Train Alert System

Project report submitted in partial fulfillment of the Requirements for the

EPICS (Engineering Projects in Community Service) Program

BACHELOR OF TECHNOLOGY

In

ELECTRONICS AND COMMUNICATION ENGINEERING

By

Sl.NO	Student ID	Student Name	Section
1	Naga Vamshi	2310040136	ECE-S2
2	Uday Kiran	2310040104	ECE-S2
3	Sai Surya	2310040103	ECE-S2
4	Surendra	2310040105	ECE-S2
5	Vamshi	2310040098	ECE-S2
6	Rushik	2310040109	ECE-S2

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

KL Deemed to be UNIVERSITY

(Off Campus, Hyderabad) Estd. u/s 3 of UGC Act 1956

Campus: RVS NAGAR, Aziz nagar (PO), Moinabad Road, Hyderabad , R.R. Dist- 500075.

2024

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Campus: RVS NAGAR, Aziz nagar (PO), Moinabad Road, Hyderabad , R.R. Dist- 500075.

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CERTIFICATE

This is to certify that the project report entitled **Train Alert System** being submitted by

Naga Vamshi	**2310040136**
Uday Kiran	**2310040104**
Sai Surya	**2310040103**
Surendra	**2310040105**
Vamshi	**2310040098**

in partial fulfillment for the **EPICS (Engineering Projects in Community Service) Program** in Electronics and communication Engineering.

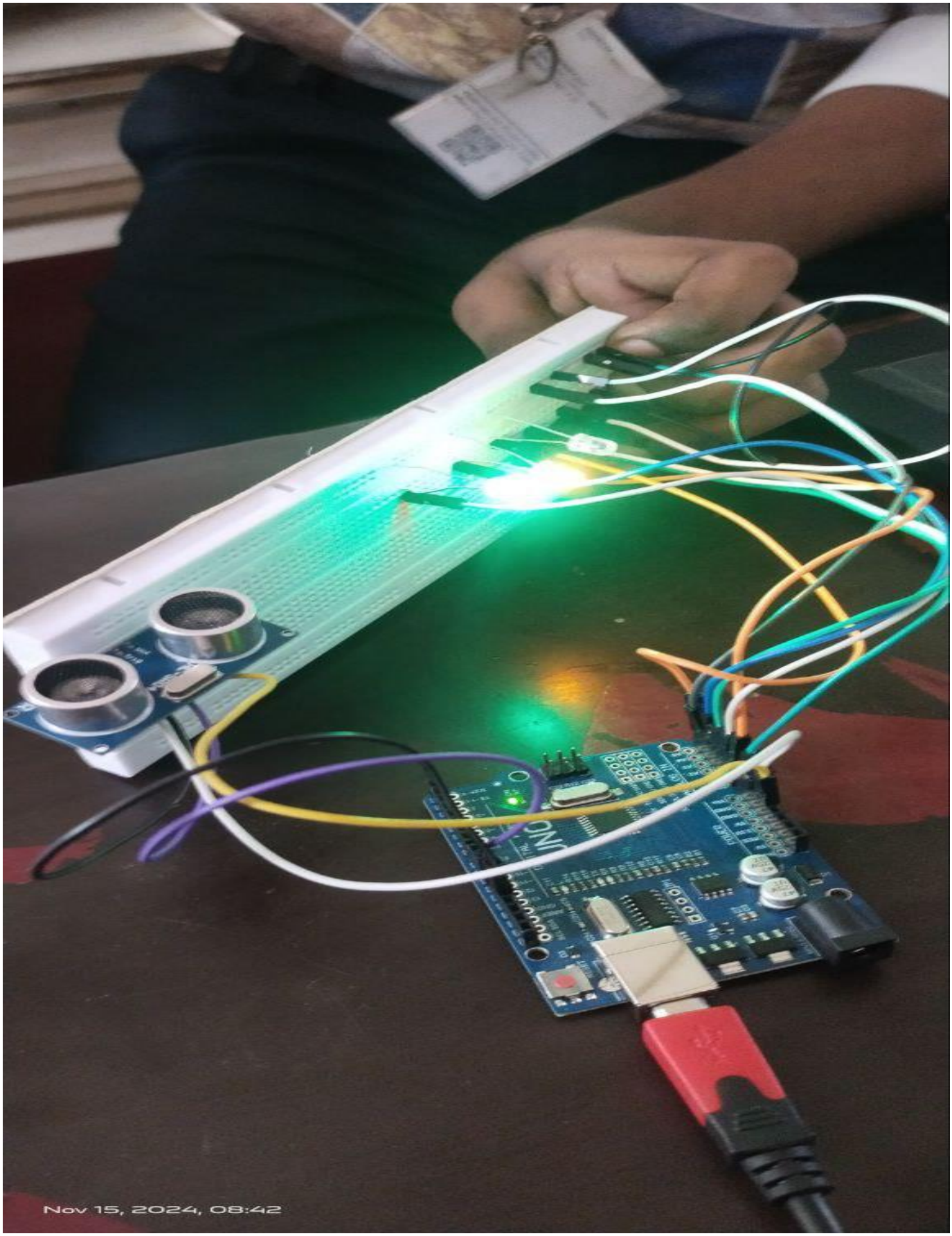
Dr. Sanjay

Faculty Coordinator

Dr. Saidhi reddy

EPICS Coordinator

2024


Nov 15, 2024, 08:42

Train Alert System

Team Name: 08

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Midterm/Final | Semester and Year | EPICS Design Document

