ElectroCap Project

Integrated Tele-Geriatric Health Monitoring Hub

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Problem definition

Portugal is one of the most rapidly ageing countries in Europe, with a growing population over 65 requiring accessible and continuous healthcare.

More than 4% of the Portuguese population (≈400,000 people) reported unmet medical needs due to barriers such as distance, costs, or waiting times.

Many elderly patients have non-urgent appointments scheduled far from their homes, facing barriers such as limited transportation and reduced mobility. These challenges contribute to missed appointments, delayed care, and increased inefficiency in healthcare services.

Approximately 24% of the Portuguese population is aged 65 or older (≈2.5 million people).

Although teleconsultations offer an alternative, they remain clinically limited. Physicians cannot collect essential physiological data, such as heart rate, respiratory sounds, or ECG signals, compromising diagnostic reliability and the quality of clinical assessment.

More than 55% of elderly people in Portugal have at least one chronic condition. (≈1,4 milhões)

Solution beneficiaries

The elderly, as they would avoid long journeys to attend face-to-face appointments and could benefit from more comprehensive and effective teleconsultations.

Family members would no longer need to compromise professional and personal time for distant appointments, while gaining greater confidence in their relatives' health monitoring.

Doctors, who would be able to see more patients, have a more organized schedule, and conduct teleconsultations with more reliable diagnoses

And, possibly, the rest of **the population**, who could also benefit from using the same device in a teleconsultation context.

Technological solution

Wearable Biometric Acquisition Module

The proposed solution consists of a wearable platform integrating biomedical sensors for the acquisition of physiological signals to support teleconsultation. At this stage, the project focuses on defining the target signals and selecting appropriate sensing technologies, ensuring reliability, user comfort, and clinical relevance.

Real-Time Data Transmission

Biometric data are transmitted in real time to the cloud, where they are stored and processed. The information is then forwarded to the hospital server and is immediately available to the medical team during the teleconsultation.

Clinical Interface & Monitoring

The doctor at the hospital receives the patient's vital signs in real time, properly organized. On the desktop interface, the ECG waveform, heart rate values, and cardiac sounds are displayed, enabling a more reliable clinical assessment during teleconsultations.

Technological solution

Why biomedical sensing?

Stable Signal Acquisition

Reliable physiological monitoring using wearable biomedical sensors requires consistent sensor placement and adequate signal quality to ensure clinically useful measurements.

Ease of Use

The sensing system must minimize user interaction and complexity, particularly for elderly users with limited technological familiarity.

Simultaneous Monitoring

Remote consultations require the acquisition of multiple physiological signals through integrated sensing modules in real time to support clinical assessment.

Clinical Consistency

Sensor-based measurements must be repeatable across consultations to enable longitudinal comparison and support medical decision-making.

Competitors and previous work

Teladoc HEALTH

- ✓ Provides teleconsultations
- ✗ No integrated physiological monitoring

amwell

- ✓ Clinical telehealth platform
- ✗ Requires multiple external devices

Medtronic

- ✓ Clinical-grade monitoring
- ✗ Expensive solutions

Our key innovation is the integration of sensing, teleconsultation and a medical monitoring platform in one workflow.

Engineering Requirements

Functional Requirements

- Acquire ECG signals for real-time cardiac monitoring.
- Estimate heart rate in near real time.
- Enable remote auscultation.
- Transmit data wirelessly to an external interface.
- Support optional local data and audio storage.
- Provide visual indicators and simple session control.

Non-Functional Requirements

- Latency < 1 s.
- Lightweight wearable (< 300 g).
- Low active power consumption (~500 mW target).
- Easy to use by elderly users or caregivers.
- Low-cost, scalable architecture.

These requirements define the technical foundation of the prototype, guiding its hardware, firmware, and communication architecture.

Description of the main blocks

Biomedical Acquisition Layer

Acquires ECG signals and cardiac sounds for monitoring and remote auscultation.

Analog Conditioning Layer

Performs signal conditioning before digital acquisition, including protection, amplification, and filtering, in order to improve signal quality and reduce noise.

Local Processing Unit

The microcontroller is responsible for the acquisition, synchronization, and preprocessing of biomedical signals, while also managing local storage and the overall operation of the device.

Wireless Communication Layer

Ensures the transmission of biomedical data to an external device or remote platform, guaranteeing low latency and communication reliability.

