Publisher: Scientific-Professional Society for Disaster Risk Management

International Journal of Disaster Risk Management

Article

Smart Life Safety Jacket for Rescuers

Subhankar Sarkar[1,2*]

[1] Disaster Management and Civil Defence, Murshidabad, West Bengal, India.

[2] Department of CSE, MAKAUT, Haringhata, Nadia, West Bengal, India.

[*] Correspondence: elinksuvankar.sarkar@gmail.com;

Received: 3 February 2025; Revised: 15 April 2025; Accepted: 5 May 2025; Published: 30 June 2025.

ABSTRACT

Smart Life safety jackets have been widely used in flood rescue operations for many years. However, most of these jackets are outdated and lack integration with modern technology. Due to this, rescuers often encounter several operational challenges. Therefore, the implementation of advanced technology in the design of life safety jackets has been considered necessary for improving disaster response efficiency. The primary objective of this study is to develop a bright life safety jacket that incorporates modern technologies, including the Internet of Things (IoT), wireless sensor networks, GPS, and oxygen level monitoring. Real-time condition tracking, including rescue time, has also been set as a significant focus of this research. A design-based methodology has been adopted to integrate multiple advanced technologies into the bright jacket. Key components include IoT modules, sensors, GPS, wireless communication networks, and user interaction systems. Various technical and usability aspects have been explored through literature reviews and feasibility studies conducted during different stages of the research. Through this study, a bright life safety jacket has been proposed that is equipped with modern features intended to enhance rescue operations. Key functionalities, including GPS tracking, oxygen level detection, wireless sensor networks, and real-time communication through IoT platforms, have been incorporated to enhance coordination between rescuers and control rooms.

The proposed clever life safety jacket design offers several advantages, including enhanced situational awareness and reduced risk of injury. By using modern sensor and cloud technologies, the safety and efficiency of both rescuers and victims during flood emergencies are expected to be significantly enhanced.

KEYWORDS

Smart Life Safety Jacket; Internet of Things; GPS; sensors; ESP-32 microcontroller; results.

Sarkar, S. (2025). Smart Life Safety Jacket For Rescuers. *International Journal of Disaster Risk Management*, *7*(1), 367–384.

1. Introduction

The primary purpose of a life safety jacket is to act as an advanced warning system before an accident, ultimately ensuring the saving of lives. The jackets are designed for various purposes, including protection from electrical accidents, aquatic catastrophes, or industrial risks faced by workers in the building industry. Despite their extensive usage, traditional life safety jackets do not integrate contemporary innovations and technologies, thereby providing areas for improvement.

Studies have shown that incorporating Internet of Things (IoT) technology into life safety jackets has the potential to enhance their capabilities. Through IoT, it is possible to create a bright life safety jacket that monitors the wearer's physical condition and relays real-time information to control centres. This new method enables rescue teams to respond swiftly to emergencies, resulting in improved safety outcomes (Cvetković & Miljković, 2024; Molnar, 2024; Marceta & Jurišić, 2024; Sudar et al., 2024).

The application of GPS technology for determining the location of tracking devices using satellite signals plays a significant role in enhancing the safety capabilities of life safety jackets. Integrating GPS into the life safety jacket provides geo-location monitoring with high accuracy, ensuring a rapid response time during an emergency.

An intelligent life buoyancy jacket may be equipped with various sensors and technologies that can track lifesaving parameters, including heart rate, blood pressure, and body temperature. Microcontroller devices built into it can process sensor data, which is then sent to the cloud server for real-time monitoring in the control room.

Cloud technology provides a centralised location for storing and analysing sensor data, enabling instantaneous communication between rescue teams and control rooms.

The suggested jacket has incorporated sophisticated cooling technologies, such as gel cooling pads and DC fans, to ensure a pleasant body temperature in hot weather. These technologies are designed to promote the wearer's comfort while minimising the risk of heat-related disorders. By combining all these technologies, a bright life safety jacket can offer various advantages, including enhanced safety, increased comfort, and improved effectiveness during emergency response processes. The combined use of IoT sensors, microcontroller devices, cloud technology, and advanced cooling systems enables the creation of an innovative life safety jacket, a vital asset in preventing accidents and saving human lives.

The goal of this research paper is to design a bright life safety jacket that utilises the latest technologies to enhance features and provide safety in various environments. The solution presented here has the potential to improve safety outcomes and save lives; therefore, it is a valuable contribution to the domain of life safety jackets.

Figure 1 (I & II). Life Safety Jacket for Rescuers.

Life jackets are used for rescue workers (Figure 1) in flood-related situations where modern sensor technology or IoT is not utilised.

2. Literacy Review

In the realm of performance apparel, Lim et al. (2015) analysed ventilation patterns and temperature distribution in running wear jackets using computational fluid dynamics (CFD) simulations. Their study revealed that slits positioned at the lower back significantly improved air exchange due to natural upward airflow generated by body heat. This insight supports design strategies that promote efficient ventilation and thermal comfort in non-permeable garments.

