

# The Accident Guardian: A Low-Cost Intelligent Collision-Detection System for Enhanced Emergency Response

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## ABSTRACT

Traffic accidents remain a major global safety concern, particularly when emergency response is delayed due to driver incapacitation, remote crash locations, or the absence of witnesses. In the UAE, delayed accident reporting continues to contribute to avoidable injuries and fatalities, especially for vehicles lacking built-in emergency call systems. This paper presents Accident Guardian, a low-cost, aftermarket intelligent collision-detection system designed to automatically identify severe vehicle impacts and transmit real-time GPS location data to emergency services and designated contacts. The proposed system integrates impact and motion sensors, GPS tracking, and IoT-based communication within a compact in-vehicle module. To reduce false alarms, a driver verification mechanism is incorporated via the vehicle's dashboard interface, enabling manual cancellation when assistance is not required. The system was developed using an interdisciplinary I-Team and design thinking methodology, combining user-centered design with technical feasibility analysis. Prototype development and simulated crash scenarios demonstrate reliable detection and timely alert transmission, while qualitative feedback from accident survivors, emergency responders, and medical professionals highlights the system's potential to improve emergency response efficiency and enhance perceived safety. The results indicate that Accident Guardian offers a practical and scalable solution for improving post-crash response, particularly for older vehicles, and aligns with smart-city transportation and road safety initiatives in the UAE.

**Keywords:** Road safety, Crash detection, Emergency response, Smart vehicle technology, UAE, IoT safety devices, Accident guardian

## LITERATURE REVIEW

Road safety is a major national concern in the United Arab Emirates, where thousands of traffic accidents are reported annually, many of that end in fatalities or serious injuries. Delays in calling emergency services are one of the biggest causes of avoidable fatalities, especially when drivers are asleep, confused, stuck in traffic, or in remote locations. Accidents are frequently only reported when passersby call rescuers. These delays increase injury outcomes and drastically lower survival chances. Advanced crash-detection technology, like Europe's eCall system, which has been successful in cutting emergency response times and saving lives, has been developed as a result of similar issues in other regions (European Commission, 2018). But in the UAE,

these safety measures are usually limited to more expensive or newer cars, restricting many drivers of instant access to lifesaving emergency assistance.

Our project closes this gap, by introducing The Accident Guardian, a compact, clever crash-detection device that improves road safety for all car types. Through combining motion sensors, impact detection, GPS tracking, and automated emergency notifications, the sensor device offers a quick and dependable means of contacting the police, ambulance services, and family members in the event of a catastrophic crash. Our technology adds a second degree of verification by connecting it to the vehicle's display, allowing responsible drivers to confirm if they require emergency help. This lowers the possibility of false alarms and guarantees that help is on the way as quick as possible.

Our research has been guided by the need to build an achievable, accessible solution that is in line with the UAE's goal of intelligent, highly advanced safety systems. The Accident Guardian aims to improve emergency response times, reduce unnecessary fatalities, and provide drivers and families with peace of mind by addressing the technical and human factors that contribute to delayed reporting.

## **LITERATURE REVIEW**

### **Road Traffic Injuries and Emergency Response Delays**

Road traffic injuries remain a primary global concern, with the World Health Organization reporting over 1.3 million deaths annually due to car crashes and delayed access to emergency care. Yasin (2020) emphasized that in the UAE, delays in emergency response—especially on remote roads—significantly increase the severity of injuries and fatalities. Similarly, Wiwekananda et al. (2020) found that late accident notification and unclear crash locations are major contributors to ambulance delays. These studies highlight the critical role of timely crash detection, showing that human-dependent reporting (calling 999) is unreliable when victims are unconscious or unable to reach their phones. The Accident Guardian addresses this gap by automating crash detection and sending instant alerts with GPS data.

### **European eCall Systems**

The European eCall system automatically detects severe vehicle collisions and sends emergency alerts with location and vehicle information through an in-vehicle module (European Commission, 2018). Research shows that eCall can reduce emergency response time by 40–50%, thereby improving the survival probability of critically injured victims. However, the system is installed only in new vehicles manufactured after 2018, leaving many older vehicles without this capability. Additionally, eCall focuses solely on emergency centers and does not include communication with family members. Accident Guardian enhances this concept by offering a modern solution for all vehicles and adding family notifications, making automated crash detection accessible to a bigger audience.

