Project 052 Comparative Assessment of Electrification Strategies for Aviation

Massachusetts Institute of Technology

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- PI: Professor Steven R. H. Barrett; co-PIs: Dr. Florian Allroggen, Dr. Raymond Speth
- FAA award number: 13-C-AJFE-MIT, amendment nos. 062 and 072
- Period of Performance: February 5, 2020 to August 10, 2021
- Tasks for the reporting period February 5, 2020 to September 31, 2020:
    1. Develop a suite of roadmaps for aircraft electrification.
    2. Develop a system-level engineering model of power conversion processes, aircraft energy requirements, and component production processes.
    3. Develop a model for analyzing the economics of electrification strategies.
    4. Comparative validation runs [to be started in the following reporting period – not covered in the current report].
    5. Analyze the system-level costs and benefits of the electrification strategies [to be started in following reporting periods – not covered in the current report].

Project Funding Level

FAA provided $600,000 in funding. Matching funds sources are approximately $140,000 from the Massachusetts Institute of Technology (MIT) and third-party in-kind contributions of $460,000 from NuFuels LLC.

Investigation Team

Principal Investigator:	Prof. Steven Barrett (MIT) (all MIT tasks)
Co-Principal Investigators:	Dr. Florian Allroggen (MIT) (all MIT tasks) Dr. Raymond Speth (MIT) (Tasks 1, 2, and 4)
Co-Investigator:	Dr. Sebastian Eastham (MIT, Tasks 5)
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Graduate Research Assistant:	Nicolas Gomez-Vega (MIT, Tasks 1, 2, and 4)

Project Overview

The long-term goal of this project is to quantify the costs, emissions, and resulting environmental impacts (i.e., climate and air quality impacts) of different electrification approaches for commercial aviation. The electrification pathways considered range from battery-electric (or "all-electric") aircraft to electrofuel-powered and liquid hydrogen-powered aircraft (both hydrogen fuel cell and hydrogen combustion) where electrofuels and hydrogen are produced using renewable electricity. As such, the project will help identify the best approach for using one unit of electric energy to power aviation.

In the project, we analyze the costs, emissions, and atmospheric impacts associated with each electrification strategy. We develop both a system-level engineering and system-level economic model which cover electricity generation, fuel production, transport and storage, aircraft energy requirements, and aircraft operations. The models analyze different electrification pathways using what can be described as a "power station-to-wake" approach. The models quantify differences in costs and emissions associated with each electrification approach as compared to a set of baseline aircraft powered by conventional petroleum-derived fuels or drop-in biofuels. The outputs from these models will be used in a cost-benefit model which provides insights into the costs associated with each technology—both investment and infrastructure as well as operating cost—and compares them with the lifecycle climate and air quality abatement potential. The results are differentiated by mission characteristics. When comparing electrification scenarios with the conventional petroleum-derived baseline, we take into account different electricity production scenarios (e.g., different fossil fuels and renewables). We expect the results to provide insights into the relative competitiveness of using electricity as a power source for aviation.

Task 1 – Develop a Suite of Roadmaps for Aircraft Electrification

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Objectives

Under this Task, we develop a suite of roadmaps for aircraft electrification. Furthermore, we intend to discuss the mission characteristics which appear to be most suitable for each technology. Through these roadmaps, we aim to provide a high-level summary of conceptual opportunities and challenges as well as critical technologies for all electrification strategies. The results will inform the choice of pathways for detailed analysis.

In addition, this task includes defining future baseline scenarios for conventional aircraft powered by petroleum-derived fuels or drop-in sustainable aviation fuels (SAFs) considered under the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). These baseline definitions will establish consistent comparisons for electric aircraft.

Research Approach

Figure 1 shows the technology pathways for aircraft electrification as well as the baseline pathways. The electrification pathways under consideration in this study are all-electric (battery-electric) aircraft, drop-in electrofuels for conventional aircraft, and hydrogen aircraft. Turbo- and hybrid-electric aircraft which use an electrified power train in combination with other energy carriers are potentially considered in a later stage of the project.