The integration of innovative technology into wearable safety equipment has seen notable developments in recent years. Akhil Xavier et al. (2018) introduced a safety jacket designed for water accidents, which activates an automatic inflation mechanism upon contact with water. It is equipped with GPS and GSM modules to transmit the user's location to emergency services, addressing the limitations of conventional life jackets, which are often bulky and lack real-time communication capabilities.

Shingade et al. (2018) thus designed an IoT-based women's safety jacket, acknowledging the increasing concerns about physical and sexual assaults on women, especially in India. This paper presents a wearable safety system comprising a microcontroller, GSM and GPS modules, a zapper circuit, and pressure sensors, enabling real-time tracking and emergency communication. The author has designed this device in such a way that when the user is in a distress situation and needs help, she activates it, which sends an alert SMS containing her location to all pre-registered contacts, triggers a loud alarm sound, and also activates the self-defence Zapper. This project was inspired by the unfortunate incident of the Delhi Nirbhaya case in 2012, which underlined the pressing need for technological intervention in matters related to gender-based violence. Women's public safety demands responsive, proactive safety measures at its core—embedded systems and IoT.

In a parallel domain, Randhawa et al. (2018) focused on activity and posture classification using fabric-integrated sensors. Their approach utilised stretch sensors, pressure sensors, and accelerometers embedded into a bright jacket to gather physical response data. The study emphasised the importance of sensor linearity and repeatability for reliable data acquisition. Subsequently, machine learning algorithms were employed to classify human physical activities based on sensor readings. This work demonstrates the potential of wearable systems in posture monitoring and activity recognition applications, particularly in areas that require biomechanical tracking or rehabilitation assistance

In the defence sector, Rakshitha M. et al. (2019) Proposed a bright jacket for soldiers that monitors vital health parameters such as heartbeat, pulse rate, and body temperature. This information is transmitted to the base station using GSM or Wi-Fi modules, enabling timely medical intervention and enhanced situational awareness during missions.

Abro et al. (2019) proposed a bright jacket designed explicitly for coal miners, whose working conditions often lead to fatal incidents. Their work focused on integrating various sensors, including hazardous gas detectors, pulse rate monitors, GPS, and temperature and humidity sensors, into a wearable prototype. The system continuously transmits critical health and environmental parameters via a Wi-Fi shield to a dynamic IP address, enabling real-time monitoring from a remote base camp. In emergencies, the last known GPS location and continuous pulse data of miners enable prioritised rescue operations, potentially saving lives in disaster scenarios.

A multi-functional life-saving jacket was developed by Vasanthakumar M. et al. (2020), Targeting applications in aviation and marine environments. This bright jacket features advanced technologies, including GPS tracking, health monitoring sensors, a water temperature sensor, and an electric shock mechanism designed to deter marine predators, thereby significantly enhancing survivability in hostile conditions.

Further exploring the potential of wearable technology, Swati A. Sakhare et al. (2020) Reviewed the development of IoT-enabled bright clothing. They emphasised how embedded sensors in textiles can track biometric data, interact with mobile devices, and offer applications across health, fashion, and safety domains. The research depicts furthermore the future of bright garments within the global IoT framework. With increasing concern about environmental extremities and the protection of personnel enduring such conditions, especially in some military and athletic settings, recent research has focused on integrating smart textiles and wearable technologies to enhance thermal comfort, health monitoring, and environmental adaptation.

Similarly, Hashimoto et al. (2021) investigated the impact of an active cooling system in a high-heat environment during various physical exercises, including the use of a cooling vest and a fan-attached jacket. Both systems could decrease core temperature, heart rate, and sweat rate, with the fan-attached jacket indicating better performance, even at an ambient temperature of 40°C and 50% relative humidity (RH). The study's results demonstrated that evaporative cooling by forced air can be highly efficient, indicating that fan-based systems are effective in mitigating heat stress.

To address the rapidly shifting climatic challenges in India, Gaikwad et al. (2022) have designed a bright safety jacket specifically for army personnel. The jacket enhances field safety and awareness by integrating GPS, IoT modules, and other sensors, enabling the monitoring of health and geolocation tracking.

Srievatsan and Jindal (2022) developed a new method to improve water safety by creating a smart lifejacket that utilises GPS and GSM technologies. Their work contributes to an important topic, the location of victims of drowning, which is rarely covered in current life-saving methods. The system they described works on a push-pull switch principle wired between the lifejacket and the vessel. This activates a Raspberry Pi system when disconnection occurs. The device then uses GPS to track its location while sending its coordinates via GSM. This is a significant improvement to the potential for immediate rescue by contacting a responder with the victims' local before the presumed victim's drowning, which answers one critical challenge associated with drowning incidents. Their prototype demonstrates how embedded systems can address practical problems in real-time during an emergency.

Expanding the application of wearable systems to defence, Suman and Jyothi (2023) developed an innovative system for Indian Army soldiers aimed at enhancing situational awareness and improving medical emergency response. Their system integrates GPS tracking, real-time health monitoring (including pulse and body temperature), and RF-based communication. What's intriguing about the design is that they have added emergency push-buttons, which, once pressed, send a health status and the soldier's GPS location to the base via SMS. The technology allows for soldier-to-base and soldier-to-soldier communication in tactical scenarios that require rapid response.

