AERODROME CONCEPTS: TAXIBOTS

Abstract: possibility of broad introduction of the robotic tugs into daily ground operations in the aerodromes is analysed. Recent progress and future projections are considered. Certain obstacles are identified and signalized.

Many commercial pilots agree , that the terrestrial part of flight operation is often the most troublesome and stressful. It involves taxi under manual control,on the congested and sometimes complex taxiways, during which the pilots have to split their attention for simultaneously controlling the Aircraft, completing numerous checklists, avoiding ground traffic, radio communication in the busy frequency band and getting to the proper gate safely.

This is also the phase when aircraft propulsion is used particularly ineffectively , as the the turbo-fan engines are optimised for high airspeeds and air flows. GHG-emissions generated during taxi segment are the biggest contributor of all aircraft manoeuvres in the vicinity of the airport.[4].

Number of collisions of the aircaft with ground vehicles is statistically responsible for most of aviation incidents, and a source of substantial financial costs to the aviation industry.[5],[7]

Traditional pushback tractors are diesel-driven, heavy and polluting;

Various concepts to remedy the situation were considered, like autonomous electric drives for ground propulsion, airfield signalling automation and other. [2], [3]

In the recent years , a concept of robotic vehicles , usually referred to as „Taxibots" is gaining on recognition. Present state of the art in robotic vehicles proves, that their are capable of fully autonomous drive with existing sensor technology, avoiding fixed and moving obstacles.[6]. This is even easier to be programmed on the well-defined airfield. The advantages of such a solution seem obvious: possibility of extending robotic pushing/towing for complete taxi segment gives more time for the aircrafts' crews to complete check lists, program navigation computers and increase spatial awareness; it saves expensive jet fuel. Taxibots can be easily configured as battery-electric vehicles, because their weight is advantegous for better traction. Obviously, it reduces local emmissions .

There are some obstacles to quick implementation, however. Aircraft front gear is designed for vertical and axial movements, and constructed under weight limit consideration. Therefore, they are usually locked with manually inserted pins before the pushback operation. Frequent use for long towing /pushing operation would substantially overstress them. Of course, manual insertion of pins is a hinderniss for full robotization.

It seems that further progress of introduction of taxibots to the aviation requires joint action from aircraft builders to agree on common, unified system of attaching port, to be built into fuselage behind the front gear to make possible fully-robotic connecting/disconnecting of the towing arm.

There are already some market assessments for the taxibots„ projecting sound business for the manufacturers [1].

There are also research or testing programs carried out in Europe within related area. - Airbus Autonomic Taxi project (EGTS);- Lufthansa EV Tug (TaxiBot);

Among many patent applications related to the subject some are presented in Table 1.

It seems, that the future of the fully robotized ground operation of the aircraft, from run-out after landing till line-up before start is not very far.

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Table 1. Title	Publication number	Publication date	Applicant(s)
DEVICE FOR MANEUVERING AND IMMOBILIZING AN AIRCRAFT ON THE GROUND	**US2017057663 (A1)**	2017-03-02	[FR] AIRBUS (S A S)
Electric farm tractor	**USD861737 (S)**	2019-10-01	MITSUBISHI ELECTRIC [JP] CORP
Ground manipulation system and method for fixing an aircraft	**AU2018282490 (A1)**	2019-07-18	AURORA FLIGHT SCIENCES CORP
ROBOTIC REFUELLING SYSTEM FOR TACTICAL AND STRATEGIC AIRCRAFT	**USH297 (H)**	1987-07-07	[US] US AIR FORCE
AIRCRAFT AUTONOMOUS PUSHBACK	**US2019193845 (A1)**	2019-06-27	[GB] AIRBUS OPERATIONS LTD

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[2] State of the Art of Electric Taxiing Systems; P.Giangrande etal;International Conference on Electrical Systems for Aircraft, 2018 ;researchgate.org

[3] The Impact of Alternative Ground Propulsion Systems for Airliners; J.L.Campbell, J.E.Martin, Seneca College, 2016;

[4] Aircraft emissions during various flight phases;P.Glowacki,M.Kawalec; Combustion Engines. 2015, 162(3), 229-240. ISSN 2300-9896.

[5]Statistical Analysis of Ground-Related Incidents at Airports; M.Woch et al; Journal of KONES Powertrain and Transport, Vol. 25, No. 3 2018

[6] Sensor Technology in Autonomous Vehicles : A review; N.O'Mahony,L.Krpalkova et al; Signals and Systems Conference (ISSC); June 2018;www.researchgate.org;

[7] Analysis of Accidents Resulting from the Interaction of Air and Ground Vehicles at Airports ; 2021;Alexey V. Shvetsov, 10th International Conference on Air Transport – INAIR 2021,