FACULTY OF ELECTRICAL AND ELECTRONICS

MULTIDISCIPLINARY DESIGN PROJECT MANAGEMENT PLAN

Note: The form must be completed using Arial font, size 10, and should not exceed 10 pages in total.

Project Title:			
Project Management Plan Delivery Date:			
Number	**Project Team Name, Surname**	**Department** (ELM/EHM/BLM/KOM)	**Signature**
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3	**FAYZE SALEH**	BME	
4	**NOUR MNEIMNEH**	BME	
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ABSTRACT

The abstract should present an overview of the project's methodology and management approach, with a maximum length of 450 words or one page. The project design must take into account realistic constraints and conditions. Depending on the nature of the design, aspects such as economic factors, environmental impact, sustainability, manufacturability, ethics, health and safety, as well as social and political considerations, should also be addressed.

Project Summary

The global population is aging, leading to an increased demand for technologies that enhance independent living and provide timely assistance in emergencies. This project aims to address this need by developing a wearable, sensor-based smart safety system designed to detect various emergency situations in individuals, particularly the elderly, and automatically alert caregivers or emergency services. The system will integrate a suite of sensors to monitor activity, heart rate, and provide a manual emergency trigger, all communicated through a user-friendly mobile application.

Here, the methodology and management for developing a Wearable Sensor-Based Smart Safety System are outlined in the following. The system is designed to detect critical health and safety events, particularly falls, prolonged inactivity, and abnormal heart rates, and to alert caregivers via a mobile application. The study emphasizes both rule-based algorithms for initial detection and explores AI-based methods for enhanced accuracy. The system will leverage an ESP32-C3 Mini microcontroller for its compact size and integrated Bluetooth Low Energy (BLE), an MPU6050 (accelerometer/gyroscope) for accurate motion sensing, and a MAX30100 (heart rate sensor) for reliable photoplethysmography (PPG)-based heart rate monitoring, all integrated into a wearable device powered by a 3.7V 950mAh LiPo battery for extended operation. Data will then be

transmitted via Bluetooth Low Energy (BLE) to a mobile application, which then alerts caregivers via SMS or push notifications. Additionally, a GPS module is incorporated to provide the wearer's real-time location to caregivers during emergency situations.

For data transmission, the system will utilize the MQTT (Message Queuing Telemetry Transport) communication protocol to ensure fast, reliable, and lightweight data exchange between the wearable device, mobile application, and potential cloud servers. MQTT's efficiency and low power consumption make it ideal for IoT-based wearable applications, enabling real-time alerts and continuous monitoring without compromising battery performance.

Our design prioritizes real-world constraints including economy by selecting readily available and cost-effective components, ensuring the system's affordability for broader adoption. Sustainability is supported through energy-efficient design and the focus on reusability and durable materials. Ethical considerations are paramount, particularly regarding data privacy and responsible alert dissemination. We address health and safety by providing a reliable emergency response system. Socially, the project contributes to enhanced independent living for the elderly or vulnerable populations, reducing the burden on caregivers and healthcare systems and improving quality of life. Politically, adherence to healthcare data regulations will be a key consideration for future deployment. This plan details the project's objectives, systematic methodology, and a structured project management approach for execution within a 15-week timeframe.

Key Words: Wearable Sensor, Smart Safety System, ESP32-C3 Mini, MPU-6050, MAX30100, Fall Detection, Heart Rate Monitoring, IoT, Biomedical Engineering, Mobile Application.

1. PURPOSEs AND OBJECTIVES

The purpose and objectives of the project proposal should be clearly defined, measurable, realistic, and achievable within the scope and timeframe of the project.

The aim of this project is to design, simulate, and prototype a Wearable Sensor-Based Smart Safety System capable of detecting emergency situations and alerting designated caregivers in real-time.

The objectives are clear, measurable, realistic, and achievable within the project duration:

O1: Wearable Device Prototype Development: Design and assemble the hardware architecture of a functional wearable prototype (wristband/armband) incorporating the ESP32-C3 Mini, MPU-6050, MAX30100, and a manual emergency button, powered by a LiPo circuitry.