Balaji et al. (2023) introduced a bright IoT-enabled safety jacket explicitly designed to enhance the safety of workers in mining and construction environments. It discusses significant occupational hazards, including exposure to toxic gases (CO, CO_2, CH_4), fire, temperature extremes, and seismic activity associated with mining operations. This system combines various types of sensors—gas, fire, temperature, humidity, and ultrasonic sensors—on a body-worn platform that sends up-to-date environmental information via Wi-Fi. This information is processed through microcontrollers and monitored remotely through the Blynk app and a centralised control room, enabling prompt alerts and interventions. Their research underscores the importance of real-time environmental monitoring and automated hazard detection in reducing fatalities and enhancing response times in high-risk industrial operations.

Renusha et al. (2024) proposed an innovative, intelligent life jacket that incorporates Long Range (LoRa) communication technology to enhance water safety for both recreational and professional users. Their system integrates automatic inflation, GPS-based location tracking, and real-time biometric monitoring to ensure comprehensive protection in aquatic environments. A notable feature is the use of machine learning algorithms to detect emergencies such as sudden immersion or irregular vital signs, enabling timely intervention. The use of LoRa enables long-range signal transmission, which is particularly beneficial in remote or maritime locations. This study demonstrates how integrating IoT and AI technology can significantly enhance water safety outcomes, particularly in situations where there is a high risk, such as when cold water enters and becomes extremely cold itself.

The Smart Saviour life jacket introduces a new dimension to aquatic safety, as reported by Jakarta et al. (2025). The system utilises IoT technology for efficient detection and monitoring of survivors during emergencies on water. Environmental and physiological sensors (GPS: NEO-6M; heart rate and body temperature sensors) were attached using the ESP32 microcontroller and the real-time ESP-NOW data transmission protocol. Rescue teams can dynamically prioritise their responses using live geolocation and health indicators displayed on a dynamic dashboard. System evaluations demonstrated connectivity close to perfection, synchronisation speed that outstrips many competitors, and sensor accuracy (98% for heart rate measurement and ±0.5°C for water temperature variance); all of these factors point to its use in life-saving operations during aquatic disasters.

3. Problem Statements

After reviewing several research papers related to life safety jackets, it has been observed that all such jackets are primarily designed for protection during water-related incidents or flooding. Some papers focus on jacket health monitoring, while others concentrate on jacket location and tracking. The outer surface of the jackets is typically made of polyester or a similar plastic-type fabric, while the interior is composed of a sponge-like plastic material. Some jackets are capable of floating in water for up to seventy-two hours, while others function for a shorter duration. Most jackets are manufactured in red or saffron colours and are not equipped with any electronic devices or technological gadgets. Due to this limitation, the exact location of individuals wearing these jackets during rescue operations remains unknown. The physical condition of the wearer is also not separately detectable.

In addition, after examining multiple research papers on bright life jackets, it has been observed that GPS has been utilised in some cases. Still, the primary focus has remained on location tracking. Several studies have demonstrated the use of wireless sensor networks to monitor both location and physical health parameters. In some designs, jackets have been developed for medical monitoring, and technologies such as sensor systems and cloud storage have been applied in similar ways. Other research papers have only focused on the body's cooling function. While some life jackets have been designed to display information such as body oxygen levels and heart rate on an LCD, no research paper has been found that displays all parameters—health condition, location, Toxic gas detection, and cooling system—together in one system. Furthermore, while lithium batteries have been used to power innovative features in various designs, details regarding the charging process of these batteries have not been included. Although multiple outputs have been presented in some studies, proper functional steps and modern design features for the bright jacket have not been explained.

Therefore, in the present study, an attempt has been made to design a life jacket suitable for the weather conditions of the Indian subcontinent, which will include a proper communication system from the control room with the necessary instructions. It is considered essential to monitor the wearer's health condition and provide an integrated cooling system. The jacket is intended to be user-friendly for the person wearing it. Additionally, complete data will be sent to the control room through a cloud server using IoT technology. Unlike previous studies, warning sound systems and Gas sensors will also be included in the present work. As a result, significant benefits are expected to be provided to the rescue team.

4. System Requirements

The hardware and software requirements for creating an improved design of the Smart Life Safety Jacket are shortly described below:

4.2. Hardware Components-

In this research paper, the hardware used to create and develop the proposed model is described below:

- **ESP32 Microcontroller: The ESP32 is a microcontroller device that features Wi-Fi and Bluetooth capabilities**. Due to its low cost and various Internet of Things applications, this device is useful. It is also used to make a wearable bright Jacket.

Figure 2. ESP 32 Microcontroller Board.

