AUTODOCTOR

Passenger Health Monitoring

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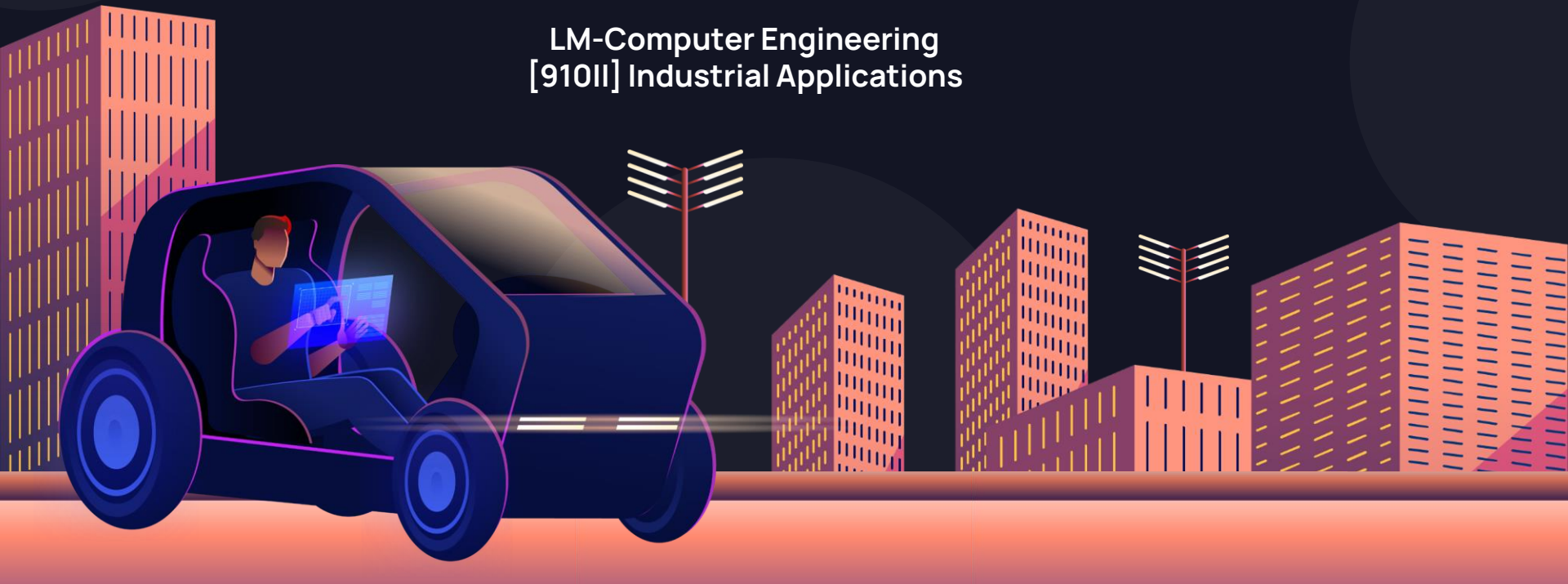
LM-Computer Engineering
[910II] Industrial Applications



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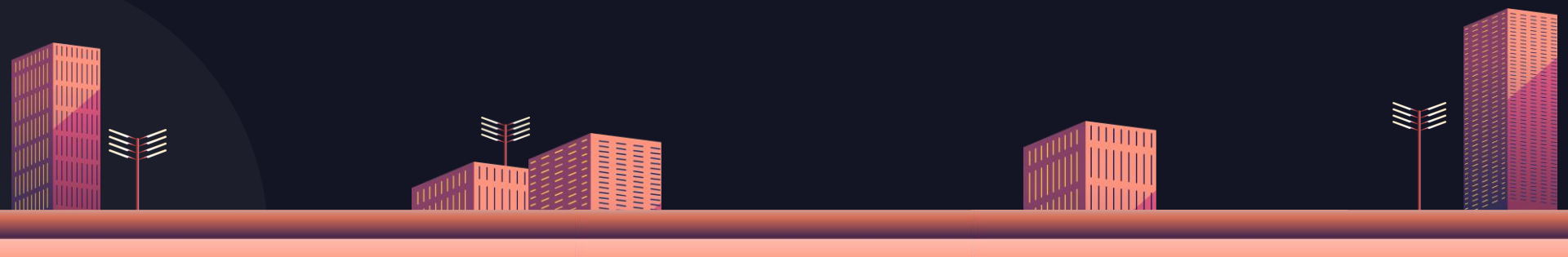


01

Introduction

How to evaluate health conditions?

