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Electric taxiing – Taxibot system

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***Abstract*—This article focuses on system for ground manoeuvring of aircrafts called Taxibot. Article focuses on principles, advantages and disadvantages of Taxibot system with basic estimations about economical benefits of the system.**

Keywords-maneuvring of aircrafts; airport; taxiing; Taxibot.

I. INTRODUCTION

In several next years there will be marketed new systems for ground manoeuvring of aircrafts. Main reason why there are going to be these new devices is maximal effort to decrease costs and environmental impacts of aviation.

There are three main players in electric taxiing market, each provides different solution. The first one is company Wheeltug which is furthest in process of certification. Wheeltug solution is based on electric engine powered by APU on front wheel of an aircraft. Aircraft manoeuvring is strongly boosted because of possibility of power back and steep manoeuvres like whirl and twist. As well the system will provide enough torque to make possible for pilot to taxi from stand to holding point without the need of starting engines. This will provide important saves on fuel and maintenance for airline.

Second device is electric taxiing system EGTS from company Honeywell which was presented last year at Air show Paris. EGTS system is similar to Wheeltug, the difference is that Honeywell prefers powering of main wheels. This concept promises better performance in situation with bad friction situations, where there is potential risk of skid. The friction shall be much better than for Wheeltug, because there is much less mass on front wheel. Disadvantage and main construction problem of Honeywell solution is the problematic of heat. Because system has to be collocated near to brakes on main landing gear what brings several issues as lower efficiency of electric engines and high risk of overheating during rejected take-off.

Third company is part of IAI (Israeli Aircrafts Industries) which provides slightly different solution called Taxibot. Taxibot is in principle classic towing car powered by diesel, or in future versions by electric engines. What makes Taxibot special is fact that the towing tractor is controlled directly from cockpit by pilot with no need of Taxibot driver. Advantage is that Taxibot is usable for heavier aircrafts than Wheeltug or Honeywell system, because towing tractor will not have lack of power or torque in any situation.

II. TAXIBOT PRINCIPLES

As mentioned earlier, Taxibot is towing tractor with special equipment for attaching aircraft´s front wheel. The system is designed in such way that it allows tractor to slightly lift up front wheel and lock it up in position, but with possibility to control front wheel from cockpit.

When the aircraft is secured in position on Taxibot, control is handed from tractor driver to a pilot in cabin. Pilot is controlling the taxiing in same way as if he would taxi via

On engaging with the TaxiBot, the nose wheel of the aircraft enters the vehicle turret and is quickly clamped securely into position. The turret is able to rotate freely and can hence take steering and braking requests directly from the nose wheel - the flight crew can thus manoeuvre the aircraft around the taxi-ways of the airport without using the plane's main engines

Figure 1 Taxibot front wheel lock; source: IAI Taxibot

engines. Front wheel, lifted up from ground, may steer left or right, this steering is captured by sensors and transmitted to tractor control and Taxibot steers same as the aircraft would. In the same way is solved braking, when pilot uses brakes, brake action on front wheel is captured by sensor and Taxibot stops. In fact the system didn't capture the braking action on front wheel, because majority of aircrafts didn't use front wheel brakes, but the system detect higher drag of towed aircraft when pilot applies brakes, by sensoring slight deformation of front wheel position in cradle. Accelerating is solved by fact that Taxibot is always accelerating, so when pilot releases brakes Taxibot starts to move.

Attached to the tractor aircraft taxis to holding position. On holding position Taxibot releases clamps, the aircraft is released and tractor returns back to terminal controlled by its driver again. Aircraft is at holding position and may start engines.

III. ADVANTAGES

Advantages of system are mainly on the airlines side. Main savings is from fact that fuel consumption of Taxibot is much lower than fuel consumption of wide-body jet during the taxi. Actual fuel savings is dependent on aircraft and engine types. Normally it is presumed that during taxi is average thrust setting at 7% of engine performance. Fuel burn rate is more than 0.1 kg per second even for narrow body aircrafts such A320. Fuel flow of A380 with four engines operating is about 1,2 kg of fuel per second. Besides direct savings of fuel there is significant decrease of air pollution, because during taxi A380 emits about 5kg of carbon dioxide per second. Another advantage for airports is fact that immediately after pushback is Taxibot ready to taxi, eliminating bottleneck in gate areas. There may be other significant advantages such FOD prevent and lowering environmental impacts by decreasing sound level, but the main savings for airlines is fuel savings and for airports is increasing of capacity due to eliminating bottlenecks.

Figure 2 Taxibot manufacturing; source: IAI

Main advantage against other taxiing systems is that there is no mass limitation for this system. Wheeltug and EGTS are limited for lighter aircrafts because APU is not able to provide enough energy to enable electric taxiing during other power consuming activities, such as air conditioning, air bleed, lights etc. The most powerful version of Taxibot has power of 1500 HP and is capable to tow fully loaded A380 up to 20 knots, so there should be no problems with adequate power. Another minor advantage of Taxibot is the fact that there are no construction changes on aircraft and additional systems which would need maintenance. Disadvantage of Honeywell and Wheeltug system is necessity to transport the system by plane what raises fuel consumption slightly.

