New Aerial Transport System – ATS

By Liviu Giurca

Introduction

NASA's Glenn Research Center reviews the prevalence of fossil fuels in keeping us flying for over a century. "Since the beginning, commercial planes have been powered by carbon-based fuels such as gasoline or kerosene. While these provide the energy to lift large commercial jets into the world's airspace, electric power is now seen as a new frontier for providing thrust and power for flight."

This would require a large shift in propulsion and overall aircraft design and Jim Heidmann, manager for NASA's Advanced Air Transport Technology project reflects on those changes. "Moving toward alternative systems requires creating new aircraft designs as well as propulsion systems that integrate battery technologies and electromagnetic machines like motors and generators with more efficient engines." That seems to allow distributed thrust with theoretically more economical ways to produce that thrust – NASA's suggesting a 30-percent fuel saving.

The question is how to expand now the electric/hybrid aircraft utilization without to wait the future battery improvements?

ATS (Aerial Transport System) proposes implementing a new and innovative concept on dynamically charging electrical aircraft -EA aiming at reducing Greenhouse gases and other emissions affecting the society as a whole and the citizen in particular. Consequently, besides the technical realisation, ATS will address economic, environmental and societal aspects relevant to the transition from traditional aircraft to dynamically charged aerial electric/hybrid vehicles.

Necessity

One of the current goals our society is to reduce the emissions of greenhouse gases by at least 40% below the 1990 level by 2030. Being one of the larger contributors, the transportation system plays an important role in achieving this goal. Consequently, large cutbacks in emissions of CO2 and greenhouse gases are required. Optimisation of transport cannot contribute sufficiently, hence, new and innovative transport system like electric/hybrid aircraft need to be put in place. ATS may solve one of the big drawbacks of current electric/hybrid aerial vehicles, namely range anxiety, once large scale implementation has been successful. However, before this can be achieved, several deployment challenges of the electrical aerial infrastructure need to be overcome as the uptake and implementation of dynamically charging electrical aircraft will have severe impact on current transport systems as well as on the society.

With large-scale systems like aerial transportation, it is per definition impossible to change overnight. Therefore the transition will be gradual, with many societal perceptions and culture playing a role. By electrifying the aerial corridors near to the ground to accommodate electric/hybrid aerial vehicles, the infrastructure is coupled to the type of vehicle that can be driven on it as well as to the electrical grid infrastructure required for supporting the ATS. Multitudes of factors affect the design, deployment and usability of ATS. The factors affecting the ATS also depend of the type of charging solution being implemented. There are two main types of charging solutions: static charging – such that an electric vehicle can be charged when they are stationary – and dynamic charging, such that an aerial electric vehicle can be charged while flying. The first type of charging is considered only for comparison, being similar with this used by the electric road vehicles.

Conventional charging technologies

Conductive static charging is widely implemented as a technique for providing power to the electric vehicle battery. The battery is charged through a conducting cable. The use of this physical device ensures a higher transmission performance than using electro-magnetic power transmission. However, the drawback is that the user has to connect manually and plug-in the cable from the vehicle to the charging station and the power grid. Several conductive charging systems are available, depending on the power transmission (AC/DC), the power level (from slow to fast and super-fast charging) and the connectors. In addition, there is no standard for the cable; consequently, it varies for each vehicle and for each country. A standardised cable might boost conductive charging for electric vehicles, since it would reduce the costs, increase the usability and ensure a higher utilisation of infrastructure. The average capacity of a battery of aerial electric vehicle gives a driving range between 80 and 500 km. Unfortunately the more driving range is, the more batteries weight, influencing negatively the payload and specially the vehicle cost.

The inductive stationary charging cannot be considered for aerial vehicle since the weight of device on the vehicle increase even more the aircraft passive weight.

Dynamically charging Electrical Aircraft

This mode refers to power transfer between the charging infrastructure and the vehicle while the vehicle is moving. The electric power flow is variable depending on the conditions, including also possible phases with power flowing from the on-board energy storage and the grid to the on-board traction system.