Car Crash

1

Dispatcher

2

Provider

3

Glascow Coma Scale Parameters:

Eye health

Verbal health

Motor health

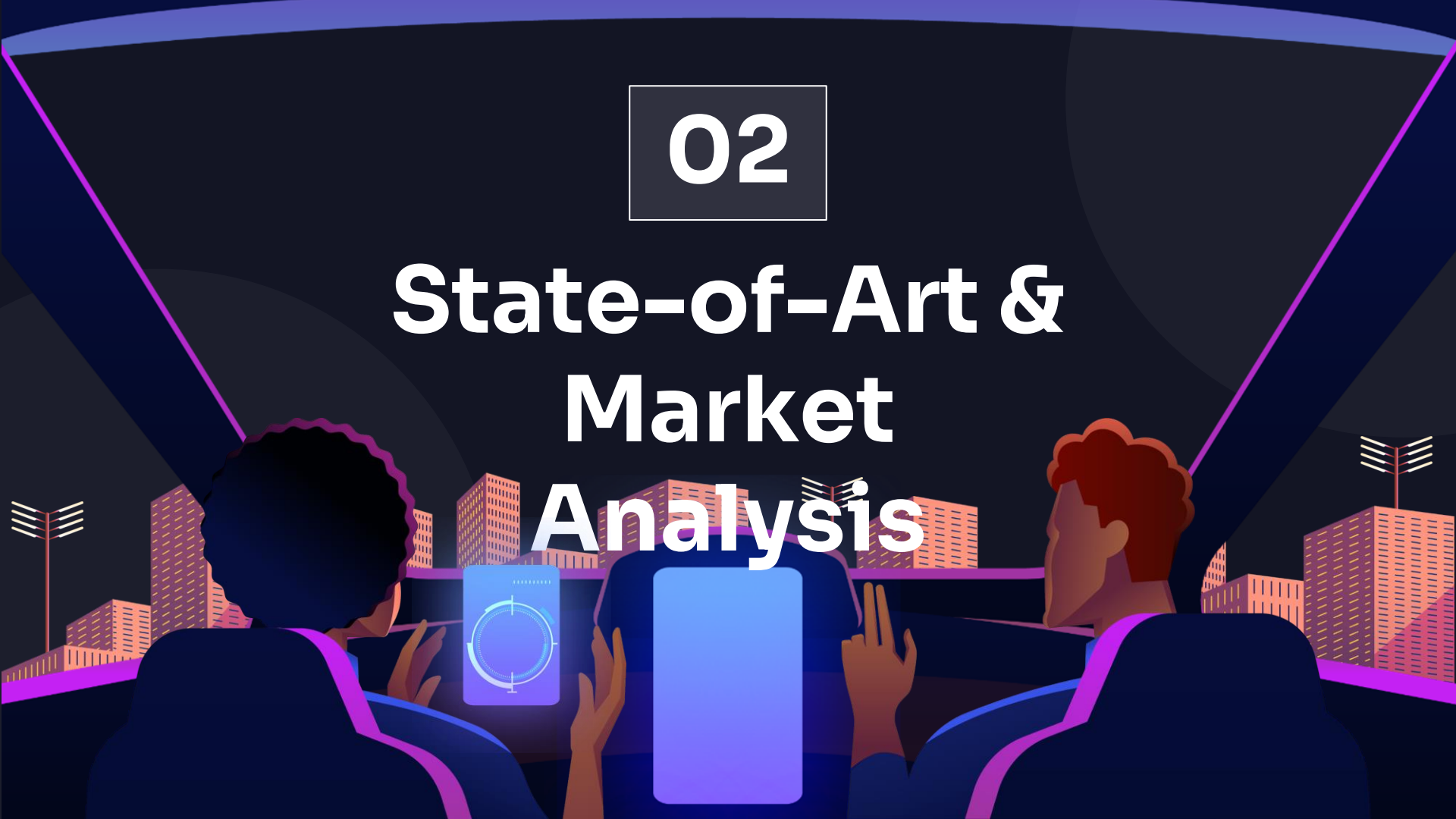
Heart state

European New Car Assesment Program

Every five years, Euro NCAP brings stakeholders together to examine current realities, predict possible challenges and identify the future opportunities that lie ahead.

