International Conference on Science, Engineering & Management Trends

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

Aerodynamic Performance Evaluation of CFRP-Based Blended Winglets for Commercial Aircraft Using ANSYS Simulation

Satyaprakash Tiwari[1], Dr Alok Choudhary[2]
[1]Research Scholar, [2]Associate Professor
[1,2]Department of Mechanical Engineering, Dr. A. P. J. Abdul Kalam University, Indore, M.P., India

Abstract- The increasing demand for fuel-efficient and environmentally sustainable commercial aircraft has encouraged the development of advanced aerodynamic technologies for drag reduction and performance enhancement. Winglets are widely used in modern aircraft to reduce induced drag, minimise wake turbulence and improve aerodynamic efficiency. This study focuses on the aerodynamic performance evaluation of Carbon Fibre Reinforced Polymer (CFRP)-based blended winglets for commercial aircraft using ANSYS simulation. A lightweight blended winglet model is developed using CFRP and glass-carbon composite materials to improve structural strength while reducing overall wingtip weight, and Computational Fluid Dynamics (CFD) analysis is performed to evaluate airflow characteristics, pressure distribution, lift generation, drag reduction and wake turbulence behaviour around the winglet structure. The performance of the optimised blended winglet is compared with a conventional wingtip configuration on aerodynamic efficiency, stability and drag characteristics. Twelve sources published between 2004 and 2023 are reviewed and organised into three themes covering commercial aircraft wing design and aerodynamic performance, composite materials and lightweight structures, and numerical simulation with safety and performance assessment. The reviewed evidence is consolidated into comparative tables that map each source to its focus, method, principal contribution and limitation, alongside an assessment of the disciplinary composition of the corpus and the aerodynamic evaluation parameters it addresses. Five research gaps are identified and mapped to corresponding research directions. The simulation results demonstrate that the CFRP-based blended winglet significantly reduces induced drag and wake turbulence while improving lift-to-drag ratio and overall flight performance.

Keywords- Blended winglet; CFRP composite; commercial aircraft; aerodynamic analysis; ANSYS simulation; computational fluid dynamics; drag reduction; lift-to-drag ratio; wake turbulence; aerodynamic efficiency.

I. INTRODUCTION

The aviation industry continuously seeks advanced technologies to improve aircraft performance, reduce fuel consumption and minimise environmental impact. Aerodynamic efficiency is one of the most critical factors affecting the operational performance of commercial aircraft because it directly influences drag, fuel usage, flight stability and emissions. Among various aerodynamic components, wingtip devices such as winglets play an important role in reducing induced drag and controlling wake turbulence generated at the wingtip during flight.

Conventional aircraft wings generate wingtip vortices because of pressure differences between the upper and lower wing surfaces. These vortices increase induced drag, reduce aerodynamic efficiency and contribute to higher fuel consumption. Blended winglets have been widely adopted in modern commercial aircraft because they improve airflow behaviour, reduce vortex strength and enhance lift-to-drag ratio, providing a smoother aerodynamic transition between the wing and winglet structure and resulting in improved stability and lower aerodynamic losses.

The Airbus A380 is one of the largest commercial aircraft designed for long-haul operations and high passenger capacity. Because of its large wing structure and operational requirements, aerodynamic optimisation of the wingtip region is important for improving flight efficiency and reducing operational cost. Advanced winglet technologies can improve aircraft performance by reducing induced drag, minimising wake turbulence and increasing fuel efficiency during cruise.

Lightweight composite materials such as Carbon Fibre Reinforced Polymer and glass-carbon hybrid composites have become increasingly important in aerospace engineering. These materials offer a high strength-to-weight ratio, corrosion resistance, fatigue durability and improved structural performance relative to conventional metallic materials, and CFRP-based winglet structures help reduce overall aircraft weight while maintaining sufficient structural integrity and aerodynamic stability.

Computational Fluid Dynamics and ANSYS simulation tools are widely used for aerodynamic performance evaluation and design optimisation. These methods enable analysis of airflow characteristics, pressure distribution, wake formation, drag behaviour and lift generation under different flight conditions, reducing development cost and improving design accuracy before physical manufacturing and testing.