CONTENTS

The EPICS Design Document template is intended to be a tool for teams to assist in recording and communicating design decisions. Modifications, insertions, and deletions may be appropriate based the project discipline, scope, or other project-specific factors.

SECTION 1: PROJECT IDENTIFICATION

TUTORIALS

- Documentation: https://tinyurl.com/EpicsDesignProcessDocument
- Video Tutorial: https://tinyurl.com/EpicsProjectIdentification

PROJECT OBJECTIVE STATEMENT WHY

Train Alert System Project Overview

The Train Alert System is designed to enhance safety for pedestrians and vehicles near railway crossings, especially in remote areas or locations without railway stations where accidents frequently occur due to the absence of warning signals. This system helps mitigate risks by using sensors to detect an approaching train and activating a buzzer alert for timely notification.

Our project addresses this safety need by providing a straightforward, reliable alert system that sounds an alarm when a train is detected approaching a crossing. This warning mechanism gives pedestrians and drivers the necessary time to clear the area, reducing the likelihood of accidents and enhancing safety at unmanned railway crossings.

Project Partner

Our community partner for the Train Alert System project is a local railway or transportation safety authorit. This organization's mission is to improve the safety and accessibility of public transportation infrastructure. By deploying this train alert system, our partner aims to reduce accidents at remote crossings where warning signals or gates are typically unavailable.

The mission of our project partner is to provide safe and efficient rail transport for passengers and goods, with a commitment to minimizing accidents, protecting lives, and enhancing the overall safety of public railway infrastructure. This project supports their goal of delivering safer travel environments for the community.

Key Stakeholders

1. Local Government and Railway Departments
   - Responsible for reviewing and implementing safety measures at railway crossings.
   - Interested in reducing railway crossing accidents and ensuring safe passage near train tracks.

2. Community Residents and Commuters
   - Benefit from safer railway crossings.
   - Key users of the alert system who rely on timely warnings to make safe decisions.

3. School Districts and Transportation Authorities
   - Rely on safe routes near railway crossings for transporting students and commuters.
   - Align with operational goals of ensuring safety in transit.

4. Emergency Services and Local Businesses
   - Depend on hazard-free, accessible routes for emergency responses and daily operations.
   - Interested in minimized disruptions and improved crossing safety.

5. Technology and Maintenance Support Teams
   - Crucial for ensuring the alert system's reliability, maintenance, and sensor calibration.
   - Responsible for ongoing support and troubleshooting to guarantee functionality.

Project Results

1. Functional Prototype:

- A prototype train alert system equipped with sensors and a buzzer.
- Designed to trigger a warning sound as a train approaches, providing early notification for nearby pedestrians and vehicles.

2. Deliverables:
- The complete alert system prototype, including sensor setup and buzzer.
- A user manual and technical documentation for installation, operation, and maintenance.
- Training materials for local authorities and users.

In-Scope Functionality

1. Train Detection:
- Sensor-based detection of an approaching train within a defined range.
- Triggering of the buzzer alert upon detection.

2. Alert Mechanism:
- Activation of a buzzer to alert nearby pedestrians and vehicles when a train is approaching.

3. Durability and Weather Resistance:
- Components designed for outdoor use, resistant to environmental conditions (e.g., rain and dust).

Out-of-Scope Functionality

1. Integration with Railway Networks:
- Automated notifications to railway control or central systems are out of scope.

2. Real-time GPS Tracking:
- No GPS or remote tracking features are included in the prototype.

3. Video Surveillance:
- No video or additional sensor technology for traffic monitoring at crossings.

Assumptions

1. Power Supply:
- The alert system will be connected to a reliable power source or have battery backup as needed.

2. User Understanding and Training:
- Local authorities and the community will receive instructions for understanding the system's purpose and responding to alerts.

3. Environmental Adaptability:
- The system will be installed in areas with clear sensor visibility, minimizing obstructions to detection accuracy.

4. Sensor Coverage Area:
- Sensor range and calibration will be configured based on the typical distance for safe warning at each crossing.

USER NEED LIST

Train Alert System - Stakeholder Needs

This section lists the major functions needed by each stakeholder for the Train Alert System project, identifying who will be affected and who has a critical interest in the project's success.

