Environmental Benefits Assessment of the Traffic Aware Strategic Aircrew Requests Concept

Executive Summary

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April 2021

Background Context

Since the mid-20th century, humans have adversely contributed to the global warming phenomenon through emissions of greenhouse gases. Atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are at unprecedented levels in at least the last 800,000 years [1], mainly from anthropogenic[1] causal factors. In 2018, the transportation sector in the United States generated approximately 1,877 million metric tons, (megatons, Mt) of carbon dioxide equivalent (CO_2e)[2] of net emissions [2], with aviation contributing approximately 9% (approximately 175.5 Mt CO_2e) of total transportation-related greenhouse gas emissions [2] from burning jet fuel or aviation gasoline. Projections based on estimated fleet growth show that the global aviation industry would contribute approximately 1,800 Mt of CO_2 in the 2050 timeframe (approximately 350 Mt CO_2e emissions from the United States) without any changes to the current technological or operational paradigm [3, 4].

To provide a framework for enabling impactful changes in the aviation industry required to minimize the impact of anthropogenic greenhouse gas emissions, specifically emissions from aircraft operations and the use of jet fuel, the Air Transport Action Group (ATAG) established a series of climate change goals. These goals ultimately seek to reduce aviation's CO_2 emissions to approximately 400 Mt of greenhouse gas emissions in 2050. ATAG presumes that a combination of advanced technology, improved operations, efficient air traffic management, and sustainable propulsion will be required to meet the CO_2 emission goal [3].

A concept developed by the National Aeronautics and Space Administration (NASA) called Traffic Aware Strategic Aircrew Requests (TASAR) [5], uses cockpit automation to recommend optimized route modifications that an aircrew may request from air traffic control. TASAR provides an opportunity for a flight to significantly reduce fuel burn, leading to fewer greenhouse gas emissions. The ATAG Waypoint 2050 report specifically calls out an operational enhancement, called flexible tracks/free-route airspace, that is directly aligned with the goals of the TASAR concept.

From 2018 – 2019, an operational evaluation of the TASAR concept was conducted at Alaska Airlines[3] with three TASAR-equipped Boeing 737-900ER aircraft [6]. A primary objective of the operational evaluation was to quantify the anticipated benefits of TASAR; namely, reduction in fuel burn and reduction in flight time, ultimately leading to a reduction in direct operating costs for a given flight [5, 7]. Data from the operational evaluation provided estimated fuel burn and flight time reduction, and these metrics were converted to direct operating cost savings [8]. Using the estimated fuel burn reduction, greenhouse gas emission reductions can also be estimated across a representative portion of the domestic United States airline fleet due to the application of the TASAR concept. The long-form report (in progress) defines the methodology for data analyses, and presents detailed findings based on the analyses. The next section of this executive summary summarizes those findings.

Summarized Results

Based on the analyses conducted for the TASAR concept, approximately 545,000 metric tons of CO_2e greenhouse gas emissions (Mid Estimate, Table 1) could be eliminated annually by implementing the TASAR concept across a fleet of appropriate vehicles[4] conducting domestic operations in the United States. In the discussion of the "flexible tracks/free-route airspace" operational enhancement in the Waypoint 2050 report, ATAG estimates that up to 500,000

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[1] The term "anthropogenic," in this context, refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities [12].

[2] Greenhouse gas emissions are quantified in literature as CO_2-equivalent (CO_2e) emissions using weightings based on the 100-year Global Warming Potentials. The 100-year Global Warming Potential of a greenhouse gas is defined as the ratio of the accumulated radiative forcing within a specific time horizon (e.g., 100 years) caused by emitting 1 kilogram of the gas, relative to that of the reference gas CO_2 [13].

[3] The use of trademarks or names of manufacturers in this report is for accurate reporting and does not constitute an official endorsement, either expressed or implied, of such products or manufacturers by the National Aeronautics and Space Administration.

[4] This estimation method assumes that modern mainline jets (e.g., Boeing 737, Airbus A320) across the top 10 U.S. airlines based on number of domestic operations were considered candidates for TASAR equipage. Regional jets and older aircraft were assumed to not be candidates for TASAR for the purpose of this calculation.

metric tons of CO_2 annually could be saved when fully implemented over European airspace [3]. The ATAG estimate is consistent with the estimate from the analysis for the TASAR concept in domestic United States airspace.

