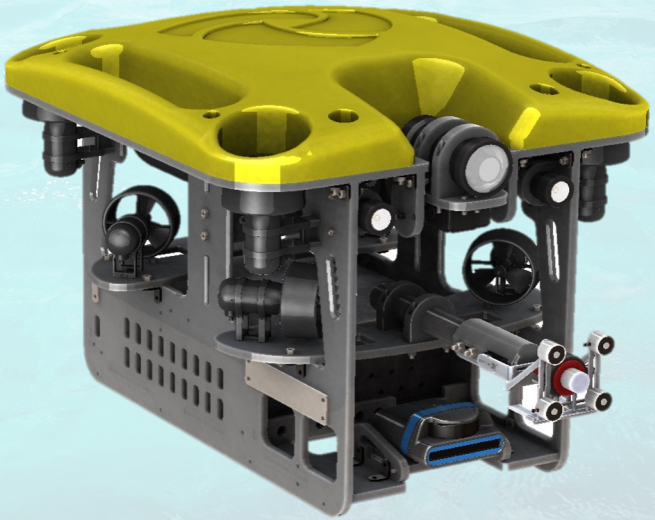
Mare Custos

2024

Final Year Internship Projects Book (PFE)



Get to know us

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Who we are

Mare Custos is a leader in underwater robotics, dedicated to advancing offshore inspection and marine exploration. With innovations like Seabot Y and Seabot X, we make underwater operations safer, more efficient, and environmentally responsible.

Our vision

We envision a future where underwater exploration and protection are seamless, powered by advanced robotics. Mare Custos is committed to setting industry standards in sustainable marine technology that benefits both people and the planet.

Our mission

Our mission is to provide reliable, eco-friendly underwater solutions that optimize offshore operations and contribute to ocean conservation. We strive to make a positive impact through technology that helps protect marine ecosystems.

Get to know us

Our team

Our team of engineers, scientists, and marine experts is united by a passion for innovation in marine technology. Together, we're dedicated to transforming underwater exploration and supporting sustainable practices across industries.

Our values

At Mare Custos, we are driven by values that prioritize innovation, integrity, and environmental responsibility. We believe in pushing boundaries to create technology that respects marine ecosystems and empowers our clients. Collaboration, sustainability, and excellence are at the core of every project we undertake, guiding our efforts to make the underwater world safer and more accessible for all.

Mechanical Engineering

Design and Development of a Mini ROV Crawler

Keywords: Mini ROV, underwater robotics, waterproof design, corrosion resistance, modular systems

Summary: Design a modular mini ROV (Remotely Operated Vehicle) crawler capable of moving in different directions with enhanced maneuverability and robustness suitable for underwater operations.

Required skills:

- Proficiency in hydrodynamics
- Knowledge in material science
- Skills in CAD modeling ,structural and CFD simulation tools
- knowledge of static and dynamic sealing techniques

Key tasks:

- Design the ROV's structural frame and waterproof housings
- Study the implementation of omni wheels in the crawler to assure best maneuverability with minimal actuators.
- Implement effective sealing solutions for electronic enclosures and actuators.
- Integrate sensors and control systems for optimal functionality
- Conduct buoyancy and movement simulations
- Prepare Manif files of the product
- Render the final proposed solution

Expected outcome: A fully developed 3D design and 2D drawings of a modular mini ROV crawler capable of executing diverse underwater tasks.

Specialized fields: Mechanical Engineering, Electromechanical Engineering,Mechatronics Engineering

Study and Design of a Test Bench for Underwater Thrust Characterization of Seabot-1 ROV

Keywords: Thrust measurement, underwater testing, data acquisition, fluid dynamics

Summary: Study and design a test bench to accurately measure the thrust of ROVs in different directions.