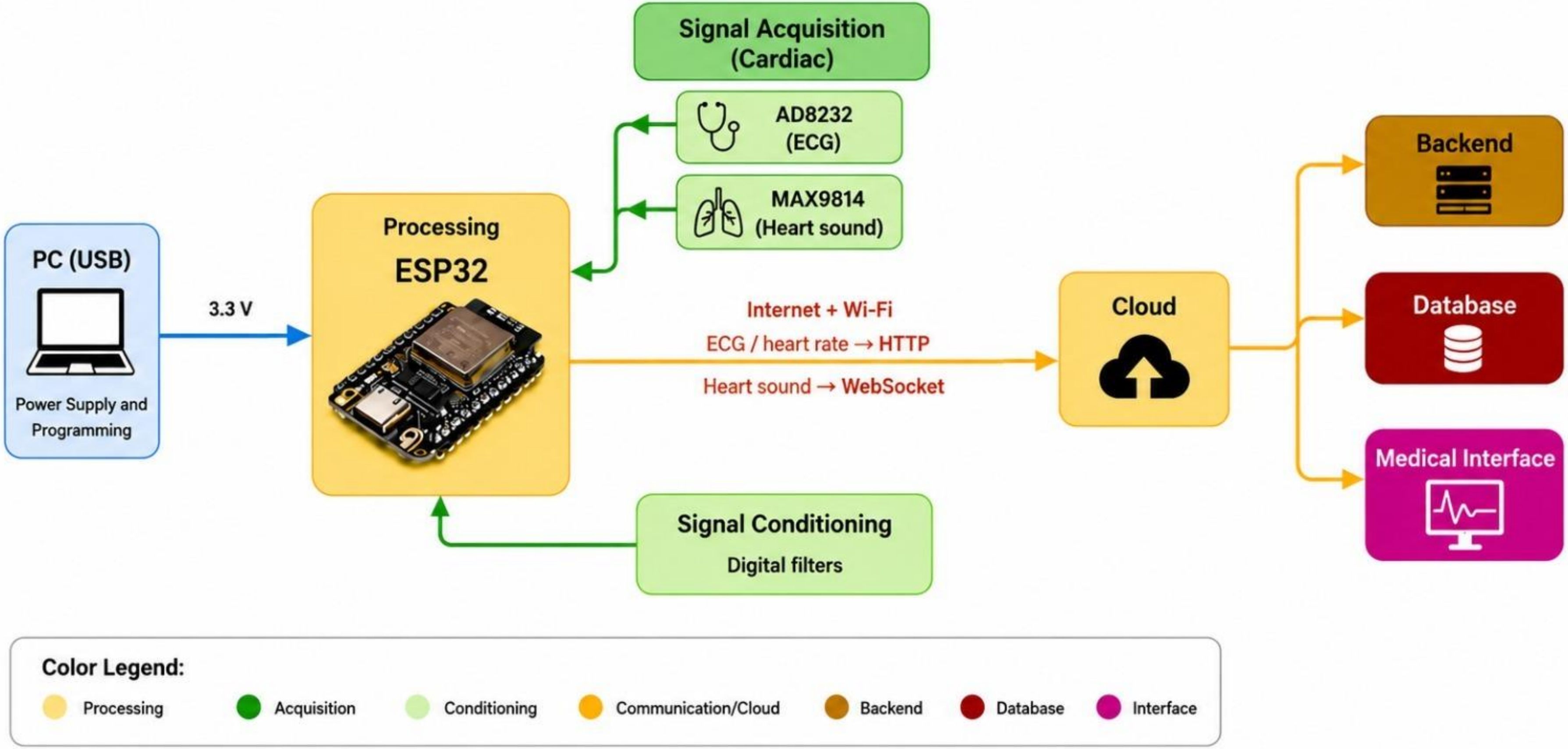
Data and Cloud Layer

Responsible for receiving, storing, and organizing the transmitted data, enabling structured access to measurements and supporting future processing and analysis functions.