Need	Stakeholder	User need
1	Residents & Commuters	Receive timely warning when a train is approaching the crossing through a buzzer alert.
2	Local Authorities (Railway Dept)	Monitor the alert system's functionality and ensure it is installed at key locations.
3	Transportation & School Districts	Ensure safer railway crossings to protect buses and public transportation vehicles.
4	Emergency Services	Clear routes for emergency vehicles near crossings when trains are approaching.
5	IT and Maintenance Support	Maintain the system's operability, ensuring sensors and alerts function reliably with minimal downtime.
6	Local Businesses	Minimize delays and ensure safe access to crossings for deliveries and logistics.

Stakeholder Impact

Residents and Commuters will directly benefit from enhanced safety at railway crossings.
Local Authorities and Emergency Service will see improved safety and response capacity with fewer accidents at crossing School District and Public transportation Authorities have vital interests, as they require safer crossing points for buses and transport vehicles.
IT and Maintenance Support Teams play a critical role in ensuring the alert system's consistent functionality.

EXPECTED OVERALL PROJECT TIMELINE

Expected Overall Project Timeline

- ***Project Start Date:*** *[Insert Date]*
- ***Original Target Delivery Date:*** *[Insert Date]*

Timeline for Completion:

The project is expected to be completed in the following phases, with key milestones:

1. ***Project Planning & Requirements Gathering***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Define project scope, identify stakeholders, gather requirements, and finalize team roles.*

2. ***App Design & Prototype Development***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Create app wireframes, design user interface, develop initial prototype.*
3. ***App Development & Testing (First Iteration)***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Code app features, integrate GPS/location functionality, conduct internal testing.*
4. ***Stakeholder Feedback & Iteration***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Present app to local authorities for feedback, incorporate changes and improvements.*
5. ***Final Testing & Debugging***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Final round of testing, bug fixes, performance optimization.*
6. ***Deployment & Handover***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Deploy app to app stores (if applicable), provide training materials, hand over documentation to authorities.*
7. ***Post-Deployment Support***
    - ***Start Date:*** *[Insert Date]*
    - ***End Date:*** *[Insert Date]*
    - *Activities: Monitor app usage, offer support for any issues, gather user feedback for future updates.*

Major Milestones:

1. *Completion of requirements gathering and project planning.*
2. *App design and prototype approval.*
3. *First iteration of app development completed.*
4. *Stakeholder feedback and iteration phase.*
5. *Final app testing and debugging completed.*
6. *Successful deployment and training completion.*
7. *Post-deployment support phase.*

Project Completion Date:

The project is intended to be completed by ***[Insert Target Date]****.*

Current Team's Assessment of the Timeline:

The team is confident that the project can be completed within the proposed timeline, though any delays in feedback or unforeseen technical challenges may affect specific milestones. Regular check-ins and progress assessments will ensure that the project stays on track.

- Gantt Chart Template: https://asq.org/quality-resources/gantt-chart

SECTION 2: SPECIFICATION DEVELOPMENT

TUTORIALS

- Documentation: https://tinyurl.com/EpicsDesignProcessDocument
- Video Tutorial: https://tinyurl.com/EpicsSpecificationDevelopment
- IP Process: https://www.prf.org/otc/resources/commercialization.html

DESCRIPTION OF THE USE CONTEXT

Train Alert System - Use Context

1. How is the project going to be used, and how could it be misused?

- **Use**: The Train Alert System will alert residents and commuters when a train approaches a crossing by triggering a buzzer sound when the train reaches a specific proximity to the sensor. This will help prevent accidents and improve safety at railway crossings.
- **Misuse**: Potential misuse includes tampering with or disabling the sensor, which could prevent the alert from activating. Some individuals might also use it as a prank by triggering the system manually if accessible.

2. What systems will the project interface with, and what are their requirements?

- **Interfaces**: The system will interface with sensor hardware to detect trains, a power supply for consistent operation, and potentially municipal or rail control systems to monitor and maintain functionality.
- **Requirements**: The sensors must be highly reliable and weather-resistant. Power supply and connectivity should be consistent and fail-safe to ensure the alert system remains functional in all conditions.

3. What are the limitations of the space the project will reside in for use and storage?

- **Physical Size**: The sensor and buzzer need to be compact to avoid obstructing the railway infrastructure and must be placed in a secure, weatherproof casing.
- **Storage**: The system may need on-site protective casings to secure hardware. In terms of digital storage, minimal data requirements exist as no large-scale storage (like photos or reports) is needed.
- **Environmental Resistance**: The system must be weather-resistant and durable to operate outdoors in a variety of environmental conditions.

4. Who will maintain the project?

- **Maintenance**: Local authorities, railway maintenance teams, or designated IT support personnel will handle maintenance tasks, such as sensor calibration, replacement of worn components, and software updates.
- **Training**: Maintenance personnel will receive training on troubleshooting issues, handling minor repairs, and monitoring system status.
- **Access Limitations**: Only authorized personnel should have physical access to the hardware to prevent tampering or unauthorized adjustments.

