Several systems that allow aircraft to taxi without using engine power are being developed. Many involve installing electric motors to the nose and/or main wheels. IAI has taken a different approach with its TaxiBot solution. TaxiBot is a semi-robotic vehicle, similar to a tractor tug vehicle, controlled by the pilot, allowing the aircraft to taxi without engine power.

TaxiBot: An alternative self-taxi solution

There are several self-taxi systems currently under development, all with the potential to offer a variety of savings to airlines *(see Fuel burn reductions & savings through the use of self-taxi equipment, Aircraft Commerce, February/March 2012, page 27)*. These include fuel burn, maintenance, and time savings.

Many of these self-taxi systems involve electric motors (or other systems) to be added to the aircraft to allow it to taxi without using engine power.

IAI, however, is taking a different approach to the self-taxi concept, with its TaxiBot vehicle, which has been adapted from a conventional aircraft tug. This is currently under development and is in the final stages of testing and certification.

TaxiBot is a modified tractor tug vehicle, whose wheels and steering are controlled by the pilot when taxiing. Like the other self-taxi systems, the aircraft can be taxied out to the runway without using its own engines. At the appropriate point, the aircraft will disconnect from TaxiBot, start its engines, complete the taxi to the runway threshold and take off.

TaxiBot therefore provides many of the same benefits as the other self-taxi systems, but it differs because it does not modify or add systems to the aircraft. The TaxiBot system is examined here.

System development

TaxiBot is a tractor tug vehicle, which carries the aircraft's nose gear in a special chamber, referred to as a turret, at the back of the tractor tug.

The tractor, using its own power, then tugs the aircraft to a holding point near the runway. The steering of the tractor, however, is controlled by the pilot through the aircraft's nose-wheel steering tiller. The tractor disconnects from the aircraft at a remote site close to the taxi way, and returns to the terminal. The aircraft starts its engines in the last few minutes that it is still connected to TaxiBot, which is the only time that they are used during taxiing.

"TaxiBot is a semi-robotic vehicle controlled by the pilot," says Ran Braier, TaxiBot project director at IAI. "The nose wheels of the aircraft sit on a rotable turret located in the back of the vehicle. The pilot uses the tiller to turn the nose gear, as normal. The turning nose wheels turn the turret on the vehicle. The turning of the turret results in TaxiBot's ground wheels being steered. TaxiBot detects any braking action by the pilot on the aircraft wheel brakes, and a system in the vehicle slows its own engine in response in real-time.

"TaxiBot has a special interface to sense pilot operations and the nose gear loads in real-time and adjusts the tractor vehicle's traction, braking and steering to the pilot request," continues Braier. "This means that the TaxiBot system seems and feels the same way to a pilot as conventional taxiing."

Electrical motors generate the traction in TaxiBot, with a diesel engine used to generate the electricity. This allows TaxiBot to accelerate up to 23 knots. When cornering, however, TaxiBot's speed is limited to 10 knots.

The pilot would normally apply brakes anyway when approaching a corner, but with the automatic reduce-speed-function, TaxiBot reduces taxiing speed to 10 knots. To reduce speed, the pilot applies pressure to mainwheel brakes to slow the aircraft, and TaxiBot's sensors signal its engine to reduce power and slow down. These speeds are comparable to an aircraft taxiing conventionally under its own engine power.

A tractor driver will also be needed in the process, just as a tractor driver is required for conventional pushback. "A tractor driver is required for TaxiBot certification, although it could be robotic in the future," says Braier. "This means the pushback procedure is performed in the same way it is performed today. The TaxiBot driver will push the tractor's turret under the aircraft's nose wheels and raise the turret, since the pilot has no visibility under the aircraft. TaxiBot can transfer control between the tractor driver and the pilot, so once pushback is complete, the pilot takes control and taxies to the runway."

TaxiBot can be used during taxi-out and taxi-in, although more savings will be realised during taxi-out for departure. "Taxi-out usually takes twice as long as taxi-in," says Braier. "Taxi-out times average about 20 minutes, whereas taxi-in times average only nine. In most cases, therefore, the maximum benefit is achieved in taxi-out."

An important factor is that aircraft engines usually need a 'warm-up' period of three to five minutes before commencing the take-off roll. This means the engines must be started before reaching the holding point where the TaxiBot vehicle is disconnected, or else there is a risk of delays. "TaxiBot is designed to support engine start-up during taxi," says Braier. "The pilot will start the engines according to the warm-up time required for the aircraft, and the take-off time."

