The event will be invitation only, so anyone who would like to attend should contact us," says Cox.

IAI Taxi Bot

TaxiBot is semi-robotic pilot-controlled hybrid aircraft-towing vehicle, with the capability to drive aircraft away from the airport gate to the take-off runway. TaxiBot allows the pilot to move and manoeuvre the aircraft without its engines running at the same taxiing speed as normal taxiing (20-23kts). This reduces fuel burn while lowering engine foreign object damage (FOD) and CO2 emissions. Additionally, TaxiBot is proven to improve the operational efficiencies of an airline by reducing taxi-out-times.

It is reported that TaxiBot can improve the time taxiing between the gate and the take-off runway by an average of four minutes. As airlines introduce newer fuel-efficient aircraft with more intricate engine start-up procedures, it is forecasted that TaxiBot will reduce the taxi-out time for these types by about seven minutes.

TaxiBot achieves this by streamlining the taxi-out process, saving the need to push the aircraft all the way into an innocuous part of an airport's apron called the breakaway area. The breakaway area is a safe place for pilots to start their engines without causing damage by jet blast to other aircraft, ground equipment or personnel. With TaxiBot, an aircraft does not need to start its engines in an area where the jet blast is a hazard.

As breakaway areas are communal, and can be used to facilitate as many as 10 airport gates at a time, when an aircraft is pushed back into this area it denies pushback for other aircraft, so the resulting queue for aircraft to enter the breakout area is often the reason for a flight to depart later than scheduled.

According to the business development director at IAI, Ran Braier: "Normally it will take the crew an average of three to four minutes to start the engines for a twin-engined aircraft in the breakaway area. By using TaxiBot, the aircraft does not need to start its engines in the breakout area and block the gates for other users.

"Using TaxiBot makes the pushback shorter, because the aircraft does not need to be reversed to a faraway sterile place before it can begin to taxi forward. Once the aircraft has been pushed back the system goes from tug-driver mode to pilot-driving mode, and then the pilot will taxi the aircraft forward," says Braier.

When clear of the airport terminal, the pilot can then start the engines during any phase of taxi. "Using the TaxiBot system, the pilot can drive the aircraft out of the gate area where it is permitted to start the engines. The main point is that the pilot can start the engines when he is ready to do so and save time during the taxi-out phase," says Braier.

As the system mimics the taxiing of the aircraft under normal conditions, pilots do not need specialised training to operate TaxiBot. "The pilot uses the same controls that they would normally use while taxiing. TaxiBot also simulates the same feeling and behaves in the same way as any aircraft taxiing under normal jet power," says Braier.

Training is completed by a computer-based training kit which the pilot can study in his own time. Therefore, there is no need to take the pilot off the line for simulator training or type training with an instructor. "We are not modifying anything within the aircraft, which is quite a unique innovation," adds Braier.

Restricted rearward view means the pushback is done by the TaxiBot driver and not the pilot. Once the driver has pushed the aircraft backwards and into position, the pilot will take control. The TaxiBot driver will drive the unit back to the terminal after it has separated from the aircraft.

Taxibot has a fatigue management system that is designed to protect the nose landing gear. "During development we worked very closely with both Boeing and Airbus to design a system that does not change the limitations of the original design," says Braier. "The main limitation of any towing system is the strength introduced to the nose leg, since it is not designed to take extreme loads for long time."

Using intelligent adaptive algorithms, TaxiBot learns from pilot inputs to decide how it should best manoeuvre the aircraft, and at what speeds. According to Braier the system will automatically calculate the optimal operating taxiing speed to best serve the pilot's braking use.

TaxiBot can be fully autonomous, yet airside regulations banning such vehicles dictate that a driver remains within the system and drives it back to the gate. "When we were getting the system certified, the regulations relating to autonomous vehicles meant we had to adapt the original design to include a driver. If regulations on the use of airport vehicles change, it will be easy to upgrade TaxiBots to their original fully autonomous configuration," says Braier. AC