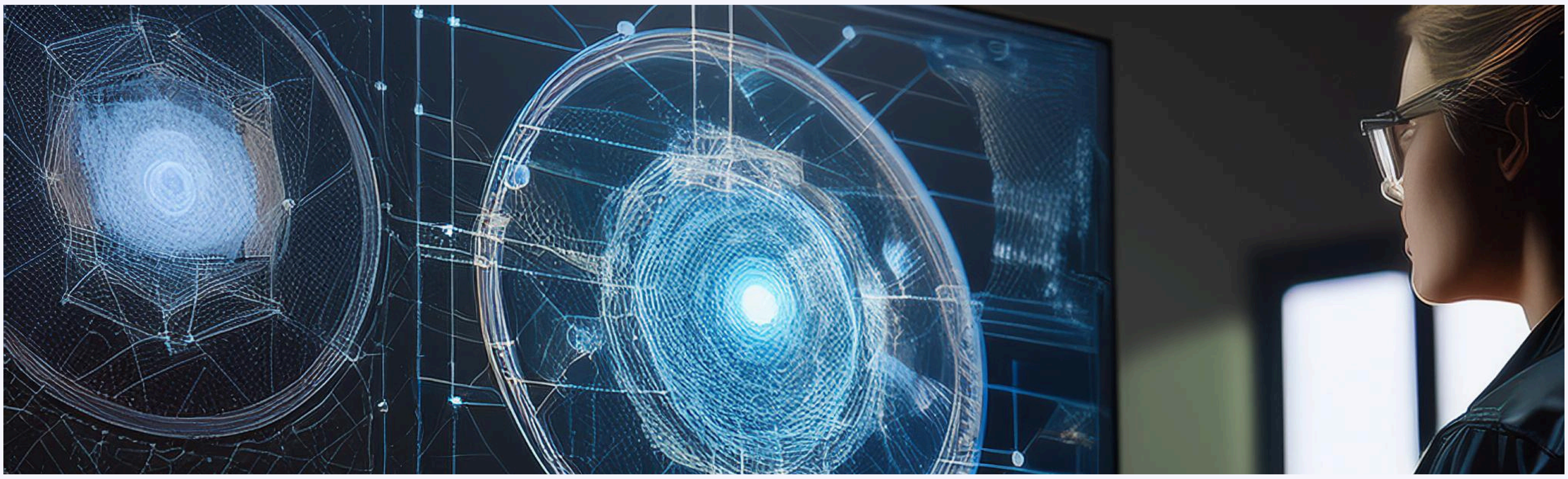
# BQPhy®Design Optimization Problem for Mission-Critical Applications