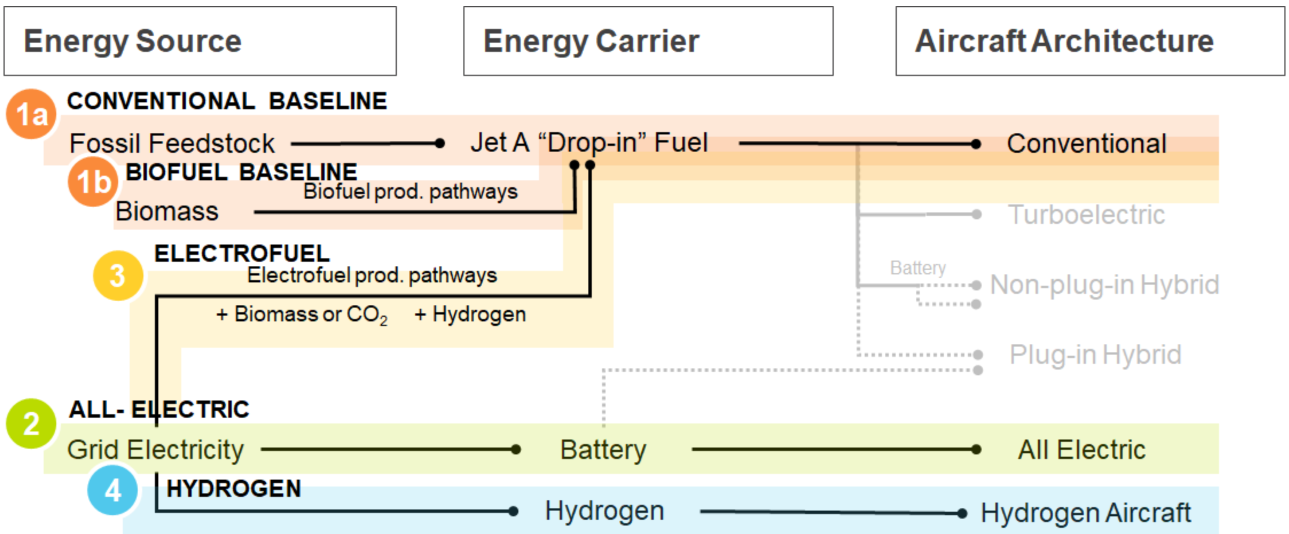

Figure 1. Overview of aircraft electrification pathways. Combinatory pathways, such as hybrid or turboelectric, are shown in gray and will be explored once the methods for the "pure" pathways have been developed.

Conventional and SAF baseline

To establish a conventional and SAF baseline, fuel use and emissions impacts of aircraft powered by conventional jet fuel and SAF are needed. In their efforts to model all-electric aircraft, Gnadt et al. (2019) use the aircraft design and optimization tool TASOPT (Drela, 2016) to establish reference conventional aircraft for missions similar to the missions proposed for all-electric aircraft. This approach allows them to conduct consistent comparisons between all-electric aircraft and their baseline aircraft. Lifecycle impacts of different fuels can be modeled using established and vetted results obtained in the CORSIA process (ICAO, 2019), while atmospheric impacts of aircraft emissions can be modeled to first order using results from Grobler et al. (2019).

All-electric aircraft

An all-electric aircraft (AEA) is powered by batteries and uses an all-electric powertrain. As a result, AEA offer several advantages over traditional jet engine-propelled aircraft:

- **Reduced environmental impact**: AEA do not have direct emissions. Considering life-cycle impacts of power generation, Schäfer et al. (2018) estimate that a 150 passenger (PAX) AEA with a range of 400 nmi would produce 91 g of CO_2 per revenue passenger-kilometer (RPK), when the aircraft is powered by electricity drawn from an electric grid resembling the year-2015 U.S. grid. These emissions are 20% higher than those of conventional aircraft. However, once non-CO_2 impacts are taken into account (e.g., contrails), AEA would have a 30% lower impact than conventional aircraft (Schäfer, et al., 2018). The impacts of the proposed AEA could further be reduced by charging batteries with electric energy from renewable sources.
- **Reduced air quality impact**: AEA eliminate all emissions during takeoff, cruise, and landing. These are estimated to result in ~16,000 premature mortalities when accounting for all aviation (Yim, et al., 2015).
- **Reduced noise**: Schäfer et al. (2018) estimate a 36% reduction in the noise contour area compared to the best-performing conventional aircraft.