- **Moisture sensor:** Moisture moisture is a sensor device that usually determines the amount of water in some parts. This device is known in response to sudden increases or acceptance of water levels.
- **Body Temperature Sensor**: A body temperature sensor is a specialised electronic device created to measure body temperature accurately. This device can monitor the exact temperature of the body.
- **Heart Pulse Sensor:** A pulse sensor is a device that measures an individual's heart rate. Typically, the heart rate in adult people is 70-100 beats per minute.
- **Gas Sensor:** Gas sensing is primarily used to detect various types of natural, unnatural, or harmful gases. Gas sensors can convert gas concentrations into electrical signals, which are then considered as an output value. These sensors are primarily used to detect the presence of odourless gases in the environment that pose a threat to human health. Depending on the type of gas, these gas sensors can be of different types. In this Proposed model, a simple gas sensor is used, which will indicate in a hostile environment when the oxygen content is low or a flammable gas is present.
- **SPO2 Sensor:** The SpO2 sensor measures blood oxygen saturation by detecting the percentage of haemoglobin that is bound to oxygen. This is typically used in a medical environment, particularly in cases involving patients with dementia, and provides essential health information. As integrated into wearable devices like life jackets, it can continuously monitor the user and check whether they have proper oxygen levels of 96%-100%.

Figure 3. SPO2 Sensor.

- DC Fan: A fan that operates on DC (Direct Current) or at a constant current, such as a battery voltage, is referred to as a DC fan. Typically, DC fans use 5 volts, 12 volts, 24 volts, and 48 volts. Usually, we see DC fans used for cooling in various computer devices. However, I have shown the use of two DC fans here. The whole-life safety jacket, which I aim to demonstrate in my research paper, incorporates health monitoring capabilities within the coat, enabling the person wearing it to maintain a cool body temperature throughout their life.
- **GPS Sensor:** It stands for Global Positioning System. GPS is a modern technology that knows the exact location of a place or user through satellites. In the GPS sensor system, a satellite tracking system is installed, allowing the precise location of the person with the GPS device to be determined through the antenna.

Figure 4. GPS Sensor Device.

- **Buzzer:** A buzzer is a mechanical audio device that transforms any electrical signal into sound. The primary purpose of a buzzer is to act as a signal, alerting individuals to potential danger or an alarm. DC voltage and current are usually used to run this device.
- **Lithium Ion Battery:** In this research paper, the use of lithium-ion batteries as a part of a power supply. This battery is composed of lithium-ion cells and is rechargeable. It is used in devices like smartphones, Smart Watch, and laptops. It is increasing due to its lightweight design, fast charging capabilities, and long service life.
- **Connecting Wires:** Connecting wires is necessary to create various types of experimental circuits or to connect microcontroller devices to different sensor devices. Additionally, a connecting wire is required to complete a circuit on the breadboard or to supply power to other devices. For ease of understanding, different colours of connecting wires are used.
- **LED Indicator:** These LED lights are used to indicate a signal. Different colours indicate the direction of the signal. Here, we mainly tried to highlight the aspects of night rescue and life-jacket operations associated with these lights.
- **LCD Screen:** On the LCD screen, we see the output, which is displayed in abbreviated form. So that some information is available to the beneficiaries and they can observe it directly.
- **Cooling gel Pad:** A gel cooling pad is a type of device that helps regulate body temperature. These pads contain a specially formulated gel. Those that absorb body heat and lower the melting temperature to feel cool. As it requires no external power, its use is increasing in jackets and medical applications. Control can be managed as needed with the help of innovative applications. Rescuers use this device to keep the body cool. Using this device in a bright life safety jacket will provide the rescuer with a comfortable experience.

Figure 5. Cooling Gel Pad.

4.3. Software Descriptions-

In this research paper, the software used to create and develop the proposed model is as follows:

- **Arduino:** Arduino programming language. Here, after sketching a plan, the program required for execution is uploaded to the Arduino microcontroller board or ESP32 Microcontroller Board.
- **Cloud Server:** A Cloud server is an internet technology that allows users to store and access data from anywhere at any time, provided an Internet Connection and a Computer Device are available. Here, users can Store and manage data. A Cloud Server is a virtual infrastructure that performs application data processing and storage.

5. Proposed System

The earlier sections of this research article identified several issues with bright life safety jackets. To address these issues, sensor devices such as SPO2 sensors, water moisture sensors, gas sensors, and heart pulse sensors are integrated into the life safety jacket. These sensors collect various essential data, including information on the body, location, and other real-time conditions, which are then transmitted to the cloud server via an ESP-32 microcontroller. The collected data is communicated to the user or control room at specified time intervals through a wireless sensor network. A lithium-ion battery powers the entire system, offering advantages such as quick recharging times and portability due to its lightweight nature. Additionally, two DC fans are incorporated into the life safety jacket to maintain a cool body temperature. The article also explores potential improvements and upgrades to enhance the technological capabilities of the bright life safety jacket. As a result, rescuers wearing this jacket can benefit from advanced features when participating in emergency rescue operations.

Figure 6. Proposed Model Front Side.

Figure 7. Proposed Model with Cooling Pad Back Side.

The design shown in the proposed model *(Figure 6 and Figure 7)* includes the entire circuit device installed on the life safety jacket in a waterproof manner. Two LED indicators and two DC fans are installed at the front (*Figure 6*). The back of the coat *(Figure 7)* features a cooling gel pad for added comfort.