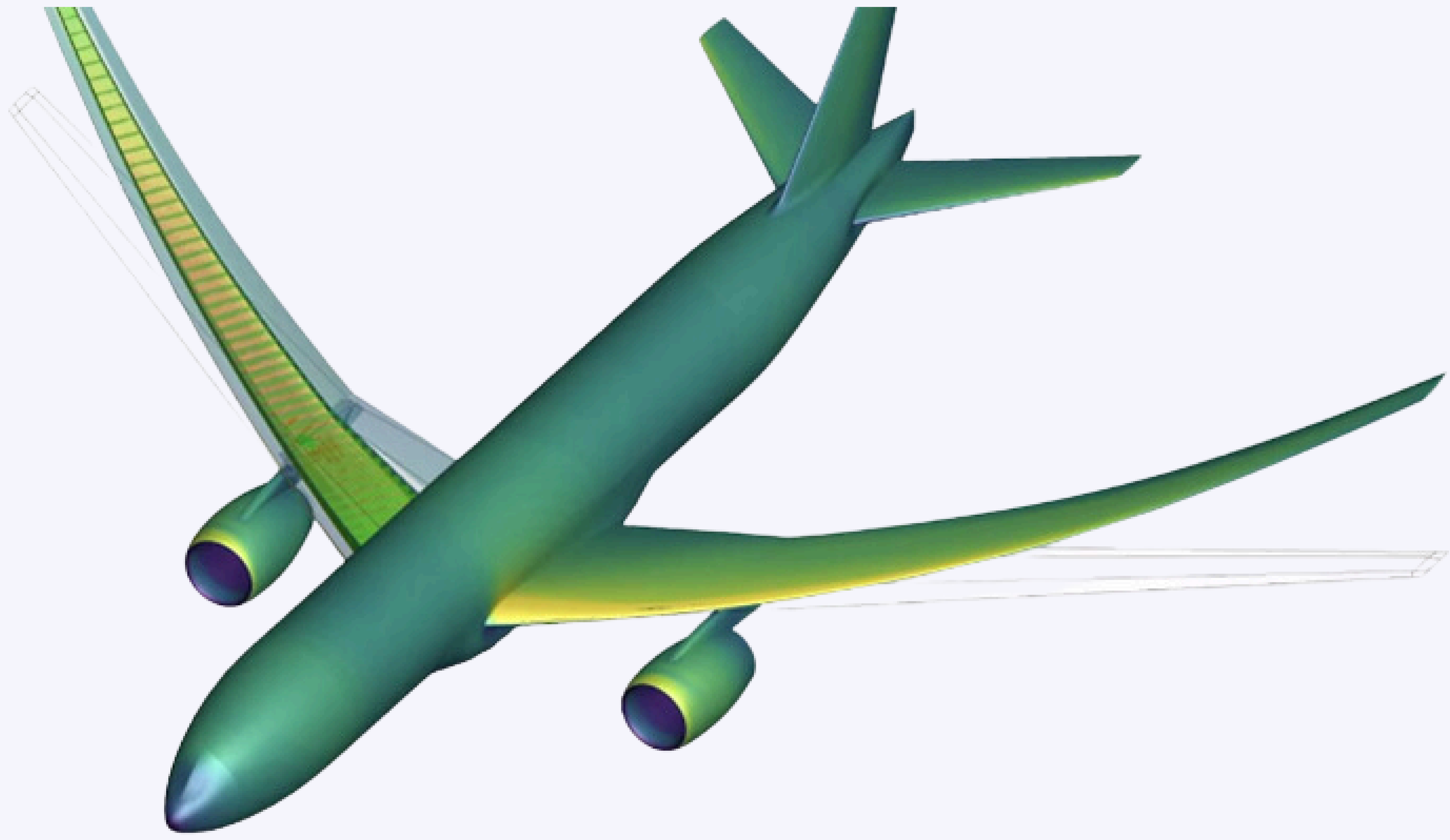


## Summary


BQPhy®'s QIEO™ solver revolutionized airfoil optimization by significantly reducing iterations and enhancing weight reduction.

This breakthrough improves fuel efficiency, extends aircraft range, and increases payload capacity for aerospace and defense applications.

## Improving Aircraft Performance and Efficiency for the Aerospace and Defense Sector



**Optimization** in mission-critical aerospace applications faces challenges related to design complexity, number of variables and objectives involved, computational cost, accuracy, and time-to-market.

Conventional methods often converge into local optima due to complex design space, resulting in suboptimal designs, requiring extensive iterations, thereby increasing computing expenses and delaying product development.

## Challenges in Aerospace Design Optimization

- Achieving an optimal balance between weight reduction and structural integrity is challenging for traditional optimization solvers.
- Managing complex aerodynamic constraints with high computational overhead.
- Classical solvers require large-scale computational resources and often fail to find the global optimum efficiently.

## Limitations:

**Computational Bottleneck:** The increasing number of variables, Dimensions in optimization problems, such as in wing airfoil designs, overwhelms traditional classical methods.

**Algorithmic Limitations:** Classical optimization algorithms fail to handle the growing complexity of aerodynamic designs, constraints, and multiple objectives and converge at local minima.

**Complexity of Optimization problems:** With the rising number of constraints and objectives, optimization becomes increasingly challenging, often leading to local minima rather than the global optimum.

**Failure to Find Global Minima:** Traditional methods are unable to efficiently search for the global minimum, leading to suboptimal solutions and unnecessary computational overhead.

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## Our Methodology: Quantum-Inspired Evolutionary Optimization

BQPhy's QIEO solver applies quantum principles like superposition and entanglement to explore large design spaces efficiently, reducing computational overhead.

In the context of airfoil structure volume minimization, QIEO brings a different optimization landscape compared to classical methods. Aerospace structures have a low volume fraction due to stringent weight constraints.

The added complexity of slenderness, buckling, and strength considerations makes it difficult to achieve optimal low-weight, high-performance designs using traditional solvers.

QIEO's topology optimization approach removes excess material from unintended structures, ensuring maximum efficiency for low-volume fraction aerospace components. Unlike traditional finite element-based topology optimization, which uses continuous design variables (0 to 1).

QIEO eliminates fictitious elements, providing a clear, manufacturable boundary for fabrication.

## Key Advantages of QIEO Over Classical Approaches:

**Finds global minima –** Ensures more optimal designs.

**Requires fewer iterations –** Reduces the need for extensive CFD/FEA solver calls.

**Faster iteration time on GPUs –** Lowers high-performance computing (HPC) costs.

BQPhy's Optimization Solver specializes in Quantum-Inspired Design Optimization for aerospace applications, significantly enhancing efficiency and accuracy.