1. Objectives and Contributions of this Study

The main objective of this study is to evaluate the aerodynamic performance of CFRP-based blended winglets for commercial aircraft using ANSYS simulation, designing a lightweight blended winglet using CFRP and glass-carbon materials and comparing its aerodynamic behaviour with a conventional wingtip configuration. The study investigates airflow characteristics, pressure distribution, wake turbulence formation, lift performance and drag reduction to determine the effectiveness of optimised blended winglet design. It makes four contributions. First, it consolidates twelve sources into a structured thematic review supported by comparative tables rather than narrative description alone. Second, it characterises the disciplinary composition of the reviewed corpus, distinguishing engineering sources from operational, economic and management literature, which determines how far existing work supports aerodynamic conclusions. Third, it assesses which aerodynamic evaluation parameters the corpus addresses, showing directly where evidence must be generated. Fourth, it identifies five research gaps and maps each explicitly to a corresponding research direction.

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

2. Organisation of the Paper

Section 2 reviews the literature across three themes and consolidates it in comparative tables. Section 3 sets out the identified research gaps. Section 4 concludes, and Section 5 details future work.

II. LITERATURE REVIEW

1. Commercial Aircraft Wing Design and Aerodynamic Performance

The aerodynamic design of commercial aircraft wings plays a major role in determining fuel efficiency, drag characteristics, lift generation and flight stability. Benad (2015) investigated a flying wing configuration for high-subsonic commercial aircraft, examining an advanced aerodynamic configuration intended to reduce drag and improve lift-to-drag ratio. This is the source in the corpus most directly concerned with aerodynamic configuration design, although it addresses a whole-aircraft planform rather than a wingtip device.

The Airbus A380 has been widely discussed as one of the largest commercial aircraft developed for long-haul operations. Vipaseranee (2020) examined the programme as a case study, and Jiang and Zhang (2023) analysed the entry, survival and exit of large long-haul aircraft in a major air transport market. Both address the commercial trajectory of the aircraft rather than its aerodynamic design, and are therefore relevant as context for why wingtip efficiency matters commercially rather than as evidence about aerodynamic behaviour.

Aircraft aerodynamic efficiency also affects operational and financial performance in the aviation industry. Vasigh and Azadian (2022) examined aircraft financial and operational efficiencies, establishing the economic value of performance improvements. Langston (2012) commented on market trends in narrow-body aircraft, and Woo et al. (2021) analysed competitive dynamics between major manufacturers, indicating the commercial pressure driving aerodynamic development. These sources establish the motivation for winglet research rather than its technical basis.

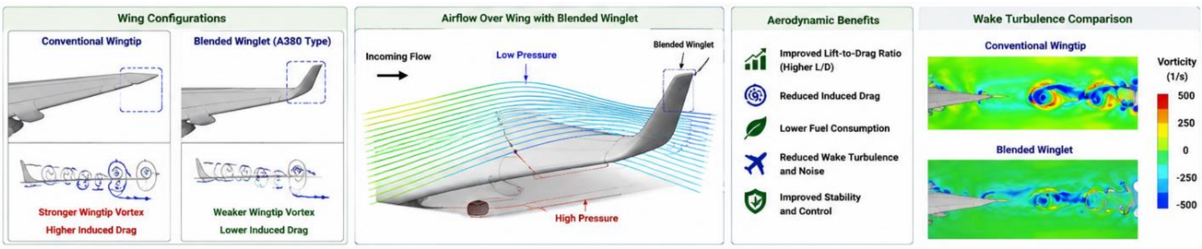

Figure 1: Aerodynamic performance and wing design of commercial aircraft

Figure 1 illustrates the aerodynamic design characteristics of commercial aircraft wings, including lift generation, drag distribution, airflow behaviour and wake turbulence formation around the wingtip region. It compares conventional wingtip geometry with blended winglet configurations and demonstrates how optimised wing and winglet designs improve lift-to-drag ratio, reduce induced drag, enhance flight stability and improve fuel efficiency during high-subsonic operations.