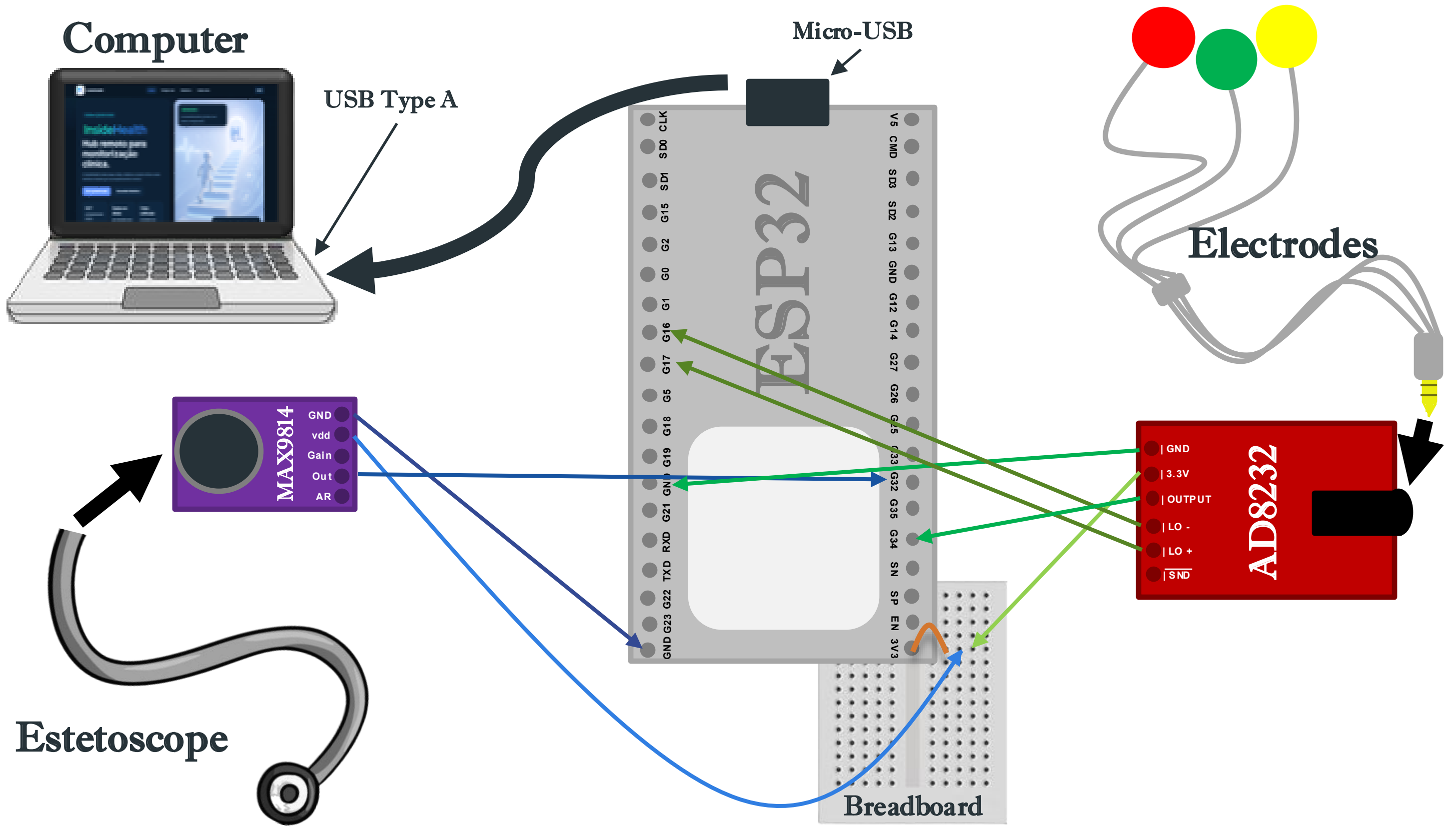
Clinical Interface

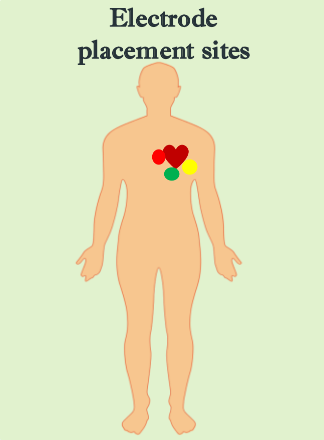
Provides healthcare professionals with near real-time visualization of physiological parameters and access to relevant biomedical information during the teleconsultation.