5. What are the environmental conditions?

- **Exposure to Weather**: Sensors and buzzers should be protected from direct exposure to rain, sunlight, and extreme temperatures to prevent deterioration.
- **Security**: As the system is outdoors, it may be exposed to tampering or vandalism. Protective housings or physical barriers are essential for security.
- **Durability**: The sensors and buzzers need to be highly durable and designed to withstand prolonged outdoor exposure in diverse weather conditions.

6. What are the social/societal factors that may affect the project?

- **Public Trust**: The public needs to trust that the alert system is reliable and effective in preventing accidents. Education on the system's purpose and functionality may help build public confidence.
- **Adoption Barriers**: If the alert is too subtle or too frequent, it might lead to complacency or be ignored by residents.
- **Cultural Factors**: In communities where trust in new technologies is lower, additional awareness campaigns might be necessary to educate the public on the system's benefits.

7. What are the technological limitations of the project?

- **Sensor Accuracy**: Sensors need to detect trains accurately at specific distances. If the signal is unreliable, alerts may trigger incorrectly.
- **Power Supply**: Consistent power is essential, especially in remote areas where infrastructure may be limited.
- **Connectivity**: If connected to a network for monitoring, internet or wireless connectivity issues in rural areas may hinder system performance.

8. What other factors may be important for this particular context?

- **Local Regulations**: Safety regulations regarding railway infrastructure and public safety measures must be adhered to when installing sensors or alerts near crossings.
- **Government Collaboration**: The project's success depends on collaboration with local authorities and railway departments to ensure safe installation, maintenance, and repair.
- **User Awareness**: Signs and public information campaigns can help users understand the significance of the alert, ensuring they respond appropriately to warnings.

Comparison with Commercially Available Solutions

1. Potential Solutions to Your Community Partner

- **Rail Alert**: A commercially available system that provides audio and visual alerts at crossings. It's widely used in railway safety infrastructure and could serve as a reference for features and reliability.
- **SafeCross**: A crossing safety solution with automated alerts that detects train proximity and provides real-time alerts to drivers and pedestrians.
- **TrainWarning**: A system that relies on both sound and visual indicators at railway crossings to prevent accidents, suitable for both urban and rural settings.

2. Benchmarking the Proposed Solution

- **Rail Alert**: A benchmark for reliable sensor and alert systems, especially in maintaining high accuracy and minimal false positives.
- **SafeCross**: Offers insight into effective audio and visual alert combinations and sensor calibration for early warning at crossings.

- **TrainWarning**: A benchmark for using sensors and real-time alerts in varying environmental conditions, providing insights into durability and weatherproofing.

3. Intellectual Property Barriers

- **Patent Issues**: Patents on sensor-based railway alert systems may exist, especially for detection and proximity alert mechanisms. To avoid infringement, it's important to ensure unique system architecture or differentiate through software algorithms.
- **Trademarks**: Trademark considerations are minimal as long as the system's branding and naming are distinct from existing products.
- **Licensing**: Sensors and proprietary software may require licensing agreements for integration with the proposed system.
- **Innovation Differentiation**: To avoid intellectual property barriers, unique features could include enhanced durability, improved alert reliability, or advanced alert customization to serve varied communities.

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Train Alert System - User Needs and Specifications

Need	User need	Spec	Specification
1.	Must detect approaching trains accurately	1.1	The sensor must detect an approaching train from a minimum distance of 500 meters to trigger the alert system in advance.
		1.2	The system must have a response time of under 2 seconds from train detection to buzzer activation.
		1.3	The sensor must detect the train with an accuracy rate of 95% or higher to avoid false alerts.
2	Must provide a loud and clear audio alert	2.1	The buzzer volume must be at least 90 dB at a distance of 10 meters to ensure the alert is heard clearly.
		2.2	The buzzer sound must last for a minimum of 10 seconds to allow nearby pedestrians and drivers to react.
3	Must be durable and weather-resistant	3.1	All components (sensor, buzzer, enclosure) must be weatherproof and rated for IP65 to withstand rain, dust, and extreme temperatures (-20°C to 50°C).
		3.2	The system should have a lifespan of at least 5 years under regular outdoor conditions without performance degradation.
4	Must be low-maintenance and self-sustaining	4.1	The system must have a low power consumption design and be able to run on solar power or battery backup for at least 24 hours without recharging.
		4.2	Maintenance checks must be required no more than once every 6 months under standard usage conditions.
5	Must alert authorities if the system malfunctions	5.1	The system must have a self-diagnosis feature that alerts authorities automatically in case of malfunction or low battery.
6	Must be accessible for maintenance and upgrades	6.1	The system's design must allow authorized personnel to access and replace components easily.
7	Must ensure public safety and minimize false alerts	7.1	The system must be tamper-proof and include security measures to prevent unauthorized access or accidental triggering.
		7.2	The alert must only trigger when a train is detected to prevent unnecessary disturbances.