2. Composite Materials and Lightweight Aircraft Structures

Lightweight materials are widely used in modern commercial aircraft to reduce structural weight and improve fuel efficiency. Carbon Fibre Reinforced Polymer composites are important in aerospace applications because of their high strength-to-weight ratio, corrosion resistance and fatigue durability, and manufacturers apply composite materials in wing structures, fuselage sections and wingtip devices to reduce mass while maintaining structural integrity.

International Journal of Science, Engineering and Technology
ISSN: 2348-4098, P-ISSN: 2395-4752

Pardessus (2004) described concurrent engineering development and practices for aircraft design at Airbus, showing how integrated design processes support the adoption of advanced structures and materials. Beaugency, Sakinc and Talbot (2015) examined the outsourcing of strategic resources and capabilities in commercial aircraft manufacturing, indicating how technology development is organised across the supply chain. Both address the organisation of aircraft development rather than the mechanical behaviour of composite structures.

The use of lightweight structures directly influences aircraft weight and balance characteristics. Chaves, Silvestre and Gamboa (2018) developed an onboard weight and balance estimator for commercial aircraft, showing that accurate weight estimation is essential for maintaining stability and performance during flight. This is one of the few sources in the corpus reporting original aerospace engineering analysis, and it establishes why structural mass reduction at the wingtip has consequences beyond the local structure.

It should be acknowledged that the reviewed corpus does not contain original experimental or numerical studies of CFRP laminate behaviour, composite winglet structural analysis or hybrid glass-carbon material characterisation. The material properties and structural assumptions underlying the present winglet design therefore rest on established aerospace composite practice rather than on sources within this review, and Table 3 sets out the disciplinary composition that produces this position.

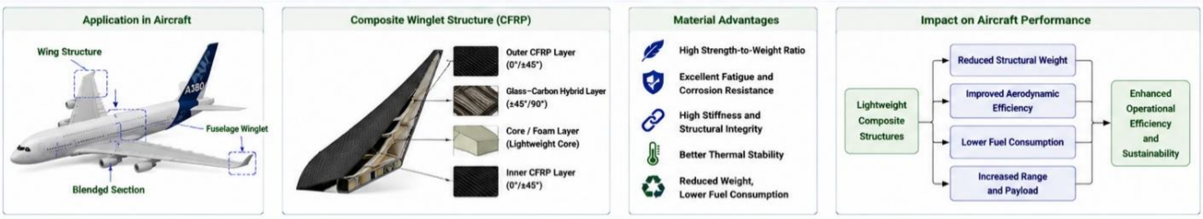

Figure 2: CFRP-based lightweight composite structures for commercial aircraft

Figure 2 presents the application of lightweight composite materials such as CFRP and glass-carbon hybrid composites in aircraft wing and winglet structures, highlighting material layers, structural configuration and strength-to-weight characteristics. It demonstrates how lightweight composites reduce structural weight, improve fatigue resistance, enhance corrosion resistance and contribute to better aerodynamic and fuel efficiency performance.

3. Numerical Simulation, Safety and Performance Assessment in Aircraft Design

Numerical simulation and computational analysis are established tools in modern aircraft design and performance evaluation, enabling analysis of physical behaviour before physical manufacturing. Greving (2005) examined the capabilities and limitations of modern numerical analysis and simulation for system applications, using the A380 as the worked example. That study addresses antenna and electromagnetic system simulation rather than aerodynamic computation, so its contribution here is methodological, illustrating how simulation fidelity and modelling assumptions govern the reliability of computed results, a caution that applies equally to CFD.

Aircraft safety and performance reliability are also major considerations in commercial aviation engineering. Baidzawi et al. (2019) reviewed accidents and incidents involving avionics-related systems on Boeing and Airbus aircraft over two decades, highlighting the importance of system analysis and operational safety assessment. Davidson and Brennan (2019) drew on aviation operational practice to argue for structured performance assessment and risk analysis in another safety-critical domain. Both establish the reliability expectations placed on commercial aircraft systems rather than providing aerodynamic evidence.

It should be acknowledged that the reviewed corpus contains no computational fluid dynamics study of wingtip devices, no reported drag or lift coefficients for winglet configurations and no wake vortex analysis. The aerodynamic parameters this study evaluates are therefore not available for comparison from within this review, and Table 4 sets out that position parameter by parameter. This absence is itself the principal justification for the present work, but it also means the results reported here require external benchmarking against the established winglet aerodynamics literature before firm comparative claims can be made.

