RAMAIAH UNIVERSITY OF APPLIED SCIENCES

CENTER FOR ENTREPRENEURSHIP

AMBUBEAM

Group Project Report

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JUNE– 2025

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Certificate

This is to certify that the Project titled "AMBUBEAM" is a bonafide record of the group project work carried out by Mr. AAMIR MOHAMMED KHAN, Mr. ANJAN.S, Mr. B.JAGADISH, Mr. CHIRAG G.K, MR.GIRIDHAR PRABHU, Mr. KM VINAYAK RAM, bearing Reg. No. 23ETCS002002, 23ETCS002013, 23ETCS002025, 23ETCS002030, 23ETCS002040, 23ETCS002052. Department of Computer Science Batch of 2023 in partial fulfilment of requirements for the course BAU201A of M. S. Ramaiah University of Applied Sciences.

JUNE/2025 (Submission)

Professor Mr. Vinay murudi

RAMAIAH UNIVERSITY OF APPLIED SCIENCES
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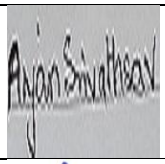
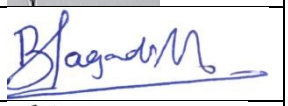
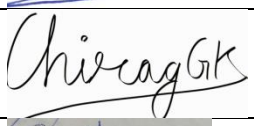
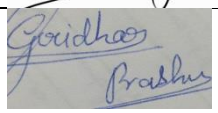
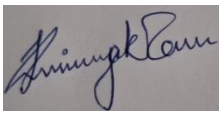
Declaration

AMBUBEAM

The Group Project report submitted herewith is a result of our own work and in conformance to the guidelines against plagiarism as laid out in the University Student Handbook. All sections of the text and results which have been obtained from other sources are fully referenced. We understand that cheating and plagiarism constitute a breach of University regulations and will be dealt with accordingly.

Sl. No.	Reg. No.	Student Name	Department	Signature
1	23ETCS002002	AAMIR MOHAMMED KHAN	CSE	
2	23ETCS002013	ANJAN S	CSE	
3	23ETCS002025	B JAGADISH	CSE	
4	23ETCS002030	CHIRAG GK	CSE	
5	23ETCS002040	GRIDHAR PRABHU	CSE	
6	23ETCS002052	KM VINAYAK RAM	CSE	

Date: 10 June 2025

Acknowledgements

We would like to express our heartfelt gratitude to all those who supported and guided us throughout the development of our project.

First and foremost, we extend our sincere thanks to Dr. Vinay Murudi, our mentor and Entrepreneurship faculty, for his constant encouragement, expert guidance, and invaluable feedback. His mentorship played a crucial role in shaping our idea into a viable and impactful solution.

We are also deeply thankful to our university, MS Ramaiah University of Applied Sciences (MSRUAS), for providing us with the resources, ecosystem, and platform to explore innovative solutions to real-world problems. The university's commitment to nurturing entrepreneurship and innovation has been instrumental in our journey.

Our special thanks go to Abhijit Nair, co-owner of Velectron Labs, for generously sharing his insights and experiences during our interviews. His practical advice and knowledge greatly enriched our understanding of the entrepreneurial landscape.

Finally, we thank all the faculty members, peers, and institutions who contributed to our understanding and growth during this project.

Abstract

The AmbuBeam project focuses on developing an AI-powered green corridor system to eliminate life-threatening ambulance delays at traffic intersections. The motivation for this work stems from the critical time lost by emergency vehicles due to poor signal prioritization, leading to undesirable statistics where over 30% of ambulance trips are delayed and 1 in 5 critical patients do not reach the hospital in time. This initiative aims to address a significant public health issue and improve emergency response.

The scope of AmbuBeam involves creating an automated system using smart reflectors with embedded audio sensors to detect ambulance sirens. The methodology includes data triangulation to determine ambulance location and overriding the nearest VAC signal logic to clear the path. This solution is designed to be low-cost, energy-efficient, and scalable, leveraging solar power for self-sustenance.

The main results indicate a viable product with core features like siren detection, solar power, wireless communication via RF/LoRa modules, and signal override logic. Customer validation involved discussions with traffic police and ambulance drivers to understand the problem and validate the product. The project's conclusion is that AmbuBeam offers a competitive edge by providing a GPS-independent, low-maintenance, and retrofittable solution to existing traffic systems.

