The power of digital:

IT solutions and their role in aviation's path to net zero

December 2024

This report is the result of a collaboration between Amadeus and Accenture, with calculations provided by Accenture.

AMADEUS | accenture

Executive Summary
Purpose of the Report

As sustainability gains increased focus from both businesses and customers, it is important that businesses continue to evaluate the environmental impact they generate and the solutions that can support more sustainable practices. Amadeus has taken this concept in mind and, with the support of Accenture, has evaluated the relevance and impact potential of IT solutions to support airlines and airports on their path to reducing the carbon impact of the aviation industry.

The purpose of this report is threefold:

01
Provide a brief overview on the current state of decarbonization in the aviation industry.

02
Highlight the role and relevance of IT solutions to foster sustainability, focusing on operational efficiency improvements.

03
Illustrate the potential carbon reduction impact of selected Amadeus IT solutions.

To support this study, two example IT solutions were selected:

1 / Amadeus Airport Sequence Manager
2 / Amadeus Altéa Departure Control – Flight Management

The solutions were evaluated and assessed to understand and substantiate the current estimated carbon emission reduction that is achieved over a one-year period by leveraging the technology and forecasting the potential savings if expanded to a global footprint in comparison with not using them or with the use of other similar IT solutions.

Decarbonization Levers

This study explores the different levers to decarbonization in aviation, which include fleet renewal, Sustainable Aviation Fuel (SAF), new aircraft technology, carbon removal/offsets and operational efficiency improvements. This last lever is where IT solutions, such as those included in this report, may contribute – with their primary advantage being the current availability. IT solutions do not require major upfront investments compared to other levers and are generally associated with cost savings due to a more efficient use of fuel.

IT Solutions

The IT solutions analyzed in the two featured case studies deliver operational efficiency improvements that decrease overall fuel burn. If we extrapolate these findings to apply to all Amadeus customers using the solutions, the net reduction in CO_2 emissions, achieved over the year 2023, is estimated to amount to ~2.6 million metric tons based on the Accenture calculation included in this analysis.

From a global perspective, if all airlines and airports that could benefit from this technology were to implement the solutions, this would contribute to a decrease of CO_2 emissions of ~5.7 million tons as compared to operations without these types of IT solutions, over a one-year period. This is equivalent to 0.6% of global aviation emissions in 2023[1] or 10,000 flights from London Heathrow to John F. Kennedy International Airport.

1. International Energy Agency (IEA) (Jul 2023) ↗ "Transport: Aviation" and Accenture's aviation carbon calculator.

Decarbonizing aviation

The current state of the Net Zero transition in aviation

The aviation industry is often raised in conversations taking place around the climate and sustainability. Estimates suggest that aviation accounts for 2-3% of total global carbon emissions[2], a relatively small but still significant proportion. However, there is a momentum for change within the industry, driven by various factors.

Industry recovery and growth

The aviation industry's COVID-19 recovery has been strong, with Revenue Passenger Kilometers (RPKs) reaching ~99% of pre-pandemic levels[3]. Overall demand for air travel is also expected to increase, growing at ~3.4% annually and doubling by 2040[4]. Measures to reduce the environmental impact of flying need to be scalable to manage increased volumes.

Non-CO_2 effects

The vast majority of fuel used today has an environmental impact beyond CO_2. The emission of additional greenhouse gases, such as nitrous oxides, sulfur dioxides, and water, at altitude results in the potential formation of high, contrail cirrus clouds. These clouds can trap heat, resulting in net warming approximately two times greater than that of CO_2 emissions[5].

Public attention

Customer behavior across industries is shifting with 50% of consumers having a new focus on personal values, leading to changes in consumer travel behavior and preferences[6]. Pressure on the industry also comes from government entities, such as the 2023 enactment of the EU's Corporate Sustainability Reporting Directive (CSRD).

Many airlines are setting decarbonization targets with corresponding roadmaps and initiatives. As of October 2024, 16 airlines have published targets in line with the Science-Based Targets initiative (SBTi), while an additional 8 airlines have committed to launching an SBTi target soon[7]. Additionally, many airlines are joining industry initiatives, such as Clean Skies for Tomorrow, led by the World Economic Forum.

2. International Air Transport Association (IATA) (Jan 2024). ↗ "Air Travel & Sustainability"

3. International Air Transport Association (IATA) (Nov 2023). ↗ "Air Passenger Market Analysis"

4. International Air Transport Association (IATA) (Jun 2023). ↗ "Global Outlook for Air Transportation"

5. Umweltbundesamt (Dec 2019) ↗ "Integration of Non-CO_2 Effects of Aviation in the EU ETS and under CORSIA"

6. Accenture Insights (2021) ↗ "Life Reimagined: Mapping the motivations that matter for today's consumers"

Key levers to decarbonize aviation[8]

According to the World Travel & Tourism Council, aviation is a "hard-to-abate industry"[9], alongside sectors such as iron and steel, concrete and petro-chemicals.

However, there are multiple levers available to the airline industry which can support its decarbonization:

Fleet renewal

Aviation Original Equipment Manufacturers (OEMs) are developing fuel-efficient aircraft, such as the Airbus A320neo, which can consume ~20% less fuel than its predecessors[10]. Airline orders reflect this interest, such as Lufthansa Group's purchase of 80 new short- and medium-haul aircraft, 40 Boeing 737-8 MAX and 40 Airbus A220-300, in December 2023[11].