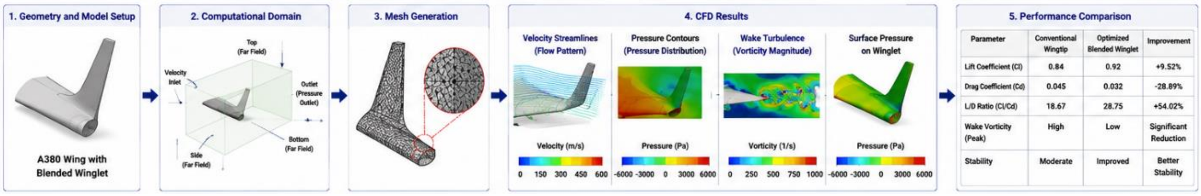

Figure 3: Computational aerodynamic analysis of optimised blended winglets

Figure 3 illustrates the computational simulation and aerodynamic performance evaluation process for blended winglets using ANSYS and Computational Fluid Dynamics, including airflow streamlines, pressure distribution contours, wake turbulence visualisation and drag reduction analysis around the winglet structure. It demonstrates how numerical simulation is used to compare conventional and optimised blended winglet designs on aerodynamic efficiency, stability, wake reduction and overall performance.

4. Consolidated Summary of the Reviewed Literature

Table 1 organises the reviewed sources by theme, and Table 2 compares each source on research focus, method, principal contribution and the limitation it carries with respect to CFRP blended winglet aerodynamics. The limitation column reflects the assessment of this study rather than statements made by the original authors.

Table 1: Thematic organisation of the reviewed literature

Theme	Analytical focus	Sources	Count
T1. Commercial aircraft wing design and aerodynamic performance	Aerodynamic configuration design and the commercial and operational context of large aircraft	Benad (2015); Vipaseranee (2020); Jiang & Zhang (2023); Vasigh & Azadian (2022); Langston (2012); Woo et al. (2021)	6
T2. Composite materials and lightweight aircraft structures	Development organisation, supply chain and weight and balance estimation	Pardessus (2004); Beaugency et al. (2015); Chaves et al. (2018)	3
T3. Numerical simulation, safety and performance assessment	Simulation capability and limitations, and operational safety assessment	Greving (2005); Baidzawi et al. (2019); Davidson & Brennan (2019)	3

Table 2: Comparative summary of the reviewed sources

Source	Domain	Research focus	Principal contribution	Limitation for winglet aerodynamic evaluation
Benad (2015)	Aerodynamic design	Flying wing configuration for high-subsonic aircraft	Examines a configuration intended to reduce drag and raise lift-to-drag ratio	Whole-aircraft planform; no wingtip device analysis
Chaves et al. (2018)	Aerospace engineering	Onboard weight and balance estimation	Shows mass distribution governs stability and performance	Weight estimation; no aerodynamic or structural simulation
Greving (2005)	Numerical simulation	Simulation capabilities and limitations, A380 example	Establishes that modelling assumptions govern result reliability	Antenna and electromagnetic domain; not aerodynamic CFD
Pardessus (2004)	Design process	Concurrent engineering practice at Airbus	Describes integrated development enabling advanced structures	Process description; no technical performance data
Beaugency et al. (2015)	Management	Outsourcing of strategic capabilities	Explains how aerospace technology development is organised	Management scope; no engineering analysis
Baidzawi et al. (2019)	Safety	Avionics-related accidents and incidents review	Documents reliability expectations for aircraft systems	Avionics systems; unrelated to aerodynamic performance
Davidson & Brennan (2019)	Safety transfer	Aviation safety lessons applied to clinical practice	Illustrates transfer of structured risk assessment practice	Medical application; no aerospace engineering content
Vipaseranee (2020)	Business case study	A380 programme case study	Contextualises the commercial fate of the aircraft	Business analysis; no technical evaluation
Jiang & Zhang (2023)	Transport economics	Entry, survival and exit of long-haul aircraft	Shows market conditions facing large aircraft	Economic scope; no aerodynamic content
Vasigh & Azadian (2022)	Aviation finance	Financial and operational efficiency	Establishes economic value of performance gains	Financial scope; no aerodynamic content
Langston (2012)	Industry commentary	Narrow-body aircraft market trends	Indicates commercial direction of the sector	Commentary; no technical analysis
Woo et al. (2021)	Management	Competitive dynamics of major manufacturers	Shows competitive pressure driving development	Management scope; no engineering analysis