"A safer future for mobility Euro NCAP Vision 2030"

Post-Crash Protection:
Looking to the future, it is possible that internal sensors could transfer live the images and vital life signs of injured persons, such as heart rate, breathing etc., taken from in-cabin sensors, allowing for instance an assessment of driver consciousness (Glasgow Coma Score)


02
State-of-Art &
Market
Analysis

Market Analysis

Philips
Vital signs camera for automotive

Key features:

High accuracy and high availability

Robust to motion and lighting changes

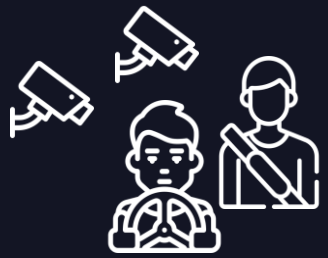
Able to accurately track heart rate and respirations fluctuations

Market Analysis

Continental Engineering Services

Advanced Cabin Sensing Solutions

Key features:



Driver and cabin monitoring

Vital sign monitoring (Heart-rate and respiration)

Thermal Comfort Measurement

State of Art

Accurate contactless heart rate monitoring with Philips' vital signs camera for automotive

This paper presents an integrated monitoring system for the driver and the vehicle in a single case of study easy to configure and replicate. On-board vehicle sensors and remote sensors are combined to model algorithms for estimating polluting emissions, fuel consumption, driving style and driver's health.

SSW: Smart Steering Wheel for Real-Time Heart Rate Monitoring of Drivers

This work is aiming for the development of a system which includes multiple sensors incorporated with the steering wheel which is capable to measure the pulse rate and alert the rescue team dynamically about the health-related data of a driver, to prevent accidents.

Sapra A, Malik A, Bhandari P. Vital Sign Assessment.

Improvements in emergency response can help prevent deaths and life-changing injuries in road collisions. However, emergency response has not been getting a fair share of attention in terms of research, best practice exchange and measures in the European Union. (Source: European Transport Safety Council)