Required skills:

- Knowledge in Fluid mechanics and hydrodynamics
- Mastery of structural design
- Knowledge of data acquisition and processing methodologies

Key responsibilities:

- Design a robust thrust measurement platform
- Integrate high-precision sensors for data capture
- Develop protocols for data analysis and interpretation

Expected outcome:

A reliable and efficient test bench for evaluating underwater thrust performance in ROV systems.

Specialized fields: Mechanical Engineering

Design and Sizing of an Underwater Thruster

Keywords: Underwater thruster, ROV propulsion, hydrodynamic efficiency, material durability, propeller design

Summary: This project focuses on designing and optimizing an underwater thruster to ensure high performance and reliability for ROV applications.

Required expertise:

- Knowledge of fluid dynamics and hydrodynamic optimization
- Skills in CAD modeling and CFD simulation tools
- Skills in reverse engineering
- Mastery of mechanical and electrical systems integration
- Knowledge of static and dynamic sealing techniques

Key responsibilities:

- Analyze thrust requirements and motor specifications
- Design efficient propellers
- Implement effective sealing solutions
- Prepare 2D drawings
- Render the final proposed solution
- Prototype and test the thruster performance

Expected outcome:

A durable, high-efficiency underwater thruster optimized for ROVs.

Specialized fields:

Mechanical Engineering, Electromechanical Engineering,Mechatronics Engineering,

Design and Development of a Subsea 4-DOF Robotic Arm Prototype

Keywords: Robotic arm, 4-DOF, underwater manipulation, IMU control, structural analysis

Summary: Develop a subsea robotic arm with four degrees of freedom (4-DOF) using IMU-based control for precision tasks underwater.

Required expertise:

- Mastery in CAD and FEA softwares
- Knowledge of kinematics and control systems
- Knowledge of static and dynamic sealing techniques

Key responsibilities:

- Select technical solutions for different DOF of the arm.
- Size transmissions and actuators
- Model components using CAD
- Conduct FEA for optimisation and validation
- Select and integrate actuators and IMUs
- Prepare manufacturing files
- Render the final proposed solution
- Prototype and test the arm

Expected outcome:

A 4-DOF robotic arm prototype capable of precise underwater manipulation.

Specialized fields: Mechanical Engineering, Electromechanical Engineering,Mechatronics Engineering

Study, Design, and Development of a Modular Docking System for ROVs and Payloads

Keywords: Docking system, ROV payload, underwater stability, modular integration

Summary: Design a docking system to securely attach and detach our payloads and ROV on and from subsea platforms.

Required expertise:

- Knowledge of hydrodynamics
- Knowledge of vacuum generation techniques
- Familiarity with pumps, suction cups and electromagnets

Key responsibilities:

- Study and select the most suitable docking technique for underwater applications (electromagnets, electrical suction cup…)
- Calculation of the necessary docking force to resist specific underwater conditions.
- Material and shape optimization to adjust the docking system to subsea platforms (curved surfaces, marine growth …)

Expected outcome:

A reliable docking system for ROV and payloads to facilitate underwater operations and accurate measurements.

Specialized fields: Mechanical Engineering

Study, Design, and Development of a New Subsea Cleaning Solution for ROVs

Keywords: Marine cleaning, biofouling removal, underwater maintenance

Summary: Study and design of a new subsea ROV cleaning solution to efficiently remove marine growth from underwater structures to prepare them for inspection.

Required expertise:

- Mastery of transmission mechanism design
- Knowledge of material science
- Skills in CAD modeling and simulation tools
- Knowledge of static and dynamic sealing techniques

Key responsibilities:

- Study and select the most suitable cleaning solution for our ROV
- Develop a compact and reliable design of the selected solution
- assure the reliability of different components using FEA method softwares
- Choose the suitable actuators and assure they are properly sealed to work at the required depth
- Prepare manufacturing files
- Render the final proposed solution
- Test the developed solution

Expected outcome:

A reliable prototype of a subsea cleaning solution for marine growth removal.