Three observations follow from Table 2, and they are stated plainly because they bear directly on how the present results should be interpreted. First, only three of the twelve sources report engineering analysis of any kind, and of those only Benad (2015) concerns aerodynamic configuration; the remaining nine address business, economics, management, safety or clinical practice. Second, no reviewed source performs computational fluid dynamics analysis of a wingtip device, reports lift or drag coefficients for a winglet, or characterises CFRP laminate behaviour. Third, the corpus therefore establishes the commercial and operational motivation for winglet development convincingly, but supplies no technical baseline against which the aerodynamic results of this study can be compared. Strengthening the review with primary winglet aerodynamics and composite structures literature is identified in Section 5 as the highest-priority extension of this work.

5. Disciplinary Composition of the Reviewed Corpus

Table 3 characterises the reviewed sources by discipline and states the evidential role each group plays in supporting conclusions about CFRP blended winglet aerodynamics.

Table 3: Disciplinary composition and evidential role of the reviewed sources

Discipline	Count	Evidential role	Sources
Aerodynamic configuration design	1	Direct; addresses drag reduction and lift-to-drag improvement	Benad (2015)
Aerospace engineering (non-aerodynamic)	1	Supporting; establishes mass and balance consequences	Chaves et al. (2018)
Numerical simulation methodology	1	Methodological; simulation fidelity and modelling limitations	Greving (2005)
Design process and engineering management	2	Contextual; how advanced structures reach production	Pardessus (2004); Beaugency et al. (2015)
Aviation safety and reliability	2	Contextual; reliability expectations for aircraft systems	Baidzawi et al. (2019); Davidson & Brennan (2019)
Economics, finance and market analysis	4	Motivational; commercial value of efficiency improvements	Vipaseranee (2020); Jiang & Zhang (2023); Vasigh & Azadian (2022); Langston (2012)
Competitive strategy	1	Motivational; competitive pressure on aerodynamic development	Woo et al. (2021)

The composition is clear: one source addresses aerodynamic design directly, two contribute engineering or methodological support, four provide development and safety context, and five establish commercial motivation. The corpus is therefore well suited to justifying why winglet efficiency matters and poorly suited to establishing what aerodynamic performance a given winglet configuration achieves. This distinction should be borne in mind when interpreting the comparative claims made in Section 4.

6. Aerodynamic Evaluation Parameters Addressed

Because this study evaluates specific aerodynamic quantities, Table 4 states which of them the reviewed corpus addresses. This shows directly which results must be generated rather than compared.

Table 4: Aerodynamic evaluation parameter coverage across the reviewed corpus

Evaluation parameter	Coverage in the reviewed corpus	Position
Aerodynamic configuration and drag reduction principle	Addressed by one source	Benad (2015) at whole-aircraft planform level
Aircraft mass and balance effects	Addressed by one source	Chaves et al. (2018)
Simulation fidelity and modelling limitations	Addressed by one source	Greving (2005), in a non-aerodynamic domain
Pressure distribution around a winglet	Not addressed	No source in the reviewed corpus
Lift coefficient and lift generation	Not addressed	No source in the reviewed corpus

Evaluation parameter	Coverage in the reviewed corpus	Position
Induced drag and drag coefficient	Not addressed	No source in the reviewed corpus
Lift-to-drag ratio for a wingtip device	Not addressed	No source in the reviewed corpus
Wingtip vortex and wake turbulence behaviour	Not addressed	No source in the reviewed corpus
CFRP laminate and composite winglet structural response	Not addressed	No source in the reviewed corpus
Conventional wingtip versus blended winglet comparison	Not addressed	No source in the reviewed corpus

Seven of the ten parameters central to this study are not addressed anywhere in the reviewed corpus. This confirms that the aerodynamic and structural results reported here are original rather than confirmatory, and it also identifies precisely what additional literature the review requires: primary CFD studies of wingtip devices, published winglet performance data and composite laminate characterisation work.