Using the estimate of 175.5 Mt CO_2e produced by aviation operations in the United States and the "mid" estimate for CO_2e emissions reduction from the TASAR analyses, use of the TASAR concept would create a 0.31% reduction in annual greenhouse gas emissions, translating to a 9.3% overall reduction in emissions by 2050. The low-end of the range of estimated benefits (Low Estimate, Table 4) provides a 0.13% reduction in annual greenhouse gas emissions, which is slightly better than the ATAG "mid improvement" operational scenario (Scenario O_2, 0.1% annual reduction). The high end of the range of estimated benefits (High Estimate, Table 4) provides a 0.51% reduction in annual greenhouse gas emissions, significantly exceeding the ATAG "high improvement" operational scenario (Scenario O_3, 0.2% annual reduction).

Table 1: Estimated Annual CO_2e Emission Reductions from TASAR

	Estimated Fleet Emissions Reduction from TASAR (metric tons CO_2e)	Annual Emissions Reduction Percentage	Cumulative Emissions Reduction in 2050[5]	ATAG Operational Efficiency Scenario Comparison
Low Estimate	228,499.6	0.13%	3.9%	+30% Scenario O_2
Mid Estimate	544,936.7	0.31%	9.3%	+55% Scenario O_3
High Estimate	902,499.7	0.51%	15.3%	+155% Scenario O_3

Figures 1 – 3 below provide estimates of annual greenhouse gas emissions reduction by airline, by aircraft type, and by flight duration using 2018 operational data. These estimates are based on similar assumptions presented in Section 4 of reference [8]. The error bars indicate 95% confidence intervals around the estimates.

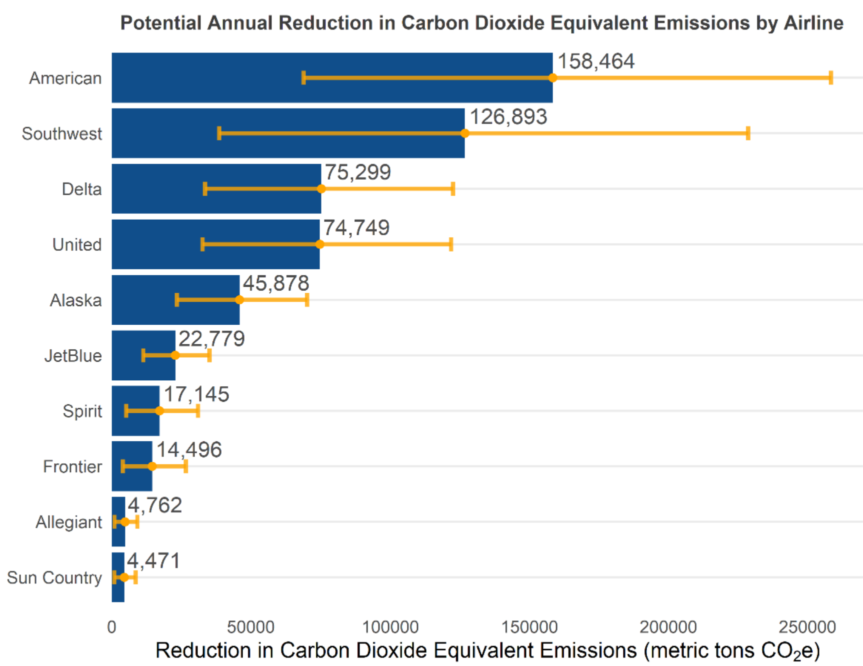

Figure 1: Potential TASAR Annual CO_2e Emissions Reduction by Airline

[5] This value is a cumulative reduction based on multiplying the annual emissions reduction percentage by the years remaining until 2050, per the methodology performed in the ATAG report. This value represents the emissions reduction due to TASAR concept compared to the emissions projection in 2050 without the TASAR concept (i.e., if TASAR was not implemented, emissions in 2050 may be approximately 9.3% higher for the "Mid" estimate).

Results in Figure 1 are heavily dependent on the number of aircraft in each airline's fleet (e.g., American Airlines has a much larger potential fleet that can support TASAR than Sun Country Airlines). Similarly, results in Figure 2 are dependent on the number of vehicles in the family (e.g., the vast majority of the vehicle types analyzed were in the Boeing 737 and Airbus A320 families). Finally, results in Figure 3 are dependent on the number of operations in each flight duration category. Further discussion of these results will be included in a full report that will be published in late Spring of 2022.