After designing the proposed model, the necessary devices were connected and placed in a waterproof box on the right side of the bright life safety jacket. A rechargeable Lithium-Ion Battery powered it. Additionally, after installing the circuit in the life safety jacket, a Wi-Fi network connection was used for communication. After a test run, the circuit worked properly and was monitored through a report. The range of Wi-fi is 100 meters (approximately). If it is necessary to extend the range beyond this, the GSM 4G/5G data connection method can be used. And its range will be as far as the sim's tower location.

6. System flowchart diagram for Smart Life Safety Jacket

Flow-chart diagrams illustrate the process flow of how the proposed model works. In this research paper, a system flowchart diagram for a bright life safety jacket is presented. This diagram illustrates how the proposed Smart Life Safety Jacket enhances user safety. This diagram illustrates that the sensor devices are first activated and begin working. The real-time data is collected and processed by the microcontroller device and subsequently converted into various signals. If an abnormal reading is detected, the meter sends a buzzer sound or a message to the control room via a cloud server. This flowchart diagram was created for continuous monitoring to protect the wearer of the Smart Life safety jacket. Additionally, this research paper includes a flowchart diagram and a working algorithm to facilitate technical understanding.

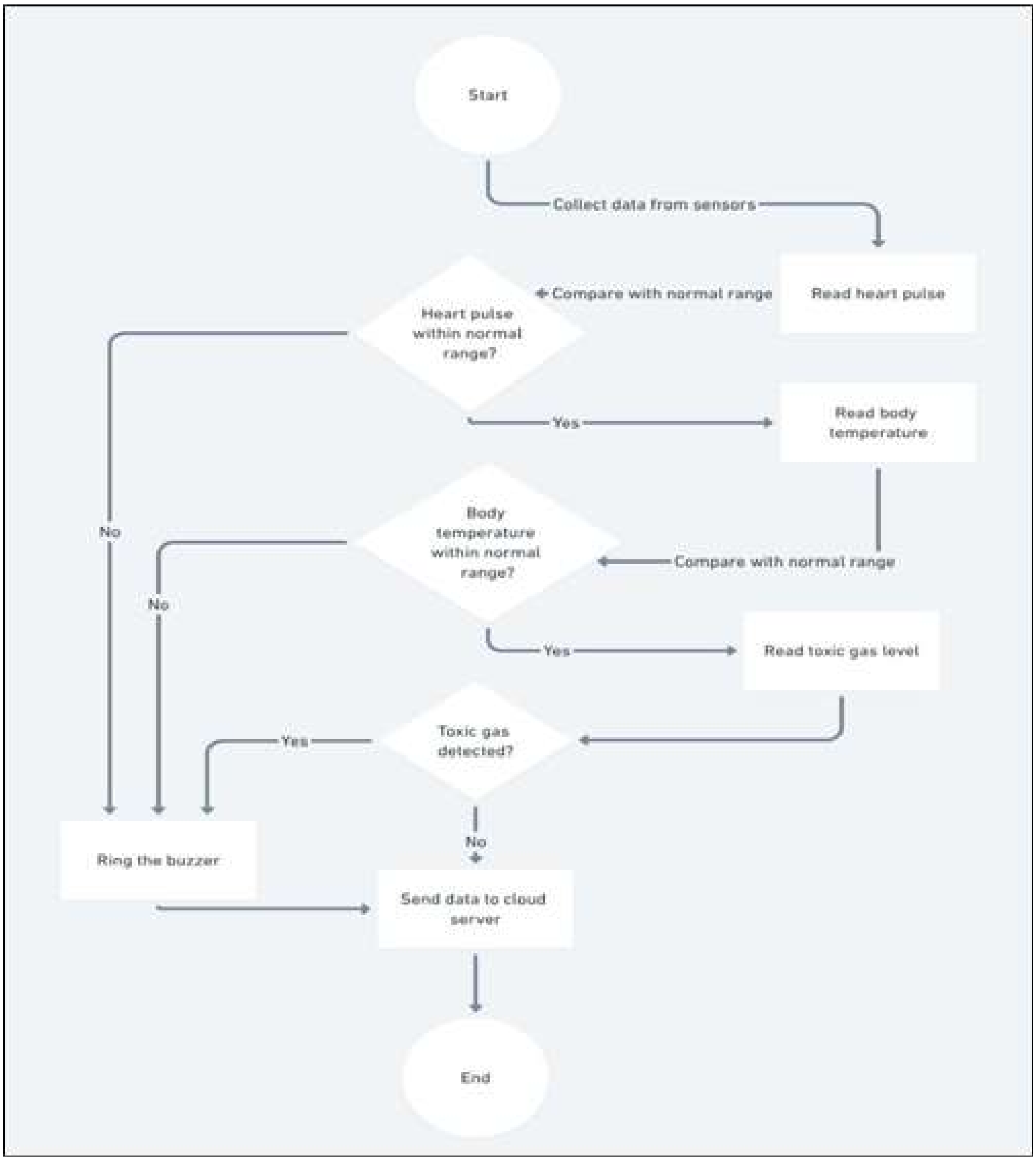

Figure 8. System Flowchart Diagram for Smart Life Safety Jacket.