03

Auto Doctor

Functional requirements

Heart Monitoring

Continuous monitoring of the HR of the passenger during an accident

Breath and Movement Monitoring

Detection of the breathing dynamics and movement for any car occupant

Vital sign transmission

Real-time data transmission to first responders

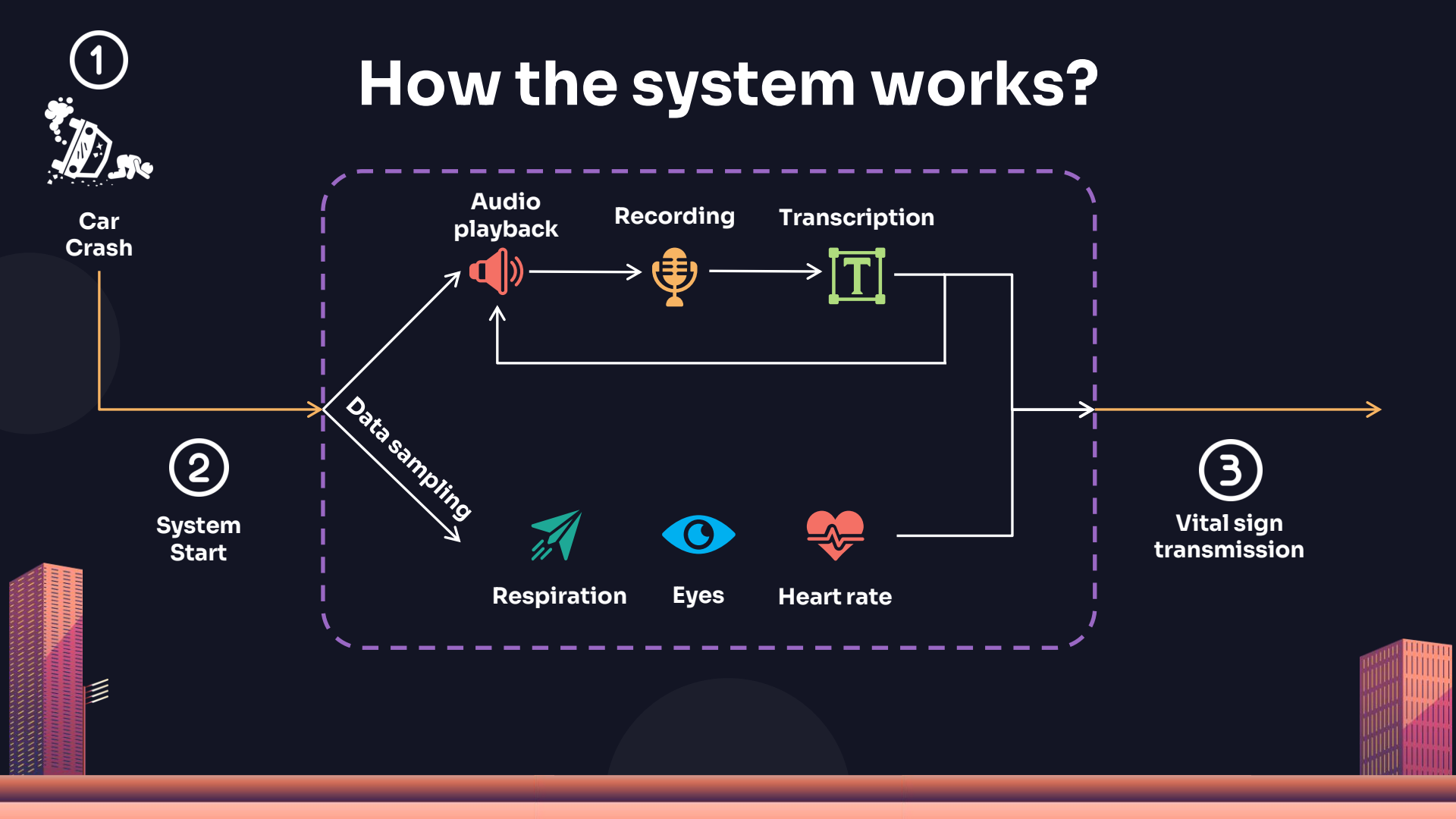
Eye tracking

Real-time eye tracking system classifies eye status

Voice assistant

Voice assistant assesses the patient's verbal state, with text-to-speech used to interpret responses

How the system works?



Competitors

	Implementation						
HEART RATE MONITORING Detection of driver's heart rate anomalies	Steering wheel	■	■				
	RGB Camera			■	■		■
BREATHING MONITORING Detection of the breathing dynamics for any car occupant	IR thermography					■	
	RGB Camera						■
VITAL SIGN TRANSMISSION Real-time data transmission to first responders.	Customization						■

Non-Functional Requirements and Constraints

Network Coverage

The system needs to collect data in a variety of network coverage scenarios.

Network Speed

The network speed must be at least equivalent to 3G connectivity.

Non-invasive

The sensor system should operate transparently, without disrupting the user experience.

