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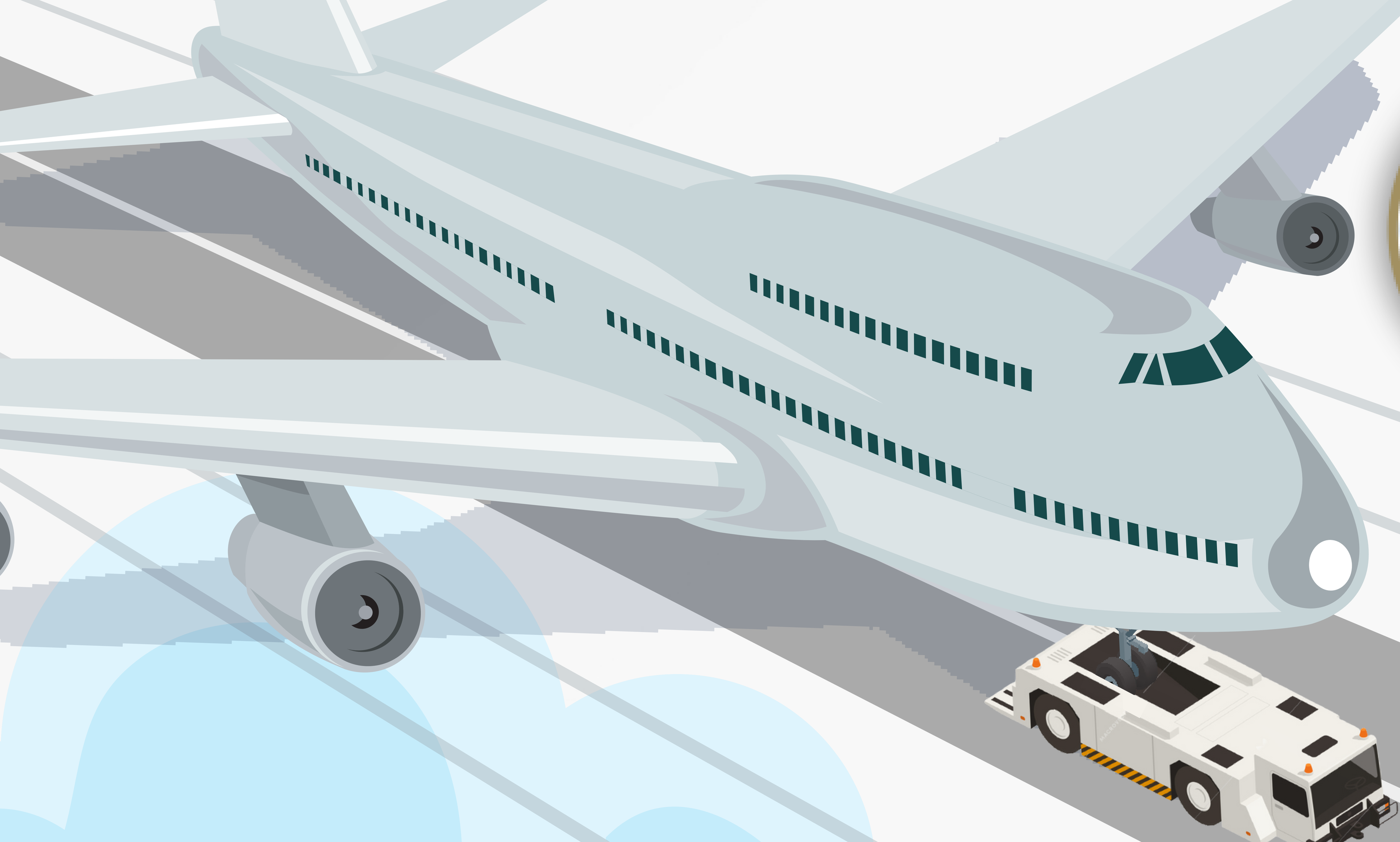
Alternatives to Reducing Aviation Fuel-Burn with Technology: Fully Electric Autonomous Taxibot