Sustainable Aviation Fuel (SAF)

The use of Sustainable Aviation Fuel (SAF) is being explored and adopted by several airlines around the world. It has the potential to account for nearly two-thirds of the reductions needed for the industry to achieve net zero carbon by 2050[12]. From initial production to use, SAF can produce up to 80% fewer CO_2 emissions compared to traditional fossil fuels[13 14].

New aircraft technologies

New types of aircraft will expand options for decarbonization. Fully electric aircraft are available in small numbers while research and development continue. Additionally, hydrogen-powered aircraft also provide a low-to-zero CO_2 emission potential. Traditional OEMs are currently exploring new aircraft designs.

7. Since Based Targets initiative (SBTi) (Jan 2024) ↗ "Target Dashboard"

8. ↗ "Making Net Zero Aviation possible"

9. World Travel & Tourism Council (Nov 2021) ↗ "Net Zero Roadmap for Travel & Tourism"

10. Airbus (Jan 2024) ↗ "A320neo | Creating higher customer value"

11. Lufthansa Group Newsroom (Dec 2023) ↗ "Lufthansa Group orders 80 new highly efficient short- and medium-haul aircraft and agrees on a further 120 purchasing options"

12. International Air Transport Association (IATA) (Jun 2023). ↗ "Net zero carbon 2050 resolution"

13. U.S Department of Energy (Nov 2024). ↗ "Pathways to Commercial Liftoff: Sustainable Aviation Fuel"

14. International Air Transport Association (IATA) (Jan 2024). ↗ "Air Travel & Sustainability"

Operational efficiency improvements

Improvements in airport operations and flight coordination provide an opportunity for decreased fuel burn from long taxiing and departure/arrival wait times. Improved loading and aircraft balancing can also enhance efficiency during flight while maintaining operational and safety standards. Many of these efficiency gains may be supported with IT solutions providing better models, algorithms, and insights.

Carbon removal & offsetting

Carbon offsets and removal may compensate for carbon emissions that have not been or cannot be avoided. Through these programs, companies can allocate funds directly or in collaboration with consumers toward environmentally positive activities. Carbon removal through direct air capture (DAC) is an emerging technology that allows CO_2 from the atmosphere to be captured and stored and, in some cases, converted into stone.

The pathway to sustainable aviation

Significant investments in time, resources, and financial capital are needed to drive the industry towards its goals set for 2050. This paper considers that the transition to net zero carbon by 2050 will depend on three distinct drivers:

Driver 01 → **Focus on fuel efficiency**

This initial phase is addressable now and can be seen by the current changes being made by aviation companies. Updates in fleet and changes to operational processes allow the industry to decrease fuel burn both in the air and on the ground, resulting in fewer emissions and corresponding cost savings.

Driver 02 → **Focus on fuel alternatives**

The next phase will focus on Sustainable Aviation Fuel (SAF) but poses a challenge with scalability. Current SAF production is minimal and large investments and infrastructure are needed to develop the entire supply chain, from sourcing of raw materials to distribution to airports around the world. This will take time and is unlikely to arrive in a scaled fashion in the near-term as production capacity is currently expected to only reach 1-2% of demand by 2027[15].

Driver 03 → **Focus on fuel replacements**

The final wave will see the wider adoption of aircraft powered by alternative energy sources, with a material increase in the numbers of airlines offering flights on planes powered by electric batteries and/or hydrogen energy. However, there are challenges that need to be overcome before these alternative fuels are fit for commercial flight at scale, particularly regarding the battery weight impacting potential flight range for long-haul and cargo operations.

15. International Energy Agency (IEA) (Jul 2023). ↗ "Transport: Aviation"

IT solutions to help decarbonize operations

IT solutions and their impact on sustainable aviation

The financial benefits of IT solutions are commonly tracked and managed, whereas the environmental impact is often overlooked. This study seeks to address this by taking a data-driven approach to assess how an airline and an airport can reduce their environmental impact through the use of two Amadeus solutions. The study also extrapolates the findings to suggest the potential for further savings from additional rollouts.

IT solutions may have a role to play in the transition to net zero and with many providers active in this space and solutions available, airlines and airports can start their path to net zero today. Technology, including data-driven dashboards, forecasting models, and management tools, enables enhanced insights and decision-making across employee levels, from front-line to senior leadership. These solutions allow impactful changes to be made to operations and profitability for airlines, airports, and service providers.

Technologies that power operational improvements also play an important role in increasing more sustainable business practices, especially in the near-term. According to the Air Transport Action Group, improvements in operations and infrastructure have an annual potential to decrease carbon emissions by 7-10% in 2050[16]. These savings, enabled by IT solutions, can be supported by decreasing activities that result in excessive emissions, i.e., unnecessary fuel burn.

16. Air Transport Action Group (ATAG) (Sep 2021) ↗ **"Waypoint 2050 | Pg. 23-26"**

Advantages of IT solutions to drive operational efficiency

The major levers needed to decarbonize aviation are changes in aircraft design and power sources, which will require a significant amount of time and investment. However, IT solutions may represent an initial step that the aviation industry can implement today to bring change and that may have the potential to reduce their carbon emissions immediately. These come with multiple advantages:

Readiness

IT solutions are ready to implement in the near-term, unlike changes in aircraft types, fuel sources, and general infrastructure which are a medium- to long-term considerations. The operational and environmental impact will quickly become evident, while new use cases will emerge which will enhance cost savings and emission reductions.

Ease of implementation

IT solutions require less investment and change management than new aircraft or large infrastructure updates. They can be used with and enhance existing aircraft types and airport infrastructure enabling greater efficiency in areas such as idle fuel burn.

