1. Elevator Pitch: Pitch your innovation, sharing its essence, impact, customers and business potential.

Hardware Designers spend up to 30% of their time, recreating previous designs. Now, hardware design finally gets its AI revolution with ArCADia, an AI-powered CAD design software modernizing the hardware development process. ArCADia introduces AI to tangible, physical innovation by automating part creation and searches. ArCADia eliminates the inefficiencies that stifle creativity, allowing designers to focus on innovation rather than repetitive tasks. ArCADia's impact spans industries like automotive, medical devices, and consumer electronics, reducing development cycles and boosting productivity. With a potential user base of over 281,000 companies, ArCADia is set to reshape hardware design, fostering efficiency, collaboration, and economic growth.

2. Team: How did your team form? What role will each team member play? What motivated you to make this innovation? What special capabilities, resources or experiences do your team members bring?

The ArCADia team was formed through a shared passion for STEM and innovation. Having known each other throughout high school through robotics club, we decided to collaborate on this challenge after Anushka proposed the idea.

Each member brings unique strengths to the project.

Anushka: Leads the team with her research and hardware development expertise.
Zoe: Organizes and plans with her background in computer programming and website development.
Karthik: Applies engineering and physics knowledge to lay the foundation for the innovation.
Grace: Strengthens the team's presentation and marketing strategies with her communication skills.

Our shared interest in advancing technology motivates us to create a tool that enhances creativity and efficiency for CAD designers. Together, our diverse skill sets enable us to design, develop, and promote this groundbreaking innovation effectively.

3. Opportunity: What issue or pain point does your innovation address?

The primary issue ArCADia addresses is the technological lag in the hardware design industry compared to software. In contrast to the lack of innovation in the hardware design space over the last 30 years, the software engineering landscape has experienced impressive growth and innovation leading to web-based collaboration platforms like Github that offer myriad time-saving developer tools [1]. While software development has embraced AI tools to accelerate workflows, hardware design has struggled to keep pace. ArCADia bridges this gap by introducing real-time recommendations, aligning hardware design with the efficiency and creativity seen in software engineering.

One cause of this lag that ArCADia addresses is the significant time and effort wasted on creating parts from scratch and searching for components. By generating real-time AI-driven component suggestions that users can automatically add to the workspace, ArCADia eliminates the need to manually recreate or hunt for components, enabling them to focus on innovation rather than redundant tasks.

Additionally, for non-expert users and freelancers, the steep learning curve of CAD software is a barrier to entry that restricts participation in hardware development. ArCADia promotes easier access by providing component suggestions, allowing users to design by selecting options instead of manually creating, without requiring extensive expertise in the software. This accessibility expands the user base and fosters innovation.

Finally, the lack of collaboration in hardware development is a major factor that hinders the progress of the hardware sector [2]. ArCADia contributes to a cultural shift towards more open and collaborative design processes by promoting users to contribute to the databases. Its reliance on our databases promotes knowledge sharing and reduces barriers to entry for small businesses and independent creators. This democratization of design resources fosters innovation at all levels and encourages the emergence of diverse, groundbreaking ideas.

4. Innovation:

Describe your innovation, its design and your technology. How does it work? What is new or proprietary about the innovation?

How does it meet needs and resolve pain points? What impact does your innovation create for individual users and for humankind? Describe this qualitatively and quantitatively.

How can new or proprietary aspects be protected and made valuable by one or more methods such as a patent, trade secret, copyright or otherwise competitively defensible configuration?

Our innovation bridges traditional CAD design workspaces with AI-driven real-time suggestions, combining the familiarity of CAD tools with the efficiency of AI prompting. As users edit their designs, ArCADia provides real-time recommendations based on components detected in our database. A “component” can refer to an entire object in the workspace or a specific portion selected by the user. By leveraging a database of prior designs, ArCADia reduces the time spent on redundant editing and tweaking, empowering users to focus on creativity.

ArCADia’s core functionality relies on its ability to match user designs with existing ones in its database. This process begins by translating 3D models into machine-learning-friendly data through “shape signatures,” which encapsulate critical features of the designs [3].

These shape signatures are categorized by AI into groups such as chairs, tables, or other objects, narrowing the search space for future matches. To build an initial labeled dataset, ArCADia may use third-party services like Scale AI to acquire human-reviewed data. Once categorized, the system assigns shape signatures to user designs in real time and calculates probability distributions to identify similar objects in the database.

To populate its database, ArCADia employs web scraping to gather open-source design data and purchases licensed data from CAD development repositories. Web scraping bots extract image files from publicly available design websites, while quality assurance processes ensure the accuracy and utility of the collected data. This approach parallels

data acquisition methods used by organizations like OpenAI, ensuring that ArCADia's dataset remains robust and comprehensive [4].

