

A Review on IoT-Based Smart Movable Road Dividers for Ambulance Path Clearance and Adaptive Traffic Management

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Abstract — Ambulances and other emergency vehicles routinely lose critical minutes to urban traffic congestion, and that lost time can directly affect whether a patient survives the journey to hospital. Over the last few years, several research groups have tried to solve this problem by building road dividers that can physically move out of the way, guided by sensors, microcontrollers and cloud connectivity rather than by a human operator. This paper reviews four such studies — a smart movable divider combined with patient health monitoring, a YOLO-based camera-driven divider project, an EVATL framework that pairs adaptive traffic signals with GPS-based vehicle-to-infrastructure communication, and a related movable-divider prototype — and places them side by side to see what each one actually contributes and where each one still falls short. Rather than simply restating the abstracts of these papers, the review tries to pull out the common thread running through them: detect the emergency vehicle reliably, verify that the request is genuine, clear a path safely without endangering other road users, and prove that the whole chain works outside a lab bench. Building on these observations, the paper also sketches a conceptual IoT-based divider architecture that borrows the strongest ideas from the reviewed work — RFID or GPS-based detection, a locally-running safety interlock, MQTT-based cloud reporting, and manual override — while flagging the open questions (field validation, weather robustness, cybersecurity and cost) that future student projects in this area should address.

Keywords— IoT, Smart Road Divider, Ambulance Path Clearance, Emergency Vehicle Detection, Adaptive Traffic Light, RFID, YOLO, V2I Communication..

I. INTRODUCTION

Traffic congestion in Indian and other fast-growing cities has stopped being just an inconvenience — it is now a genuine public-safety problem. When an ambulance gets stuck behind a wall of private vehicles at a signal or on a narrow two-lane stretch, every extra minute reduces the chance that a trauma patient reaches hospital within the so-called golden hour. Traditional fixed concrete dividers were never designed with this problem in mind; they simply split the road into static lanes and offer no way to react when one side is jammed and the other is empty, or when an ambulance needs to borrow a lane that technically belongs to oncoming traffic.

The idea behind a smart, movable road divider is fairly simple to state even though it is not simple to build safely: let the divider shift position on its own, using sensors and a small amount of onboard intelligence, so that it can open a temporary corridor for an emergency vehicle and then return to its normal position once the vehicle has passed. Over the past three to four years this idea has attracted a noticeable amount of student and early-career research, mostly because the hardware involved — Arduino- or ESP32-class microcontrollers, RFID tags, ultrasonic or IR sensors, and small motors — has become cheap

and accessible. This review looks at a handful of these projects together, compares how each one approaches detection, decision-making and safety, and tries to identify what a next version of this kind of system would need to actually work on a real road rather than just on a tabletop model.

II. LITERATURE REVIEW

1. Smart Movable Road Divider with Patient Health Monitoring (Sivaranjani et al., 2026)

This paper, published in IJLTEMAS, proposes a system that does two things at once: it clears a path for an ambulance using RFID-based detection, and it also streams the patient's heart rate, SpO2 and temperature from inside the ambulance to a central dashboard so that hospital staff can prepare in advance. The road-side unit uses IR or ultrasonic sensors to gauge traffic density on each side of the road and shifts the divider toward the less congested side, while an interrupt-style rule immediately overrides this density logic the moment an ambulance is detected nearby. The authors report, from simulation and a small hardware mock-up, that ambulance transit time through congested stretches dropped by roughly 30-50%, with communication delay between detection and divider movement staying under about 500 milliseconds. What

stands out about this paper is the combination of traffic management with health telemetry — most other papers in this space treat the divider and the patient monitoring as two separate problems. What is missing is any real discussion of how the system behaves in bad weather, or how it would scale beyond a single two-lane test rig.

2. Smart Movable Divider for Ambulance Path Optimization (Gunjal et al., 2025)

This project, from JCOE's own Artificial Intelligence and Data Science department, takes a computer-vision route instead of RFID. A camera mounted near the divider captures live video, and the vehicle density on both roads is estimated from that footage before the data is pushed to the cloud. Based on this analysis, an Arduino-controlled motor decides whether and how far to shift the barrier. The paper frames this mainly as a traffic-balancing tool rather than a dedicated emergency-vehicle system, and its own literature review notes that getting a YOLO-based model to recognise an ambulance reliably across different lighting and weather conditions is still an open problem, not a solved one. The experimental setup shown in the paper is a small physical model with a camera, Arduino and stepper-driven barrier, which is useful as a proof of concept but does not by itself demonstrate real-road performance.

3. EVATL: Emergency Vehicle Adaptive Traffic Lights for Smart Cities (Dodia et al., 2023)

Published in IET Smart Cities, this is the most rigorously evaluated paper among those reviewed here, even though it does not touch a physical road divider at all— it works on the traffic signal itself. EVATL combines two things: an adaptive traffic-light algorithm that sets green-light duration from a YOLOv8 vehicle count at the junction, and a GPS-based vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication layer that lets an ambulance's telematics unit talk directly to the nearest signal pole over MQTT. When the ambulance enters a preset radius of the signal, calculated with the Haversine formula, the light turns green for that lane, and nearby vehicles get a 'Emergency Vehicle Nearby' alert on their infotainment display. The authors built a working GUI-based simulation on NVIDIA Jetson Nano hardware and showed a timing-diagram comparison in which the proposed adaptive method clears an ambulance through a four-cycle, two-lane intersection in 317 seconds against 520 seconds for a fixed-time system. The paper is a good reminder that physically moving a concrete divider is not the only way to clear a path — sometimes changing signal priority is a lighter-weight and more easily deployable alternative, though of course it does not help on a road segment with no traffic signal at all.