The vehicle might travel at a variable speed while power transfer level would be real-time responsive to vehicle power demand or the condition of the electric grid/distribution system, within the constraints of the system capability or other fixed parameters. Charging commences automatically with pilot-confirmation from within the vehicle as soon as the vehicle enters a charging zone on the infrastructure. The pilot is on-board during charging. Of course, entirely autonomous vehicles (UAVs) can be also used.

Vehicle speed variation might result in increased power demand, which again causes increased power transfer level, subject to power supply availability and other affecting parameters such as price, charging solution capability, demand from other nearby vehicles, etc.

An aerial electric or hybrid vehicle can be of VTOL (Vertical Takeoff and Landing) or non-VTOL type. We prefer the VTOL vehicles because they can reach low speeds which are sometimes be necessary when the vehicle is coupled to infrastructure, but the non-VTOL vehicles are not excluded.

A typical electrical or hybrid VTOL vehicle can show as in the figure 1.

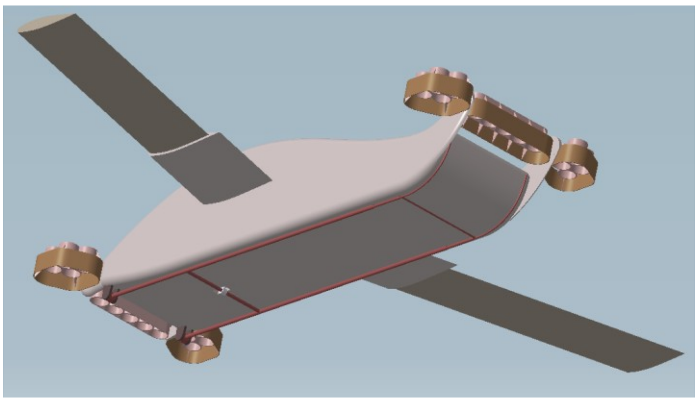

Fig. 1

In the underside of the vehicle is unrolled a kind of telescopic “pantograph”, integrated in the vehicle aerodynamics when the vehicle flies outside of the infrastructure. The pantograph is extended when the vehicles is approaching on the infrastructure as in the figure 2.

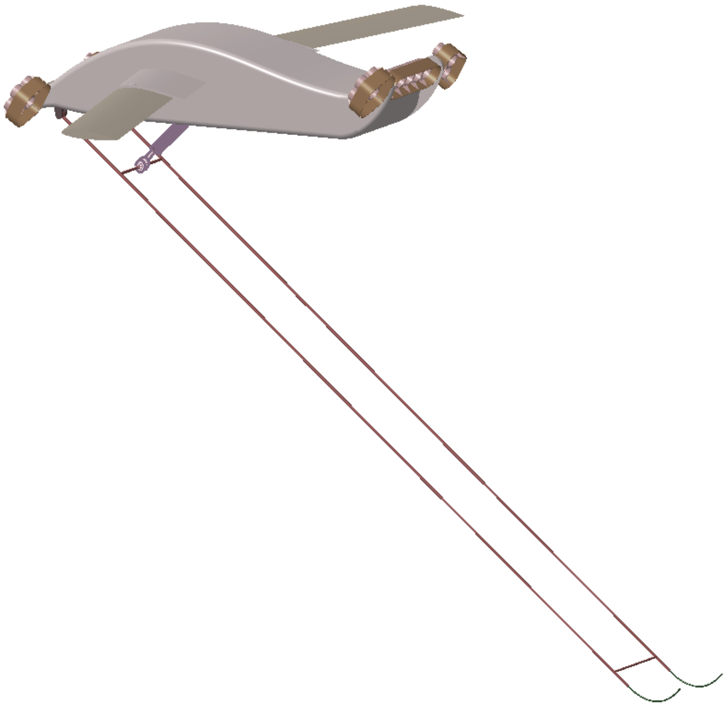

Figure 2

In the next phase the pantograph is coupled with the infrastructure and the vehicle begins to use the external source of energy instead of its internal resources and concomitantly recharges its batteries as in the figure 3.