Cost savings

Fuel expense is a major focus for airlines. Prices dynamically fluctuate based on economic and political factors and account for ~30% of operating expense[17]. Digital tools aimed at driving improvements in efficiency have the potential to decrease fuel consumption, resulting in both near- and long-term cost savings, in addition to a reduction in emissions.

Additional benefits

By addressing multiple areas of the industry, benefits expand past fuel cost and greenhouse gas savings. IT solutions can help reduce pollution levels near airports, optimize how labor is deployed through more efficient planning and resource management, reduce the touchpoints where human error can occur and automate many processes required by regulators, governments and internal demands.

IT solutions may represent an initial step that the aviation industry can implement today to bring change and that may have the potential to reduce their carbon emissions immediately

17. Fuel prices: ↗ **Fuel Fact Sheet**
Jet fuel portion of operational expenses (sustainability section): ↗ **IATA's website**

Areas supported by IT solutions

IT solutions with the potential to reduce carbon emissions are present in multiple phases of the operational lifecycle (see Figure 1). The landscape of such technology continues to expand with solutions being introduced and improved to address different business needs. Technology and data are used to improve operations from network and flight planning to runway management and flight loading. While the savings from each use case are limited, the cumulative impact can be significant to decrease overall fuel burn and carbon emissions.

IT solutions within aviation with potential carbon reduction impact

Network Planning Solutions	Commercial Solutions	Flight Planning Solutions	Aircraft Handing Solutions	Airport Control Solutions
Network Planning & Scheduling Match flying with demand, to maximize fuel efficiency and avoiding unnecessary flying	**Passenger Revenue Management** Forecast and manage inventory to maximize availability and fuel intensity	**Flight Path Planning** Identify most economical, fuel-efficient flight path and low cirrus clud generation	**Weight & Balance** Manage aircraft loading to optimize weight, balance, and center -of-gravity	**Runway Congestion** Manage runway usage to decrease waiting times and fuel burn on the ground
Aircraft Fleet Management Match aircraft type with appropriate demand and capacity needs	**Cargo Inventory Management** Forecast and manage inventory to maximize availability and fuel intensity	**Crew Planning** Manage crew location and trips to avoid unnecessary repositioning and travel	**Flight Path Management** Adjust active flights paths based on live inputs to optimize fuel burn	**Airport Traffic & Aircraft Movement** Optimize aircraft movement to decrease congestion, taxiing time, and fuel burn
Aviation Carbon Calculator Understand carbon emission scenarios & derive insights to enable emission reductions	**Sales and Distribution** Manage carbon emitting activities such as travel and waste creation		**Maintenance Planning** Manage maintenance and hanger activities to minimize carbon emissions	**Pushback Management** Delay pushback to final minute to avoid early engine starts and fuel burn

■ Examples explored in this report (Weight & Balance, Runway Congestion, Pushback Management)

Figure 1: Outline of aviation business process and sustainable IT solutions to support each.

Example IT solutions

Overview of example IT solutions

To illustrate the impact potential, two Amadeus IT solutions were selected as an example (see **Figure 2**):

1 / Amadeus Airport Sequence Manager
2 / Amadeus Altéa Departure Control - Flight Management

Selected Digital Solutions

Amadeus IT Solution	**Amadeus Airport Sequence Manager**	**Amadeus Altéa Departure Control - Flight Management**
Description	• Optimizes airports flight departure process. • Maximizes the use of available resources. • Calculates optimal aircraft start-up, off-block and take-off times.	• Automates the zero fuel weight calculations (ZFW) using passenger, baggage and cargo data. • Optimizes the use of aircraft capacity by providing visibility on available space.
Carbon Reducion Drivers/Levers	[1] Reduces holding time (and thus fuel consumption)	[1] Reduce fuel consumption [2] Reduce fuel per pax/cargo

Figure 2: Example IT solutions and corresponding descriptions and carbon reduction levers associated with the implementation of similar solutions.

These two solutions were selected from Amadeus' portfolio to show tools which impact different functional areas. A common feature of both tools is the potential to improve fuel efficiency, which reduces costs and carbon emissions. They are currently in use at airlines and airports and use advanced data and AI (Artificial Intelligence) to automate estimates and recommendations.

IT solution #1: Amadeus Airport Sequence Manager

General application

The Amadeus Airport Sequence Manager optimizes airport departures, decreasing congestion and maximizing runway capacity. The solution leverages flight schedules, real-time data inputs, and sophisticated sequencing algorithms to improve the flight departure process. The order in which flights should leave from their stands is based on aircraft readiness and runway availability. Data is continually re-calculated based on real time flight and constraint updates and automatically calculates the Target Start-Up Approval Time (TSAT) for each departing flight.

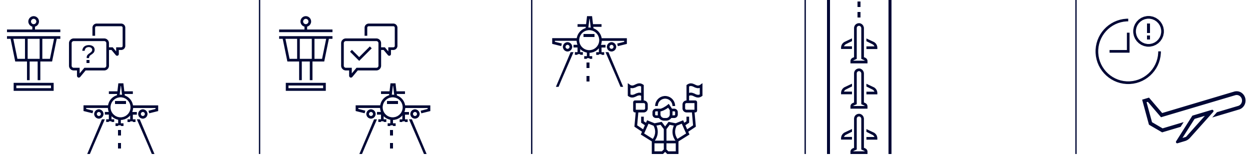
This allows aircraft to stay on the gate as long as possible, avoiding potential congestion and takeoff delay.

Additionally, accurate sequencing allows airports to maximize the usage of their existing runway capacity.