What sets ArCADia apart is its ability to eliminate the need for manual searches. Unlike traditional systems that rely on user-provided tags or filenames, ArCADia's AI-driven identifiers streamline the process, offering recommendations without requiring explicit input. This broader, unrestricted approach enhances usability and accelerates design workflows, creating a seamless experience for users.

Open-source collaboration has already transformed many industries, but ArCADia takes this a step further by prioritizing efficiency. By automating repetitive tasks and facilitating access to existing designs, the platform fosters creativity and innovation. This dynamic mirrors developments in software engineering, where AI tools like Copilot have been able to minimize routine tasks which allows developers to focus on complex problem solving, increases developer wellbeing, and allows developers to evolve as organizational problem solvers [5]. ArCADia aims to deliver similar gains in CAD design, enabling designers to spend more time innovating rather than reworking.

The impact of ArCADia extends beyond individual users, driving progress in product design and hardware innovation. By accelerating development timelines, the platform addresses stagnation in hardware design, heralding a new era of creative and efficient technology. Industries ranging from architecture to aerospace and consumer goods will benefit from products that are more innovative, aesthetically creative, and rapidly iterated. Based on parallels with software development, we estimate a 26% efficiency boost in the design process, potentially leading to corresponding improvements in product quality and speed to market [6].

ArCADia's competitive advantage lies in its proprietary dataset of geometric identifiers. While many algorithms and design datasets are publicly accessible, the unique collection of geometric identifiers tailored for machine learning is a distinct asset. To maintain this edge, ArCADia's dataset will not be open-source. Users can access design suggestions through the platform, but the underlying data and identifiers remain proprietary, ensuring a first-mover advantage and safeguarding against competitors replicating the system.

5. Validation and Progress:

How have you validated your innovation, technology or processes? What progress have you made in developing your innovation?

Due to the multipart process that drives the functionality of ArCADia, the innovation was validated by testing each process individually.

We have acquired a large dataset of 3D model designs via the open source ABC database [7]. This shows validity in our approach to use “web scraping” bots to gather our initial designs for our database. Since we were able to gather such a large amount of data in one resource and manual search, an automated and more far reaching acquisition of data would prove to be sufficient.

The translation of several CAD designs into their “shape signatures” was successful. This test was done first by taking a CAD design in AutoCAD and utilizing the feature that allows for the translation of components to a specific quantity of cartesian coordinates. Using this representation, the surface area of the design is divided into polygons, and each polygon is given a random sampling point. These sampling points were then converted to a histogram, done via open source code on GitHub with minor modifications, to create the shape distribution [8]. To create the shape signature we evaluate N samples from the shape distribution and construct a histogram by counting how many samples fall into each of B fixed sized bins. From the histogram, we reconstruct a piecewise linear function with V (≤ B) equally spaced vertices, which forms our representation for the shape distribution. We compute the shape distribution once for each model and store it as a sequence of V integers [1].

There was approximately a 3% error when creating the shape signature of smaller designs manually, vs. using the automated process, validating the accuracy of this process.

The open source deep learning model ABC has shown that deep learning models have the ability to sort objects into various categories fairly accurately, when there is a large and diverse enough dataset. Due to the processing power needed, we did not train our own model, but the results from this paper were enough validation for us to continue pursuing this method [7].

We have acquired data, and have created the program to acquire the shape signatures for each of the CAD designs. Currently our team is trying to acquire greater processing power, in order to train our models. This will be done by outsourcing this training to a third party since the model will be fairly large. In terms of creating the actual program,

we have done everything stated so far and are now currently working on trying to integrate the various steps together. Currently we have the automated shape identifiers aspect of our application completed and are working to raise funds to train our deep learning model.

6. Market:

Describe your customers and your target segments. What is important to them? What is the size of the opportunity? Is the buyer or payer different from the customer in this market? Describe the industry ecosystem.

ArCADia's customers are primarily companies that rely on CAD tools for rapid prototyping and iterative product development. These companies span industries such as robotics, healthcare devices, and manufacturing, with a strong focus on product design and innovation.

These industries prioritize efficiency in their processes. Companies using CAD tools are constantly reiterating designs and testing prototypes to stay competitive. The speed at which they can achieve design turnover directly impacts their ability to succeed. ArCADia aligns with these values by offering a solution that streamlines prototyping and development, helping customers maintain an edge in their industries.

There are approximately 437,296 companies that utilize CAD as a core part of their operations, along with many freelancers, hobbyists, and content creators [9]. By offering a service that enhances competitiveness for all users, ArCADia can tap into this large potential market.

The distinction between buyers and customers is crucial. Companies or educational institutions may purchase ArCADia for their development teams, while individuals may buy it for personal use. Regardless of the buyer, the end-users are those who depend on CAD for creative and development work.