O2: Robust Algorithm Implementation: Develop and optimize firmware algorithms for the ESP32 to accurately detect fall events (sudden acceleration + prolonged inactivity), prolonged inactivity (absence of significant movement), and abnormal heart rates (high/low thresholds) using sensor data.

O3: Mobile Application Development: Develop a user-friendly mobile application to receive data from the wearable via BLE, display real-time health status, and send emergency notifications (SMS/Push Notifications) to pre-defined caregiver contacts upon detection of an emergency event.

O4: Energy Efficiency Optimization: Implement low-power operating modes for the ESP32 and sensors, such as sleep cycles and dynamic sampling rates, to maximize battery life and achieve an operating duration of at least 3–5 days under typical usage conditions.

O5: System Simulation and Validation: Conduct comprehensive simulations and real-world testing of all primary emergency scenarios using generated and collected data to validate algorithm performance, assess feasibility, and evaluate system accuracy and reliability.

O6: Innovation Integration: Integrate advanced features, namely AI-based fall differentiation and a GPS for location tracking during emergencies.

2. METHOD

The methods and research techniques to be applied in the project must be explained clearly. Their suitability for achieving the project's goals and objectives should be demonstrated. Preliminary and feasibility studies should also be included, and the selected methods must be explicitly linked to the corresponding work packages.

The project will follow an iterative design and development methodology, emphasizing collaboration between multidisciplinary engineering backgrounds. The approach ensures systematic progress, continuous testing, and optimization at each stage. The project will be managed using a structured, team-based approach that ensures coordination, accountability, and consistent progress throughout the 15-week duration. Each team member has been assigned specific roles based on their technical background, ensuring balanced workload distribution and interdisciplinary collaboration between the different majors in the team.

Preliminary studies have confirmed the feasibility of integrating the chosen components (ESP32-C3 Mini, MPU6050, MAX30100) and developing the required algorithms within the project timeframe [1].

Component Research: Initial research confirms the ESP32's capabilities for BLE and low-power operation [2], the MPU6050's suitability for motion tracking [1,3,4], and the MAX30100's effectiveness for PPG in wearables [1,4,5]. The 950mAh LiPo battery offers sufficient capacity for target battery life. All selected components (detailed in Table 1) are commercially available off-the-shelf and are cost-effective for prototype development. Also, the chosen components are small enough to fit into a comfortable wristband or armband design.

Initial Power Budget Analysis: Preliminary calculations (detailed in section "Necessary Calculations Used") suggest that a 950 mAh Li-Po can provide several days of operation.

Necessary Calculations Used:

1. Power & Battery Life
   Battery: 3.7 V × 950 mAh ≈ 3.5 Wh
   Avg. current (ESP32 ≈ 9 mA + sensors ≈ 5 mA): ≈ 15 mA
   Estimated life = 950 / 15 ≈ 63 h (~2.5 days)
   With duty-cycling (sleep modes) → ≈ 4–5 days operation

2. I²C Throughput
   MPU6050 (12 B×100 Hz) + MAX30100 (6 B×100 Hz) ≈ 1.8 kB/s
   I²C @ 400 kHz ≈ 50 kB/s capacity → Safe margin