Specialized fields: Mechanical Engineering

Design and Development of a Modular Subsea Electric Linear Actuator

Keywords: Linear electric actuator, control system integration, material durability, underwater applications

Summary: Design an electric linear actuator aimed for subsea applications, emphasizing precision and resistance to harsh conditions.

Required expertise:

- Mastery of transmission mechanism design
- Skills in CAD modeling and simulation tools
- Knowledge of material science
- Knowledge of static and dynamic sealing techniques
- Familiarity with electric motors and control systems integration

Key responsibilities:

- Study and choose the accurate technical solution for linear movement
- Size transmissions and actuators
- Integrate control electronics
- Properly seals the actuators and sensors
- Prepare manufacturing files
- Render the final proposed solution
- Test the developed solution

Expected outcome:

A reliable depth proof electric linear actuator for subsea applications

Specialized fields: Mechanical Engineering

Design and Development of a Deep Sea Pressure Test Chamber

Keywords: Subsea simulation, high-pressure testing, pressure vessel design, fluid dynamics

Summary: Develop a deep sea pressure test chamber to test the reliability of our products (Enclosures , waterproof housing,thrusters...) thrusters at different depths by exposing them to similar pressure.

Required expertise:

- Knowledge in Fluid mechanics and hydrodynamics
- Skills in CAD modeling and simulation tools
- Mastery of structural design
- Knowledge of data acquisition and processing methodologies
- Knowledge of sealing techniques

Key responsibilities:

- Design and implementation of a high-pressure chamber
- Integrate sensors for monitoring conditions
- Develop testing protocols for accurate evaluation

Expected outcome:

A functional and secure pressure chamber to test our products at different depths.

Specialized fields: Mechanical Engineering

Linux Development Projects

Update Flow for Single Board Computers

Summary: Develop, integrate, and test an automated update flow using the apt package manager for single-board computers (SBCs). This ensures that deployed systems can be maintained remotely, minimizing manual intervention.

Required expertise:

- **Languages/Technologies:** Bash, SSH, apt package manager, Linux
- **Tools:** VPN, version control (Git), shell scripting

Key responsibilities:

- Develop scripts for package updates, including handling dependencies.
- Set up a secure remote update mechanism via SSH.
- Test the update flow in a production-like environment for reliability.
- Handle version control and rollback scenarios in case of faulty updates.

Expected outcome:

A fully tested update flow that can be integrated into mass production systems for SBCs, with detailed documentation.

ROS 2 Based Arm Simulation (4 Degrees of Freedom) with IMU-based Control

Summary: Create a ROS 2 simulation of a robotic arm with 4 degrees of freedom (DOF), allowing users to simulate motion and test control algorithms. Extend the simulation to integrate IMU-based control for real-time adjustments based on sensor data.

Required expertise:

- **Languages/Technologies:** Python, C++, ROS 2, Gazebo, RViz, IMU (Inertial Measurement Unit), TF library
- **Tools:** ROS 2 packages, simulation tools like Gazebo, RViz for visualization

Key responsibilities:

- Set up a ROS 2 environment and create a package for the robotic arm.
- Simulate arm movement using predefined trajectories.
- Integrate an IMU sensor for real-time feedback and control.
- Implement a control node for real-time interaction with the simulation and IMU feedback.
- Test and refine control algorithms based on the simulation results.

Expected outcome:

A functional 4 DOF robotic arm simulation with IMU-based control, including tested control algorithms and a complete ROS 2 package.

Linux Software Deployment and Testing for Mass Production

Summary: Develop and test a system for deploying, configuring, and testing software on Linux boards, targeted for mass production environments

Required expertise:

- **Languages/Technologies:** Bash, Python, Ansible, Docker, Git
- **Tools:** CI/CD (Jenkins, GitLab CI), configuration management tools (Ansible, Chef), Docker

Key responsibilities:

- Design a deployment flow that includes software installation, configuration, and testing on each board.
- Automate configuration management and testing for seamless mass production.
- Develop a testing environment that simulates real-world usage.
- Implement logging and error tracking to handle failures during the production process.