Amadeus Airport Sequence Manager Solution Overview

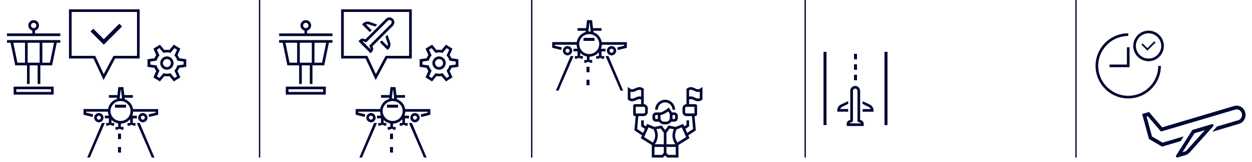
Without Airport Collaborative Decision Making (A-CDM) compliant solution

Pilor calls ATC[1] for start-up approval	**ATC and pilot exchange on when take-off is due**	**Aircraft gets pushed off from the gate**	**Aircraft taxies for take-off but finds runway congestion**	**Aircraft takes-off delayed**



With A-CDM compliant solution

ATC communicates, using system, the TSAT[2]	**Pilot calls ATC for approval as per assigned take-off time**	**Aircraft gets pushed off from the gate**	**Aircraft taxies for take-off without runway congestion**	**Aircraft takes-off on time**



Value drivers

Automatic calculation of aircraft start-up time by solution	Real-time vision of TSAT[1] and TOBT[3] provided by airlines	Optimized flight departure order given runway capacity	Reduced aircraft holding time with engines on	Increased on-time departure
Maximized usage of the airport runway with the existing capacity				

Carbon reduction levers/drivers

1. ATC: Air Traffic Control.
2. Target Start-up Approval Time.
3. Target Off-Block Time.

Figure 3: High-level overview of the value drivers of an Airport Collaborative Decision Making (A-CDM) compliant solution during pre-departure.

Carbon reduction levers

An overall reduction in fuel use is the primary carbon reduction value lever seen by using this type of technology (see **Figure 4**). Airports can expect a reduction in departure holding times, decreasing aircraft time-on-ground with engines running. Without such technology, airports risk runway congestion and departure delays, resulting in added fuel burn due to longer engine run times. Decreasing this fuel burn can decrease absolute carbon emissions.

Amadeus Airport Sequence Manager Value Levers

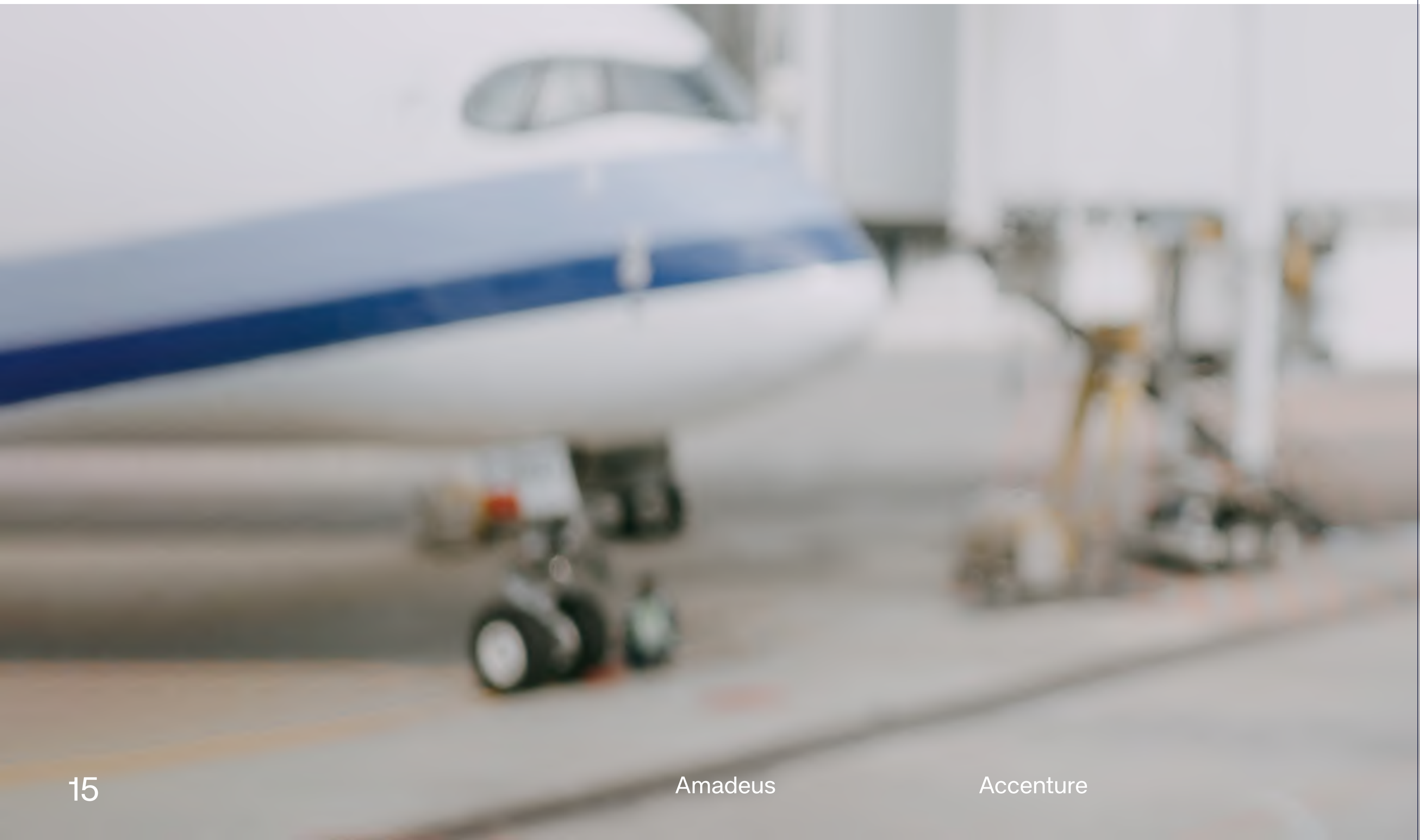
KEY VALUE DRIVERS	KEY VALUE LEVERS		IMPACT METRIC
Maximized usage of the airport runway with the existing capacity	Automation of aircraft start-up time calculation		
	Real-time vision of TSAT[1] and TOBT[2] provided by airlines		
	Optimized flight departure order given runway capacity		
	Reduced aircraft holding time with engines on →	Reduce Fuel Consumption (in liters) →	Reduced Absolute Carbon Emissions (in Mt CO_2)
	Increased on time departure		