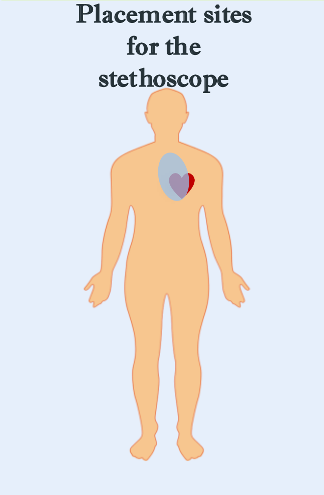
System Architecture



System Architecture

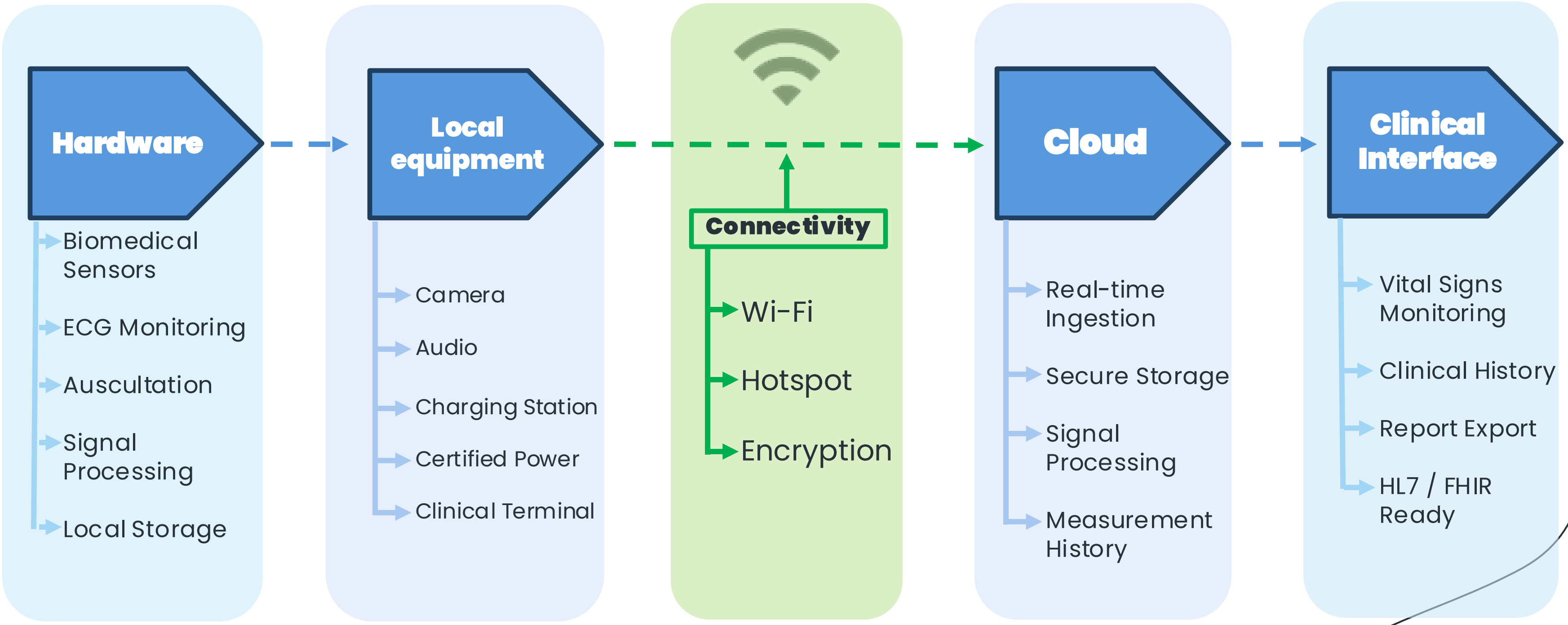






Solution requirements

- **Technical System Requirements**



Solution requirements

- **Requirements for Local Health Access Points**

Physical Infrastructure
- Private clinical space Adequate
- Lighting Proper ventilation
- Soundproof environment
- Reduced mobility accessibility

Local equipment
- Clinical platform compatibility
- HD camera
- Two-way audio
- Certified power supply
- Device charging station

Data Security and Protection
- Secure authentication
- End-to-end encryption
- Access control
- GDPR compliance
- Data protection

Connectivity
- Stable internet connection
- Low latency
- Redundancy system
- 4G/5G connectivity
- Service continuity

Operationalization
- Sanitization procedures
- Local manager training
- Remote technical Support
- Operational maintenance
- Staff onboarding

Solution requirements

- ## Requirements for Local Health Access Points

To ensure the correct implementation of the telemonitoring system, local access points (e.g., parish councils, community centers, or social support units) must meet the following requirements:

Physical infrastructure –Private clinical space with adequate lighting, ventilation, soundproofing, and accessibility for people with reduced mobility.