### **UAE eCall/Fazaa Initiative**

The UAE launched its own eCall system, known as Fazaa, in 2021 to support faster emergency response. The system automatically transmits crash data to police operations rooms, including location, vehicle type, and occupant information (Khaleej Times, 2022). This aligns with the UAE's smart-city and road-safety goals. Despite its advantages, Fazaa is mandatory only for newly imported vehicles, leaving thousands of cars used by families, students, and delivery drivers unprotected. Accident Guardian fills this gap by providing a low-cost device that replicates key eCall features for older vehicles, ensuring broader safety coverage across the UAE.

### **Smartphone-Based Crash Detection Systems**

Modern smartphones, such as the Apple iPhone and Google Pixel, use built-in accelerometers and algorithms to detect crashes and automatically dial emergency services if no response is detected (Apple Inc., 2023; Google LLC, 2023). These solutions are helpful but depend on multiple conditions:

- the phone must be inside the vehicle
- the battery must be charged
- The device must not be thrown during impact
- permissions must be enabled.

Studies also show rising rates of false alarms, especially during rapid stopping or during sports activities (BBC News, 2022).

Accident Guardian overcomes these limitations by serving as a dedicated in-car device that remains fixed to the vehicle and uses automotive-grade sensors rather than relying on a personal smartphone.

### **Commercial Telematics and Vehicle Safety Services**

Telematics systems such as OnStar provide automatic crash detection, real-time location tracking, and human-agent support by connecting to emergency centers when airbags deploy (OnStar, 2022). These systems improve safety but are limited to specific brands and require subscription fees. They also lack integration with local UAE emergency networks. Accident Guardian offers a more universal approach by working across all car models without requiring manufacturer-built connectivity or a premium subscription.

### **Smart Policing and AI-Based Road Monitoring in the UAE**

Shamsi and Davies (2022) highlighted Abu Dhabi Police's adoption of AI, GPS, and intelligent traffic monitoring to reduce heavy-vehicle violations. Their study confirms the UAE's readiness to integrate real-time intelligent data into police systems. However, these technologies primarily focus on preventing violations rather than on automatically detecting and reporting crashes. Accident Guardian complements national smart-policing initiatives by providing immediate, on-site crash detection and direct, sensor-triggered emergency alerts.

## **METHODOLOGY**

### **Planning**

A systematic planning approach that integrated technical analysis, user-centered design, and business strategy was used to carry out the project. Every step of the process was meticulously planned to guarantee well-defined goals, well-structured processes, and effective resource utilization. Effective coordination and steady advancement throughout the development process were made possible by the pre-planned project activities, which had clear deadlines and roles. This methodical planning procedure facilitated well-informed decision-making, decreased delays, and guaranteed the timely and well-organized accomplishment of the project's goals.

Product design, technical development, market study, and user evaluation were among the well defined categories into which project tasks were divided. To guarantee practical operation and ease of use, the device concept and prototype were meticulously planned and built. High sensor precision, dependable GPS integration, and steady system performance were the main goals of technical planning. In order to ensure long-term sustainability, market planning comprised competitive evaluation, cost analysis, and feasibility studies. Testing and user research were planned in order to get input and direct ongoing enhancements.

The methodical progression from problem identification to technical development and business viability assessment was guaranteed by this structured planning methodology, which also improved workflow efficiency.

### **Design Thinking**

Accident Guardian was developed using an effective and user focused methodology. To learn more about the difficulties brought on by delayed emergency response, particularly in remote locations and major accidents, interviews with accident survivors, family members, paramedics, police officers, and emergency physicians were undertaken.

These results demonstrated that delayed notification to emergency services raises the risk of fatalities, injuries, and psychological distress for families. Another significant safety flaw found in many older cars was the absence of integrated emergency systems.