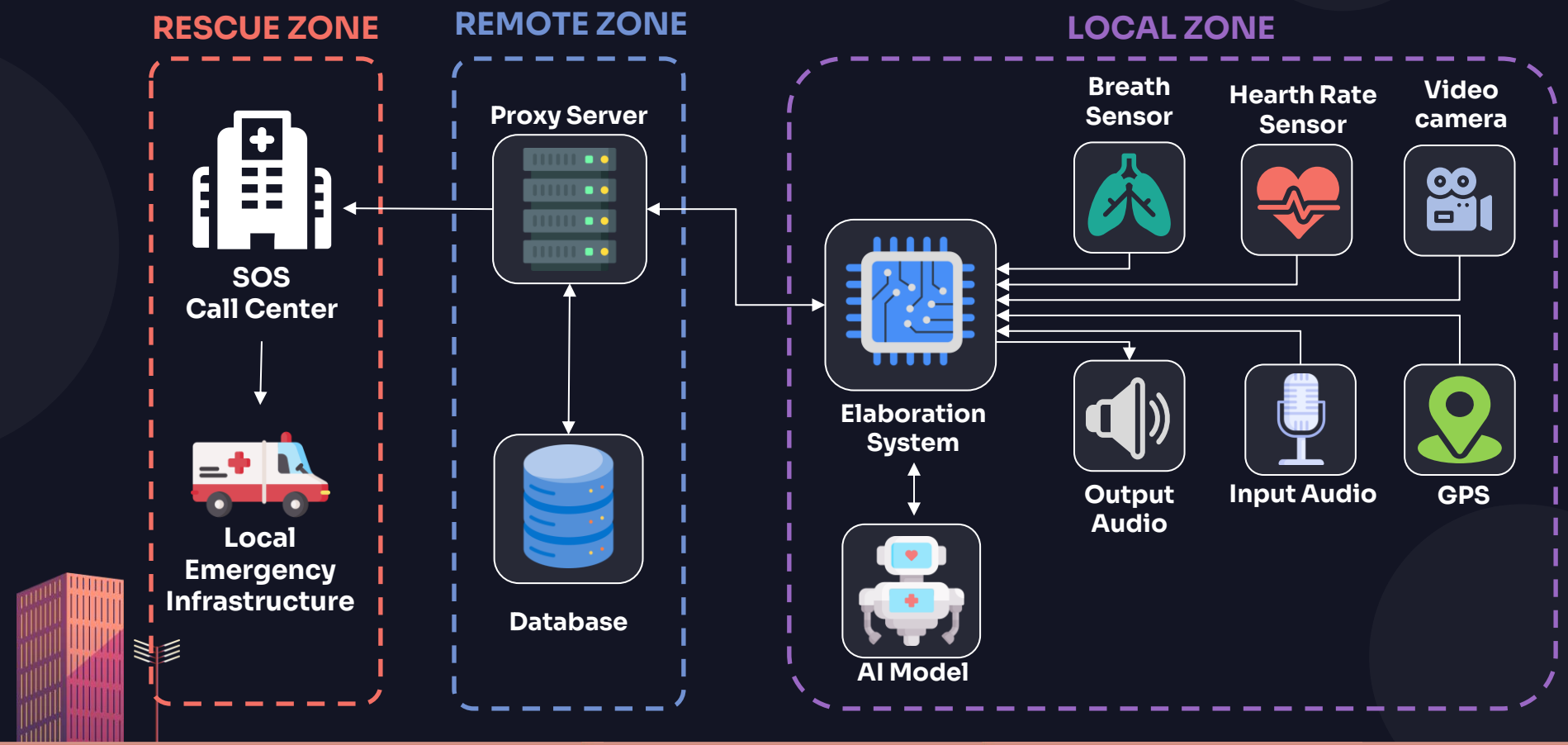
Power Efficient

The system should run on low power requirements. (25 watts)

Durability

The system must be designed to withstand impacts at speeds of up to 120 km/h.

Product Architecture



04

Work Packages

Profile Analysis


Project Manager


Data and AI Engineer


Neurologist


Paramedic


Trauma Specialist


Biomedical Engineer


Energy Engineer


UX Designer


Embedded Engineer


Frontend Developer

Work package 1 (I)

WP1	Title: Medical Attention Analysis for Post-Crash Accidents. Type: R.I	Starting Month 1	Ending Month 4
Months/Man: 7			
Objectives: Develop a system to analyze and communicate post-crash medical attention needs based on data collected from in-vehicle sensors.			

Work package 1 (II)

Activities:

T1: Initial Triage and Vital Sign Evaluation

- ✓ Perform a rapid initial assessment to identify life-threatening conditions (e.g., airway obstruction, severe bleeding) and evaluate vital signs (heart rate, blood pressure, respiratory rate, oxygen saturation).

T2: Injury Identification and Classification

- ✓ Conduct a thorough examination to identify visible and non-visible injuries (e.g., fractures, head trauma, internal bleeding), and classify them based on severity.

T3: Neurological and Pain Assessment

- ✓ Assess the patient's neurological status (e.g., using the Glasgow Coma Scale) and evaluate pain levels using standardized pain scales.