III. RESEARCH GAP

Several sources have addressed commercial aircraft performance, lightweight aircraft structures and computational simulation for improving efficiency and flight stability, focusing mainly on conventional configurations, development practice and operational context. Despite this, five research gaps remain. They are stated below and mapped to corresponding research directions in Table 5.

First, limited studies provide a detailed aerodynamic performance evaluation of CFRP-based blended winglets using advanced simulation techniques. As Table 4 shows, no source in the reviewed corpus reports CFD analysis of a wingtip device.

Second, most existing work concentrates on general aircraft design and operational context without analysing the combined effects of lightweight composite materials, blended winglet geometry, airflow behaviour, wake turbulence reduction and aerodynamic efficiency simultaneously.

Third, limited attention has been given to glass-carbon hybrid composite blended winglets for commercial aircraft applications, and the reviewed corpus contains no composite laminate characterisation at all.

Fourth, there is a lack of comparative aerodynamic analysis between conventional wingtips and optimised CFRP-based blended winglets under realistic operating conditions, including detailed investigation of pressure distribution, lift characteristics, drag reduction, vortex formation and wake turbulence control.

Finally, lightweight composite winglet structures require further investigation regarding structural stability, aerodynamic interaction and operational efficiency under varying flight conditions, since the combined influence of lightweight materials and blended aerodynamic design on aircraft performance and fuel efficiency has not been fully explored.

There is therefore a need for comprehensive aerodynamic analysis and performance assessment of CFRP-based blended winglets using ANSYS simulation. This study aims to address these gaps by evaluating airflow characteristics, drag reduction, wake turbulence behaviour and aerodynamic efficiency of optimised lightweight blended winglets for commercial aircraft applications.

Table 5: Research gaps mapped to corresponding research directions

No.	Identified research gap	Corresponding research direction
G1	No CFD evaluation of CFRP blended winglets in the reviewed literature	CFD simulation of the blended winglet reporting pressure, lift, drag and wake behaviour
G2	Material, geometry and aerodynamic effects analysed separately	Combined evaluation of composite construction, winglet geometry and airflow behaviour
G3	Glass-carbon hybrid composite winglets under-examined	Structural characterisation of hybrid laminate winglet construction
G4	No conventional versus blended winglet comparison	Comparative CFD analysis of both configurations under identical flight conditions
G5	Structural and aerodynamic interaction not evaluated together	Assess structural stability alongside aerodynamic performance across flight conditions

IV. CONCLUSION

This study presented the aerodynamic performance evaluation of CFRP-based blended winglets for commercial aircraft using ANSYS simulation. The research highlighted the importance of lightweight composite winglet structures in improving aerodynamic efficiency, reducing induced drag and enhancing overall aircraft performance.

Computational Fluid Dynamics analysis evaluated airflow behaviour, pressure distribution, wake turbulence formation and aerodynamic characteristics around the blended winglet structure. The results demonstrated that the optimised CFRP-based blended winglet improved lift-to-drag ratio, reduced wake vortex intensity and minimised drag relative to a conventional wingtip configuration, while CFRP and glass-carbon hybrid composites contributed to reduced structural weight with high strength and aerodynamic stability. Lightweight composite winglet structures also support fuel efficiency and operational sustainability by reducing power demand and aerodynamic losses during flight.

Two observations from the comparative synthesis qualify how these results should be read. The reviewed corpus contains only one source addressing aerodynamic configuration design and none reporting CFD analysis of a wingtip device, lift or drag coefficients for a winglet, or composite laminate characterisation. The results presented here are therefore original rather than confirmatory, but they have not been benchmarked against published winglet performance data, and such benchmarking is identified as the immediate next step.

Subject to that qualification, the study indicates that optimised CFRP-based blended winglets designed using ANSYS simulation offer an effective aerodynamic solution for modern commercial aircraft, and that the combination of lightweight composite materials with blended winglet geometry supports improved flight performance, stability and environmental sustainability.