■ Carbon reduction drivers

1. Target Start-up Approval Time.

2. Target Off-Block Time.

Figure 4: Value drivers, levers, and impact seen with an A-CDM compliant solution, when compared to an airport not using this technology.

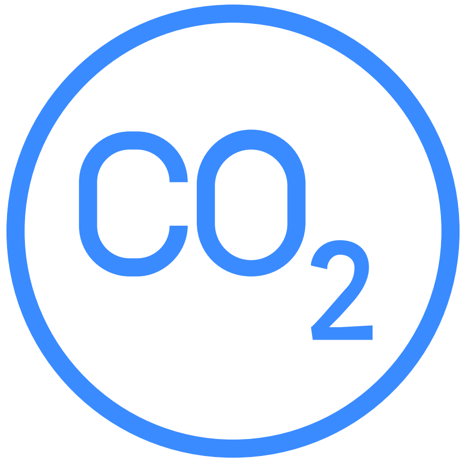


Carbon reduction impact potential

The implementation in the last decade of **Amadeus Airport Sequence Manager** at a major international connecting airport with over 100,000 departures was analyzed to better understand the impact that this technology can provide.

Departure data during the nine years before and nine years after implementation was used to understand the types of aircraft flying and the departure wait times seen over the period under analysis. This comparison allowed for the clear measurement of the time savings pre- and post-implementation. Average waiting time comparisons, defined as the time between the aircraft reaching the runway and taking off, indicated a decrease of 35 seconds per flight which equals a 19.5% reduction in waiting time.

Next, average fuel burn estimates by aircraft and engine type were applied to the findings to calculate final fuel burn savings over a one-year period. These savings were converted into carbon emissions to understand the overall impact. This average 35 second reduction per flight resulted in a potential saving of approximately 1.3 million kilograms of fuel and 4.1 thousand metric tons of CO_2 during 2023 at this single airport alone. This carbon saving is equivalent to the carbon emissions produced by ~7,282 one-way flights in economy cabin from London to New York[18].



18. Accenture's aviation carbon calculator. On average a one-way flight from LHR to JFK emits 563 kg CO_2 in economy cabin.

IT solution #2: Amadeus Altéa Departure Control - Flight Management

General application

Amadeus Altéa Departure Control - Flight Management automates load control and optimizes flight departures while ensuring that weight and balance processes are adhered to. It automates the Zero Fuel Weight (ZFW) calculation – the total weight of the aircraft and its contents without the weight of the fuel onboard – to provide a precise quantity of fuel required in advance, based on the flight and the aircraft's unique specifications.

Automation decreases the need for manual data entry from ground staff, freeing up their time and reducing potential risk of errors. Moreover, advancements in the Center of Gravity (CoG) calculation can allow aircraft weight and balance to be optimized to decrease drag and reduce fuel burn.

Automating essential pre-departure functions helps minimize the possibility of increased fuel burn which might result from last-minute changes and departure delays.

Amadeus Altéa Departure Control - Flight Management Solution Overview

Without weight & balance solution		**With** weight & balance solution
Segregated systems used to calculate ZFW[1] (performed manually by the crew for Low Cost Carriers (LCC)) [2]	FUEL	Determine the exact fuel quantity needed per flight through ZFW[1] calculation automation
Segregated systems used to calculate load distribution/centre of gravity	FUEL	Optimise the calculation of the centre of gravity of the aircraft before departure
Reduce visibility on available space per flight in real time [3]	CAPACITY	Increase load factor per flight by providing more accurate estimates on available capacity in real time [3]
Manual load planning per flight (5-6 flights handled per load controller per shift)	PRODUCTIVITY	Automate load planning per flight (90-100 flights handled per load controller per shift)
Increases probability of human error due to manual intervention	SAFETY	Reduce human intervention and potential errors due to automation

■ Carbon reduction levers/drivers

1. ZFW: Zero fuel Weight.
2. LCC Low Cost Carrier.
3. Up to 5 to 10 hours before departure.

Figure 5: High-level overview of the value drivers of a weight and balance solution

Amadeus Altéa Departure Control - Flight Management Value Levers

KEY VALUE DRIVERS	KEY VALUE LEVERS	IMPACT METRIC
Determine the exact fuel quantity needed per flight through ZFW[1] calculation automation	Reduce Fuel Consumption (in liters) →	Reduced Absolute Carbon Emissions (in Mt CO_2)[3]
Optimise thte calculation of the centre of gravity of the aircraft before departure		
Increase cargo load factor per flight by providing more accurate estimates on available capacity in real time[2]		
Automate load planning per flight (90 - 100 flights handled per load controller per shift)		
Reduce human intervention and potential errors due to automation		

■ Carbon reduction levers/drivers

1. ZFW: Zero fuel Weight.
2. Up to 5 to 10 hours before departure.
3. Metric tonnes of CO_2.

Figure 6: Value drivers, levers, and impact seen with a weight and balance / flight management solution.