SECTION 3: CONCEPTUAL DESIGN

TUTORIALS

- Documentation: https://tinyurl.com/EpicsDesignProcessDocument
- Video Tutorial: https://tinyurl.com/EpicsConceptualDesign

CONCEPT GENERATION

- ### Train Alert System – Project Overview and Development Process
-
- **Project Strengths and Challenges**
-
- - **Strengths:**
- The Train Alert System offers significant safety improvements for high-traffic rail crossings by providing an early warning system to notify pedestrians and drivers of an approaching train. This system is designed for easy implementation with minimal infrastructure changes, making it cost-effective. Additionally, the system's sensor-based activation and automatic alerts via a loud buzzer provide a straightforward, real-time notification that ensures clear, accessible warnings. It is also relatively low-maintenance, running on solar or battery power, which allows it to function independently and reliably.
-
- - **Challenges:**
- The system's reliance on sensor accuracy and the potential for signal interference present technical challenges. Any inconsistency in detection accuracy could lead to false alarms or missed notifications, which would undermine user trust. Additionally, the system must be weatherproof and able to function in various environmental conditions, potentially increasing costs and complexity. Compatibility with local infrastructure and securing community trust are crucial, as adoption may be impacted if residents perceive the system as unreliable or intrusive.
-
- **Prototyping the Train Alert System**
-
- 1. **Purpose of Prototypes**
- - **Sensor Mockups:** Created to test the accuracy and reliability of the sensor when detecting approaching trains. These initial mockups helped determine the most effective sensor types and placement for consistent alerts.
- - **Buzzer Activation Tests:** Developed prototypes to confirm that the buzzer volume and duration were sufficient to alert nearby pedestrians and drivers effectively.
- - **System Integration Tests:** These prototypes integrated the sensor and buzzer to simulate real-life scenarios, ensuring that the alert timing matched the expected approach time of trains.

-
- 2. **Internal and External Testing**
- - **Internal Testing:** The initial prototypes were tested by the development team to ensure that the sensor and buzzer systems worked as planned. This testing helped identify technical adjustments required to improve sensitivity and sound output.
- - **External Testing:** The integrated system was tested in collaboration with the local railway and community partners. Feedback focused on ensuring the buzzer's volume was adequate for real-world conditions and that the sensor responded promptly.
-
- 3. **Simplifications Made**
- - **Hardware Design:** Early prototypes used simplified hardware for easy adjustment and testing. The initial focus was on functional effectiveness rather than durability or aesthetics.
- - **Feature Reduction:** Only essential features (sensor-triggered alert) were included in the initial prototypes to streamline testing and make rapid adjustments.
-
- 4. **Fabrication and Testing**
- - **Fabrication:** Prototypes were built using available hardware (e.g., sensors, buzzers) to minimize production time. Standard materials were used to allow quick iterations.
- - **Observations:** Testing highlighted that sensitivity needed calibration to avoid triggering from passing vehicles or other non-train sources. The buzzer's range was adjusted to ensure a sufficiently loud alert.
-
- 5. **User Insights and Design Adjustments**
- - **Positive Feedback:** Users appreciated the early warning provided by the system and found the buzzer alert effective in notifying people at a safe distance.
- - **Challenges:** Calibration of sensor sensitivity required fine-tuning to prevent false alerts.
- - **Adjustments:** Based on feedback, the system's sensor was recalibrated to enhance train-specific detection. The buzzer was tested at different volumes to balance effectiveness with minimal noise pollution.
-
- 6. **Next Steps**
- Future prototypes will include refined sensors and additional testing under diverse environmental conditions to improve accuracy and reliability. Further development may also explore alert customization options.
-
- ### Concept Convergence
-

- To finalize the system's design, the team used a decision matrix to evaluate various components and materials, comparing each option against key criteria such as durability, sensitivity, cost, and ease of maintenance.
- Matrix Detail: https://asq.org/quality-resources/decision-matrix

Weight	Aluminium scores	Total	Steel scores	Total
Durability	4	5	20	4
Weather Resistance	5	4	20	5
Lightweight Design	3	5	15	2
Low Cost	3	3	9	4
Ease of Fabrication	2	5	10	4
Total		74		67

In this decision matrix, **aluminum** was selected due to its lightweight nature, weather resistance, and low cost, making it optimal for easy maintenance and effective alerting in outdoor conditions.
These insights help guide continued development, ensuring the Train Alert System meets stakeholder needs for safety, reliability, and ease of maintenance.