Benefits

The TaxiBot system can provide airlines with a number of benefits. "The

The key feature of the TaxiBot is the turret which holds the aircraft's nosewheel. Once attached, the pilot uses conventional tiller steering to turn the nose landing gear. Sensors in TaxiBot's turret turn its ground wheels. Pilot braking action is also sensed by TaxiBot's turret, and its wheels are slowed in response.

benefits of TaxiBot are huge," claims Braier. "This includes fuel savings, reductions in carbon dioxide emissions, reduction in foreign object debris (FOD) damage, and reduction in noise emissions at the airport. It also avoids the need to make any modifications to the aircraft."

Since fuel is such a large part of an airline's operating costs, it is one of the primary drivers of self-taxi technology, including TaxiBot. "With TaxiBot, airlines can save up to 84% of the fuel burned on the ground during taxi," explains Braier. "For example, typical 747 fuel consumption for a 17-minute taxi is one ton of fuel (1,250 litres). In comparison, for the same taxi time, TaxiBot only consumes 25–30 litres.

"Similar reductions can be seen in terms of carbon dioxide emissions. An aircraft's engines burning one ton of fuel emit 3.2 tons of carbon dioxide, while TaxiBot emits less than 60 kilograms," continues Braier.

Reduction in FOD damage is also a key benefit to using TaxiBot. The intake of FOD damages engine parts and results in expensive repairs. Using TaxiBot means the aircraft's engines are only operating on the ground near the runway. This means there is less likelihood of FOD intake and damage on the ground, because about 50% of FOD damage occurs either at the gate (10%), or on the taxiway (40%). IAI estimates that using TaxiBot can reduce FOD damage by 50%, thereby reducing engine maintenance and its costs.

All self-taxi systems offer the above benefits, however. Where TaxiBot differs is in the benefits it offers in comparison to other, on-board self-taxi systems. First, is that TaxiBot requires no modification to the aircraft, unlike other self-taxi systems that require electric motors (or other systems) to be added and installed on the aircraft to power its wheels. "Because the aircraft is not modified in any way, there is no extra weight," says Braier. "Additional weight can limit the overall fuel saved during taxiing, since the aircraft will be carrying extra weight during flight.

"Also, to operate TaxiBot, the pilot uses the same controls normally used for conventional taxiing," continues Braier. "No extra control panel is therefore required on the flightdeck." This is in comparison with other self-taxi systems, which require subsequent modifications to the flightdeck to allow the pilot to operate them."

TaxiBot also requires less training. "Since there is no change to the flightdeck, pushback procedure, or taxiing operations, pilot training on TaxiBot is easier and safer than other self-taxi systems," explains Braier.

Since other self-taxi systems are installing electric motors (or other systems) to each individual aircraft, an airline customer of these systems must purchase multiple units to equip their fleet. These systems also require maintenance. With TaxiBot, however, one TaxiBot vehicle could serve many aircraft throughout the day, so there is no need for an operator to purchase one for every aircraft in its fleet. Depending on the size of its fleet and its hub operations, an airline need only purchase a few TaxiBot vehicles for each station.

TaxiBot is also equally applicable to narrowbodied and widebodied aircraft. Other self-taxi systems, however, are currently being designed for narrowbodies first, with widebodies to come later. TaxiBot, on the other hand, will be available for all aircraft at the same time, and gives operators an opportunity to realise the benefits of self-taxi across their entire fleet.

The TaxiBot vehicle provides an additional benefit when compared to traditional towbarless tug tractors, which also house the nose gear for pushback and towing the aircraft. The use of these tractors causes fatigue damage because the force of braking is transferred to the nose gear leg. This can shorten the working life of the nose gear to less than half of what it should be. Using TaxiBot, however, means that pilots brake the aircraft using main wheel brakes and so the main landing gear legs absorb the force of braking, and none is transferred to the nose gear. This is aided by a vertical piston in the turret of TaxiBot that absorbs the braking energy.

Summary

The TaxiBot system looks set to save operators significant amounts in terms of fuel and maintenance costs. Airlines will still have to pay ground-handlers pushback fees.

TaxiBot vehicles can be purchased by airlines themselves, by airports, or by ground-handling agents. This means airlines can use TaxiBot vehicles themselves for their own aircraft, or can be rented by airlines, airports, or ground handlers to other operators.

Maintenance costs will also not be a major factor to TaxiBot operators. "Maintenance costs for TaxiBot will be similar to those of other towbarless tractors," says Braier. "They could even be lower, since TaxiBot has a diesel electric drive line and is not hydrostatic like other towbarless tractors."

TaxiBot has been demonstrated on an A340-600 and 747-400, with the narrowbody prototype currently testing on an A320-200 in Chateauroux, France.

TaxiBot is also in the process of certification for the A320 and 737NG families, which IAI expects to be granted in 2013. IAI currently has an order in process for dozens of TaxiBot units, from launch customer Bankers Capital Transportation and Leasing LLC. AC