Denzil Neo
Embry-Riddle Aeronautical University



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Abstract

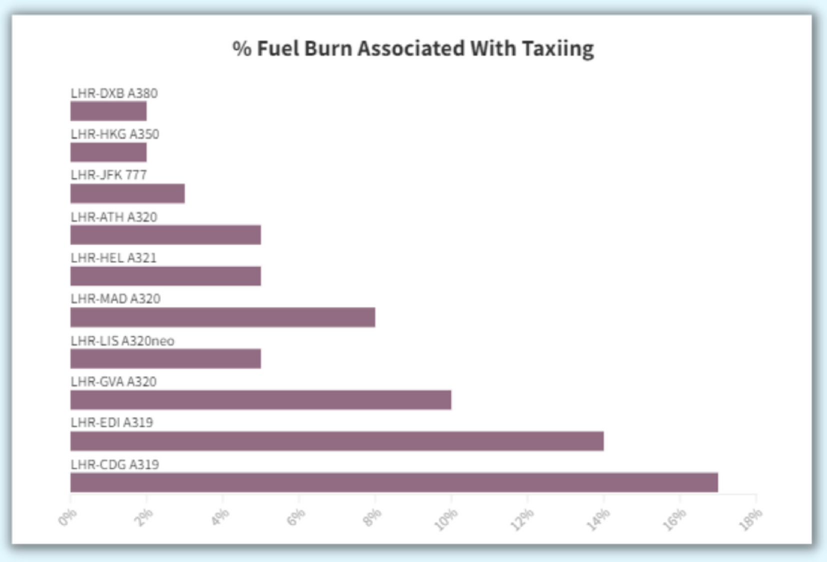
- Aircraft taxiing operations in the aerodrome were identified to consume the most jet fuel apart from the cruise phase of the flight. This was also well supported by various research associating taxi operations at large, congested airports, with high jet fuel consumption, high carbon emissions, and noise pollution. Existing literature recognised the potential to address the environmental issues of aerodrome taxi operations by operating External or Onboard Aircraft Ground Propulsion Systems (AGPS). Designed to power aircraft with sources other than their main engines, external Aircraft Ground Power Systems (AGPS) have shown the potential to significantly cut jet fuel consumption and carbon emissions by as much as 98%. They also **mitigate the risk of Foreign Object Damage (FOD) and decrease noise pollution around the aerodrome.**
- Nevertheless, current AGPS systems come with certain limitations that offer room for enhancement. These improvements can further reduce greenhouse gas emissions, elevate safety standards, and optimize human resource allocation. The proposed, Fully Electric Autonomous TaxiBot (FEAT) tractor combines two excellent external AGPS tractors with an autonomous capability, and should be developed to replace current-day traditional towtugs.
- The FEAT tractor operates by pushing back aircraft out of the stand, towing it to the runway under the pilot's control without the aircraft's main engines running, disconnecting with the aircraft short of the runway, and returning to Apron autonomously while the aircraft prepares for departure. This is a viable solution to combat the identified environmental impacts of taxi operations and improves on the limitations of existing technology.

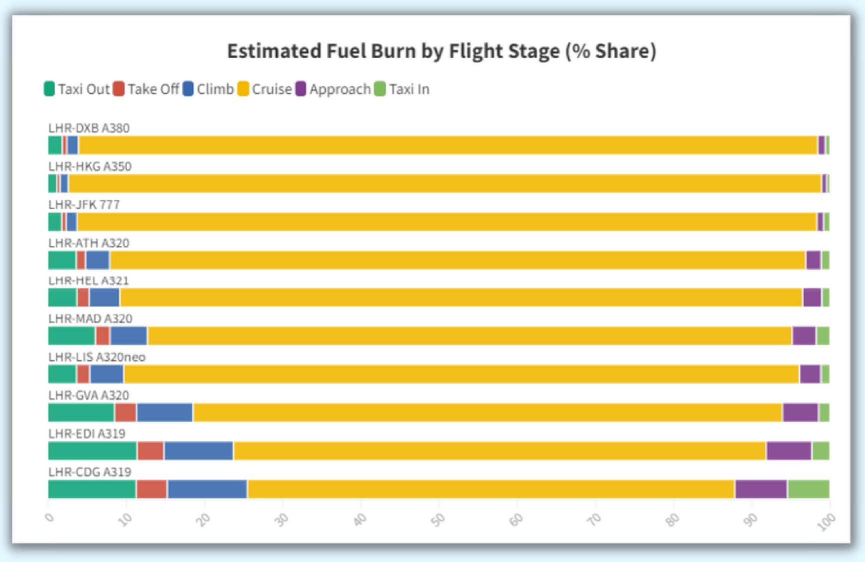
Alternatives to Reducing Aviation Fuel-Burn with Technology