T4: Documentation and Coordination for Transport

- ✓ Document the medical findings, injury assessment, and treatment plan. If transportation to a medical facility is required, communicate the patient's condition to receiving medical teams.

Checkpoints:

1) **Initial Stabilization and Injury Classification Completed** (Month 2)
2) **Final Assessment and Patient Prepared for Transport** (Month 4)

Work package 1 (III)

Deliverables:

- Medical Assessment Report (Month 2)
- Transport and Treatment Coordination Documentation (Month 4)

Costs:

- Project Manager : €6,600/month x 0,5 months = €3.300
- Paramedic/EMT: €3,300/month x 1,7 months = €5.610
- Doctor/Trauma Specialist: €3,700/month x 2,4 months = €8.880
- Neurologist: €5,000/month x 2,4 months = €12.000

Total costs: €29.790

Work package 2 (I)

WP2	Title: Analysis of Sensors and Technologies for Low Power Environments Type: R.I.	Starting Month 3	Ending Month 6
Months/Man: 7,1			
Objectives: This work package aims to identify and analyze suitable sensors and technologies (e.g., heart rate sensors, movement recognition cameras, and breathing detection systems) for use in low power medical environments, focusing on optimizing energy consumption while ensuring reliable performance for healthcare applications.			

Work package 2 (II)

Activities:

T1: Requirement Definition and Power Constraints in Medical Environments

- ✓ Define the system requirements specific to medical applications (e.g., heart rate monitoring, movement recognition, and respiratory monitoring). Analyze power constraints unique to medical devices, ensuring that sensors meet regulatory standards (e.g., ISO, IEC).

T2: Research of Medical Sensors and Low Power Technologies

- ✓ Conduct research on available low power sensors suitable for medical applications such as heart rate, movement detection, and breathing sensors. Focus on energy efficiency, accuracy, and feasibility in real-world medical scenarios.

T3: Prototype Evaluation and Testing for Medical Use

- ✓ Build prototypes for selected sensors and technologies (e.g., heart rate sensors, movement recognition cameras) to assess their performance, accuracy, and energy consumption in a simulated medical environment.

Checkpoints:

1) **Selection of Medical Sensors and Technologies (Month 4)**
2) **Prototype Evaluation and Testing Completed (Month 6)**

Work package 2 (III)

Deliverables:

1) Medical Sensors and Technologies Research Report (Month 4)
2) Prototype Evaluation and Performance Report for Medical Applications (Month 5)

Costs:

- **Embedded Engineer:** €5.000/month x 2,7 months = €13.500
- **Biomedical Engineer:** €4.500/month x 2,7 months = €12.150
- **Energy Engineer:** €4.000/month x 1,3 months = €5.200
- **Project Manager:** €6.600/month x 0,4 months = €2.640

Total costs: € 33.490

Work package 3 (I)

WP3	Title: Backend and Server development Type: R.I.	Starting Month 5	Ending Month 9
Months/Man: 5,5			
Objectives: This work package aims to build the backend infrastructure to enable secure and reliable system operations. Additionally, it involves integrating a notification system to relay critical incident data to the SOS system, ensuring efficient and timely emergency responses.			

Work package 3 (II)

Activities:

T1: Research and realize the Machine Learning Model

- ✓ Design Develop and implement a Machine Learning model by researching suitable algorithms, designing the architecture, and training the model on a suitable dataset. Ensure optimal performance through validation and fine-tuning, delivering a fully trained model with accompanying documentation and evaluation metrics.

T2: Implementation of Microcontroller logic

- ✓ Design and implement the logic for a microcontroller ensuring the code is optimized for performance, reliability, and power efficiency. Focusing on the management of the sensors and the utilization of the Machine Learning Model.

T3: Database Configuration

- ✓ Implement a robust database to store real-time sensor data for efficient access, analysis and transmission.

T4: Implementation of a Proxy Server

- ✓ Develop a secure and efficient proxy server combined with CoAP REST APIs to ensure a secure and reliable integration between the microcontroller and cloud infrastructure. This includes routing requests, transferring the sensor data and machine model classification.