Current studies on AEA highlight limitations in the feasibility of AEA designs. Most importantly, Gnadt et al. (2019) quantified the dependency of AEA on battery energy density: with a 400 Wh/kg battery, the only viable 180-seater aircraft design had a range of 200 nmi; this range could be improved to 1600 nmi with a 2000 Wh/kg battery. Current Li-ion technology has a theoretical maximum energy density of 387 Wh/kg; however, other battery architectures are theorized to provide significantly higher energy densities. For example, Bruce et al. (2011) show that the maximum energy density of Li-S is 2567 Wh/kg, and that of Li-O_2 is 3505 Wh/kg.

Electrofuels

Electrofuels are liquid or gaseous synthetic fuels produced through converting syngas derived from electricity to a hydrocarbon fuel, often using Fischer-Tropsch (FT) synthesis. Syngas production requires a carbon source and a hydrogen source. In electrofuel pathways, the hydrogen is generally produced from renewable sources (i.e., electrolysis). The carbon may come from two sources: from biomass, resulting in a power and biomass-to liquid (PBtL) pathway; or from direct air capture, resulting in a power-to-liquid (PtL) pathway. For this project, we focus on liquid drop-in electrofuels which can be used onboard conventional aircraft.

Isaacs (2019) performed an environmental analysis of PBtL and PtL pathways for use in transportation. The study found that if electricity is obtained from renewable sources and carbon is captured from the air, PtL pathways have the potential to be near carbon neutral (Isaacs, 2019; Fasihi, Bogdanov, & Breyer, 2016), whereas PBtL pathways would reach approximately zero emissions, depending on the lifecycle impacts associated with obtaining carbon from biogenic sources. Generally, the lifecycle emissions of both PBtL and PtL pathways vary with grid emissions: with the current average grid emissions of the U.S., the lifecycle GHG emissions from PtL and PBtL fuels are between 1.5–3.5 times greater than conventional petroleum-derived fuel. The lifecycle impacts of PBtL pathways are less dependent on grid emissions due to lower electricity requirements as compared to the PtL pathway.

The economics of electrofuel production pathways have been studied by König et al. (2015), Herz et al. (2018), Blanco et al. (2018) and Isaacs (2019), among others. They concluded that electrofuels currently have a higher minimum selling price than conventional fuels: a PtL pathway with electrolysis and reverse water-gas shift (RWGS) drawing wind power would result in productions costs of 3.0–5.2 $/L depending on the electricity price and the electrolyzer cost (König, Freiberg, Dietrich, & Wörner, 2015). This is one order of magnitude higher than the selling price of conventional fuels. The underlying electricity price plays a key role in these costs—the minimum selling price has been found to vary approximately linearly with electricity price (Herz, Reichelt, & Jahn, 2018; Isaacs, 2019). However, these costs are projected to decrease significantly (Drünert et al., 2020).

Hydrogen

Using hydrogen as an energy carrier onboard aircraft offers the potential to completely eliminate CO_2 emissions from fuel combustion. There are two main ways in which hydrogen can be used to produce thrust:

- **Combustion**: hydrogen replaces jet fuel in a jet engine. Challenges include the combustor design and flame stability (Khandelwal, Karakurt, Sekaran, Sethi, & Singh, 2013). Since combustion at high temperatures is still necessary, NOx is still likely to be emitted, resulting in surface air quality degradation.
- **Fuel cell**: Hydrogen can be used to produce electricity in an electrochemical fuel cell, which releases water and heat. The generated electricity then powers an electric motor attached to a fan or a propeller. Since this architecture relies on an electric powertrain, it offers opportunities for distributed propulsion and boundary layer ingestion. Potential drawbacks include low power density (resulting in high mass), excess residual heat, and relatively low demonstrated power output (Renouard-Vallet, et al., 2010).

If hydrogen is produced using renewable electricity, the lifecycle impacts of fuel production are small (e.g., production through electrolysis with renewable wind electricity: <11 g CO_2e/MJ (Valente et al., 2017)). In contrast, if hydrogen is produced through steam-methane reforming (SMR), the lifecycle impacts of >100 g CO2e/MJ are larger than the impacts of conventional fuels at around 90 g CO_2e/MJ.

Since hydrogen is a non-drop-in fuel, its introduction requires novel aircraft to be developed. In general, hydrogen storage onboard aircraft is associated with opportunities and challenges for aircraft design.