Expected outcome:

A fully automated system for deploying and testing Linux software across multiple boards, with minimal human intervention.

NDT Projects

Software Architecture Design for NDT Modules

Summary: Design a software architecture to handle multiple Non-Destructive Testing (NDT) modules, ensuring seamless data acquisition, processing, and reporting.

Required expertise:

- **Languages/Technologies:** Python, C++, RESTful APIs, RS232, RS485, MongoDB
- **Tools:** API development tools (FastAPI, Flask), MongoDB, communication protocols (RS232/RS485)

Key responsibilities:

- Define the overall architecture for handling multiple NDT modules.
- Specify communication protocols for interfacing with hardware probes.
- Design APIs for data acquisition, real-time processing, and reporting.
- Create detailed system flow diagrams and technical specifications.

Expected outcome:

Architectural diagrams, API specifications, and a complete technical document outlining the software architecture for NDT systems.

Ultrasonic Testing (UT) Module Development

Summary: Develop a UT module to acquire, process, and visualize ultrasonic signals in real time, focusing on A-scan data and thickness measurement.

Required expertise:

- **Languages/Technologies:** Python, C++, Qt, MongoDB, DSP (Digital Signal Processing)
- **Tools:** Signal acquisition hardware, Qt for GUI development, MongoDB for data storage

Key responsibilities:

- Build the UT module to capture ultrasonic signals.
- Implement real-time signal processing algorithms to interpret A-scan data.
- Develop a GUI for displaying real-time ultrasonic data, including thickness measurements.
- Test the module with different materials and thicknesses for accuracy.

Expected outcome:

A functional UT module capable of acquiring, processing, and visualizing ultrasonic signals, with a user-friendly interface for real-time monitoring.

Flooded Member Detection (FMD) Module Development

Summary: Develop an FMD module for detecting flooded members in offshore structures using ultrasonic waveform data, with real-time processing and reporting capabilities.

Required expertise:

- **Languages/Technologies:** Python, C++, RS232, RS485, MongoDB, Qt
- **Tools:** Communication protocols (RS232/RS485), waveform processing algorithms, MongoDB for data storage

Key responsibilities:

- Acquire waveform data from the FMD probe using serial commands like WFGRAB?.
- Process waveform data to detect flooded members based on predefined criteria.
- Implement a reporting tool to export results to PDF or Excel.
- Test the module in real-world scenarios to ensure reliability.

Expected outcome:

A complete FMD module with real-time detection capabilities and automated report generation, ready for deployment.

NDT Method Integration

Summary: Integrate various NDT methods (UT, FMD, Eddy Current Testing) into a unified software system, with a centralized interface for operators and centralized logging of all inspection data.

Required expertise:

- **Languages/Technologies:** Python, C++, MongoDB, Qt, RESTful APIs
- **Tools:** MongoDB for centralized data logging, Qt for UI/UX, API development tools (FastAPI, Flask)

Key responsibilities:

- Integrate the UT and FMD modules with additional NDT methods (e.g., Eddy Current Testing).
- Design a unified dashboard for switching between methods and viewing results.
- Implement centralized logging to store inspection data from all methods in a unified format.
- Test the system to ensure smooth transitions between methods and accurate logging.

Expected outcome:

A unified NDT software system with support for multiple inspection methods, real-time monitoring, and centralized data logging for operator convenience.

Eddy Current Testing (ECT) Module Development

Summary: Develop a real-time Eddy Current Testing (ECT) module to detect surface cracks or corrosion in conductive materials, with real-time signal processing and visualization.

Required expertise:

- **Languages/Technologies:** Python, C++, Qt, MongoDB, DSP (Digital Signal Processing)
- **Tools:** Signal acquisition hardware, Qt for GUI development, MongoDB for data storage

Key responsibilities:

- Develop a module to acquire and process ECT signals in real-time.
- Implement signal processing algorithms to detect surface anomalies.
- Create a GUI for real-time ECT data visualization, highlighting cracks or corrosion.
- Test the module on a range of conductive materials to ensure accuracy.