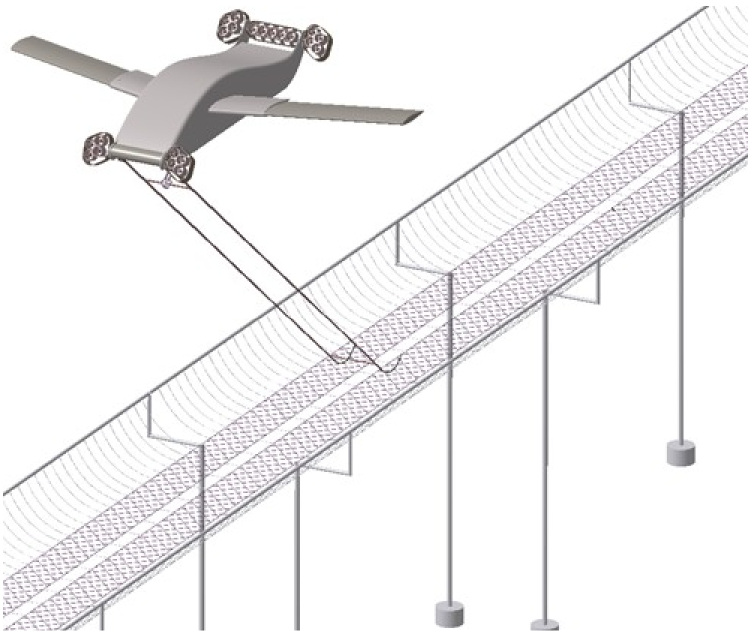

Fig. 3

The infrastructure contains mainly two polarities isolated electrically between them and is suspended from the ground with some pillars to keep the environment in a clean state.

Other vehicle type can use simultaneously the same infrastructure as in the figure 4. The infrastructure can contain solar panels which recharge the ATS. In this case the aerial vehicle can fly with ground effect, increasing even more the flight efficiency.

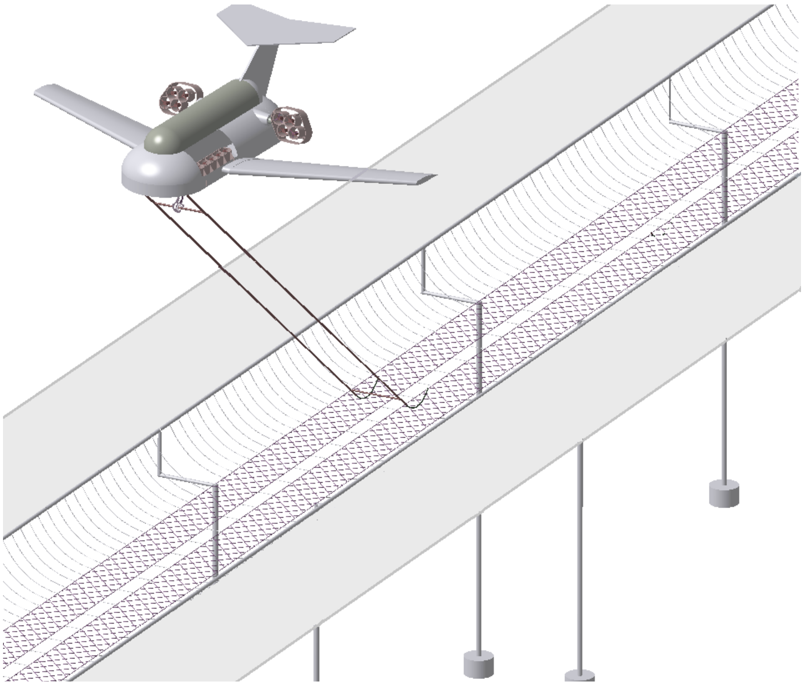

Fig. 4

Other VTOL vehicles proposed by the author can use the infrastructure and are shown in the figure 5.