- First, since hydrogen has a lower heating value (LHV) of 120 MJ/kg— approximately 3 times higher than that of Jet-A—it is associated with lower fuel weight, which can result in payload advantages.
- Second, because jet fuel has four times the energy content per unit volume than liquid hydrogen, a hydrogen aircraft will require higher fuel storage volume than its conventional counterpart. In general, hydrogen can be stored onboard as a high-pressure gas or as a cryogenic liquid. For high-pressure gaseous storage, Colozza (2002) estimated that a high-pressure system at 62 MPa could store hydrogen with a density of 20 kg/m^3. However, these high-pressure storage systems only offer storage mass fraction of approximately 5% due to the high mass of the pressure vessel (Colozza & Kohout, 2002). Liquid hydrogen can be stored at lower pressure and has a density of

71 kg/m^3 (Verstraete D. , 2013; Khandelwal, Karakurt, Sekaran, Sethi, & Singh, 2013; Brewer, 1982). However, it needs to be stored in spherical or cylindrical tanks to minimize the heat flux into the tank (Mital, et al., 2006).

Milestone
The MIT team presented a first overview of the literature review and the resulting electrification roadmaps to the FAA project manager in September 2020.

Major Accomplishments
MIT is producing an exhaustive overview of the current understanding of different electrification strategies as presented in the literature.

Publications
None

Outreach Efforts
The team summarized the preliminary findings outlined above in an overview presentation for the ASCENT Fall Meeting in September 2020.

Awards
None

Student Involvement
During the reporting period, the MIT graduate student involved in this task was Nicolas Gomez Vega.

Plans for Next Period
The team is aiming to present an exhaustive overview of electrification roadmaps and rank their attainability based on an initial technical and economic assessment using data and results from the literature.

Task 2 – Develop a System-level Engineering Model of Power Conversion Processes, Aircraft Energy Requirements, and Component Production Processes
Massachusetts Institute of Technology

Objectives
The goal of this task is to develop an aircraft technology, production, and operation model (from here referred to as the "aircraft model"), which will enable comparisons of the technology pathways outlined above. This system-level engineering model aims to capture the most significant energy conversion processes, emissions, and costs.

In order to support the overall lifecycle cost-benefit assessment, the aircraft model considers both the operating and the production stages of "electrified" aircraft (see Task 1). Specifically, for a given aircraft type and mission combination, the model calculates the energy needed onboard the aircraft (either in the form of drop-in jet fuel, liquid hydrogen, or electric battery), the emissions resulting from onboard energy conversion and propulsion processes, and the operating costs of the mission. In addition to these outputs, the model estimates the emissions and costs associated with aircraft production, including the most significant component production processes (e.g., battery production for battery electric aircraft).

Research Approach

Aircraft Types
ASCENT Project 52 aims to assess electrification options across the entire global civil aviation market. Therefore, in addition to modeling different technology options, the aircraft model applies these technologies to different types of aircraft with differing passenger capacities and to aircraft operating on routes with differing flight distance. Balancing the ability to cover

a broad spectrum of aircraft—and corresponding large portion of the relevant market (i.e., generalizability)—against the ability to model aircraft components and systems in high detail (i.e., fidelity) poses a significant challenge to model development. For this project, we divide the market into six "route classes" defined by route length. For each route class, we then model an aircraft (for each viable technology pathway). Figure 2 summarizes the class definitions and shows the route class breakdown for an example airport, Paris Charles de Gaulle (CDG).