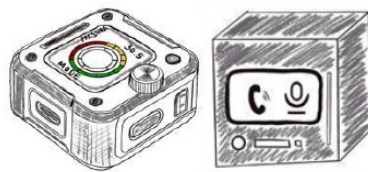
After evaluating several ideas for solutions, a small crash-detection gadget that immediately notifies authorities and emergency contacts of its GPS location and emergency alerts was chosen. Because of its dependability, cost, and simplicity of installation, this solution was selected.

### **Prototype Design and Testing Phase**

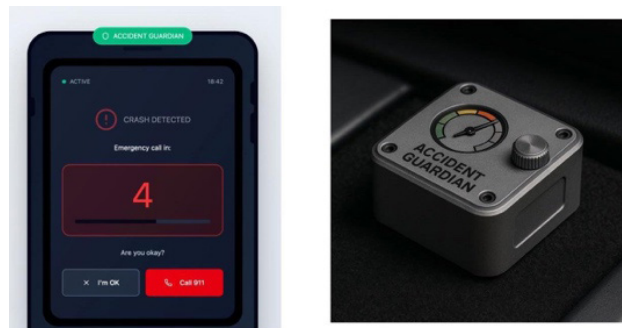
The Accident Guardian prototype is a small, cube-shaped intelligence gadget that can be easily mounted on the dashboard or next to the rearview mirror. It incorporates cutting-edge multisensor technology to precisely identify abrupt collisions and unusual vehicle movement in real time. The driver, emergency services, and family members may communicate instantly thanks to the system's connection to a smartphone application and smart dashboard alert

interface. While physical mockups were made to verify sensor responsiveness and alert transmission under realistic settings, digital prototypes were constructed using Figma to depict system interactions.

Digital crash simulations, actual demonstration models, and in person user assessments were all used to carry out extensive testing. Strong user confidence, excellent reliability, and a definite improvement in perceived safety were all demonstrated by the results. The importance of ongoing battery monitoring and automated family notifications was highlighted in user comments. As a result, these elements were incorporated into the finished design, improving system reliability and establishing Accident Guardian as a cutting-edge, user focused approach to contemporary road safety.



**Fig. 1:** Initial conceptual prototype of the accident guardian device.



**Fig. 2:** Supporting view of the accident guardian system.



**Fig. 3:** Final integrated prototype of the accident guardian system.

## **Interview Procedure and Qualitative Data Gathering**

A qualitative interview method was used to better understand the practical difficulties associated with delayed emergency response following traffic accidents. Ten semi-structured interviews were done with accident survivors, victims' relatives, an emergency physician, a police officer, and a paramedic. Individual interviews were carried out in comfortable settings, either in person or over the phone. Every participant gave their voluntary consent, was assured of confidentiality, and was made aware of the goal of the study. Response time, emotional reactions, and thoughts on automated crash detection systems were among the procedural, emotional, and physical aspects of accident experiences that were the focus of the interview questions. This method made it possible to gather both operational insights and subjective sensations.

During the waiting period following collisions, accident survivors expressed intense feelings of vulnerability, dread, and helplessness. A number of individuals reported that they were asleep, hurt, or had misplaced their cell phones, which prevented them from contacting emergency personnel. The loneliness they felt while waiting for help was highlighted by survivors in isolated locations. Family members emphasized the need of instant alerts for peace of mind, highlighting the emotional discomfort brought on by delayed communications.

The majority of incidents are being reported manually through emergency calls, according to professional respondents, and delayed reporting is still a significant problem. They underlined that autonomous alarm systems could enhance survival rates and drastically cut down on reaction times. All things considered, the interviews offered compelling qualitative proof of Accident Guardian's necessity and directed more system design improvement.

## **Product Description and Technical Functionality Equations**

Impact and motion sensors are used by the Accident Guardian device to continuously track vehicle movement. A confirmation alert appears on the dashboard when unusual activity is found. The device automatically alerts emergency agencies and designated contacts if the driver does not react within ten seconds.

To guarantee dependable data transfer, the hardware consists of impact sensors, a GPS tracking module, and an Internet of Things communication chip. A mobile application, an emergency control interface, and a cloud-based routing system make up the program. Reliability is improved, false alarms are reduced, and quick emergency response is made possible by this integrated hardware–software design.