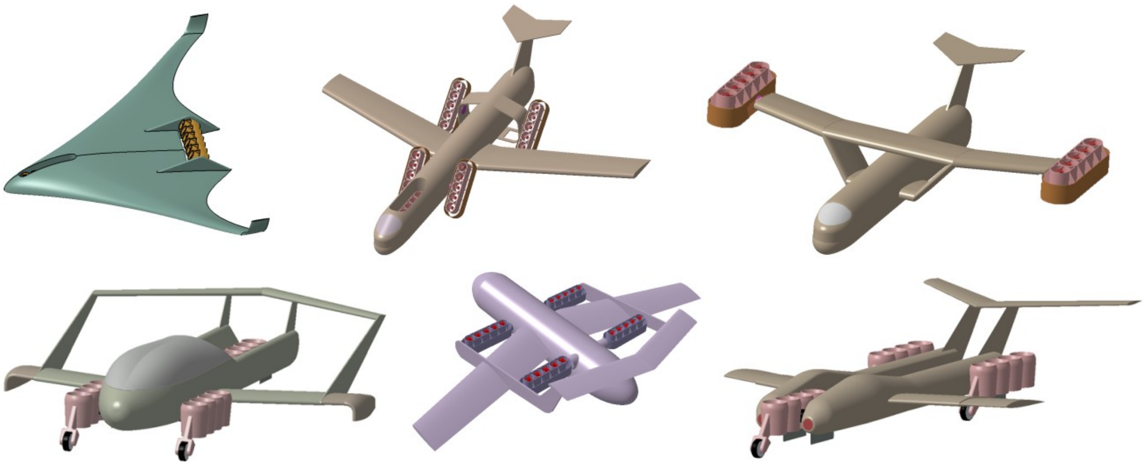

Fig. 5

There are also some existent non-VTOL vehicles which can use this type of infrastructure, respectively Eviation Alice (pure electric) and Zunum Aero (hybrid-electric) as are shown in the figures 6 and 7.

Fig. 6

Fig. 7

Driving assistance while charging

Adaptive Cruise Control, Intelligent Speed Adaptation and Trajectory Departure Warning are safety applications that are potentially valuable for a dynamic charging system. Given the stricter requirements for dynamic charging trajectories, major advances compared to state-of-the-art approaches regarding adaptations and improvements are necessary.

Benefits of ATS compared with the existent technologies

Plug-in systems have some inherent issues that hinder the wide adoption of electric aircraft EA. A major obstacle is the time needed to recharge the batteries. Typically, recharging lasts for several hours when using low voltage and amperage power outlets, which limits the usage of EA. Advances in static charging technology have reduced the time needed to 30 minutes using fast chargers, however when travelling, this time is still long compared to refuelling time of conventional fuelled vehicles that also have larger driving range.
A second factor for the low EA penetration is the cost of the batteries that is relevant to the battery size. In order to increase EA range the manufacturers are pushed to use larger batteries, which affect the aircraft weight and price.

Dynamic charging aims at alleviating some of these issues thus easing the path towards large-scale adoption of aerial electromobility. The advantages of dynamic charging comparing to static are:
-Smaller batteries, since the EA will be able to pick up energy from the infrastructure while travelling. This should also affect the price of the EA.
-Charging on the go means that the EA will not have to stop to recharge which is an advance even compared to conventional fuelled aerial vehicles. The comfort factor is expected to be a major decision factor for using an EA in the future.
-The cost of passenger/kilometre is very low.
-The aerial vehicles remain flexible, because they can fly also without to use the infrastructure.

On the other hand, the infrastructural cost of high speed train as TGV is between US $5 bn and $7 bn/100 km. Other emerging concepts as Hyperloop are highly more expensive. All these transport systems suffer from flexibility and the passengers must combine different means of transport to reach their destination.

ATS cost is a fraction of TGV infrastructure cost and is environmentally friendly. With ATS in place, the electric aircraft exploits the aerodynamic Wing-In-Ground (WIG) effect increasing the forward flight efficiency. Using ATS the electric aircraft can fly as long as the infrastructure is extended. The destination can be reached with a single transport means, saving time and money.

Conclusions

In principle, dynamic charging solution allows power to be continuously supplied to the vehicle from an external source, thus enabling a significant reduction of the on-board battery size and, at the same time, reducing virtually to zero the time the vehicle needs to stop for the recharging operations and the related range anxiety.
The reduction in battery size allows a lighter vehicle to be realized in comparison to other EA. A reduction is therefore expected in terms of energy required for traction and related CO_2 emissions. In addition, CO_2 emissions related to the energy required for the production of the battery should also benefit from a reduction of the size of the on-board pack.

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