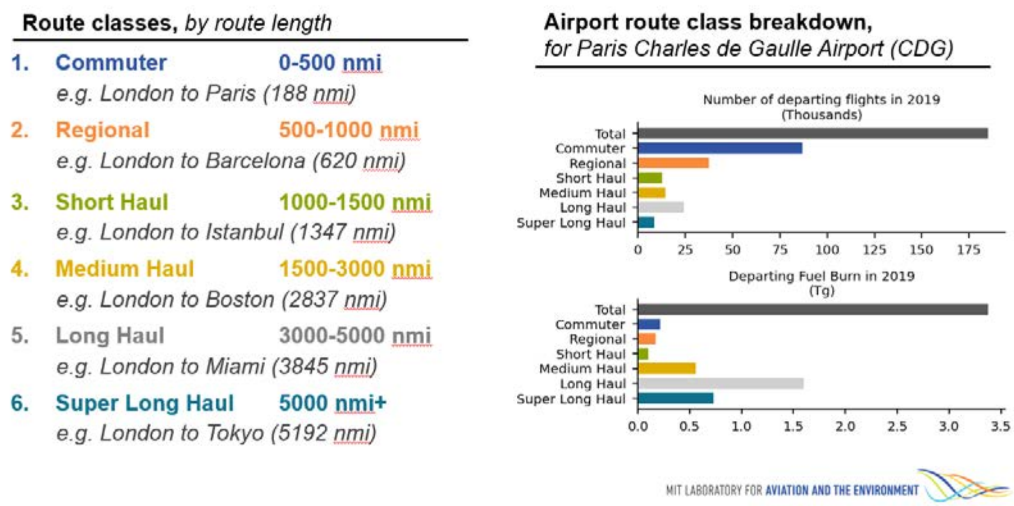

Figure 2. Route class definitions used in aircraft modeling along with a traffic breakdown for CDG airport, representative of a large international hub airport.

Aircraft Technologies

For each route class, our preliminary analysis considers four aircraft architectures described in Figure 1: 1) a conventional baseline, 2) a liquid hydrogen fuel cell aircraft, 3) a liquid hydrogen combustion aircraft, and 4) a battery electric aircraft.

While the baseline technology of Jet-A combustion aircraft currently covers all of the civil aviation market across all route classes, not all of the electrification pathways are technologically feasible for all route classes. In particular, the literature suggests that specific energy of batteries and the specific power of hydrogen fuel cells limit the feasibility of those technologies for use in longer range missions. Similarly, the added weight of onboard cryogenic hydrogen storage for smaller liquid hydrogen combustion aircraft are likely to make them less competitive. Figure 3 shows the route classes for which each technology is considered to be viable in our preliminary analysis in green, with areas of uncertainty in yellow (Gnadt, Speth, Sabnis, & Barrett, 2019; Verstraete D. , 2013; Brelje & Martins, 2019). This uncertainty stems from the exact performance capabilities of the various technology pathways and is currently driven by inconsistencies of assumptions and methods across different studies. This study will address these uncertainties in a consistent framework.

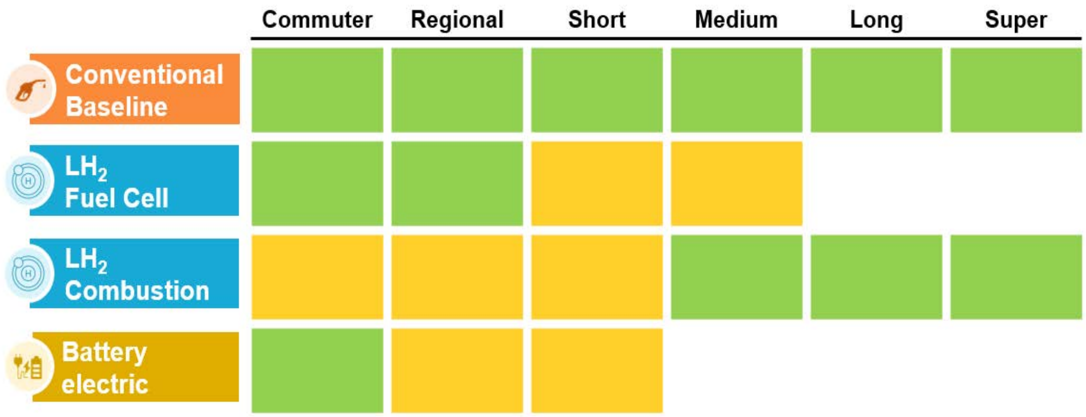

Figure 3. Aircraft technologies under consideration. Not all technologies are viable for all route classes. Green shows route classes for which a technology is currently viable and potentially competitive; yellow shows route classes where the viability of a technology is currently considered to be uncertain.