Table of Contents

1. Introduction

Context of the project

1.1 Introduction should address the following:

- Interesting research issues that the proposed project plans to explore
- Brief preview to facilitate recognition and appreciation of core theme or the central focus of the project
- Succinct and yet informative explanation for quick establishment of the significance of the proposed project

1.1.1 Sub Heading

- Heading and sub-heading can be highlighted in bold

2. Customer Value Proposition

Our core customer value proposition for AmbuBeam is to deliver a transformative solution that is characterized by its low-cost implementation, exceptional energy efficiency, fully automated operation, and remarkable scalability, all tailored for emergency traffic management. The primary job that our venture performs for its users—comprising ambulance drivers, patients in critical need, and traffic management departments—is to ensure swift and safe passage to hospitals. This is achieved by dynamically granting "green lights" as an ambulance approaches, eliminating the need for manual intervention and reducing critical response times. A significant differentiating factor of AmbuBeam is its inherent self-sustainability, powered entirely by solar energy. This feature not only reduces operational costs but also minimizes environmental impact, making the system a sustainable long-term investment for urban infrastructure. Our solution moves beyond simply "getting green lights" to truly enabling critical care access when every second counts

Conversation about AMBUBEAM with Ambulance driver and Traffic Police.

3. Problem/Project Idea

The genesis of the AmbuBeam project idea stems directly from the critical and persistent problem of emergency vehicles encountering significant delays at traffic intersections. This issue is not only a logistical challenge but a profound humanitarian concern, directly contributing to undesirable health outcomes. The team was compelled to develop this solution after observing the severe impact of these delays, which result in over 30% of ambulance trips being prolonged and, tragically, one in five critically ill patients failing to reach medical facilities in time. The initial concept revolved around leveraging advanced technology to create an automated system that could proactively manage traffic signals in favor of emergency vehicles. This vision rapidly evolved into a comprehensive project aimed at designing and implementing a "green corridor" system. The core innovation lies in using smart roadside reflectors that detect ambulance sirens, thereby enabling real-time signal prioritization and ensuring unobstructed passage, ultimately transforming emergency response in urban environments.

4. Team Formation

The AmbuBeam project was undertaken by a dedicated and diverse team known as "Above Average Nibbas". The team was strategically assembled to encompass a wide range of technical and business expertise essential for developing a multi-faceted solution. Each member was assigned a specialized role that aligned with their skills and contributed directly to the project's success. **B Jagadish** took on the crucial role of **Hardware Engineer**, responsible for the physical design and construction of the smart reflectors. **ANJAN S** served as the **AI/ML Developer**, spearheading the intelligence behind the system, including siren detection and data analysis. **CHIRAG GK** was the **Power Systems Lead**, ensuring the energy efficiency and solar self-sufficiency of the devices. **VINAYAK RAM** contributed as the **Product & UX Designer**, focusing on the usability and overall user experience of the AmbuBeam system. **AAMIR MK** managed the **IoT & Communication Development**, establishing the wireless connectivity necessary for seamless communication between reflectors and traffic signals. Lastly, **GIRIDHAR P** functioned as the **Business & Partnerships Lead**, responsible for market understanding, stakeholder engagement, and strategic alliances. This diverse skill set allowed for a holistic approach to the project, from conceptualization to validation and potential market entry.

5. Opportunity Evaluation

The evaluation of AmbuBeam as a worthwhile opportunity revealed compelling market indicators and supportive trends. India's aggressive pursuit of "Smart City" projects, with over 70 such initiatives underway, presents a fertile ground for the deployment of intelligent traffic management solutions. This urban development focus creates a direct demand for technologies like AmbuBeam that enhance city infrastructure and services. Furthermore, the sheer volume of emergency vehicles, with over 10,000 ambulance vehicles operating in Tier-1 cities alone, underscores the massive potential user base for our system. Financially, the Indian government's substantial allocation of ₹500 crore towards Smart Traffic Management in the 2023-24 budget signals a clear governmental commitment and financial backing for innovative solutions in this sector. Beyond policy and infrastructure, the decreasing costs and increasing accessibility of solar and IoT hardware have made the development and large-scale deployment of AmbuBeam not just technically feasible but also economically attractive. These converging factors collectively validate AmbuBeam as a highly opportune and commercially viable venture.