7. Working Algorithm

The ESP32 and sensors are set up by integrating temperature sensors (LM35), gas sensors (MQ2), output censorship, and GPS sensors._Wi-Fi is connected through the ESP32. Rules for detecting problems are defined, which include excessive body temperature (above 38°C or 100.4°F), high concentrations of gas that pose a threat, abnormal heart rate (less than 50 or greater than 120 beats per minute), and hypoxemia (SpO2 lower than 90%).

Sensor data is read every second, with the temperature values being captured from the LM35 sensor, gas concentration from the MQ2 sensor, heart rate from the pulse sensor, and location data from the GPS sensor. These readings are then compared to the predefined threshold values to identify any abnormalities.

If any issue is identified, an alert is sent immediately. If no problems are found, a message containing the sensor readings, recorded location, and timestamp is compiled and transmitted to the cloud server. The process is repeated every second, ensuring that the limit settings and parameters are considered as needed.

8. Circuit Diagram

The schematic for a bright life safety jacket, designed primarily for rescuers, shows the integration of both health and environmental monitoring sensors and components. The central element is an ESP-32 microcontroller, which performs all connections through wires on a breadboard. These include a heart pulse sensor and LM35 temperature sensor for vital sign measurements, along with a gas sensor for detecting hazardous gases. The GPS module will provide the user's real-time location. All data from these sensors will be processed and displayed on an LCD screen by the ESP-32. In the event of high temperatures or other hazardous conditions related to toxic gas detection or irregular heartbeat, an alert can be triggered using a buzzer with an LED indication to notify either the user or the rescue team. This compact system has been adequately powered and interlinked using a breadboard, allowing for seamless integration within the jacket. This bright jacket is, therefore, much safer for rescue personnel, as it continuously monitors their health and surroundings during critical missions, alerting them remotely and tracking their location in real time.

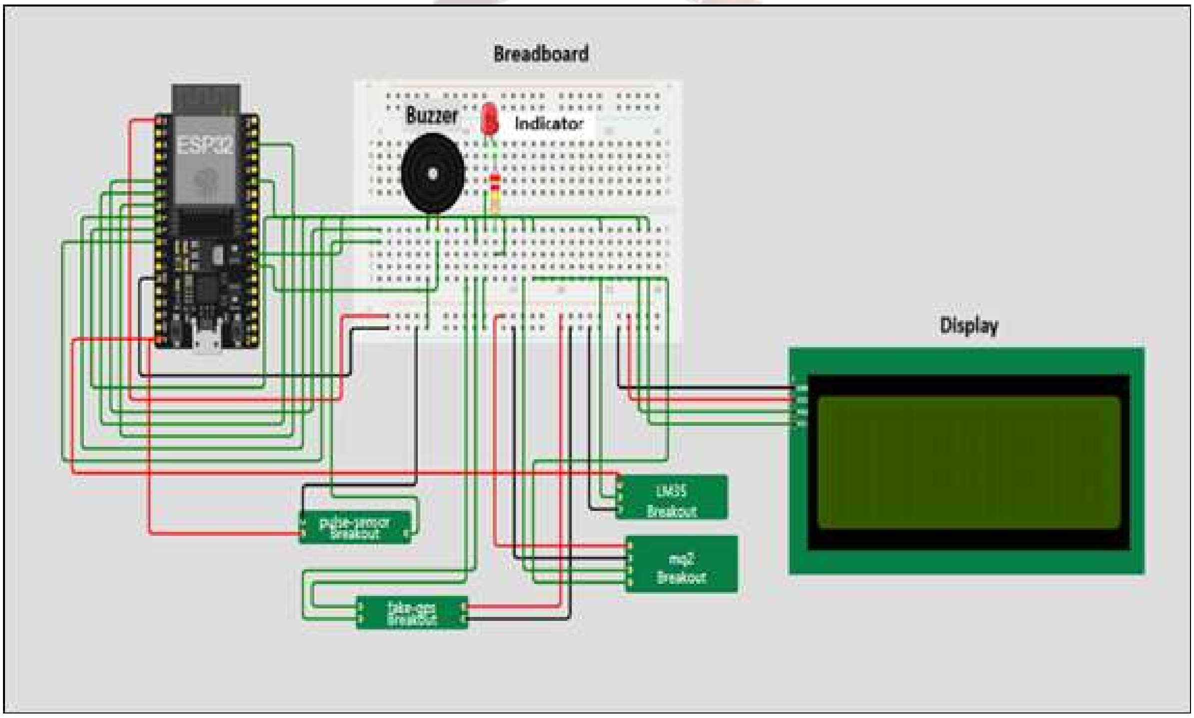

Figure 9. Circuit Diagram.

9. Hardware Specifications and Estimated Cost for Smart Life Safety Jacket

The hardware specifications, limitations, and possible estimated costs to build the circuit design of the Bright Life safety jacket are described below

9.1. Hardware Specifications and Limitations-

The specifications and limitations of the sensor technologies and hardware devices used in this research paper are as follows –

- **LM35 Temperature Sensor**

  Accuracy: ±0.5°C at 25°C;

  Output: Analog voltage, 10mV/°C

  Current Consumption: ~60μA

- **MQ Series Gas Sensor**

  Preheat Time: approximately 24 hours for optimal accuracy.