Our target industries focus on innovation and fast-paced prototyping rather than mass production. This fosters a community driven by creativity and efficiency, as companies compete to create better products. The ability to quickly prototype, test, and improve products is a key differentiator in these industries [10].

However, this ecosystem is often less profitable compared to larger, more traditional software or hardware companies. Many businesses in this space depend on investments from larger technology firms to sustain growth. Increased efficiency in their processes attracts these investments, making ArCADia's services essential. Efficiency is a metric that drives both competitiveness and investment, further cementing ArCADia's role in the market.

7. Competition:

What competes with your innovation, and how does your innovation compare? What are the advantages and disadvantages of your innovation? What is your positioning?

There are two primary innovations that directly compete with ArCADia. The first is the dominance of large, established CAD platforms such as AutoCAD, SolidWorks, and Fusion360. These platforms offer robust design features and perceived reliability, but they lack intelligent automation. As a result, users must manually search public databases or create parts from scratch, leading to time inefficiencies. Additionally, their interfaces are often considered difficult for new users, causing frustration with learning and operation [11].

The second competing innovation is component library platforms like GrabCAD, 3D Content Central, and TraceParts. While they provide access to pre-existing designs, users must still search manually, making it difficult to find optimal components. ArCADia addresses this gap by offering real-time AI integration to automate and improve the design search process. Unlike competitors focused on expanding traditional CAD functions, ArCADia's AI-powered matching connects users with the most relevant open-source designs, saving time and improving workflow.

As a new entrant to a decades-old industry, ArCADia faces challenges in establishing reliability and trust. Our initial database will be smaller compared to established platforms, and long-term success will depend on growing a comprehensive, well-organized design library that enhances our machine learning model. Providing users with an efficient and dynamic search experience will be key to encouraging users to switch from competitor software.

Despite the advancements of AI in software development, hardware design remains behind in adopting automation, causing dissatisfaction within the industry. The need for

a general-purpose, automated design tool is largely unmet. By positioning ArCADia at this intersection, we address the industry's increasing demand for faster prototyping and iteration cycles, providing a unique and timely solution to an untapped market. Since we will be the first in this specific market, there will be a large first mover advantage because of our capture of the initial consumer base.

8. Go-to-Market:

How will you attract and sell to customers? Who are the best initial or pilot customers? Is the market best served through direct sales, distribution, licensing, strategic partnerships or other strategies?

ArCADia will prioritize B2B partnerships, targeting engineering firms and academic institutions during its initial rollout. By offering discounted rates and early access, these partnerships will help establish credibility and gather valuable feedback for new iterations of ArCAdia. Marketing efforts will include live demonstrations at tech conventions, direct outreach via emails and forums, and collaborations with industry professionals to showcase the platform's benefits.

After a strong B2B foundation is established through the early access program, ArCADia will expand to B2C channels, targeting freelancers, hobbyists, and smaller startups with social media campaigns and influencer testimonials.

ArCADia will also establish a loyalty program with consumers that want to opt into sharing their designs for ArCADia machine learning model to train with. In exchange the user will receive tokens at a discounted rate and allow our suggestions to improve over time.

9. Business Model:

What are your key revenues and costs? What are the pricing and costs to deliver one product or service unit?

ArCADia's revenue model uses a token system, where users exchange virtual tokens for feature access, removing direct monetary transactions. Token systems have proven successful across industries, offering more upfront capital than traditional models [12]. Businesses receive lower per-token rates through wholesale-only purchases, securing upfront capital for ArCADia's development. Individual users can buy smaller token packages at higher rates, catering to hobbyists and freelancers.

Wholesale pricing allows 10,000 token uses for $50 ($0.005 per use). If companies with 10 engineers use 100 tokens daily, ArCADia could generate $2 million in daily revenue if it captures the entire market of 400,000 companies [9]. This highlights its potential for profitability even with limited market penetration.

Subscription plans bundle tokens at discounted rates to encourage frequent use. For example, a basic plan could offer 500 tokens for $5 monthly ($0.01 per use), while premium plans lower the per-token cost. Occasional users can purchase single-use tokens at $0.02 each. Free trials are limited to a set number of accepted suggestions, creating urgency to upgrade.

Development costs include training the deep learning model ($500,000), acquiring and labeling datasets ($100,000), and storing designs ($300,000 per year), totaling $900,000 initially, with a recurring $100,000 annually. These costs will grow as the database expands, with additional labeling needed over time. The cost per AI suggestion is approximately $\$10^{-5}$, based on comparisons to popular ML models like OpenAI's GPT-4 [13].

Labor costs include a 10-person team with a median salary of $200,000, totaling $2 million annually. Additional expenses include office rent ($240,000) and utilities ($80,000).