In a world where air traffic is projected to double by 2040, greenhouse gas emissions from the aviation industry could increase by a factor of two to four times 2015 levels by 2050. There are numerous environmental and economic benefits to reducing aviation fuel consumption. Airlines can not only cut costs associated with aviation fuel but also make substantial contributions to reducing carbon emissions as the world progresses towards net-zero emissions. Therefore, this research focuses on the further reduction of aviation fuel consumption, particularly during ground operations in airport movement areas. Recent technological advancements, such as Artificial Intelligence (AI) and Machine Learning, as seen in Tesla Electric Vehicles, present a promising solution to reduce aviation fuel consumption in ground operations and decrease aviation carbon emissions by 2035.

Background

- Aviation is the only unique industry to provide a rapid worldwide transportation network, facilitating business growth, international trade, and tourism. As such, air traffic volumes are expected to double by 2040. This rapid growth in air traffic is expected to increase aviation fuel burn, increase carbon emissions, and congest global air space capacity if left unresolved.
- In 2021, the International Air Transport Association (IATA) 77th Annual General Meeting approved the resolution for the global aviation industry to achieve net-zero carbon emission by 2050 in alignment with the Paris Agreement for global warming not to exceed 1.5 °C. Considerable research has been conducted to reduce the aviation industry's carbon footprint and improve sustainability, fuel efficiency, and cost-saving strategies. Today, the global aviation industry produces about 2.1% of all human-induced greenhouse gas emissions, and there are ongoing initiatives to neutralise and stabilise carbon emission growth.
- With multiple research and resources invested into Sustainable Aviation Fuel (SAF), this research will focus on other aspects of the aviation industry that substantially contribute to greenhouse gas emissions. Fuel burn data shows that bout 2% to 17% of fuel burn goes to taxiing in and out of the airport. The data reveals that taxiing burns proportionately more fuel on shorter flights than on longer flights.





- Considerable research and testing have been conducted to tackle aircraft taxi fuel consumption, and among the notable solutions is Wheeltug. Wheeltug entails an electric motor affixed to the nose of the aircraft, drawing power from the Auxiliary Power Unit (APU). This research endeavors to expand the capabilities of Wheeltug, integrating automation to not only enhance safety standards but also reduce carbon emissions and slash operational costs.

Results

Table 1.

Comparison Between Various AGPS

	System Configuration	On-board weight (kg)	Max. Power (kW)	Max. Speed (kts)	Max. Towing Capacity	Potential Fuel Burn Reduction	Potential CO2 Emission Reduction
EGTS	On-board	400	120	20	A320	>75%	>75%
WheelTug		130 - 140	N/A	9	A330 / B757		
TaxiBot	External	N/A	500	23	A380 / B747	>80%	>80%
Phoenix E			291	13 - 19	A350 / B777		

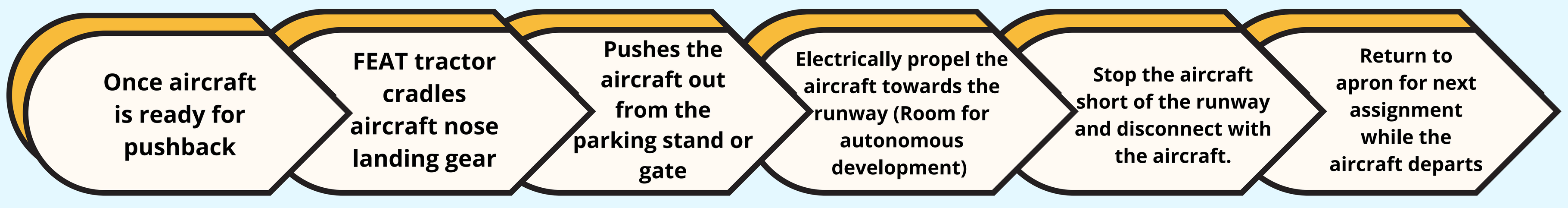
Note. This table compares the afore-selected WheelTug and Taxibot with other viable AGPS alternatives

Existing literature reveals the challenge of increasing air traffic at large airports, which include **extended aircraft taxi-out times, elevated jet fuel consumption, and high greenhouse gas emissions during taxi-out operations.** It emphasizes the need for an effective Aircraft Ground Power System (AGPS) that not only meets current needs but also has room for further development and sustainability. This research presents a comparison table that assesses various AGPS options, with a focus on WheelTug and TaxiBot.