  Current Consumption: 150mA approximately (due to heating element)

  Limitations: High power consumption; sensitive to humidity and temperature variations.

- **Heart Rate Sensor**

  Current Consumption: 0.6mA during active measurement.

  Limitations: Sensitive to motion artefacts; requires proper placement.

- **16x2 LCD Display**

  Display Type: Alphanumeric.

  16 Character 2 no of Line

  Current Consumption:

  Without Backlight: <1mA

  With Backlight: Approximately 20mA

  Limitations: Backlight brightness may vary between units; current draw depends on the backlight resistor value.

- Power Consumption Analysis

  ESP32 Microcontroller: 160–260mA approximately during Wi-Fi operations.

  MQ Gas Sensor: approximately 150mA.

  Heart Rate Sensor: approximately 0.6mA.

  LM35 Temperature Sensor: approximately 0.06mA.

  Buzzer: 30mA approximately (active state)

  LCD Display: 20mA approximately.

- **Total Estimated Current Draw**: Approximately 360–460mA

- **Battery Life Estimation**

  Using a 3.7V, 2000mAh LiPo battery with a DC-DC boost converter (assumed efficiency of 90%) to supply 5V:

Adequate Capacity at 5V:

$$Effective\ Capacity = 2000mAh \times \frac{3.7v}{5v} \times 0.9 \approx 1332mAh$$

Total Calculated Battery Life:

$$Battery\ Life = \frac{1332\ mAh}{460\ mA} \approx 2.9h$$

The runtime battery life is approximately 2.9h, which corresponds to about 2 hours and 54 minutes.

9. The device performance and estimated cost of various devices used in the Smart Life Safety Jacket are presented in the form of two tables below:

9.1. Table 1. Device Performance (Heart Rate and SpO_2) -

Parameter	Measured Value	Standard Deviation
Heart Rate Accuracy	96 bpm	0.6 bpm
SpO_2 Accuracy	1.9%	0.5%

Heart Rate and SpO_2 Accuracy Level.

Here, with an average heart rate of 96 bpm and a standard deviation (SD) of 0.6 bpm, the graphic shows us that we have a consistent and balanced heart rate. With a standard deviation of 0.6 bpm, the heart rate measurements are very close to the mean value and hence show a stable Rhythm.

The given SpO_2 accuracy values, ±1.9% and 0.5%, likely refer to the accuracy of the SpO_2 Sensor and how it compares to actual blood oxygen saturation values.

9.2. Total estimated Cost for Smart Life Safety Jacket circuit-

The cost estimate is calculated below:

Table 2. Total estimated Cost to make Smart Life Safety Jacket internal circuit.

Component	**Estimated Price (USD)**
ESP32 Development Board	$9.95
Active Buzzer Module	$5.99
LED Module	$0.52
Breadboard	$4.95
SpO_2 Sensor (MAX30102 Module)	$5.61
MQ-2 Gas Sensor Module	$5.50
Body Temperature Sensor (MAX30205)	$7.82
Total	**$40.34**

Total estimated Cost *(in USD $)* to create the primary circuit.

Therefore, the circuit design of the bright life safety jacket proposed in this research paper will cost about **$40.34** to build.

10. Results:

Here are the results obtained from the cloud after successfully running the complete Smart Life Safety Jacket circuit-

Heart Rate: 96 BPM || GAS: Non Detected || Temperature: 96.05 F || LAT: 24.123793 LON: 88.695635

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In this Results section, the output of the experimentally run entire circuit design is reported. The heart rate is 96, 97, **or 98 BPM** ***(Heart Rate: 96 BPM)***. The gas being detected is either toxic or non-toxic. However, no poisonous gas was detected in this case *(GAS: Non-Detected). The body temperature reads 96°F (Temperature: 96.05°F)*, which is considered normal. The output here displays the latitude and longitude geo-location (LAT/LON: 24.123793, 88.695635), which is detected via the GPS sensor. The geo-location is also being recorded on the server for emergencies and future analysis. Whenever a rescuer goes to a remote location to rescue, this record may help the monitoring team identify some crucial moments.

Figure 10. Position the jacket according to the current location using the GPS sensor.

Other devices, such as the buzzer, LED indicator light, and DC fan, were not included in the report but functioned as expected, directly connected to the power source. Life safety jackets, which are utilised in rescue missions conducted under direct sunlight, are made of heavily heat-trapping and low-breathability polyester materials. Their extended use can lead to thermal discomfort and even heat stress. To mitigate this issue, the integration of active cooling technologies, such as DC-powered fans and cooling pads, has been implemented into the jacket design. *(Figure 6)* The cooling pads enhance heat dissipation, while the DC fans augment airflow and provide relief. These modifications aim to improve comfort and operational performance while maintaining safety and enabling the extended use of life jackets in high environments.