**Finds global minima**

**Requires fewer iterations**

**Faster iteration time on GPUs**

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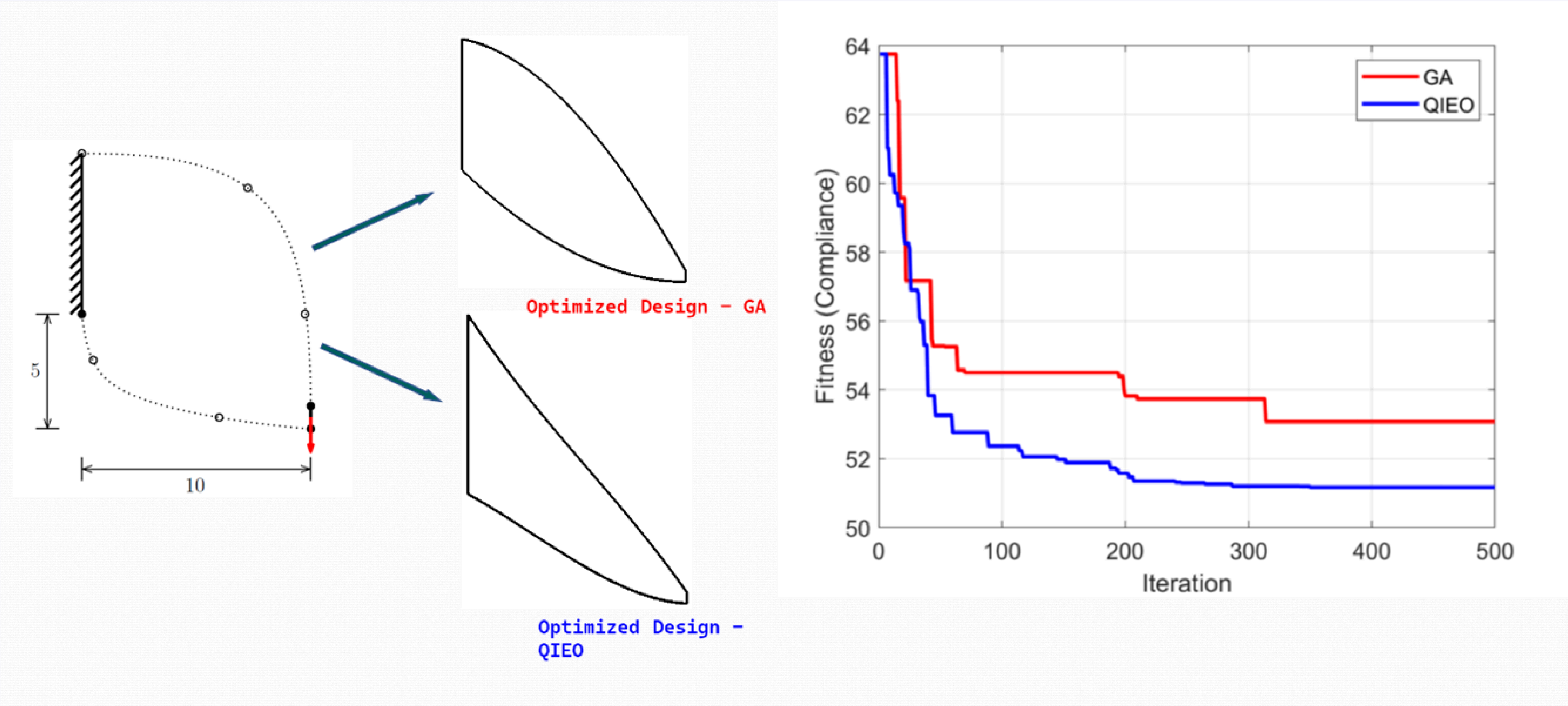
## Results: Achieving Optimal Airfoil Design with QIEO




When compared to traditional Genetic Algorithms used in classical optimization, QIEO delivered superior results. Classical methods, like Genetic Algorithms, often require extensive iterations and computational resources to explore large design spaces, frequently resulting in suboptimal solutions.

In contrast, QIEO significantly reduced iteration count by 90%, achieving a 60% reduction in airfoil structure weight while maintaining structural integrity. Moreover, QIEO's approach ensured a 6% greater weight reduction compared to Genetic Algorithms, which often struggle to efficiently handle the complex aerodynamic constraints and multi-objective nature of aerospace design problems.

Additionally, QIEO's topology optimization provided a clear manufacturable boundary, unlike the fictitious elements generated by Genetic Algorithms, ensuring that the designs were both optimal and suitable for real-world fabrication.

## Impact & Applications

- Enhanced fuel efficiency and extended mission range for aerospace and defense applications.
- Significant cost reduction in aircraft design, maintenance, and operations.
- Scalability to solve large scale aerospace and automotive engineering challenges.