Checkpoints:

1) **Realize the Machine Learning Model (Month 6)**
2) **Implement the microcontroller logic (Month 7)**
3) **Complete Proxy Server and Database implementation (Month 9)**

Work package 3 (III)

Deliverables:

1) Trained machine Learning Model with its documentation (Month 6)
2) Fully functional microcontroller (Month 7)
3) Proxy Server and Database implementation (Month 9)

Costs:

- Data and AI Engineer: €5.000/month x 2,2 months = €11.100
- Embedded Engineer : €5.000/month x 2,8 months = €14.000
- Project Manager: €6.600/month x 0,5 months = €3.300

Total costs: € 28.400

Work package 4 (I)

WP4	Title: Frontend development for medical emergency personnel Type: R.I.	Starting Month 6	Ending Month 9
Months/Man: 3,2			
Objectives: This work-package aims to design and develop an intuitive and responsive interface for medical emergency personnel to access real-time post-crash data. Provide functionalities for quick decision-making, including alerts, patient status visualization, and communication tools.			

Work package 4 (II)

Activities:

T1: UI/UX Requirements Analysis:

- ✓ Define user stories and UI/UX requirements based on feedback from stakeholders (e.g., emergency responders).

T2: Prototyping and Wireframing:

- ✓ Create low-fidelity wireframes to visualize workflows. Develop high-fidelity prototypes for key screens such as the dashboard, patient details, and alert systems.

T3: Frontend Framework Selection and Setup:

- ✓ Select appropriate frontend frameworks (e.g., React, Angular) for scalability and performance. Set up the development environment.

T4: Interface Development:

- ✓ Build and test core components: Real-time dashboard for displaying passenger health metrics (breathing, heart rate, video feeds). Emergency alert system. Patient history and status log.

Checkpoints:

1) Completion of user stories, UI/UX requirements, and wireframes (Month 7)
2) Finalized prototypes and development environment setup (Month 8)
3) Completion of core interface development (Month 9)

Work package 4 (III)

Deliverables:

1) Wireframes and high-fidelity prototypes (Month 7)
2) Functional, responsive frontend interface (Month 8)
3) Documentation for user workflows (Month 9)

Costs:

- **Frontend Developer:** €5,000/month x 2.1 months = €10,500
- **UX Designer:** €4,500/month x 0.7 months = €3,150
- **Project Manager:** €6,600/month x 0.4 months = €2,640

Total costs: €16,290

Work package 5 (I)

WP5	Title: System integration and testing Type: S.S.	Starting Month 9	Ending Month 12
Months/Man: 5,4			
Objectives: **This workpackage aims to e**nsure seamless integration of all system components, including sensors, microcontroller, cloud backend, and frontend interface. It also provides API specifications early in the project for alignment between frontend and backend development. Furthermore, it validates the performance, reliability, and usability of the system in real-world scenarios. Finally, detects and resolves system-level issues before deployment.			

Work package 5 (II)

Activities:

T1: API Design:

✓ Collaborate with backend and frontend teams to define API specifications. Share API documentation with development teams.

T2: Integration of System Components:

✓ Connect sensors, microcontroller, cloud backend, and frontend interface. Ensure proper communication between modules, including data flow and error handling.

T3: Unit and System Testing:

✓ Conduct individual tests on components such as sensors, microcontroller firmware, backend server, and frontend interface. Validate compliance with functional requirements. Perform end-to-end testing to ensure all components work together as intended. Test critical use cases, including emergency response triggers and data transmission reliability.

T4: Bug Fixes and Optimization

✓ Address issues identified during testing phases. Optimize system performance, including response times and resource utilization.

Checkpoints:

1) Completion of API design, with documentation (Month 9)
2) Completion of unit testing and system testing (Month 11)
3) Final system optimizations (Month 12)

Work package 5 (III)

Deliverables:

1) **API Documentation:** Completed API specifications and documentation. (Month 9)
2) **Integration Report:** Documentation of component integration and communication protocols (Month 10)
3) **Testing Results:** Reports from unit, system phases (Month 11)
4) **Final System Release:** Fully integrated and tested system ready for deployment (Month 12)

Costs:

- System Engineer: €5.000/month x 2,6 months = €13.000
- Project Manager: €6.600/month x 0,5 months = €3.300
- QA Tester: €4,500/month x 2.3 months = €10,350