Carbon reduction levers

As seen in **Figure 6**, the key value lever for this technology is an overall reduction in fuel consumption, in comparison to an airline not using this technology. This is supported through improvements in ZFW and CoG calculations. A more accurate ZFW calculation increases precision in the amount of fuel required on board, which avoids carrying unnecessary fuel and fuel burn. Improved CoG determination enables aircraft to fly in a way that is more fuel efficient by decreasing drag. Through these improved calculations, aircraft weight and balance can be optimized to decrease the overall fuel required and burned.

Carbon reduction impact potential

Amadeus Altéa Departure Control - Flight Management helps airlines reduce their carbon emissions during flight due to two main reasons: first of all, if an aircraft's required fuel for a specific flight is estimated and provisioned correctly, then less excess fuel is carried, and ultimately, a lighter aircraft will burn less fuel during the flight (this is the Zero Fuel Weight calculation). Secondly, if the aircraft's center of gravity is calculated correctly, the plane will fly more efficiently, and so burn less fuel during the flight. To analyze these impacts, the findings from a major international customer of **Amadeus Altéa Departure Control - Flight Management** are used to inform this section:

Zero Fuel Weight (ZFW)

To estimate the impact of the ZFW calculation, more than 100,000 of the customer's flights during a 6-month time-period in 2017 before the implementation of Amadeus Altéa Departure Control - Flight Management were analyzed. The data from these flights was then compared to flights in the Amadeus Altéa Departure Control - Flight Management database over a 6-month period. To ensure integrity of the results, an aggregated fleet was put together that was similar to that of the major international customer (in size, number of flights, aircraft type, etc..). **The Zero Fuel Weight was analyzed to understand the overestimation that occurred before implementation and how that compared to the data of the aggregate fleet in the Amadeus Altéa Departure Control - Flight Management database.** The higher the overestimation, the more fuel that would be onboard the plane and burned during flight as a result of carrying additional – and unnecessary – weight. Average specific fuel consumption by body type (i.e., narrowbody and widebody) was then applied to these overestimations to calculate the impact they had on fuel consumption.

Center of gravity

For center of gravity impact, **slight changes to the center of gravity by shifting weight towards the back of the aircraft results in fuel savings**. We analyzed data for around 1,500 departures over a 6-month period in 2017 before the implementation to determine the average CoG. We then compared this to the average CoG from departures with similar aircraft types in the Amadeus Altéa Departure Control - Flight Management database after implementation. Through this, **an estimated fuel consumption reduction was identified and applied to the airline's fleet**. Average specific fuel consumption by body type was then further applied, similar to the ZFW calculation, to understand overall impact.

Analysis

Based on the analysis described above it was estimated that **the implementation of the solution will have resulted in a 64% reduction in unnecessary fuel carried**. For this particular airline, this leads to 940 metric tons of fuel burn avoided on an annual basis. Additionally, through the solution, a **~1.7% improvement in the position of the center of gravity was realized**, translating to 13,600 metric tons of fuel burn.

As a combined result of these two impacts, based on our calculations and estimations, by using Amadeus Altéa Departure Control - Flight Management, the airline was able to decrease fuel burn across their fleet by approximately 14,540 metric tons in year 2023, which, at a rate of ~3.16 metric tons of CO_2 per ton of fuel burned, **would result in a potential annual avoidance of the equivalent of ~46,000 metric tons of CO_2 emissions**.

An analysis of more recent data (~26,000 flights in 2024) from this customer, using the solution since 2017, shows that an improvement is still sustained today on average per aircraft type. This analysis is based on the data available nowadays and as more data becomes available in the future, further analysis can be carried out in detail per aircraft type for other airlines to complement the results highlighted previously.

Impact potential of IT solutions

Select Amadeus Solution Impact Overview

~177x Amadeus' scope 1 & 2 emissions*

*Amadeus emissions in 2023 amounted to 14,766 tCO_2 for scope 1 & 2

~0.6% Global Aviation Emissions**

**Global aviation emissions in 2023 amounted to ~902m tCO_2

Figure 8: Example IT solutions and carbon reduction potential.

IT solutions alone are not enough to decarbonize aviation, but they can bring significant benefits in terms of CO_2 reduction when applied at scale. With millions of annual departures seen around the world, and passenger volumes tipped to grow over the next two decades, small individual savings create large global returns.