Local equipment –Terminal compatible with the clinical platform, HD camera, two-way audio system, certified power supply, and device charging station.

Data Security and Protection – Secure authentication, end-to-end encryption, access control, and GDPR compliance.

Connectivity – Stable internet connection with low latency and redundancy system (4G/5G) to ensure service continuity.

Operationalization – Sanitization procedures, basic training for the local manager, and remote technical support.

Technical challenges

Multi-User Reliability

- Consistent performance across different users
- Supports cleaning and disinfection between uses

Biomedical Signal Acquisition

- Reliable measurements outside clinical environments
- Robust against noise, motion, and sensor displacement

Sensor Durability & Maintenance

- Frequent use may affect sensor accuracy
- Requires maintenance and periodic calibration

Fault Detection & Self-Diagnostics

- Real-time detection of sensor and system failures
- Automatic identification of abnormal readings

Technical challenges

System Integration

- Hardware, software, & clinical interfaces Synchronization
- Ensures reliable data processing and operation

Battery & Power Management

- Balances autonomy with patient safety
- Protection against overheating and battery failure

Data Security & Privacy

- Secure transmission and storage of patient data
- Compliance with healthcare privacy regulations

Certification & Regulatory Compliance

- Compliance with medical device standards
- Validation of safety, reliability, and clinical performance

TÉCNICO LISBOA

Partners

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Unidade Local de Saúde do Alto Alentejo

Stakeholders

Key Stakeholders Identified

- Healthcare Technology Company
- Health Centre

Importance of Stakeholder Engagement

- Ensures alignment with real clinical needs
- Supports validation of the proposed solution
- Bridges the gap between technology and healthcare practice

Added Value

- Access to expertise (clinical & technological)
- Availability of infrastructure and real use contexts

Role of Stakeholders

Healthcare Professionals

- Validate relevance and quality of biomedical data
- Ensure integration into clinical workflows
- Provide clinical feedback

Elderly Users

- Assess usability, comfort, and ease of use
- Identify practical limitations (e.g., low digital literacy)

Caregivers & Local Staff

- Support system usage in real contexts
- Ensure correct operation and assistance

Real-World Testing & Validation

Stakeholder Contribution to Testing

- Provide access to elderly participants
- Ensure clinical supervision
- Enable testing in realistic environments

Testing Conditions

- Teleconsultation-like scenarios
- Use by representative users
- Real-world environments (e.g., health centres)

Evaluation & Outcomes

- Assess system performance, usability, and clinical impact
- Collect feedback from users and healthcare professionals
- Support iterative improvements and ensure clinical relevance

Testing and validation metrics

Testing Methods

- Functional system testing in a real environment;
- Use of the system by elderly users in teleconsultation scenarios;
- Evaluation of usability and ease of use

Validation

- Evaluation by a healthcare professional regarding the reliability of the solution;
- Collection of testimonials from elderly users;
- Analysis of the impact on users' quality of life

Key Metrics

- User satisfaction rate (%);
- Ease of use (rating scale);
- Perceived improvement in quality of life;
- Clinical validation of system reliability