6. Initial Assumptions

Upon commencing the AmbuBeam project, several key initial assumptions guided our development process. Foremost among these was the belief that the critical time loss experienced by emergency vehicles at traffic intersections was a pervasive and significant issue, directly impacting patient outcomes. We hypothesized that an automated system capable of accurately detecting ambulance sirens and subsequently overriding traffic signals in real-time would substantially mitigate these delays. This assumption was foundational to our technical design. Furthermore, we assumed a high level of receptiveness from key stakeholders: both municipal traffic authorities and state health departments. We anticipated that they would view a low-cost, energy-efficient, automated, and self-sustaining solution as highly desirable, given their mandates to improve urban mobility and emergency response. We also initially assumed that current traffic signal infrastructure, while often basic, could be retrofitted with our technology without requiring prohibitively expensive overhauls. These assumptions formed the basis for our initial research and validation efforts.

7. Assumptions Test

a. To rigorously test our initial assumptions, we embarked on a comprehensive validation process that involved both observational research and direct stakeholder interviews. Our research aimed to deeply understand the multifaceted problem of ambulance delays. We utilized the **AEIOU framework** (Activities, Environments, Interactions, Objects, Users) to observe the situational settings where our problem manifests, though specific details of this framework's application are not explicitly detailed in the provided content. This qualitative approach helped us gain a holistic understanding of the operational context.

b. A crucial component of our validation involved direct engagement with potential users and stakeholders. We interviewed key personnel, including visits to the **Peenya Traffic Police Station** to discuss the problem of ambulance delays and our proposed solution. During these discussions, we gathered valuable insights from their operational context, understanding existing procedures and challenges related to traffic signal prioritization for emergency vehicles. Simultaneously, we engaged directly with **ambulance drivers**, who are the primary end-users, to gain firsthand insights into their daily struggles with traffic congestion and delays. This direct interaction allowed us to understand the practical implications of the problem and validate the real-world utility of our proposed product. While the exact number of interviews is not specified beyond "at least 20" in the template, this indicates a significant quantitative target for our qualitative data collection. We primarily decided who to interview by focusing on **those most affected** by the problem (ambulance drivers) and **those responsible for managing traffic** (traffic police).

c. Our **key aims for these interviews** were two-fold: to confirm the severity and widespread nature of the problem, and to gauge the practical feasibility and desirability of an automated siren-detection and signal-prioritization system. We achieved these aims by asking targeted questions about current delay points, existing manual override procedures, and the perceived benefits of an automated

system. We asked about their current frustrations, how much time is typically lost, and what features they would value in a solution. Our **interview strategy evolved as we gained more insights**, allowing us to delve deeper into specific pain points and refine our understanding of user needs. For example, initial questions might have been broad, but as common themes emerged (e.g., the inefficiency of manual overrides), follow-up questions became more focused on the practicalities and benefits of an automated system.

d. The presentation does not explicitly state how many interviewees rejected the idea or refused to use the offering, nor how the team felt or handled such responses. However, the overall tone of the customer validation sections suggests a positive reception and reinforces the need for the solution.

e. We also investigated **similar players in the market** or those offering similar services to understand the existing landscape. We found solutions such as high-cost GPS-based ambulance tracking systems and slower manual override systems that rely on police communication. We did not explicitly "reach out" to these competitors in the sense of direct collaboration, but rather studied their offerings and market presence to identify our competitive differentiators. From their journey, we learned that existing solutions often come with **high setup costs** or are **slow and inefficient**, reinforcing the need for our differentiated approach which prioritizes affordability, automation, and speed without reliance on GPS. This market intelligence was crucial in positioning AmbuBeam as a superior alternative.