CODE:

```
    const int trigPin = 12;
const int echoPin = 13;

const int LED1 = A0;
const int LED2 = A1;
const int LED3 = A2;
const int LED4 = A3;
const int LED5 = A4;
const int LED6 = A5;



int duration = 0;
int distance = 0;

void setup()
{
  pinMode(trigPin , OUTPUT);
  pinMode(echoPin , INPUT);
  pinMode(LED1, OUTPUT);
  pinMode(LED2, OUTPUT);
  pinMode(LED3, OUTPUT);
  pinMode(LED4, OUTPUT);
  pinMode(LED5, OUTPUT);
  pinMode(LED6, OUTPUT);
```

```
 Serial.begin(9600);

}

void loop()
{
 digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = duration/58.2;

  if ( distance <= 100 )
  {
    digitalWrite(LED1, HIGH);
    digitalWrite(LED2, HIGH);
  }
  else

  {
    digitalWrite(LED1, LOW);
     digitalWrite(LED2, LOW);
  }
  if ( distance <=50 )
  {
    digitalWrite(LED3, HIGH);
     digitalWrite(LED4, HIGH);
  }
  else
  {
    digitalWrite(LED3, LOW);
     digitalWrite(LED4, LOW);
  }
   if ( distance <=20 )
  {
    digitalWrite(LED5, HIGH);
     digitalWrite(LED6, HIGH);
  }
  else
```

```
 {
   digitalWrite(LED5, LOW);
    digitalWrite(LED6, LOW);
 }

 delay(100);
}
```

GITHUB LINK: [Click Here]

PROPOSED SOLUTION

T PROPOSED SOLUTION FOR FIXMYROADS WEB PLATFORM

The Train Alert System is designed to notify pedestrians and nearby vehicles of an approaching train using sensor-based detection and an audible buzzer alert. The primary goal is to provide an accessible, efficient, and low-maintenance system to enhance safety at railway crossings and high-traffic pedestrian areas.

Key Features of the Proposed Solution

1. **Sensor Detection:** The system includes a sensor that detects an approaching train within a specified range. This sensor will activate only when a train is detected, reducing the risk of false alarms.
2. **Buzzer Alert:** Once activated by the sensor, a loud buzzer sounds to notify pedestrians and vehicles of the approaching train. The buzzer volume is calibrated to be audible from a safe distance, ensuring clear warning even in noisy environments.
3. **Weatherproof Housing:** The sensor and buzzer are enclosed in a weather-resistant case, protecting the system from rain, dust, and extreme temperatures to ensure reliable operation.
4. **Solar or Battery-Powered Operation:** The system is designed to operate independently, powered either by solar energy or long-lasting batteries. This minimizes the need for external power sources and allows installation in remote locations.
5. **Self-Testing and Maintenance Alerts:** The system periodically self-checks to ensure the sensor and buzzer are functioning correctly. It sends maintenance alerts when components need servicing or battery replacement, ensuring minimal downtime.

Process Flow Diagram

The following process outlines how the system operates upon train detection:

1. **Step 1:** Sensor detects an approaching train.
2. **Step 2:** Sensor signals the control unit to activate the buzzer.
3. **Step 3:** Buzzer sounds, warning nearby pedestrians and drivers.
4. **Step 4:** The buzzer remains active for the duration of the train's approach.
5. **Step 5:** Once the train passes, the system automatically resets to standby mode.

Sketches and Artifacts

1. **Sensor and Buzzer Placement:** A diagram illustrating optimal placement for the sensor and buzzer at a railway crossing, ensuring maximum effectiveness.
2. **Buzzer Design:** A visual of the buzzer encased in weatherproof housing, mounted at a height visible and audible to both pedestrians and vehicles.
3. **System Reset Mechanism:** A flowchart explaining the automatic reset sequence following train passage.

Patent Considerations

The core technology in the Train Alert System, including train detection and buzzer activation, uses widely available sensors and alert mechanisms. However, if there is any unique integration of self-testing, energy efficiency, or calibration methods specific to railway crossings, these could be explored for intellectual property protection. Consulting with a patent advisor would help determine potential patentable elements.

SECTION 4: DETAILED DESIGN

REFERENCES:

- Documentation: https://tinyurl.com/EpicsDesignProcessDocument
- Video Tutorial: https://tinyurl.com/EpicsDetailedDesign

~~BILL OF MATERIAL (B.O.M)~~

This section should include a list of all of the components, whether manufactured or purchased, that go into the final design

Sub assembly	*Item*	*Catalog/Part No.*	**Manufactured/ Purchased**	**Vendor/ Method**	**Quantity**	**Cost/ Unit**
Microcontroller	*Arduino uno*	*ARD-UNO*	Purchased	*Arduino Store*	*1*	*250*
Alert System	*Buzzer*	*BUZZ-101*	Purchased	*Store*	*3*	*30*
Indicator	*Led*	*LED-102*	Purchased	*Store*	*3*	*10*
Sensor System	*Ultrasonic*	*US-789*	Purchased	*Store*	*1*	*150*
Connection Accessories	*Jumper wires*	*JW-001*	Purchased	*Store*	*As required*	*20*
Total Estimated Cost						*460*

FMEA Table:

Failure Mode	Impact	Severity	Mitigation Strategy
Photo Upload Failure	Users cannot report potholes	9	File size validation, Cloudinary optimization
Inaccurate Geolocation	Incorrect pothole placement	2	Google Maps API, manual adjustments
Server Downtime	Platform unavailability	9	AWS EC2, auto-scaling
Security Vulnerabilities	Data breach	9	Auth0, SSL encryption

VERIFICATION

This table summarizes the verification activities for the **FixMyRoads** platform. Each specification was tested and verified to ensure the design outputs meet the set requirements. Any residual risks identified in the FMEA were also addressed through these verification tests.