Expected outcome:

A fully functional ECT module that can detect and visualize surface defects in real-time, providing critical feedback for material integrity assessments.

Thermal Imaging Inspection for NDT

Summary: Develop a thermal imaging module for non-destructive testing that captures heat patterns and identifies irregularities in materials, such as delamination or poor bonding in composites.

Required expertise:

- **Languages/Technologies:** Python, C++, OpenCV, Qt, MongoDB
- **Tools:** Infrared cameras, OpenCV for image processing, Qt for real-time GUI, MongoDB for data storage

Key responsibilities:

- Integrate a thermal imaging camera with an embedded Linux system.
- Develop image processing algorithms to identify irregular heat patterns that may indicate defects.
- Implement a user interface for real-time monitoring and analysis of thermal data.
- Generate reports based on thermal inspection results.

Expected outcome:

A thermal imaging module capable of detecting and visualizing heat irregularities in materials, providing operators with real-time insights into material integrity.

AI-Powered Defect Detection in NDT

Summary: Develop an AI-based module for automatic defect detection using machine learning algorithms applied to NDT data, such as ultrasonic or eddy current data.

Required expertise:

- **Languages/Technologies:** Python, C++, TensorFlow, PyTorch, MongoDB
- **Tools:** AI/ML frameworks (TensorFlow, PyTorch), MongoDB for data storage, NDT data acquisition tools

Key responsibilities:

- Collect labeled NDT data (ultrasonic, eddy current, etc.) for training an AI model.
- Train and validate a machine learning model to detect anomalies (e.g., cracks, corrosion) in NDT data.
- Implement the AI model into an NDT software module, allowing for real-time analysis and feedback.
- Test the system in various conditions to ensure robustness.

Expected outcome:

An AI-powered defect detection module capable of analyzing NDT data in real-time, with high accuracy in identifying material defects and reporting the results.

Remote NDT System Using IoT for Pipeline Inspection

Summary: Develop a remote NDT inspection system using IoT technology to monitor pipelines or offshore structures, allowing for real-time data collection and analysis from remote locations.

Required expertise:

- **Languages/Technologies:** Python, C++, MQTT, MongoDB
- **Tools:** IoT frameworks (MQTT), MongoDB for data storage, communication systems (LoRa, NB-IoT)

Key responsibilities:

- Integrate NDT sensors with an IoT platform to enable remote data collection.
- Develop a communication system to transmit inspection data from remote locations.
- Implement a central dashboard to visualize and analyze incoming NDT data in real-time.
- Ensure the system is robust and capable of operating in harsh environments (e.g., offshore platforms).

Expected outcome:

A remote NDT inspection system that allows real-time monitoring of pipelines or structures, significantly reducing the need for manual inspections.

Automated Report Generation and Analysis for NDT Inspections

Summary: Develop an automated system for generating inspection reports from NDT data, with analysis and recommendations included based on the results.

Required expertise:

- **Languages/Technologies:** Python, openpyxl, ReportLab, MongoDB
- **Tools:** MongoDB for data storage, ReportLab for PDF generation, openpyxl for Excel export

Key responsibilities:

- Develop algorithms to analyze NDT data and automatically generate conclusions (e.g., defect detection).
- Create a reporting tool that exports results into professional PDF or Excel reports.
- Implement custom templates for different inspection types (e.g., UT, ECT, FMD).
- Test the report generation system to ensure accuracy and usability.

Expected outcome:

An automated report generation system that analyzes NDT data, generates comprehensive reports, and provides recommendations based on the inspection results.

Mare Custos

Interested?

Send your applications with to:

Mechanical Engineering: omar.zouch@mare-cutos.com
Other topics: aymen.rachdi@mare-custos.com

IMPORTANT: Please include the project's reference in the email subject otherwise your application will be rejected.