8. Critical Insights

The rigorous testing of our assumptions yielded several critical insights that profoundly shaped the development trajectory of AmbuBeam. Firstly, the interviews with both traffic police and ambulance drivers unequivocally confirmed the severity and pervasive nature of ambulance delays at intersections. This validation strengthened our foundational assumption that this problem represents a critical bottleneck in emergency healthcare. Secondly, our market analysis revealed that existing solutions, such as GPS-ambulance-based tracking systems, are often burdened by high setup costs, making them inaccessible for widespread implementation, while manual override systems are inherently slow and inefficient. This insight not only validated our problem statement but also highlighted a significant gap in the market for a cost-effective, automated, and efficient alternative. Critically, the concept of a low-cost, solar-powered, GPS-independent, and retrofittable system was met with considerable enthusiasm from stakeholders, reinforcing our initial assumptions about the market's receptiveness to such an innovative solution. Based on these insights, we strategically acted by refining our solution's unique selling propositions, emphasizing its core differentiators: its independence from GPS, its edge ML processing capabilities integrated directly into the reflectors, its complete reliance on solar power for minimal maintenance, and its ability to seamlessly integrate with existing Vehicle Actuated Controller (VAC) systems. These critical insights ensured that AmbuBeam is not just a technological solution but a deeply market-aligned and impactful one

9. Resources Used

The development of AmbuBeam relied on a comprehensive suite of resources, categorized into technology, hardware, and software tools, essential for bringing our innovative concept to fruition. Our **Technology Stack** formed the backbone of the system, comprising the ESP32 Microcontroller for processing, a precise Audio Sensor Module for siren detection, a robust Solar Panel Kit for energy autonomy, LoRa Transceiver Modules for reliable long-range wireless communication, a VAC Interface Relay Module for signal control, alongside foundational components like Breadboard & Jumper Wires for prototyping, and a custom 3D Printed Casing for durable housing. For **Hardware Tools**, we utilized the Arduino IDE for programming microcontrollers and the Thonny IDE, likely for Python-based development, given the AI/ML components. Our **Software Tools** included powerful libraries and platforms such as NumPy and SciPy for numerical operations and scientific computing, TensorFlow Lite for efficient on-device machine learning inference, Audacity for audio analysis and processing, TinkerCAD for 3D design prototyping, Firebase for potential backend services or data management, and Fusion 360 for advanced 3D modeling of the physical components.

Our approach to resource utilization strongly aligns with effectual principles. We started with our available means—the expertise within our diverse team and the accessible, affordable hardware and software technologies—to iteratively build and refine our solution. The project embodies the principle of **Affordable Loss** by targeting a remarkably low per-unit cost of ₹800, ensuring that even if initial deployments face challenges, the financial exposure is managed. The future strategy of seeking government subsidies and CSR support, alongside aiming for mass manufacturing, reflects the **Crazy Quilt** principle, where diverse partners are brought together to co-create the future and pool resources. While the presentation does not explicitly detail newly discovered resources or specific individuals approached for help beyond the general customer validation process, the emphasis on affordable and accessible technology implies a continuous search for optimal, cost-effective components. Similarly, the presentation does not highlight any specific person or resource that proved unhelpful, suggesting a focused and effective resource acquisition process.

10. Progress Made

Significant progress has been achieved in the AmbuBeam project, moving from conceptualization to a tangible demonstration of our solution. We have successfully defined and outlined the core features of our system: the siren detection capability, its self-sufficient solar power source, reliable wireless communication, and the critical signal override logic. As a testament to our advancement, we have developed and deployed a functional **prototype/MVP (Minimum Viable Product)**, which is accessible for demonstration online at https://chiraggk5.github.io/AmbulanceSim/. This interactive prototype allows stakeholders to visualize and understand the real-time operation of our green corridor system. While specific figures for the number of customers serviced or sales made are not provided in the current stage, the project's primary focus has been on product development and initial validation. Given the promising results from our customer validation efforts and the identified market opportunity, the clear decision is to **proceed** with the idea. This decision is reinforced by the positive feedback from ambulance drivers and traffic police, the competitive advantage identified over existing solutions, and the strong market trends supporting smart traffic management. We are now at a pivotal point, seeking further funding to scale up development by building three field prototypes for more extensive real-world testing. This next phase will involve deploying our system in operational environments to gather comprehensive data and refine its performance further