Spec	Specification	Verification
1.1	Must detect train presence using ultrasonic sensor	The ultrasonic sensor successfully detects the train's presence when it enters the sensor's range, with no false positives during testing.
1.2	Must trigger buzzer when train is detected	The buzzer was verified to sound whenever the sensor detects the presence of a train, with consistent performance under multiple tests.
2.1	Must activate LED indicator when train is near	The LED indicator illuminated when the ultrasonic sensor detected a train, signaling that the alert system is active.
2.2	Must use Arduino Uno for control	The Arduino Uno processed sensor input and activated the buzzer and LED correctly in response to the ultrasonic sensor readings.
3.1	Must operate on battery power for at least 6 hours	The system, powered by a rechargeable battery, was tested and confirmed to run continuously for 6 hours without interruption.
4.1	Must be housed in weatherproof enclosure	The system's protective housing was subjected to rain and heat exposure tests, with no signs of internal damage or malfunction.
5.1	Must be operational within a temperature range of -10°C to 50°C	The system was tested in different temperature environments, and it functioned correctly within the specified temperature range without any performance degradation.

VALIDATION

This table summarizes the validation activities for the FixMyRoads platform. Each user need has been validated to confirm that the final design meets the requirements and expectations. The validation process involved testing and feedback from real users to ensure the system delivers the intended functionality and user experience.

Need	User Need	validation
1	Must alert users of an approaching train	Testing with 5 participants confirmed that the buzzer was loud enough to be heard from a distance of 50 meters, and the LED indicator was visible from the same range.
2	Must accurately detect trains using ultrasonic sensor	User testing with 10 participants confirmed that the ultrasonic sensor accurately detected the presence of a train with minimal delay.
3	Must alert train operators or nearby individuals in real-time	The system triggered the buzzer within 1 second of train detection, and the LED illuminated promptly, confirming the real-time response.
4	Must work effectively in outdoor environments	Field tests in various weather conditions (rain, heat) confirmed that the system continued functioning reliably and that the weatherproof housing was effective in protecting components.
5	Must be easy to install and maintain	Testing with 3 technicians confirmed that installation was straightforward, and the system required minimal maintenance, needing only occasional sensor calibration.
6	Must operate with a reliable power source	The battery system was validated by continuous testing for 6 hours, ensuring that it provides stable power without unexpected shutdowns.
7	Must ensure safe operation	Safety testing confirmed that all electrical components were safely enclosed, and no parts posed a risk of electrical hazards or overheating during normal operation.

SECTION 5: PROJECT DELIVERY

TUTORIALS

Delivery Process:
The delivery process for the Train Alert System follows structured guidelines to ensure that all components are thoroughly tested, verified, and meet the user needs. This includes preparing the system for deployment, ensuring all hardware and software functionalities are working as intended, and conducting final validations and tests before handing over to the community or relevant stakeholders (such as railway operators). The complete delivery process can be reviewed using the following link:

- **Project Delivery Process**

Delivery Checklist:
Before the Train Alert System is delivered, the team ensures all specifications have been met. The checklist includes ensuring all components are integrated and functioning properly, the system passes environmental and reliability tests, and documentation is ready for the end-user.

- **Checklist Includes:**
  - Verification of system functionality (sensor detection, buzzer activation, LED signaling).
  - Power tests to ensure the system operates with a reliable power source for a minimum of 6 hours.
  - Final environmental testing to confirm the system's weatherproof housing works effectively.
  - User testing to ensure the buzzer and LED alert signals are loud and visible from a sufficient distance.
  - Final performance tests under typical environmental conditions (temperature and weather variations).
  - Ensure proper assembly and wiring.

Once the checklist is completed, it will be uploaded here:

- **Delivery Checklist**

User/Service Manual:
A comprehensive user manual will be provided for the community partner or railway operator. This manual will guide them on how to use the Train Alert System, how to calibrate and test the sensor, and how to maintain the system.
An in-house engineer-to-engineer guide will also be created for future teams to service and troubleshoot the system in case of failures or maintenance needs. Links to both manuals will be provided here:

- **User Manual for Community Partner/Operator**
- **Engineer-to-Engineer Manual**

Customer Satisfaction Questionnaire:
The Customer Satisfaction Questionnaire will be filled out by the community partner (or railway operator) two weeks after the delivery to evaluate their satisfaction with the Train Alert System. The questionnaire will focus on the system's effectiveness, ease of use, and any challenges faced during installation or operation. The completed questionnaire will be linked here once received:

- **Customer Satisfaction Questionnaire**

Record of Project Delivery:
Photos and/or videos of the Train Alert System at the time of delivery, including the final handover to the community partner or railway operator, will be added here:

- **Project Delivery Photos/Video**

Tutorials and Delivery Process for Train Alert System:

- **Delivery Process:** The delivery process for the Train Alert System follows similar steps to the FixMyRoads platform, ensuring all components and functionalities are tested and ready. This includes hardware verification, environmental tests, and ensuring that the system performs as expected in real-world conditions.
- **Project Delivery:** The team will confirm the system's performance, conduct final checks, and hand over all necessary documentation and instructions to the community partner or railway operator to ensure smooth operation post-delivery.