This pricing model scales with usage, encouraging bulk token purchases and fostering long-term customer retention among enterprises and casual users alike.

10. Fundraising:

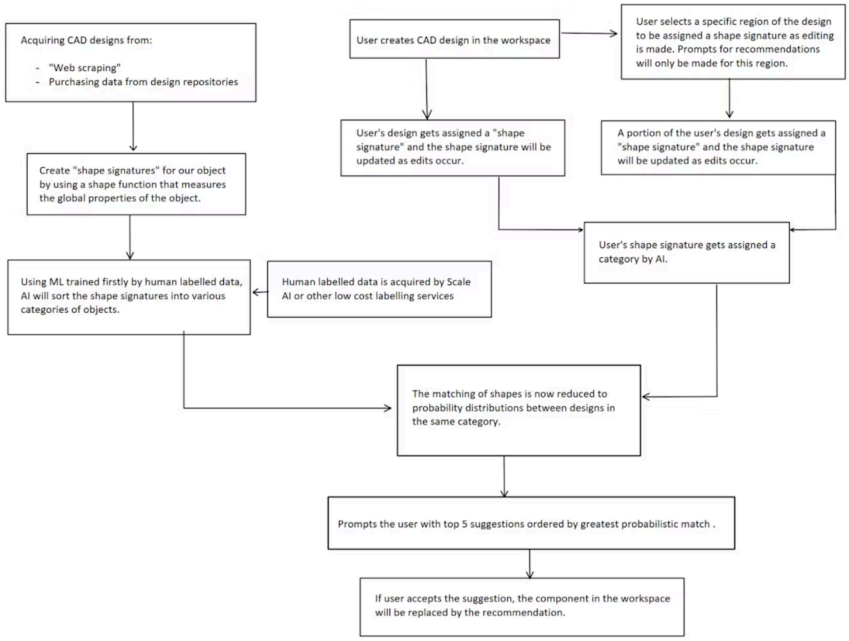
What funds do you need to get started, and how will you use these funds? How much will it cost to develop the product and roll it out? What different sources will you pursue for funding, and why are these a fit?

To bring ArCADia to market, initial funding will cover web domain setup, storage via AWS, server costs, and salaries for a skilled software development team. The estimated cost for development and rollout is $500,000, including $100,000 for AI model outsourcing, dataset acquisition, and R&D.

Our primary funding strategy focuses on B2B partnerships with businesses that will benefit directly from ArCADia's innovation. By collaborating with engineering firms and academic institutions, we can secure initial funding through discounted access and early adoption agreements. This approach creates customer loyalty and provides real-world validation for our product while ensuring alignment with market needs [14]. Moreover, these businesses can provide critical feedback for our model in the prototyping-era so that our team can optimize our design. Grants for technological innovation will also be pursued to supplement these efforts, emphasizing ArCADia's role in advancing AI in hardware design.

Sources

1. Hardware is Hard: Why We Are Excited About Hardware Engineering | by The Westly Group | Medium
2. The Future of Hardware Development: Collaborative tools and techniques
3. Matching 3D Models with Shape Distributions
4. How ChatGPT and our foundation models are developed | OpenAI Help Center
5. How AI can unleash the creativity of developers with the right attitude to productivity
6. New Research Reveals AI Coding Assistants Boost Developer Productivity by 26%: What IT Leaders Need to Know - IT Revolution
7. https://arxiv.org/pdf/1812.06216
8. https://github.com/HdrHistogram/HdrHistogram
9. Type of CAD Software and Market Share of Dassault CATIA and Siemens NX
10. An Ecosystem Of Innovators: The Dynamic Formula For Corporate R&D Success
11. Research Report: User Satisfaction With CAD Software 2017 - Engineering.com
12. The Token Economy: Reinventing Business Models Through Tokenization | HackerNoon
13. https://openai.com/api/pricing/
14. B2B Loyalty Programs: A Comprehensive Guide


Acquiring CAD designs from:
- "Web scraping"
- Purchasing data from design repositories
Create "shape signatures" for our object by using a shape function that measures the global properties of the object.
Using ML trained firstly by human labelled data, AI will sort the shape signatures into various categories of objects.
Human labelled data is acquired by Scale AI or other low cost labelling services
User creates CAD design in the workspace
User selects a specific region of the design to be assigned a shape signature as editing is made. Prompts for recommendations will only be made for this region.
User's design gets assigned a "shape signature" and the shape signature will be updated as edits occur.
A portion of the user's design gets assigned a "shape signature" and the shape signature will be updated as edits occur.
User's shape signature gets assigned a category by AI.
The matching of shapes is now reduced to probability distributions between designs in the same category.
Prompts the user with top 5 suggestions ordered by greatest probabilistic match .
If user accepts the suggestion, the component in the workspace will be replaced by the recommendation.