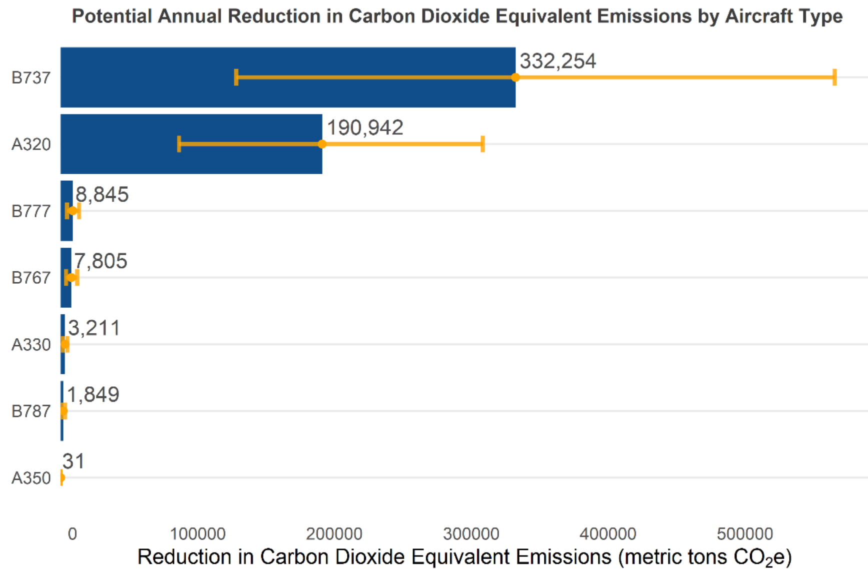

Figure 2: Potential TASAR Annual CO2e Emissions Reduction by Aircraft Family

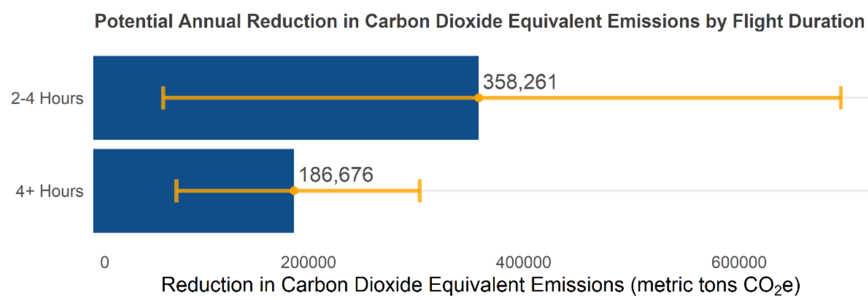

Figure 3: Potential TASAR Annual CO2e Emissions Reduction by Flight Duration

Key Takeaways

The TASAR concept and its associated technology were developed at NASA and tested in an operational evaluation on revenue service flights with Alaska Airlines. The results from that operational evaluation validated the cost-saving benefit estimates for the concept and provided researchers with real-world data to be used in subsequent analyses. This activity focused on analyzing those data to determine estimated greenhouse gas reduction benefits across a representative portion of the domestic United States airline fleet due to the application of the TASAR concept.

The data analyses show that there is the potential for significant emission reductions by applying the TASAR concept in operations. The TASAR analyses of emissions reduction based on operational flight data aligns well with the ATAG operational efficiency scenarios. This confirms that cumulative emissions reduction on the order of 10% by 2050 is a reasonable estimate, assuming widespread application of flight-optimizing technologies and procedures such as TASAR. A full report will be published in late Spring of 2022 that will provide detailed information regarding the analysis techniques and will further discuss the results.

There is an opportunity for the TASAR concept to significantly reduce aviation greenhouse gas emissions. Follow-on roadmap applications such as Digital TASAR (replaces voice communication of TASAR with FAA DataComm, enabling more complex optimizations with simpler procedures) [9], Four-dimensional TASAR (adds speed management to minimize excess emissions for scheduled operations) [10], and Strategic Airborne Trajectory Management (adds air/ground integration and operator authority for closely coordinated strategic routing) [11] may further reduce aviation greenhouse gas emissions. While commercialization activities are on-going for the TASAR concept, further research and development is required to quantify the additional environmental benefits achievable from these TASAR roadmap applications.

References

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