The aircraft modeling will build on prior work by the project team. The team has used the Transport Aircraft System OPTimization (TASOPT) tool (Drela, 2016) to establish baseline performance of conventional jet fuel aircraft and also developed a complementary electric version of TASOPT, TASOPTe, which adapted TASOPT for optimizing an all-electric tube-and-wing aircraft design based on first principles. The TASOPT tool was originally developed to analyze MIT's D8 "double bubble" aircraft (Drela, 2011). TASOPT will be further extended to include hydrogen combustion and fuel cell technologies.

Power Conversion and Energy Requirements

The power conversion modeling will leverage the existing literature on power systems and their aircraft integration; they cover energy carrier storage and fueling systems, significant steps of power conversion, and propulsion. A range of current and feasible conversion efficiencies is considered. We aim to set up the model at a fidelity level which allows us to modularize the conversion chain. As a result, new technologies for aircraft electrification can be added to the assessment framework.

Our first version of the power conversion model for hydrogen aircraft is similar to that of jet fuel combustion, with the expectation that turbofan engines based on those existing today would be used (with modifications to the combustion chamber), although significant changes to the fuel system to incorporate cryogenic storage and distribution of liquid hydrogen and hence changes to overall aircraft configuration are likely necessary (Verstraete, Hendrick, Pilidis, & Ramsden, 2010).

The power conversion models for the battery electric and hydrogen fuel cell pathways share similar downstream electric transmission and propulsion architectures, which will be electric and likely distributed. Some components are already modeled in TASOPTe (Gnadt, Speth, Sabnis, & Barrett, 2019) and further work will draw on existing literature which addresses electric power systems (Chen, Wang, & Chen, 2018; Sarlioglu & Morris, 2015; Cao, Mecrow, Atkinson, Bennett, & Atkinson, 2012). The upstream battery and hydrogen fuel cells energy systems for these two pathways are significantly different and the model will include detailed considerations of battery performance and energy density (Bills, Sripad, Fredericks, Singh, & Viswanathan, 2020) for the former, as well as cryogenic hydrogen storage and fuel cell performance (Colozza & Kohout, 2002; Mital, et al., 2006; Verstraete D. , 2015) for the latter.

Operating Emissions and Costs

Direct emissions can be estimated from the aircraft fuel requirements, while upstream emissions will be calculated using the upstream system model developed as part of Task 3; the energy requirements calculated by the aircraft model here will be used as an input to the system model. Similarly, some direct operating costs can be estimated using the aircraft model, while costs of fuel will be a function of the upstream processes. The economic model will leverage prior work by the project team to derive the economics of aircraft electrification (Schäfer, et al., 2018).

Production Emissions and Costs

To estimate the full lifecycle costs of electrification, it is necessary to account for potential changes in the production processes due to the adoption of certain electrification technologies. For example, the production emissions and cost of batteries are significantly different from the energy storage devices in other pathways; for this part of the analysis, we will leverage prior work in the literature (Kim, et al., 2016). In order to account for changes in individual components such as batteries, we will perform a bottom-up component-wise or aircraft-system-wise summation, again focusing on those aircraft systems which are sensitive to changes in energy carrier (e.g., the fuel system, the energy conversion system, and the propulsion system).

Milestone

An initial outline of the modeling structure has been completed (see above).

Major Accomplishments

An initial outline of the modeling structure has been compiled which will inform future research and will ensure consistent comparisons between the different pathways under consideration. In addition, the team has compiled an initial model of estimating energy and fuel demand under different electrification strategies.

Publications

None

Outreach Efforts

The team summarized the preliminary model structure above in an overview presentation for the ASCENT Fall Meeting in September 2020. In addition, the team prepared a presentation to ICAO's Long-term Aspiration Goal (LTAG) Task Group, to be held in October 2020.

Awards

None

Student Involvement

During the reporting period, the MIT graduate student involved in this task was Nicolas Gomez Vega.

Plans for Next Period

Over the coming year, the team will expand the existing capabilities of TASOPT and TASOPTe, which are currently limited to A320-class aircraft that operate in medium-haul routes. The goal is to include models of aircraft of the other route classes which will have longer and shorter ranges.

In addition to the assessment of operating emissions, which will be a direct result of the aircraft performance, we will review the existing literature to provide estimates of cost for the different aircraft designs: that is, direct operating costs as well as production cost for the different aircraft technologies and components.