4. Related Movable-Divider and Ambulance-Clearance Prototypes

Several other short conference-style papers describe close variants of the same basic idea — an IR- or RFID-based sensor network feeding an Arduino Mega, with RF communication and a cloud dashboard such as ThingSpeak used to log traffic density and divider position. These papers generally agree on the core control loop (sense traffic, compare density across lanes, move the divider, and override that logic the moment an authorised emergency vehicle is sensed) but differ in the sensing technology used and in how much of the system has actually been tested outside a benchtop demonstration. None of the papers surveyed here report a trial on an actual public road, and none give a statistically meaningful sample size for their reported accuracy or latency figures.

III. COMPARATIVE ANALYSIS

Table I summarises the five works discussed above side by side. Because the papers report different metrics, and in several cases do not report a metric at all, the comparison is necessarily qualitative in places rather than a clean numeric leaderboard.

Ref.	Technique	Reported Outcome	Key Limitation
[1]	RFID, IR/ultrasonic density sensing, patient vitals telemetry	~30-50% cut in transit time; <500 ms detection-to-move delay (simulation)	Small test rig; no weather or scale discussion
[2]	Camera + YOLO vehicle detection, Arduino, stepper motor	Working physical model; density-balancing demonstrated	No quantitative accuracy reported; lighting/weather sensitivity noted by authors
[3]	GPS + YOLOv8 + MQTT, V2V/V2I, adaptive signal timing	317 s vs 520 s across a 4-cycle junction in simulation	Does not move a physical divider; signal-only solution
[4]	IR sensors, Arduino Mega, RF link, ThingSpeak cloud logging	Density-based divider shift with ambulance priority override	Sensor and RF-link reliability not evaluated in field
Proposed	RFID/GPS detection, local safety interlock, motorised divider, MQTT reporting	Conceptual — to be measured during prototype testing	Needs simulation, prototype and independent safety review before deployment

IV. RESEARCH GAPS AND CHALLENGES

Reading these five papers together, a few gaps keep showing up regardless of which detection technology is used:

- Physical safety is harder than signal control. Moving a concrete or steel barrier near live traffic is riskier than simply changing a light, and only the proposed system in this review explicitly designs for a local, cloud-independent safety interlock.
- False or spoofed detection. An RFID tag can be cloned and a camera can misclassify a vehicle; none of the reviewed papers describe an authentication step strong enough to stop an unauthorised vehicle from triggering divider movement.
- Weather and lighting robustness. The camera-based approach [2] is explicitly flagged by its own authors as weather- and lighting-sensitive, and the IR-based approaches share a similar vulnerability to rain and fog.
- Small, single-site datasets. Every hardware demonstration surveyed here was built and tested on one benchtop model; none report multi-site or multi-season field trials.
- Fail-safe behaviour. What happens to the divider if the network drops, the motor jams, or power is lost mid-movement is rarely discussed in detail, even though this is exactly the situation that would cause an accident.

V. PROPOSED SYSTEM OVERVIEW

Building on the strengths and gaps identified above, this review proposes a conceptual architecture rather than a finished product. The idea is to keep the parts of each reviewed system that worked well and close the gaps that each paper left open.

- Detection layer: RFID or GPS-based identification of the authorised emergency vehicle, cross-checked against camera-based density sensing so that a single sensor failure does not trigger a false action.
- Control layer: a microcontroller that runs the safety rule locally — divider movement is allowed only if the request is verified, the target lane is clear, the divider mechanism reports itself healthy, and no obstacle is detected. The cloud is used for logging and dashboards, never as the safety decision-maker.
- Actuation layer: a motor-driven divider with position feedback and limit switches, moving in small, sequential segments rather than all at once, so nearby drivers have time to react.
- Communication layer: MQTT over Wi-Fi or GSM for cloud reporting, mirroring the approach used in both [1]

and [3], since MQTT's lightweight publish-subscribe model keeps communication delay low.

- Human oversight: manual override, event logging and alerts, so that an operator can always intervene and so that every movement can be reviewed after the fact.

VI. CONCLUSION AND FUTURE SCOPE

The papers reviewed here show that the core idea of an IoT-assisted emergency corridor — whether implemented as a physically moving divider or as an adaptively-timed traffic signal — is technically achievable with inexpensive, widely available hardware, and that early results on transit-time reduction are encouraging. At the same time, every one of these studies is still at the prototype or simulation stage; none has been tested on a live public road, and the harder engineering questions around weather robustness, cybersecurity, cost and fail-safe behaviour remain largely unanswered. The conceptual architecture proposed in this paper tries to combine the detection accuracy of RFID/GPS-based approaches with the locally-enforced safety logic that a real deployment would need. Future work should focus on building a tabletop prototype, measuring detection rate, false-trigger rate and response latency under realistic fault conditions, and only then considering a controlled, supervised field trial on a low-traffic campus or private road before any public-road deployment is contemplated.

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