11. Business model Canvas

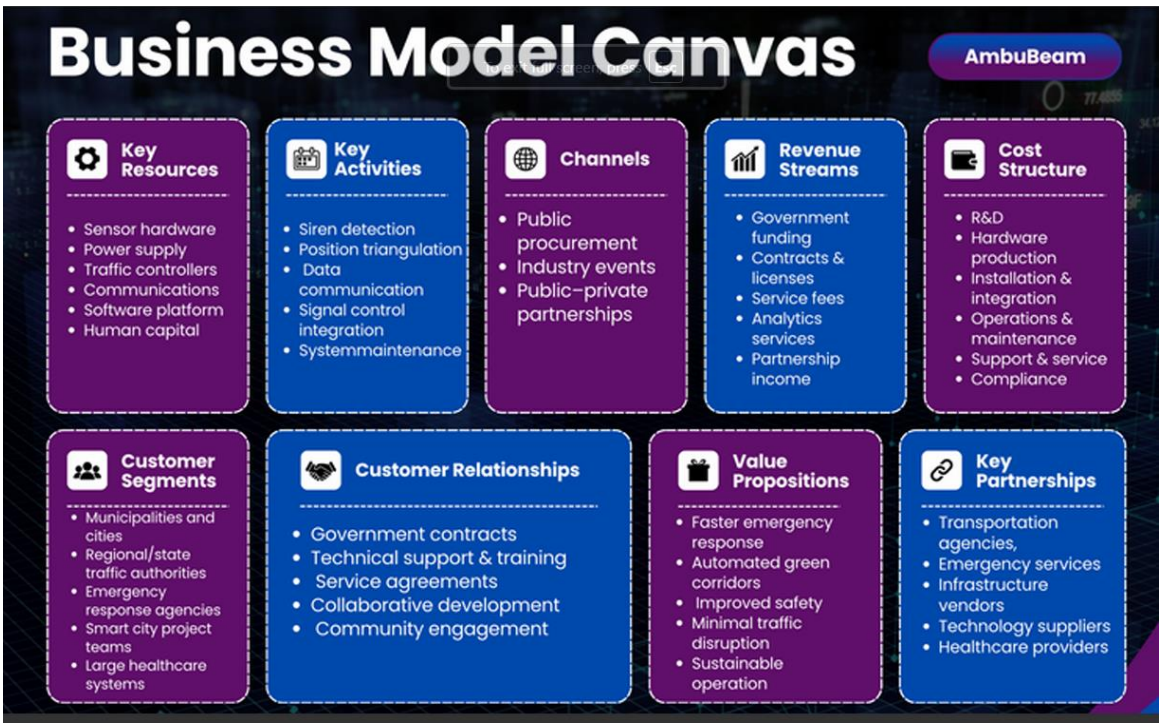
The Business Model Canvas for AmbuBeam comprehensively illustrates the foundational elements of our venture, highlighting how we create, deliver, and capture value.

- **Key Resources:** Our critical assets include the sophisticated Sound Detection technology, the underlying IoT infrastructure for connectivity, the sustainable Solar Power system for self-sufficiency, robust Communication protocols (RF/LoRa modules), advanced AI/ML algorithms for intelligent operations, and the invaluable Human Capital (our specialized team).
- **Key Activities:** Core activities involve precise Siren Detection, efficient Signal Override mechanisms, accurate Data Triangulation to pinpoint ambulance locations, consistent Solar Charging for uninterrupted operation, and ongoing Maintenance to ensure system reliability.
- **Channels:** We plan to reach our customers primarily through Public Procurement processes, participation in relevant Industry Events to showcase our innovation, and strategic Public-Private Partnerships to facilitate broader adoption and deployment.
- **Revenue Streams:** Our financial viability will be driven by diverse revenue streams, including direct Government Funding, securing various Grants & Subsidies, engaging in Direct Sales of our units, and offering Annual Maintenance Contracts (AMC) for long-term support.
- **Cost Structure:** Key cost drivers encompass significant R&D expenses for continuous innovation, Hardware procurement, Software development and licensing, Manufacturing costs for mass production, Marketing and promotional activities, and ongoing Operations & Maintenance (O&M) and Overhead costs.
- **Customer Segments:** Our primary customers are Municipal Traffic Authorities and State Health Departments, who are responsible for urban infrastructure and emergency services. The ultimate End Users of our system are Ambulance Drivers and Emergency Teams, who directly benefit from the cleared traffic paths.
- **Customer Relationships:** We aim to foster strong relationships through dedicated Government Liaisons, comprehensive Service Agreements, and collaborative development initiatives, ensuring our solution continually meets evolving needs.
- **Value Propositions:** AmbuBeam offers compelling value by enabling Faster Response Times for emergency services, providing an Automated and Scalable solution, significantly Improved Safety for patients and emergency personnel, a

Low-Cost implementation barrier, and an Eco-Friendly operation due to solar power.