3. MQTT Data Rate
   One JSON packet ≈ 60 B; one every 15 min → < 0.3 kB/h → Negligible bandwidth

4. Pull-ups & Switch
   I²C pull-ups: 4.7 kΩ for SDA/SCL
   Push-button debounce: R = 10 kΩ, C = 0.1 μF → τ ≈ 1 ms

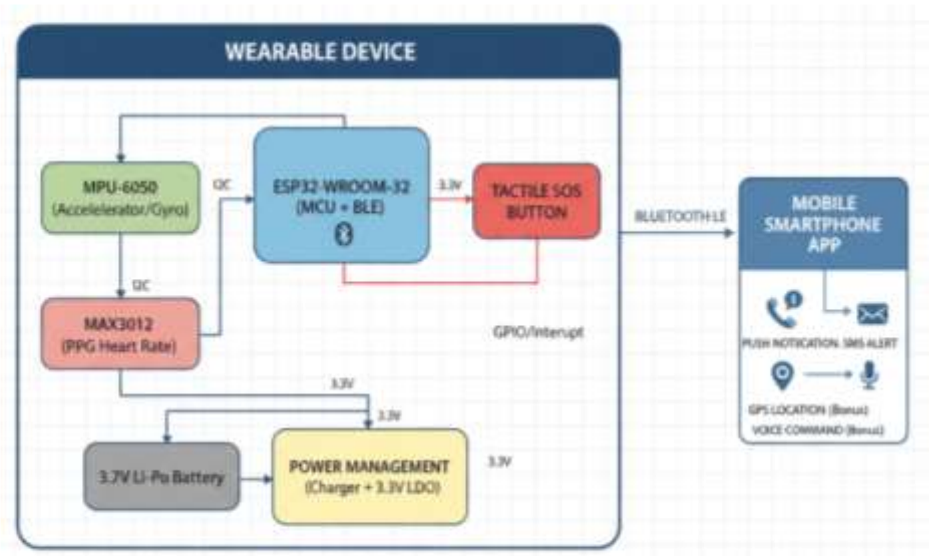
5. Buzzer Driver
   I_L = 30 mA, h_{FE} ≈ 100 → I_B ≈ 0.3 mA → R_B ≈ 10 kΩ (NPN transistor)

So our battery is sufficient for our project, we expect a runtime of 2–5 days depending on how efficiently we manage sleep and Wi-Fi/BLE usage.

TABLE 1: DEVICE COMPONENTS			
COMPONENT NAME	**COST IN TL**	**DESCRIPTION**	**Advantages / Reason for Use**
ESP32 Mini (with Wi-Fi & Bluetooth)	140	Microcontroller that manages all sensors, processing, and communication.	Dual-core processor with built-in Wi-Fi and BLE makes it ideal for IoT wearables — low power, compact, and supports MQTT or BLE communication.
3.7V 1S 950 mAh 40C Li-Po Battery	339	Rechargeable battery powering the entire wearable device.	Provides stable 3.7 V output, high discharge rate (40C) for short current peaks, and lightweight design suitable for portable wearables.
MAX30100 Heart-Rate Sensor	77	Measures heart rate and SpO_2 using infrared and red LEDs.	Combines pulse oximetry and heart-rate sensing in one compact module; accurate, low-power I^2C interface compatible with ESP32.
MPU6050 6-Axis Accelerometer & Gyroscope (GY-521)	134	Detects motion, acceleration, and orientation changes.	Allows fall detection and movement tracking; built-in digital motion processor reduces computational load on ESP32.
Medium-Size Breadboard	50	Prototyping board to connect and test circuit components.	Enables easy assembly and modification of circuits without soldering during prototype development.
6 × 6 × 5 mm 4-Pin Red Push Button (Tact Switch)	2	Manual emergency trigger button for the user.	Simple tactile interface allowing the user to manually send alerts; very compact and reliable.
5 V Buzzer	7	Audio alert output device.	Provides immediate audible feedback for events such as fall detection or emergency activation; low power and easy to control with GPIO.
PLA FILEMENT	200	For printing the watch or object we will use	High flexibility in usage,and cheap.

Sensor Communication:
The I²C protocol will connect the MPU6050 and MAX30100 sensors to the ESP32 mini for synchronized, low-latency data exchange.

External Communication:
The MQTT protocol (over Wi-Fi) will handle data transfer between the wearable device and the mobile/cloud system, ensuring lightweight, reliable, and real-time alert delivery.



Software Development Tools:

- Arduino IDE / PlatformIO for coding
- MQTT Broker (Mosquitto / HiveMQ) communication hub
- MATLAB / Simulink for algorithm testing
- Fusion 360 for designing the casing
- Flutter for application development

Risk Mitigation Strategies:

For Risk mitigation strategies, they include maintaining redundant backups for code and design files, testing each module separately before integration, and allocating buffer weeks for debugging and optimization. Quality control will be ensured through peer reviews and cross-verification between sub-teams (hardware, software, biomedical, and mobile).