Taxibot also allows higher taxi speed than classic tow bar trucks. New world record was made by Taxibot in 2014 with A320 aircraft Taxibot reached speed 23 knots while taxiing. [1]

IV. DISADVANTAGES

Main disadvantage of this system is price. Price of one Taxibot is triple than price of similar towing tractor. To avoid delays airport has to be equipped with more than one Taxibot because one taxi operation takes about twenty minutes on main European airports, with pushback and preparation for operation we may presume one cycle about 40 minutes, at least. For an airport with 30 moves per hour there will be requirement of about 20 Taxibots to provide advantage for everyone, to achieve higher airport effectiveness.

Second problem is fact that there have to be some movement of Taxibots on taxiways between taxing aircrafts. Taxibots will be returning from runway holding points and in several cases there will be waiting for arriving aircraft somewhere on taxiway. Such movement of vehicles on taxiways may lead to higher risk of accident.

There is also one economical disadvantage of such system because costs of Taxibot purchase will be brought by handling operators whose have to invest large sum of money in new towing vehicles, but the saving will be benefit of airlines which would use Taxibot and which will have lower fuel consumption, there is high financial disproportion for handling operator. This conflict has to be solved by some special subsidiaries or agreement between handling company and airline. Another possible solution is purchase of Taxibot by airlines and operating of own handling on their main bases, what is model prioritised by Lufthansa.

V. IMPACTS OF TAXIBOT

For best case scenario we may estimate that fuel consumption of Taxibot will be about 5% of fuel consumption A380 during taxi. If we presumed average 7% thrust setting for A380 during taxi there will be about 0,6 USD per second save in fuel. According EUROCONTROL CODA reports is average taxi out time, on 20 main airports in Europe, about 17 minutes what makes average saving more than 600 USD for one operation. As mentioned before one operation may take about 40 minutes (taxi out time + return of tractor + waiting before start of taxi) what make possible to achieve rate 25 operations per day with 360 days in operation savings may achieve 5.4 million USD per year.

Figure 3 Wide body Taxibot testing; source:

These savings will be of course lower in other than best case scenario because of need of payment to Taxibot driver, maintenance, driver training, tires and brakes wear etc. IAI featured value ROI (return on investment) indicator 2 years seems to be reasonable in situation when Taxibot will have sufficient usage. Better return of investment is achievable on airports with higher number of movement. Average operational usage of tow tractor on regional airports often doesn´t exceed 500 hours per year. On the other hand operational time on hub airport may over exceed 5000 hours per year. And for Taxibot we may presume higher operational time than for standard tow tractor because operation is longer for taxi out time and return of vehicle from holding position. Raised cost of insurance might slight lower the saves of Taxibot system. Because Taxibot operations will be new type of operations with unskilled crew and movement on new areas of airport it is obvious that price of insurance will be higher. Today insurance costs may achieve about 10% of total operational costs of tow truck.

Taxibot system was successfully tested on Frankfurt airport by Lufthansa with very good results and in next few years there will boost in number of Taxibots used around the world, because, by words of one of Taxibot co-inventors" It Makes so much sense, I wonder why it isn't already widespread."[2] All No Technical Objection (NTO) tests and the certification tests on the B-737 and A-320 have been performed. The final certification on these aircraft is expected in 2014 [4]

Because testing continues without any information about significant problems, it is possible that system will be introduced in to active duty, before system EGTS and Wheeltug, what may bring significant advantage against these systems.

VI. Future development

Future development is focused on applications which would raise effectiveness of such system. Most obvious change in system is replacing of diesel engine with electric engines using batteries, in ground electric wires or hydrogen cells. Engine exchange from diesel to electric may bring significant saves in operation costs. According to [3] is specific fuel cost per hour operation eight times lower when using electricity. Such system is prepared for testing in 2015. More complex improvement is removing tractor driver from system and using remotely controlled or even independent tractors. This autonomous performance is dependent on highly precise position control and ability to be easily detected on surveillance systems for ATM. Remotely controlled or unmanned Taxibot is technically achievable but before use in practice there is expected very long verifying and testing. Introduction of unmanned Taxibot is estimated in early 2020, but even today it may be important during airport revitalisations to keep in mind possibility of such system and adjust new development of airport to best possible usage of such modern technologies.

If optimistic forecast of IAI fulfils there will be savings about 5,8 billions of USD generated by Taxibot. But this estimate presumes that Taxibot is going to be standard equipment on all major airports around the world, what is little bit exaggerated estimation. Real success of Taxibot system will be clear after comparison of Taxibot with EGTS/Wheeltug after all these systems will be certified, because only operational usage will show real benefits of each system in comparison to others.

VII. Conclusion

The Taxibot system is viable option for cost reduction. Optimal usage is in hub airport operation with aircrafts with high fuel consumption and high taxi out times. Necessary condition is finding of suitable model for paying handling fees. With ROI 2 years Taxibot has potential to become best selled tow truck worldwide, because ROI of classic tow truck is significantly lower. ROI of classic tow truck is dependent on average working time and based on time difference between normal pushback and whole Taxibot operation, we may assume that ROI of classic tow truck is at least twice of Taxibot´s, in any ceteris paribus case. Usage of Taxibot on narrow body

aircraft is more questionable because there will be soon powerful competition of EGTS and Wheeltug systems.

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