- **Key Partnerships:** Strategic alliances are crucial, including collaborations with Government Agencies (BBMP, BTP, NHAI), Emergency Services, Vehicle Manufacturers for potential pre-installation, and Technology Providers for component sourcing and expertise.

This comprehensive canvas provides a clear roadmap for our business strategy and operational framework.



12. Key Learnings

Our journey through the AmbuBeam project has provided several invaluable key learnings that will guide future endeavors. Foremost among these is the undeniable and critical need for automated solutions in emergency traffic management. The insights from direct interactions with traffic police and ambulance drivers underscored the profound impact that even marginal time savings can have on patient outcomes. We learned the significant viability of leveraging affordable IoT and solar technology to create high-impact solutions that are not only effective but also sustainable and scalable. This demonstrated that sophisticated problem-solving does not always require prohibitively expensive technologies. Furthermore, the extensive customer validation process, involving direct interviews and feedback, proved to be indispensable. This process allowed us to refine our product features and address real-world pain points, ensuring our solution is truly aligned with user needs. Finally, a thorough analysis of the existing market landscape revealed a clear competitive edge for a GPS-independent and retrofittable system, reinforcing our belief in AmbuBeam's unique market position and potential for widespread adoption. These learnings collectively affirm the project's strategic direction and its potential for substantial societal impact.

13. Biggest Hurdles

While the AmbuBeam project has made significant strides, it is crucial to acknowledge the biggest hurdles encountered and the most difficult parts of starting this venture. One primary challenge has been the inherent complexity of integrating diverse technologies – from audio sensors and AI/ML algorithms for siren detection to solar power systems and wireless communication modules – into a cohesive, reliable, and durable roadside unit. Ensuring seamless communication between these units and existing traffic signal infrastructure, especially given the varied technical specifications across different cities, presents a considerable integration hurdle. Another significant challenge lies in the regulatory and bureaucratic landscape. Navigating approvals from multiple government agencies, such as municipal traffic authorities (like BBMP and BTP) and national highway authorities (NHAI), can be a lengthy and intricate process. Building trust and securing pilot project opportunities requires persistent engagement and clear demonstration of the solution's efficacy and safety. Furthermore, the initial capital required for developing and rigorously testing field prototypes, and subsequently for potential mass manufacturing, represents a substantial financial hurdle. Overcoming skepticism regarding a new, unproven technology within a traditionally conservative infrastructure sector also proved challenging. The most difficult part of starting the venture has arguably been balancing rapid technological development with the slower pace of public sector adoption and securing initial funding to bridge the gap between prototype and widespread deployment.

14. Ask

To propel AmbuBeam from its current prototype stage to real-world operational testing and eventual widespread deployment, we have a clear and defined "Ask" for our partners and potential investors. Our immediate funding requirement is **₹50,000**. This crucial capital is earmarked specifically for the production of **three robust field prototypes**. These prototypes are essential for conducting extensive real-world testing, gathering vital performance data in diverse traffic conditions, and demonstrating the system's reliability and effectiveness to key stakeholders. Beyond financial support, we are actively seeking **strategic support from key government agencies**, including the Bruhat Bengaluru Mahanagara Palike (BBMP) for urban traffic management, Bengaluru Traffic Police (BTP) for operational guidance, and the National Highways Authority of India (NHAI) for potential expansion onto national road networks. This support is vital for navigating regulatory frameworks, securing necessary permissions for deployment, and facilitating pilot projects. Furthermore, we are in strong need of **mentorship**, particularly for refining our go-to-market strategy and for guidance on the intricate process of Intellectual Property (IP) filing. Expert mentorship will be instrumental in scaling our venture, protecting our innovation, and ensuring a successful commercial launch. Ultimately, our "Ask" is a call to action for partners to join us in creating a system that ensures no ambulance ever gets stuck again, significantly enhancing emergency response and saving countless lives

