ANISOPTERA TECHNOLOGIES

BIO INSPIRED FLIGHT

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President's Innovation Prize

President's Sustainability Prize

February 3, 2023



Executive Summary

Anisoptera Technologies is raising capital to further develop and market a novel structural design software, based on research and preliminary software developed by Masoud Akbarzadeh and Hao Zheng in the School of Design. This research describes a bio-inspired design that results in a 25% increase in stiffness to weight ratio of airplane wing-like structures, offering the capability to build more fuel efficient aircraft. Our design process combines traditional design rules that guarantee structural performance with novel machine learning techniques that leverage evolutionary advantages displayed by dragonfly wings. Anisoptera Technologies' mission is to apply this cutting edge technology to improve the way airplane wings are designed, lower the operating cost of flight, and reduce carbon emissions.

Getting this technology into the hands of industrial designers is the first step in getting Anisoptera's wings into the skies. This novel design method is sold to consumers as a completely automated product, with necessary computations done as a service by Anisoptera over the cloud. New design methods like this one are poised to explode with advances in 3D printing, as 3D printing makes previously expensive to manufacture designs feasible and reduces their manufacturing times by several orders of magnitude. Developing an interface between our design software and 3D printing tools is essential. Our enterprise software will eventually carve out a niche in the additive manufacturing revolution.

Problem

Current commercial air travel is too expensive. The average Boeing 777 consumes 5400 metric tons of fuel per year. This directly translates to 17,000 metric tons of carbon dioxide emissions per year per plane. Airlines and their customers bear the cost directly when they fly, but everyone on the planet bears the environmental cost.

Fuel consumption increases linearly with aircraft weight. Reducing the weight of an aircraft is the most direct way to increase its fuel efficiency. While reducing aircraft weight has been a target of interest in the airplane manufacturing industry for the past few decades, the streamlined design process of modern aircraft has made it increasingly difficult to make incremental weight reductions to pre existing designs. Most recent increases in fuel efficiency of commercial flights have been due to airline management. Engineering innovations are sorely needed. A highly cited 2017 Nature paper spent 120 hours of computing time on 8000 CPUs to generate an optimized Boeing 777 design with structural detail on the level of millimeters. The result was a new wing design with a 2 to 5 percent weight reduction and the same structural integrity as the conventional design. For a commercial aircraft sized wing weighing about 20,000 kilograms, this design improvement would result in fuel savings of 40 to 200 metric tons, or cost savings of $46,000 to $230,000, per aircraft per year. This amounts to a reduction in carbon dioxide emissions of 125 to 630 metric tons per aircraft per year.

Solution

We propose a new computational platform that provides mockups of lightweight, aerodynamic wings based on proprietary technology. This technology, developed by Masoud Akbarzadeh's Polyhedral Structures Lab and collaborators enables a novel design technique for aerodynamic structures such as airplane wings or wind turbine blades, inspired by dragonfly wing morphology. The technique combines traditional graphic statics with models generated by machine learning algorithms. Anisoptera Technologies is building a platform that incorporates this design method to create a suite of airplane wing offerings, optimized for their stiffness to weight ratio, and across a variety of wing sizes. The optimal stiffness to weight ratio of such bio-inspired designs, a 25% increase over conventional designs, results in a significant reduction in material and fuel consumption in the manufacturing and operating costs of the wing. The platform would enable industrial designers to generate ready-for-manufacture 3D printable files through a single user specification of airplane wing shape and size. To date, this proprietary technology has not been integrated into airplane wing design. Patent pending.

We believe a new type of design process demonstrated by this technology, can both reduce the hours of labor required of the highly skilled (airplane wing) designer and also unlock new design principles, such as those inspired by the superior dragonfly wing, that were previously unavailable to human designers. In this case, the 'unlocked' design principles have massive sustainability implications.

Current status of development: At the moment, we have a functional web app prototype of the product, a link to which is supplied in the appendix to this business plan.

Social Impact

Greenhouse gas emissions from the aviation sector are a substantial contributor to global warming. If the aviation industry were a country, it would place sixth in emissions, between Japan and Germany.

Anisoptera Technologies' design reduces airplane weight, and thus, emissions output generated by excess fuel expenditure. If every airplane wing in the world was manufactured with Anisoptera's proprietary design, the commercial airline industry would see an approximate 6% decrease in emission output over the next two decades. This would be equivalent to making Qatar a net carbon zero nation.

Business Model

AnisoWing, our proposed aerospace manufacturing platform, will be run through an enterprise software licensing business model. We will deliver and deploy the software through cloud computing to aerospace manufacturers.

Anisoptera Technologies will utilize a server infrastructure that will reside on AWS' commonly available cloud infrastructure. In the early days (Q1 2024 our product will be ready for use), we anticipate a cloud infrastructure cost of $12K per annum to serve our early customers. Of this cost, 10% will be allocated to bandwidth usage, 20% will be allocated to data storage, and the remaining 70% will be allocated to computing. The use of common cloud platforms like AWS allows Anisoptera to start small, manage its initial cost, and grow on a scale following the demands of the market.