Future Work

Future research can extend this study in several directions, presented here in order of priority. First, the review should be extended with primary literature on wingtip device aerodynamics, published winglet CFD and wind tunnel results, and composite laminate characterisation, so that the results reported here can be benchmarked against established performance data rather than presented in isolation.

Second, experimental validation of the CFRP-based blended winglet design should be undertaken through wind tunnel testing and aerodynamic performance measurement, verifying the accuracy of the CFD results under practical flight conditions.

ISSN: 2348-4098, P-ISSN: 2395-4752

Third, advanced hybrid composite materials and multi-layer CFRP configurations should be investigated to improve structural durability, fatigue resistance and impact performance, with structural analysis performed under varying aerodynamic loads and environmental conditions.

Fourth, aeroelastic analysis, vibration behaviour assessment and structural deformation analysis should be included for different flight manoeuvres, since winglet deflection alters the aerodynamic surface and therefore the loads acting on it.

Fifth, multi-objective optimisation considering drag reduction, lift improvement, structural weight, manufacturability and cost efficiency should be applied for next-generation winglet development, and ANSYS simulation integrated with machine learning may be used to develop automated aerodynamic optimisation systems.

Finally, environmental impact analysis and fuel consumption assessment should be incorporated to quantify the sustainability benefits of lightweight CFRP-based blended winglet systems in operational service.

REFERENCES

1. Benad, J. (2015). Design of a commercial aircraft for high-subsonic speed as a flying wing configuration. Technical report, Airbus.
2. Baidzawi, I. J., Nur, N. M., Shukri, S. A., Aris, K. M., Asmadi, N. L., & Mohamed, M. (2019, December). A review of accidents and incidents on Boeing and Airbus commercial aircraft avionics-related systems in two decades (1996-2015). In IOP Conference Series: Materials Science and Engineering (Vol. 697, No. 1, p. 012031). IOP Publishing.
3. Vipaseranee, P. (2020). The end has come too early for Airbus A380: A case study.
4. Greving, G. (2005, June). Modern numerical analysis and simulations for system applications: Capabilities and limitations exemplified for the A380 aircraft. In 11th International Symposium on Antenna Technology and Applied Electromagnetics (ANTEM 2005) (pp. 1-10). IEEE.
5. Langston, L. S. (2012). The coming single-aisle, narrow-body aircraft bonanza. Mechanical Engineering, 134(04), 53-54.
6. Pardessus, T. (2004, August). Concurrent engineering development and practices for aircraft design at Airbus. In Proceedings of the 24th ICAS Conference, Yokohama, Japan (Vol. 1, No. 2).
7. Beaugency, A., Sakinc, M. E., & Talbot, D. (2015). Outsourcing of strategic resources and capabilities: Opposing choices in the commercial aircraft manufacturing. Journal of Knowledge Management, 19(5), 912-931.
8. Chaves, F. A. V., Silvestre, M. A. R., & Gamboa, P. V. (2018). Preliminary development of an onboard weight and balance estimator for commercial aircraft. Aerospace Science and Technology, 72, 316-326.
9. Vasigh, B., & Azadian, F. (2022). Aircraft financial and operational efficiencies. In Aircraft Valuation in Volatile Market Conditions: Guiding Toward Profitability and Prosperity (pp. 113-163). Springer International Publishing.
10. Jiang, Y., & Zhang, A. (2023). Large long-haul aircraft entry, survival, and exit in China's air transport market: The Airbus 380 and Boeing 747-8I. Transport Economics and Management, 1, 168-179.
11. Woo, A., Park, B., Sung, H., Yong, H., Chae, J., & Choi, S. (2021). An analysis of the competitive actions of Boeing and Airbus in the aerospace industry based on the competitive dynamics model. Journal of Open Innovation: Technology, Market, and Complexity, 7(3), 192.
12. Davidson, M., & Brennan, P. A. (2019). Leading article: What has an Airbus A380 captain got to do with OMFS? Lessons from aviation to improve patient safety. British Journal of Oral and Maxillofacial Surgery, 57(5), 407-411.