15. Financial Projections

Our financial projections are meticulously structured to demonstrate the cost-effectiveness and scalability of the AmbuBeam solution. The estimated **Total Cost (Per Unit) is ₹800**. This cost breakdown is based on optimizing component selection for both performance and affordability:

- **Basic Microcontroller (ESP8266 or ATtiny85):** ₹100
- **Basic Sound Sensor (KY-037):** ₹70
- **Solar Cell + Rechargeable Cell:** ₹150
- **RF 433 MHz Transmitter/Receiver:** ₹100
- **Relay Module (1 Channel):** ₹50
- **Basic Enclosure (Plastic Mold):** ₹80
- **PCB + Assembly + Wiring:** ₹150
- **Simplified Reflective Panel:** ₹100

Our **Selling Price Strategy** targets a per-unit price of **₹1,000**. This pricing model is designed to achieve a healthy **Gross Margin of approximately 20%**. The justification for this competitive pricing is rooted in several strategic assumptions: we anticipate benefiting significantly from **mass manufacturing subsidies** as production scales up, which will help drive down per-unit costs. Furthermore, we foresee substantial **Government/CSR support** playing a pivotal role in covering initial fixed costs, including Research & Development (R&D) and tooling expenses. This approach ensures that AmbuBeam remains an attractive and affordable solution for municipal bodies and health departments, facilitating widespread adoption and maximizing its impact on emergency services.

16. Greatest Assets

Our greatest assets at AmbuBeam are multifaceted and strategically positioned to ensure the venture's success and impact. Foremost among these is our highly skilled and **multi-disciplinary team**. Comprised of experts in hardware engineering, AI/ML development, power systems, product and UX design, IoT, and business development, our team possesses the comprehensive technical and strategic capabilities required to bring this complex solution to life and scale it effectively. Secondly, the **unique and differentiated nature of our solution** stands out. AmbuBeam is not only low-cost and solar-powered, ensuring sustainability and affordability, but also uniquely GPS-independent and easily retrofittable into existing traffic infrastructure. This distinct value proposition provides a significant competitive advantage over existing, often more expensive or less efficient, alternatives. Finally, the **significant market opportunity** for AmbuBeam serves as a powerful asset. Driven by proactive smart city initiatives across India and a heightened governmental focus on emergency healthcare reforms, there is a clear and growing demand for solutions that enhance urban mobility and emergency response. These converging factors create a highly favorable environment for our venture to thrive and make a substantial societal impact. While the ease of starting the venture is not explicitly detailed, the passion and collective expertise of the team, combined with a clear problem-solution fit, likely contributed to an efficient initial phase of development and validation.

17. Team Member Contribution

The success of the AmbuBeam project is a direct result of the collective and specialized contributions of each team member. Each individual brought unique skills and dedication, ensuring comprehensive coverage of all technical and strategic aspects of the venture.

- **B JAGADISH (Hardware Engineer):** Jagadish played a key role in making the AmbuBeam system a reality. He was primarily responsible for the hardware design, development, and assembly of the smart reflector. This involved integrating audio sensor modules for siren detection, picking suitable microcontrollers like the ESP32, and making sure the solar panel kit's power management was reliable. He was in charge of designing the actual enclosure, probably using 3D printed parts, and making sure the roadside units were weatherproof and long-lasting. His knowledge was essential in turning abstract ideas into functional, deployable hardware.

- **ANJAN S (AI/ML Developer):** AmbuBeam's intelligence was led by Anjan. Developing and implementing the AI/ML algorithms that are essential for real-time siren detection and analysis was his main duty. To do this, audio sensor data had to be processed, machine learning models had to be trained to recognise ambulance siren patterns in the midst of city noise, and the models' ability to function well on edge devices (the microcontrollers inside the reflectors) had to be confirmed. He most likely optimised the models for low-power, embedded systems using frameworks like TensorFlow Lite..

- **CHIRAG GK (Power Systems Lead):** Chirag played a crucial role in guaranteeing the AmbuBeam units' energy efficiency and self-sufficiency. He was in charge of choosing the best solar cells and rechargeable batteries as well as designing and refining the solar power system. His efforts made it possible for every smart reflector to function independently without requiring external power sources, increasing the system's sustainability and lowering maintenance expenses over time. He probably controlled the charging and power distribution circuits to increase dependability and uptime.