Task 3 – Develop a Model for Analyzing the Economics and Emissions of Electrification Strategies

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Objective(s)

The team aims to develop a model that analyses the economics and emissions of each electrification strategy at the system level (the "system model"). The goal of this task is to develop a system-level analysis capability for modeling the possible electrification *pathways* (e.g., battery electric, hydrogen fuel cell, etc.) and their deployment in various aircraft electrification *scenarios* (e.g., replacing regional flights below 1000 nmi at a specific airport).

The system model focuses on the processes which occur upstream of the fueling and operation of the aircraft itself, but also incorporates the aircraft model developed in Task 2 in order to quantify the demands of the aircraft operations on the upstream systems (both in terms of the amount of fuel or energy needed, but also the infrastructure required to fulfil this need in real-time). These upstream processes are significant for the overall environmental impact and for cost.

The system model aims to capture the most significant upstream fuel and power conversion processes in each pathway, including electricity generation, process inputs and outputs of materials and energy, process efficiency, cost (both investment and operating cost), and greenhouse gas emissions. When coupled with global flight data and models for onboard aircraft energy and costs (from Task 2), the overall system model assesses complete electrification scenarios for competing technological pathways to provide insight into their relative strengths and challenges and a quantitative comparison of their costs and potential benefits.

Research Approach

Figure 4 provides an overview of the system model and its relation to the aircraft performance model described under Task 2. The aircraft models are used to produce realistic energy carrier replacement scenarios based on historical flight data, where subsets of the global market can be replaced. The tool can analyze the costs, environmental impacts, and infrastructure at the airport level and at the granularity of different route classes; this creates a scenario simulation tool, which not only allows us to compare different electrification strategies, but also enables us to analyze various combinations of electrification strategies applied to different geographic locations and markets. This approach is reflective of the diverse and multi-faceted approach to electrification which could be pursued by the aviation industry.

Baseline and Replacement Scenario Definition

Since the objective of the project is to assess electrification pathways in policy-relevant scenarios, the first step of the system model is to establish a baseline scenario of "business as usual" for the aviation industry. The approach uses flight schedule data from the 2019 OAG database combined with a model for aircraft fuel burn to estimate the overall Jet-A fuel burn (and hence energy) requirements for each airport in the baseline case in the year 2019. Due to the nature of the flight schedule database, only scheduled passenger flights are accounted for in the study. The flights are divided into six route classes according to the distance flown as defined in Task 2. For any airport in the world, a time-resolved profile of energy demand (for departing flights) is generated for each route class.

The replacement scenarios that can be assessed in the model assume that traffic in a particular route class at particular airports is being replaced with a particular technology. The model is constructed in such a way that any combination of route class replacement with any combination of technologies at any combination of airports can be analyzed at a conceptual level. Results will be initially presented for scenario replacements at a single airport to understand the relative dynamics of the competing technologies. More complex country-wide, continent-wide, or global replacement scenarios representing progressive technology replacement will be developed to understand the overall system effects.