The team will use collaborative tools such as Google Drive, and GitHub for version control, document sharing, and progress tracking. Weekly reports summarizing completed tasks, encountered issues, and next steps will be compiled by the team leader and shared with the advisor. Through this management plan, the team aims to ensure efficient coordination, timely task completion, and a successful final demonstration of the project.

[1] Aakesh, U., Rajasekaran, Y., & Janney, B. (2023, December). Wristband for elderly individuals: esp-32 and arduino nano enabled solution for health monitoring and tracking. In *2023 IEEE Asia-Pacific Conference on Geoscience, Electronics and Remote Sensing Technology (AGERS)* (pp. 26-33). IEEE.
[2] Sophia, S., Shankar, B. M., Akshya, K., Arunachalam, A. C., Avanthika, V. T. Y., & Deepak, S. (2021, September). Bluetooth low energy based indoor positioning system using ESP32. In *2021 Third International Conference on Inventive Research in Computing Applications (ICIRCA)* (pp. 1698-1702). IEEE.
[3] Al-Rowaili, B., Al-Obaidli, N., Al-Marri, D., Abualsaud, K., & Yaacoub, E. (2024, May). Fall detection wristband with optimized security and health monitoring. In 2024 International Wireless Communications and Mobile Computing (IWCMC) (pp. 697-702). IEEE.
[4] Santhanamari, G., Choudhary, S., & Ps, S. M. M. (2025, August). A Smart Wearable-Based Fall Detection and Health Monitoring System for Elderly Care Using IoT and Machine Learning. In 2025 International Conference on Next Generation Computing Systems (ICNGCS) (pp. 1-6). IEEE.
[5] Maraqa, I., Al-Karaki, T., & Yasin, R. (2021). Smart Watch For Elderly Using Microcontroller.

3. PROJECT MANAGEMENT

The main work packages to be included in the project should be specified in the "Work Timetable," which identifies the responsible team persons for each work package and the corresponding time periods for their implementation.

WORK-TIME Table

WP No	Name of the Work Package	Work Package Description	To Be Carried Out By	WEEK														
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	Final Week
1	Literature Survey & Selection of System Requirements	Literature review, selecting final components, defining system block diagram, project planning	All Team	X	X													
2	Hardware Design & Development	Develop detailed schematics, order components, initial assembly	MOHAMED ELMAHLAVY, LEEN SAADO, FAYZE SALEH, NOUR MNEIMNEH		X	X	X	X										
3	Embedded Firmware Development & Sensor Integration	ESP32 setup, sensor drivers (I2C), basic data acquisition from MPU6050 & MAX30100, BLE peripheral setup, power management	MOHAMED ELMAHLAVY, LEEN SAADO, EMİR CAN PINAR				X	X	X	X	X	X	X					
4	Algorithm Development & Simulation	Implement fall, inactivity, HR detection algorithms. Generate simulated data for testing. Optimize thresholds. (Bonus: Initial AI model training)	MOHAMED ELMAHLAVY, LEEN SAADO, ANILCAN MUŞMUL, FAYZE SALEH, NOUR MNEIMNEH							X	X	X	X	X				
5	Mobile Application Development	Develop mobile app for data display, config, alerts, BLE client connection, real-time data display, alert trigger logic, caregiver contact management	ANILCAN MUŞMUL, EMİR CAN PINAR, FAYZE SALEH, NOUR MNEIMNEH						X	X	X	X	X	X				
6	System Integration & Testing	Integrate all modules, conduct end-to-end testing of all scenarios (fall, inactivity, HR, manual), optimize, finalize features.	All Team Led by FAYZE SALEH, NOUR MNEIMNEH											X	X	X		
7	Documentation & Presentation Preparation	Final report writing, preparing presentation	All Team Led by NOUR MNEIMNEH													X	X	X