- **KM VINAYAK RAM (Product & UX Designer):** Vinayak made sure the AmbuBeam solution was user-friendly and useful for its target audience by concentrating on the user interface and overall product experience. He helped to conceptualise how information would be efficiently conveyed and how the system would fit into the current traffic environment. Even though the system functions mostly on its own, his job would be to make sure that the operational logic is simplified and that any interfaces that are required—for example, maintenance or monitoring—are easy to use. He also added to the project concept's overall presentation and aesthetic appeal.

- **AAMIR MK (IoT & Communication Developer):** Establishing the smooth connectivity within the AmbuBeam network was made possible in large part by Aamir. Developing and integrating the Internet of Things and communication protocols that enable smart reflectors to transmit siren detection data to traffic signal controllers was his main duty. In order to ensure dependable data transmission even in congested urban settings and without depending on GPS or internet connectivity, he concentrated on deploying effective wireless communication using technologies like RF/LoRa modules.

- **GIRIDHAR P (Business & Partnerships Lead):** Giridhar was essential to AmbuBeam's commercial and strategic aspects. Among his contributions were market research, competitive analysis, and the identification of target customer segments (state health departments, municipal traffic authorities). Crucially, he oversaw the customer validation activities, speaking with ambulance and traffic police drivers face-to-face to learn about their problems and confirm the solution's practicality. In addition, he concentrated on creating the business model canvas, which included cost structures and revenue streams, and investigating possible collaborations.

Each member's specialized contribution, combined with effective teamwork and communication, was fundamental to the successful development and articulation of the AmbuBeam project, from its core technological components to its strategic market positioning.

Signature of all team members with the name and registration number

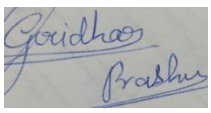
1. AAMIR MOHAMMED KHAN (23ETCS002002)

2. ANJAN S (23ETCS002013)

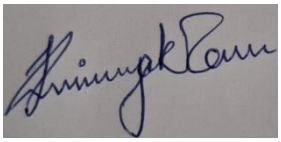
3. B JAGADISH (23ETCS002025)

4. CHIRAG GK (23ETCS002030)

5. GRIDHAR P (23ETCS002040)



6. KM VINAYAK RAM (23ETCS002052)



18. References

1. **NEMA Actuated Controller Standards**

FHWA's Technical Guide details Vehicle Actuated Control (VAC) logic, phase sequencing, and detector integration (e.g., loop sensors for traffic density assessment). Critical for designing signal preemption protocols compatible with existing NEMA TS1/TS2 controllers .

2. **SOS Siren Detection Sensor**

EliteGates' SOS 12 Sensor offers technical specs for siren-activated systems: 80–125 dB sensitivity, 3-second response time, dry-contact output, and weatherproofing (-30°F to 120°F). Validates low-power (0.1 mA standby), fail-safe emergency detection electronics .

3. **Solar-Powered Traffic Signal Case Study**

JTI's PTS-2000 demonstrates off-grid viability: solar panels + storage powering vehicle detection, LED signals, and remote monitoring. Provides real-world specs for energy autonomy in reflectors/roadside units .

4. **IoT-Enabled Traffic Management**

Telit's Smart Traffic Solutions outline connectivity requirements: cellular (LTE-M/NB-IoT), edge computing modules, and cloud integration. Essential for designing VAC-ambulance communication networks.

5. **Emergency Vehicle Routing Algorithms**

Study in Sustainability Journal quantifies impact: Route optimization + priority control reduces EMV travel time by 17.88% and cuts costs by 8.73%. Validates system's medical/financial value proposition .

6. **VAC Deployment Metrics (Bengaluru/Chandigarh)**

- Bengaluru: 103 VAC signals reduced travel time 15–17%, boosted throughput 20–22% .
- Chandigarh: VAC trials at 12 intersections cut wait times by skipping unused green phases

Proves municipal demand and ROI.

7. **EMV Priority System Market Analysis**

Symmetry Electronics cites the smart traffic management market growing at 10.1% CAGR (2028: $19.91B). Highlights demand from 250+ global smart city projects .