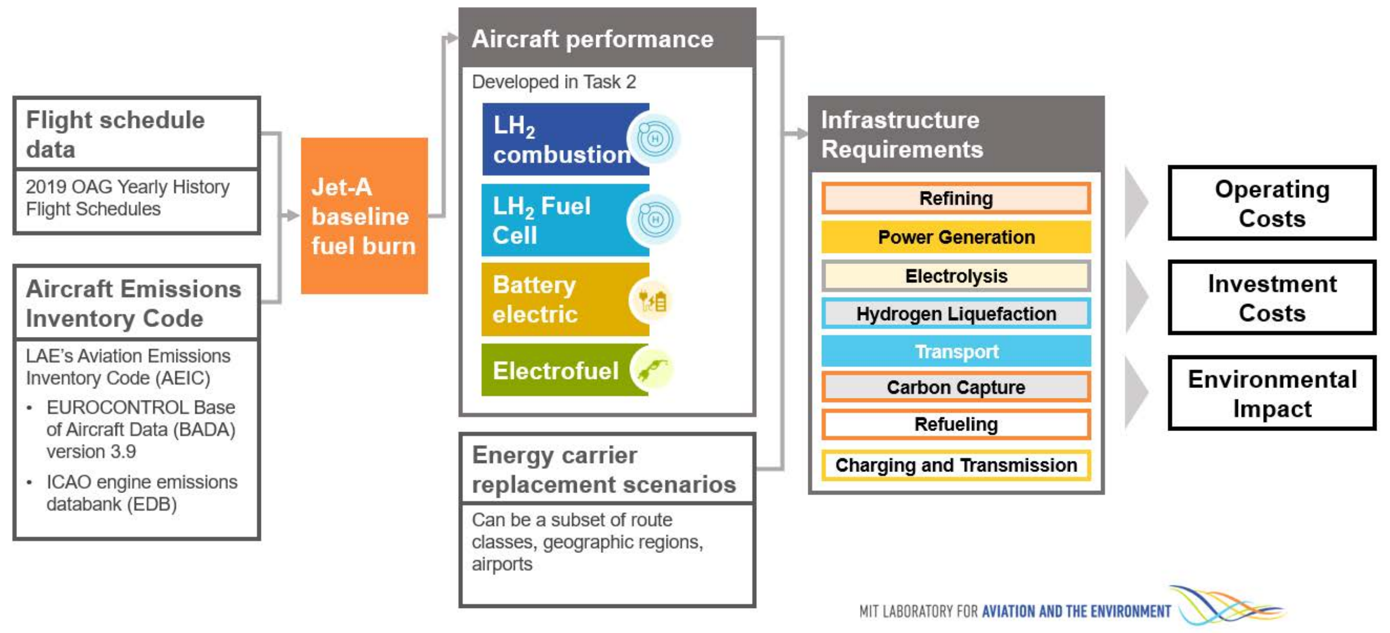

Figure 4. Block diagram of the system model showing the incorporation of aircraft models and the use of historical flight data to produce realistic electrification scenarios for all pathways.

Infrastructure and Energy System Modeling
The infrastructure and energy system model is developed following the techno-economic approach, whereby the model incorporates operational and production costs within the overall system boundary. To estimate operational costs, the tool builds on the system-level engineering approach to derive the required process steps and understand each step's technical requirements and efficiencies. It then captures all relevant operational cost differences (as compared to the baseline specification developed under Task 1) for each technology pathway. The model will also estimate the initial investment required.

A key upstream infrastructure and energy system component is electric power generation, which will be required for all electrification pathways. The model includes solar, wind, and nuclear power generation. Geographically resolved estimates for cost, area requirement, and generation profiles will be made for each generation method.

The other major system considerations are fuel production, transport, and storage. Because there are multiple combinations possible for offsite and onsite production, which result in different requirements for transport and storage, the system model will use a modular building block approach to enable assessment and comparison of all relevant combinations of production, transport, and storage.

Operating and Investment Costs
The modeling will be implemented using a discounted cash flow approach, which will enable consistent system-level comparisons between electrification pathways. Estimates for cost will be derived from the literature, drawing on previous work by the project team on the technoeconomic viability of electrofuels (Isaacs, 2019).

Milestones
An initial outline of the system modeling structure has been completed (see above). The baseline scenario fuel burn and energy demand has been established, and initial simple replacement scenarios (i.e., at a single airport) have been defined.

Major Accomplishments

An initial outline of the system modeling structure has been compiled which will inform future research and will ensure consistent comparisons between the different pathways under consideration.

In addition, the team has compiled an initial model for estimating energy and fuel demand under different electrification strategies. This model uses a simplified approach to aircraft modeling (which will be replaced by the more detailed model developed in Task 2) and incorporates a subset of the system processes which will eventually be included. Those already implemented are solar power generation, hydrogen production by electrolysis, hydrogen liquefaction, electrofuel production through co-electrolysis, and battery charging. Preliminary results from this model are presented to ICAO's Long-term Aspirational Goal task group.

Publications

None

Outreach Efforts

The MIT team prepared a presentation to ICAO's Long-term Aspirational Goal task group meeting, held in October 2020.

Awards

None

Student Involvement

None

Plans for Next Period

The next step is to incorporate more of the modular process building blocks into the system model. These building blocks include wind power generation, nuclear power generation, and hydrogen transport and storage. At the same time, the operational and investment cost estimates for these processes will be refined, and first estimates of the emissions resulting from these processes made.

The scenario definitions will be extended to include regional and global replacement scenarios. An "optimization" capability, i.e., the ability to determine the most cost effective or most environmentally optimal electrification scenario, is a long-term aspiration of this Task.

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