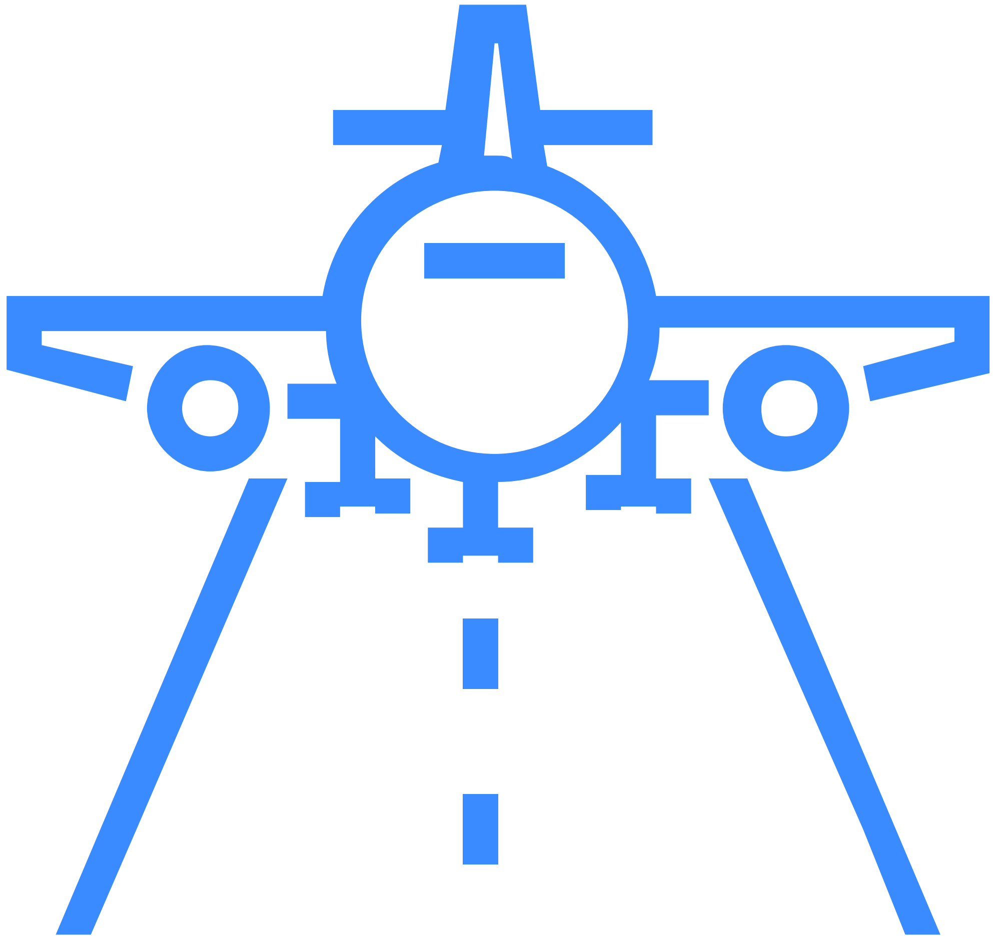
Figure 8 below summarizes our findings. The results from the two case studies are extrapolated to suggest the total reduction during the year 2023 across all Amadeus customers currently using the specified solutions compared to a situation where these Amadeus customers would not be using these IT solutions during the same time period, is calculated to reduce carbon emissions by ~2.6 million metric tons in 2023.

This figure was then used to work out the global benefits if all applicable airlines and airports based on size and flight volume used these solutions during the year 2023. The outcome of this was a drop, over a one year period, in carbon emissions of ~5.7 million metric tons in 2023, as compared to a scenario without this technology.

We have provided a comparison of these carbon savings vs Amadeus' own emissions (Scope 1 and 2) to illustrate the multiplying effect of Amadeus technology to contribute to a more sustainable industry, beyond just managing our own impact as a business. Scope 1 emissions are direct emissions a company generates, while Scope 2 emissions are indirect emissions from the generation of purchased energy.

Further considerations

Two sample IT solutions have been chosen for the purpose of this study – yet there are additional solutions that also contribute to operational efficiencies and thus carbon savings as outlined earlier in **Figure 1**, which illustrate the range of airline functions where IT solutions can help reduce carbon emissions.



Limitations of this study

The impact calculations in this study are based on real data from two case studies, but are subject to certain caveats that should be taken into account when interpreting the results:

Case study accuracy and specificity →

The calculation methodology for both solutions relies on the application of details from the case studies to the broader group of Amadeus customers. Therefore, the accuracy of the wider assessment is based on the accuracy of the original two case studies. Additionally, an average has been used to create the calculations, which may vary when applied to different flight distances or aircraft types.

Attribution of improvements to solutions →

Not all the recorded improvements can be directly attributable to the solution itself, so the methodology relies on estimating the impact of other contributing factors.

Application of solution to rest of wider industry →

To estimate the global potential impact of the solutions, assumptions have been made for the application of the solution at other airlines and/or airports.

Conclusion and Amadeus' commitment

Conclusion

The travel industry's transition to flying more sustainably is already under way, yet it will take time. The acceptance of SAF and its production at scale will continue to be a major factor in the rate at which more sustainable practices are adopted across the industry. Moreover, development and testing associated with new aircraft and energy options will require time and resources to ensure the future of flying is reliable, economical, and safe.

In the meantime, IT solutions are available on the market today and can help to start the transition to a more sustainable aviation industry by providing a near-term opportunity to improve operational efficiency and decrease unnecessary fuel burn.

In this sense, they are well aligned with the commitment to improve energy efficiency that came out of COP28.

Although this is not a 'one size fits all' solution, the application of IT solutions across operational areas can bring improved efficiency, driving toward financial and environmental goals. The improvements in operational efficiency supported by the technology that are analyzed in this report would have had the potential to contribute to the overall reduction of CO_2 emissions by an estimation of ~5.7 million metric tons in 2023 compared to operations without the types of IT solutions included in this study. With global carbon aviation emissions in 2023 estimated at ~902 million metric tons[19], this reduction would have equated to a 0.6% drop in the global aviation industry's total emissions.

19. International Energy Agency (IEA) (Jul 2023) ↗ "Transport: Aviation" and Accenture's aviation carbon calculator

Amadeus' commitment

Amadeus is committed to helping reduce the environmental impact of travel and offering travelers the option to make more informed decisions about upcoming trips through its solutions. Amadeus is tracking and addressing its own carbon emissions, which in 2023, stood at ~15,000 metric tons of CO_2 (scope 1 & 2). However, Amadeus sees a larger benefit in the ways it supports the sustainability goals of its customers. IT solutions have the ability to contribute to reducing the overall CO_2 emissions of not only the travel industry but also the global aviation industry as it continues to grow.