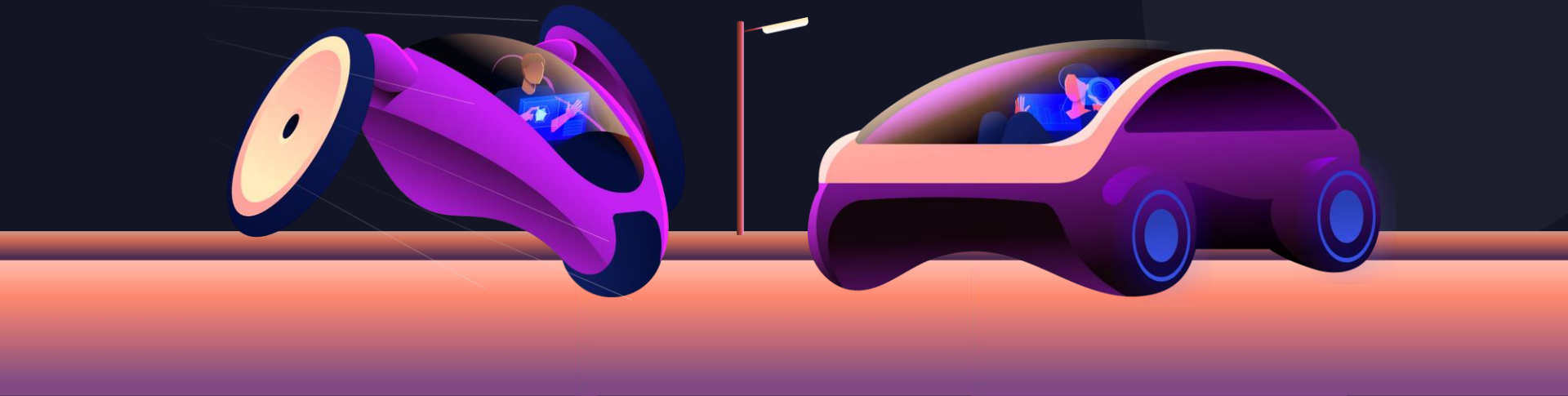
Total costs: € 26.650

Gaant Chart

	Activity	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
WP1	Initial Triage and vital sign evaluation												
	Injury identification and classification												
	Neurological and pain assessment												
	Documentation and coordination for transport												
WP2	Requirement definition and power constraint in medical environment.												
	Research of medical sensor and low power technologies.												
	Prototype evaluation and testing for medical use.												
WP3	Research and realize the Machine learning model												
	Implementation of microcontroller logic.												
	Database configuration												
	Implementation of Proxy Server												
WP4	UX requirement analysis.												
	Prototyping and wireframing												
	Frontend framework selection and setup												
	Interface development												
WP5	API design												
	Integration of system components												
	Unit and system testing												
	Bug fixing and optimization												

05

Risk Assesment



Internal and External Risks

Market Acceptance

Customers may not perceive the system as a priority, limiting adoption and overall sales.

Regulations and Privacy

Privacy laws and industry standards are subject to changes, and the system must continuously ensure compliance during these transitions.

Connectivity Interruptions

Dependence on cloud networks and communication infrastructure could compromise functionality in low-coverage areas.

Technological Obsolescence

The development of new, more advanced sensors or technologies could render our system outdated, reducing its competitiveness and long-term viability.

AI Maturity

The AI may produce false positives or negatives, affecting the quality and reliability of the service.

Internal and External Risks Solutions

Market Acceptance

Educate customers on life-saving benefits, partner with automakers for standard integration, and offer flexible pricing models to drive adoption.

Technological Obsolescence

Invest in continuous R&D, use a modular system design for easy upgrades, and collaborate with tech leaders to stay ahead of innovations.

Regulations and Privacy

Adopt a compliance framework to monitor regulatory changes, conduct regular audits, and ensure data security with encryption and anonymization.

Connectivity Interruptions

Utilize cellular and satellite networks to ensure reliable communication and system functionality, even in low-coverage areas.

AI Maturity

Continuously train AI with real-world data, integrate human validation for critical decisions, and monitor performance to improve accuracy.

Thanks!

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