In this research paper, the proposed design incorporates all sensor technology and other electronic devices used in the basic circuit design (Figure 9) by connecting them with wires. The main sensors used in the Bright Life safety jacket, as described in this research paper, functioned correctly.

11. Future Work

This research article demonstrates the functionality of various sensors with a modern design in the Smart Life safety jacket. This time, we will discuss several points on how these life safety jackets can be modernised and improved using computer science.

- **Uses Of Integrated AI and Machine Learning:** Environmental data can be processed pattern-wise by artificial intelligence. As a result, the person wearing the bright jacket will have the ability to predict environmental risk factors. In turn, this might enable the jacket to adjust to the user's bodily state and consequently offer a range of safety measures.
- **Data Analytics:** The data obtained through all the sensors used in the Bright Life safety jacket must be collected. All that collected data can help improve the user's security using mathematical models or through data analysis. To achieve this, various methods of data analysis can be applied, such as big data analysis, clustering, and regression, among others. This makes the data analysis method more accurate in terms of security.
- **Intelligent Safety System:** Buoyancy aids or firmings that save vital areas upon an impact by self-inflating can be built into the jacket. The jacket might trigger an automatic safety system after a serious crash, such as activating a rescue drone or warning a team of nearby helpers.
- **Environmental sensors and other detection techniques are used. Various types of sensors are used for environmental monitoring, and the use of these bright jackets is expected to** increase. Such as sensors used to detect temperature, toxic gases, accelerometers, etc., to alert in case of an emergency automatically. A variety of toxic gas detection systems can also be installed.
- **Energy independence and using a charging System:** A power supply is typically used to run bright jackets, which in turn draws power from a lithium battery. These batteries require regular charging. However, if this part also installs a solar charging system, then the need to charge the jackets during the rescue operation will be significantly reduced. Thus, it will be possible to design an environmentally friendly intelligent life safety jacket by incorporating these innovative technologies.
- **Improved Communication Systems:** The first thing needed is effective communication between the rescuer and the control room conducting the rescue. In the event of a minor emergency, a microphone or public announcement system may be used. However, in cases of long-distance communication, a two-way communication system or a satellite-based wireless system can be used. In some cases, hum radio communication systems can also be used, where typical cell service may not be available. Various modern drones, radios, or mobile applications can also be used.
- **Advanced Materials and Design:** To expedite rescue operations, life safety jackets must be designed and developed to be lightweight, comfortable, and constructed from strong, durable materials. It is long-lasting and improved with modern technology, which also has an indigenous touch. Additionally, jackets should be made of fabrics that are both comfortable and functional, even with minor damage.
- **Waterproof and Ruggedness:** As noted at the beginning of this research paper, these life safety jackets are designed to stay afloat for a specified period. Additionally, a special plastic sponge-type material is used in these jackets. If we can install this sponge-type material in the jackets by laminating it with a

plastic cover, the time it stays afloat in water will increase. Additionally, the durability of the coat will also be enhanced.

12. Conclusions

The Smart Life Safety Jacket is a revolutionary innovation developed using the Internet of Things (IoT) and other modern sensor technologies, along with a modern communication system. This bright life safety jacket provides physical safety for rescuers, tracking their activity and current location. This research paper presents the advanced design of a Smart life safety jacket, which includes the detection of body temperature, oxygen level, and heart condition, as well as an advanced GPS location sensor and a Gas sensor to detect toxic gases. The DC Fan and Gel cooling pad have been used to keep the body cool in the climate of the Indian subcontinent, and the physical condition of the person wearing this bright jacket can also be monitored using a cloud server. As a result, it will be possible to assess the physical condition of rescuers and provide additional security in very high-risk rescue operations. The always-on LED indicator is also attached to the shoulder of this jacket to illuminate during active rescue operations. Finally, suppose the design of this Smart life jacket is implemented. In that case, rescue work will speed up and, utilising modern computer technology (IoT), will move ahead with the modernisation of life safety jackets in an indigenous way. The modernly designed jacket has worked properly, and the work duration and estimated cost are also tabulated in this research paper. Ultimately, this research paper will play a significant role in the future, advancing or making progress in flood rescue operations. Finally, to reiterate, the safety jacket commonly used in outdoor Rescue Works activities will remain the same, with other components, such as radium, and utilise the latest technology. A Smart Life Safety Jacket for Rescuers is designed in this research paper. If this proposed model is implemented, the Smart Life Safety Jacket will play a crucial role in taking advanced measures during disaster development.

Author Contributions: In this research paper, Mr Subhankar Sarkar contributed to the study concept, material preparation, data collection, original design, and analysis. Mr. Sarkar has written the entire manuscript and completed all other tasks, including the first draft of the original manuscript on the Smart Life Safety Jacket for Rescuers. After studying the whole research paper and correcting the errors, the manuscript is submitted for publication.

Funding: Smart Life Safety Jacket for Rescuers. As the author conducts the main work in this research paper. Here, no grant or funding money of any kind has been used or required for the preparation of this manuscript.

Competing Interest: The author has no financial or non-financial interest in publishing the manuscript titled Smart Life Safety Jacket for Rescuers.

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