## **Target Users**

Families with young or inexperienced drivers, long-distance commuters, delivery and taxi drivers, and owners of older cars are the main target consumers. Government transportation authorities, fleet operators, and insurance companies looking for better safety and risk management solutions are examples of secondary users.

### **Market Feasibility and Profitability**

While mobile applications rely on manual activation, automated emergency systems currently in use are primarily seen in more recent cars. By providing straightforward installation and universal compatibility, Accident Guardian fills this gap.

The revenue plan consists of relationships with insurance companies, bulk contracts with fleet operators, one-time device sales, and optional subscription services. The product's commercial and governmental potential is strengthened by its alignment with UAE Vision 2031 and smart-city projects.

### **Market Strategy**

Partnerships with insurance companies to provide flexible payment plans, premium discounts, and targeted social media ads for young drivers are all part of the marketing approach. There are also plans to collaborate with government entities to raise awareness of public safety. "Accident Guardian: Your Silent Protector on Every Journey" is the product's tagline.

### **Operations Management**

The system is assembled locally in the United Arab Emirates using sensors that are purchased from authorized foreign sources. Within the nation, data is kept on safe cloud servers. Purchasing, assembly, testing, packing, distribution, and installation in client cars are all part of the production process.

### **Managerial and Partnership Framework**

Strategic partnerships with police departments, emergency services, car dealerships, insurance providers, and smart-mobility companies support system integration and credibility. Continuous evaluation of operational processes and customer support services ensures long-term efficiency and reliability.

### **Risk Assessment and Mitigation**

False alarms, data breaches, technical malfunctions, and small user abuse are examples of potential dangers. Multi-sensor verification helps reduce false alarms. Communication protocols that are encrypted are used to protect data. Regular maintenance and diagnostics are used to handle technical problems. Programs for awareness and appropriate training are used to combat user abuse.

### **Milestone Schedule**

The project is developed according to a six-month schedule. Research and planning take up the first month, while ideation and prototype take up the second. The third month is dedicated to testing and refinement, and the fourth

month is dedicated to market study. In the fifth month, business planning is finished, and the last month is devoted to pilot testing and practical assessment.

## **DISCUSSION**

By speeding up emergency response times following car crashes, Accident Guardian has a significant potential to increase road safety. The technology overcomes accident reporting delays that may impact survival results by automatically recognizing collisions and sending GPS position data to emergency personnel and designated contacts. Technical dependability and effective functioning are ensured by the combination of impact sensors, motion detection, GPS tracking, and Internet of Things connection. When drivers are unresponsive, the dashboard verification tool ensures prompt help while further reducing false alerts.

The device's widespread compatibility, simplicity of installation, and reasonable cost make it a strong candidate for market adoption. Families with young drivers, commercial fleets, and private vehicle owners can all benefit from the system. High acceptance and greater confidence in the gadget were revealed by user testing. Large-scale adoption is anticipated to be supported by collaborations with government organizations and insurance companies as well as public awareness campaigns.

Accident Guardian has some drawbacks despite its great potential. The system depends on a steady power source, excellent sensor precision, and network connectivity—all of which could be impacted at remote locations or in severe crash scenarios. While multi-sensor verification lowers false warnings, it cannot completely eradicate them and necessitates ongoing testing and calibration.

The requirement for aftermarket installation may also have an impact on market acceptance, deterring certain car owners. Additionally, integration with emergency response infrastructure and regulatory compliance is essential for efficient functioning.

## **CONCLUSION**

By bridging the crucial gap in emergency response after auto accidents, Accident Guardian has a great chance to increase road safety. It offers automated crash detection and instant alerting, making it a technically viable and reasonably priced option that can greatly improve survival rates, especially for drivers of older cars lacking integrated safety features. The IoT-based architecture of the system supports future integration with national emergency platforms and is in line with the UAE's Vision 2031 and smart-city objectives. All things considered, Accident Guardian is a useful and forward-thinking invention that promotes safer and more interconnected road networks by fusing technology efficacy with financial viability.

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