- WheelTug is described as an effective solution for reducing pollutants; however, it is criticized for its slow taxi speed and limited compatibility with every aircraft, potentially leading to congestion at airports. The research questions the feasibility of autonomous development for Wheel Tug due to its heavy reliance on active pilot input, which presents a significant limitation to potential automation progress
- In contrast, TaxiBot is recognized for its ability to significantly reduce jet fuel consumption during taxi operations, potentially saving up to 82% of the fuel typically reserved for taxiing. It is also commended for its compatibility with a wide range of aircraft types and standard taxi speeds. The semi-robotic nature of TaxiBot is highlighted as having potential for automation, which could enhance safety and reduce the need for manual crewed operations. However, it is noted that TaxiBot, powered by a hybrid diesel-electric motor, has yet to meet carbon-neutral objectives.
- The text underscores the urgent need for the aviation industry to transition to more sustainable power sources, especially considering the industry's goal to become carbon-neutral by 2050. It acknowledges that while using current tow tugs with aircraft engines off can reduce carbon emissions, it might result in increased nitrogen dioxide emissions.
- **In conclusion, this research asserts that TaxiBot shows greater potential for development due to its advantages in automation, ease of implementation, safety, and sustainability. It suggests further research into sustainable power sources to help the aviation industry achieve its carbon-neutral objectives.**

Recommendations

- The text introduces a new generation of tow tugs, the Fully Electric, Autonomous TaxiBot (FEAT) tractor, which combines the strengths of the TaxiBot and Phoenix E while incorporating autonomous functionality. TaxiBot, a semi-robotic tractor, enables pilot-controlled taxiing, while Phoenix E is a robust electric tractor that operates without emitting greenhouse gases. The proposed solution involves electrifying the TaxiBot to reduce emissions, noise pollution, and align with the carbon-neutral objectives of the Paris Agreement.
- Furthermore, the FEAT tractor can potentially evolve into a fully autonomous system for use in both the Apron and the Aircraft Movement Area. Recent advancements in automation technology, influenced by the likes of AI and precise manufacturing robots, have transformed various industries, and aviation is no exception.
- To ensure the safety and efficiency of the FEAT tractor, it is recommended to leverage technology akin to that used in Tesla vehicles for navigational processing. Tesla vehicles employ an array of sensors, including radar, ultrasonic sensors, and cameras, to detect and react to potential obstacles. This technology could be adapted for use in the aerodrome environment, which features standardized signages, markings, and layouts.
- In practical terms, the suggested sequence of events for the FEAT tractor is as follows:



- During the towing process, the pilot retains the capability to maintain control over the taxiing operation, allowing for immediate intervention should the taxibot exhibit unexpected behavior, thereby ensuring safety. As automation technology in aviation continues to advance in reliability, there is potential for the entire taxiing operation to shift towards full autonomy, effectively reducing the workload of the pilot..

Conclusion

- With the increasing air traffic volumes anticipated to double by 2050, congestion at large international airports with increased delays and long taxi operations can be expected. This can complicate and overwhelm air traffic deconfliction initiatives, increase jet engine idle time, generate noise pollution, increase jet fuel consumption, and increase greenhouse gas emissions. Adopting an external Aircraft Ground Propulsion Systems (AGPS), like the European Aerospace Agency (EASA) certified TaxiBot, was found to bear the most potential in terms of future development for automation, safety, and sustainability.
- In summary, the FEAT tractor offers an innovative solution that effectively addresses several critical issues. It tackles environmental concerns by significantly reducing jet fuel consumption and emissions, all the while minimizing noise pollution. Furthermore, it improves upon existing external Aircraft Ground Power Systems (AGPS) by incorporating elements from both the TaxiBot and Phoenix E systems. This technology has the potential to streamline traffic management at airports, offering a practical means of handling the expected growth in air traffic in the future.
- However, it's crucial to note that the adoption of the FEAT tractor at airports may necessitate minor infrastructure adjustments to ensure a safe transition from the Aircraft Movement Area back to the Apron.