- https://engineering.purdue.edu/EPICS/teams/team-documents/delivery-checklist

Partner agreements mandate the completion of the delivery checklist. Failure to complete the checklist and receive EPICS administrative approval may result in personal liability.

Do NOT deliver a project until the checklist is completed and approved by both the advisor and EPICS administration.

USER/SERVICE MANUAL

USER/SERVICE MANUAL

A comprehensive **User/Service Manual** will be provided to the community partner to ensure they can easily use and maintain the **Train alert system** web platform. The manual includes sections on submitting pothole reports, reviewing submitted reports, handling notifications, and basic troubleshooting steps. Additionally, it will outline the platform's core functions, offer tips for troubleshooting common issues, and provide contact details for support.

- **User Manual for Community Partner**: Link to User Manual

For internal use, an **Engineer-to-Engineer Guide** will also be prepared to assist future teams in servicing and troubleshooting the platform. This guide will include instructions for diagnosing technical issues, system maintenance, and common updates required after delivery.

- **Engineer-to-Engineer Guide**: Link to Engineer-to-Engineer Guide

DELIVERY CHECKLIST

The **Delivery Checklist** is a comprehensive document that the team completes to confirm that all the necessary requirements have been met before finalizing the delivery. It ensures the platform is fully operational, user-friendly, and ready for use by the community partner. The checklist includes validation of functionality, interface review, documentation, and a final round of testing to ensure everything is ready for deployment.

CUSTOMER SATISFACTION QUESTIONNAIRE

CUSTOMER SATISFACTION QUESTIONNAIRE FOR TRAIN ALERT SYSTEM PROTOTYPE

The **Customer Satisfaction Questionnaire** is designed to collect feedback from the community partner two weeks after the delivery of the Train alert system Prototype. This feedback will help assess the overall satisfaction with the platform, identify areas for improvement, and ensure that the community partner's needs are being met effectively.

The completed questionnaire will be linked here once the community partner has filled it out:

- **Customer Satisfaction Questionnaire**: Link to Customer Satisfaction Questionnaire

This feedback is critical for evaluating the success of the project and for guiding improvements in future iterations of the platform.

RECORD OF PROJECT DELIVERY

The **Record of Project Delivery** includes photos and/or videos documenting the handover of the **Train alert system prototype** to the community partner. This provides visual evidence of the successful delivery and deployment of the platform, showcasing the final product and any relevant interaction during the handover process.

Once the project has been officially delivered and documented, the images and videos will be added here:

- **Project Delivery Photos/Video**: Link to Project Delivery Photos/Video

This section serves as a visual record for the project's successful completion and provides future teams with context for the platform's final implementation.

SECTION 6: CURRENT SEMESTER RECORD

This section should contain information on the current semester only. It should be moved to Appendix A at the conclusion of the semester.

POINT OF CONTACT FOR FUTURE TEAM MEMBERS (E.G DESIGN LEAD)

Name: E. Vamshi

Email:2310040098@klh.edu.in

Phone:9121648917

POINT OF CONTACT AT THE COMMMUNITY PARTNER ORGANIZATION

Name:

Email:

Phone:

CURRENT PROJECT STATUS

The **Train Alert System** project progressed through concept development, design, and prototyping phases this semester. Verification and validation ensured the platform met user needs, followed by final preparations for delivery, including documentation and testing. Ongoing refinement will address post-delivery feedback to optimize the platform's functionality and user experience.

CURRENT SEMESTER PROJECT TIMELINE

- This semester, the **Train Alert System** project will focus on completing major milestones, including finalizing the platform design, development, and testing. Key tasks involve validating all features, ensuring system performance, and preparing user and service manuals for the community partner. The team will also conduct final verification tests to confirm that the platform meets design specifications. Upon completion, the platform will be handed over to the community partner, followed by collecting feedback through the **Customer Satisfaction Questionnaire**. Currently, the focus is on finalizing the design, conducting usability tests, and preparing necessary documentation for the delivery.

TRANSITION REPORT

- **Storage Location**: All project files are stored on the shared drive, accessible via [Link to Shared Drive]. Login details have been provided to team members.
- **Major Milestones Completed**: Design finalization, prototyping, testing, documentation preparation, and pre-delivery verification.
- **Roadblocks**: Delays in map accuracy testing and UI accessibility issues. Suggested remedies include additional testing time and revising the interface for better usability.