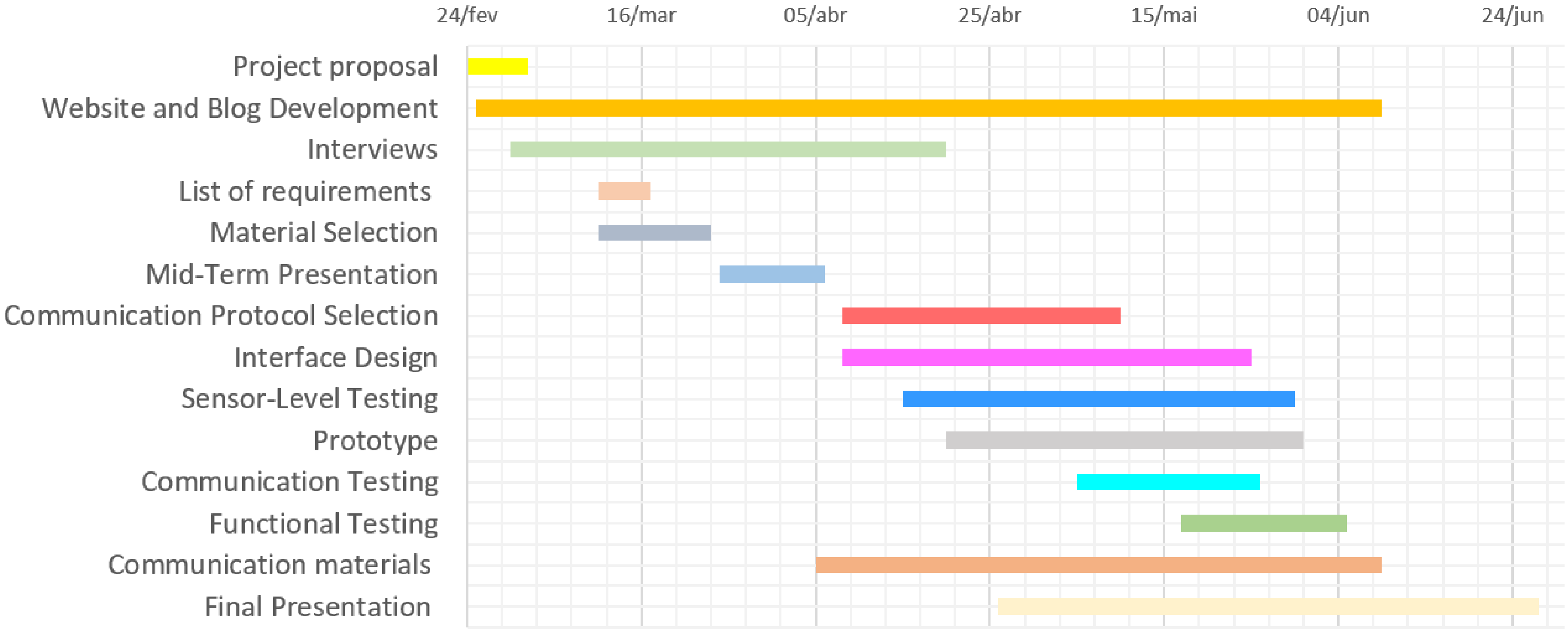
Division of labor (I)

Pedro	Filipa	Madalena
System Design & Coordination	**Software & Data Management**	**Telemedicine Platform & User Experience**
Selected the electronic components and designed the hardware schematic	Developed and maintained the technical infrastructure of the project's website	Designed the teleconsultation interface for doctors to visualize real-time ECG signals, heart rate measurements, and cardiac auscultation data.
Assembled the physical prototype and integrated the sensors	Developed the communication firmware for real-time biomedical data transmission	Structured the clinical data display to ensure it meets medical workflow requirements
Ensured hardware-software synchronization and managed system-level integration	Configured and deployed the secure cloud database for storing physiological signals	Created multimedia content for the project's website
Managed technical requirements and communication with institutional partners	Executed data transmission stability and latency tests between the device and the cloud	Coordinated and conducted usability testing with end-users

Division of labor (II)

Luís	Guilherme
Operations & System Integration	**Testing, Validation & Performance Analysis**
Defined the Standard Operating Procedures for the local health access points	Authored the formal testing protocols for the hardware and communication modules
Coordinated the physical deployment and integration of the system at the partner Health Centre	Executed sensor-level testing to ensure accurate acquisition of ECG signals and cardiac auscultation data.
Conducted operational stress testing of the complete system in a simulated real-world environment	Validated field performance and produced the final performance analytics report
Validated the final system integration ensuring all subsystems work cohesively	Defined operational scenarios for testing the device under different user conditions

Schedule



24/fev
16/mar
05/abr
25/abr
15/mai
04/jun
24/jun
Project proposal
Website and Blog Development
Interviews
List of requirements
Material Selection
Mid-Term Presentation
Communication Protocol Selection
Interface Design
Sensor-Level Testing
Prototype
Communication Testing
Functional Testing
Communication materials
Final Presentation