Since few companies currently possess the additive manufacturing capabilities required to build airplane wings at scale, we plan to initially market AnisoWing as a software for the design of military grade drones. 3D printing capability at this smaller scale is widely accessible. Within the next few years, we expect advances in additive manufacturing will enable aerospace companies to leverage our platform to assemble larger planes. Looking to the future, Anisoptera can adapt its technology to design wind turbines, sails, and a range of other aerodynamic structures whose material weight efficiency is constrained by morphology.

Anisoptera Technologies believes there is one primary market segment, the Defense & Aerospace manufacturing market segment. We believe our product is uniquely aligned with the needs of Defense & Aerospace manufacturers: 1) Willingness to pay top dollar for a great, reliable product, 2) A fast workflow (including turnaround and R&D), 3) The latest available technology, 4) Optimizing aircraft for performance, and 5) Fuel efficiency.

Data from SaaS (Software as a Service) companies with similar metrics leads us to believe an annual fee of **$1000** per year for an individual AnisoWing subscription, with demand economies of scale applying to larger organizations, is appropriate. This number takes into account server infrastructure costs, human capital costs, and marketing costs, given full market penetration.

Taking into account the tentative number of users and our tentative pricing, our Total Addressable Market (TAM) is **$750M.**

In the short term, we plan to offer AnisoWing in Beta by Jan 1, 2024 to select Defense & Aerospace manufacturers. Achieving product market fit by Q1 2025 and anticipating 12 months of growth, in 2026 cloud infrastructure costs will be around $5M per annum, human capital costs will be around $15M per annum, and marketing and sales costs will be $2.5M. Revenue targets are $25M, for a gross margin of +$2.5M. From this point on, AnisoWing will be offered using an annual subscription model, where a company will pay according to its number of users.

The Heroes' Journey

Akash, the insatiable entrepreneur, knew he wanted to apply to the President's Innovation prize since he heard about it his sophomore year. He started taking hands-on entrepreneurial classes like MEAM 415 (product design) and EAS 545/549 with Thomas Cassel and Jeffrey Babin.

Through his experience in Penn Aerospace, and as a former VIPER student, Akash became interested in the sustainable design of wing technology. In December, Akash realized he couldn't bring his vision to revolutionize wing design to fruition without some help. He remembered his good friend and senior design project colleague, Guille. Akash and Guille met each other through their chemical engineering coursework. They shared a deep passion for problem solving and a vision to make the world a more sustainable place. For their senior design project, Akash and Guille, along with a third member, are designing a process to liquefy hydrogen that is renewably sourced, a preliminary technology in a potential carbon neutral, hydrogen based economy. Guille relishes tackling difficult problems with his relentless engineering approach and is driven by a desire to deeply understand universal truths. He successfully recruited Guille to commit to his start-up dream, and Guille approached Masoud Akbarzadeh of the Weitzmann School of Design to ask him about his innovative work on dragonfly wing force diagrams. Masoud, believing in the potential of his work, encouraged the two seniors to put their energy and effort into both expanding and commercializing his bio-inspired technology.

Next Steps

Preliminary software designed by Hao Zheng and Masoud Akbarzadeh can only create two dimensional wing schematics. The primary focus of our work in the next three months is to reformulate this software to output a three dimensional schematic, and in the next ten months, to build the functional B2B platform described previously. In the short term, our goal is to complete a proof-of-concept exercise wherein we would 3D print a set of wings, attach them to a drone UAV, and compare fuel efficiency to a regular UAV with conventional wings. We bet that our wings will be more fuel efficient, thus validating our product market fit hypothesis. The success of this proof of concept is existential for Anisoptera's mission statement, and is the main risk a potential investor should consider.

Implementation Timeline

On the next page, we have attached a timeline of the various tasks we have ahead of us.

Anisoptera Technologies

Akash Kumashi, Guillermo Ribeiro-Vecino

TASK DESCRIPTION	PLAN START	PLAN END	TYPE
Product Development			
Automate Step in Design Workflow	2/5/2023	4/8/2023	G
Upgrade from 2D to 3D Graphic Statics	2/5/2023	5/8/2023	G
3D Printing Compatibility	5/8/2023	5/12/2023	G
Build Design Platform	5/12/2023	1/7/2024	G
Proof of Concept			
Prototype	7/11/2023	8/10/2023	G
Manufacture	8/10/2023	9/9/2023	G
Basic Operations Testing	9/9/2023	1/7/2024	G
Efficiency Testing	1/7/2024	5/6/2024	G
AnisoWing Platform Testing			
Customer Feedback Integration and Testing	1/7/2024	1/1/2025	G
Fundraising			
General	1/7/2024	7/25/2024	G
Marketing			
Validate demand	4/1/2023	3/1/2025	G
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