Ultimately, Amadeus will continue to look towards the future and has identified three ways it can achieve sustainable change.

Firstly, by exploring sustainability through technology tools, such as the option to choose more sustainable travel options seen in Amadeus' solutions for corporations, airlines and travel sellers (Cytric, Nevio and the Travel Impact Suite, respectively).

Next, by evaluating and measuring the impact that new solutions have where sustainability will remain a focus area.

Finally, by sharing the findings and educating about the ways in which IT solutions can support a sustainable future.

To learn more about Amadeus' commitment to sustainability, visit:

↗ Sustainability | Amadeus

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Technical appendix

01 / Amadeus Airport Sequence Manager

To estimate the carbon impact of the sequence manager, the following formula was used:

$$E_{avoided,i} = Dep_i \times \Delta t \times F_{fuel,i} \times f_{CO2}$$

Where:

$E_{avoided,i}$: the avoided emissions of all aircrafts of body type *i* during one full year

i : is the body type (i.e., WB, NB, RJ, Bizjet, Turboprop, etc.)

Dep_i : is the number of departures for body type *i*

Δt : is the decrease in waiting time attributed to the solution

$F_{fuel,i}$: is the idle fuel flow for body type *i* in [kg/min]

f_{CO2} : is the emission factor of jet fuel: $3.16\ kg_{CO2}/kg_{fuel}$

The decrease in waiting time attributed to the solution was estimated based on a case study by analyzing over 100,000 departures per year, during the nine years prior and the nine years following the implementation of the solution. The average reduction in waiting time is assumed to be identical for each body type. Due to data availability, the number of departures (Dep_i) in this case were based on 2022 data. Avoided emissions ($E_{avoided,i}$) were then re-baselined to 2023 by applying the yearly global aviation carbon emissions increase of 12.7% from 2022 to 2023[20].

20. Accenture's aviation carbon calculator.

02 / Amadeus Altéa Departure Control - Flight Management

Reduction of unnecessary fuel carried
To estimate the carbon impact of reducing the amount of unnecessary fuel carried, the following formula was used:

$$E_{avoided,i} = Fl_i \times \Delta Wt_i \times SFC_i^2 \times f_{CO2}$$

Where:

$E_{avoided,i}$: the avoided emissions of all aircrafts of body type *i* during one full year

i : is the body type (i.e., WB, NB or RJ)

Fl_i: is the number of flights of body type *i*

ΔWt_i: average reduction in *zero fuel weight* (ZFW) overestimation per flight of body type *i* achieved by solution

SFC_i: Average specific fuel consumption of body type *i* i.e., the fuel consumed per kg ZFW

f_{CO2}: is the emission factor of jet fuel: $3.16\ kg_{CO2}/kg_{fuel}$

The average reduction in Zero Fuel Weight (ZFW) overestimations is estimated by analyzing a case study containing data of well over 100,000 flights from a 6-month period from 2017. To ensure integrity of the results only overestimates above a certain level were considered (Estimated Zero Fuel Weight >101% of Actual Zero Fuel Weight). Combining all overestimates led to an average overestimate per flight. The reduction of this number through the use of the solution was then used to calculate the impact. Due to data availability, the number of flights (Fl_i) in this case were based on 2022 data. Avoided emissions ($E_{avoided,i}$) were then re-baselined to 2023 by applying the yearly global aviation carbon emissions increase of 12.7% from 2022 to 2023[21].

21. Accenture's aviation carbon calculator.

Improvement of center of gravity
To estimate the carbon impact of improving the location of the center of gravity, the following formula was used:

$$E_{avoided,i} = Fl_i \times \left(\frac{C_{fuel,i}}{1-R_i} - C_{fuel,i} \right) \times f_{CO2}$$

Where:

$E_{avoided,i}$: the avoided emissions of all aircrafts of body type *i* during one full year

i : is the body type (i.e., WB, NB or RJ)

Fl_i: is the number of flights of body type *i*

$C_{fuel,i}$: average fuel consumption of a flight of body type *i*

R_i: the reduction in fuel consumption by use of the solution for body type *i* [%]

f_{CO2} : is the emission factor of jet fuel: 3.16 kg_{CO2}/kg_{fuel}

The reduction in fuel consumption is determined based on a case study involving a customer using the solution considering 1,500 departures over a 6-month period in 2017 and reporting an improvement in the location of the center of gravity resulting in a reduction in fuel consumption of Ri [%]. The position of the center of gravity is measured in %MAC and an improvement of 1.5% will lead to a 1% increase in fuel efficiency for wide bodies (assumed to be 0.8% for narrow bodies and 0% for regional jets). As the measured improvement in the case study exceeded 1.5% (i.e., 1.71%). The beforementioned improvement is assumed to be reached. Due to data availability, the number of flights (Fli) in this case were based on 2022 data. Avoided emissions ($E_{avoided,i}$) were then re-baselined to 2023 by applying the yearly global aviation carbon emissions increase of 12.7% from 2022 to 2023[22].

Note: The MAC (Mean Aerodynamic Chord) refers to the average chord length, which is the distance between the leading and trailing edges of a wing. The position of the CoG is expressed in %MAC where 0% and 100% represent the leading and trailing edges of the MAC respectively.

22. Accenture's aviation carbon calculator.

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