Mechatronics 4CCE1MCP Group Project

Remote Control Design, Build & Test of a Ship for Environmental Clean-up

Module Instructors

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In this document, you are provided with information to complete the group project assessment for the course. This extended project will be an opportunity to design, build and test the ship and collection system in the laboratory.

Deadlines

Demonstration day: Week 32, Mar 29, 31, 2022 (timetabled)

Final Report: Week 32, Apr 4, 2022 (16:00)

Brief

You have been tasked to design, build, and test a proof-of-concept prototype for a ship system that can collect floating debris.

You are responsible for:

- designing and building a ship;
- designing and building a collection system that gathers floating objects in the provided scenario;
- testing the effectiveness of your design through simulation and experiments;
- producing a technical report and video presentation with a complete set of design specifications, analysis and engineering drawings;
- submitting a version of your design for assessment;
- competing for the quickest clean-up time for the provided scenario.

Scenario

The ship will need to collect nine spherical floating objects of 20 mm in diameter. Collection is defined as storing the floating debris in a recipient so that it is not allowed to be released back into the environment.

The floating objects will be randomly dispersed in a tank that is 1.2 by 1.2 m^2 in area and 250 mm in water depth. You will have 10 min to demonstrate the effectiveness of your design.

Expected design components

Your ship system is expected to have the following components:

- a ship that can float in a stable configuration and adequately manoeuvre in a water tank
- a propulsion mechanism for the ship, *e.g.* DC motor with gearbox and / or propeller drivetrain;
- as steering mechanism for the ship, *e.g.* a rudder or a two-propeller system;
- a debris collection system, *e.g.* net, basket or gripper;
- a remote control for teleoperation.

Refer to the *Final demonstration day* section for specific assessment criteria.

Deliverables

- a working prototype of the ship for the demo day;
- a video log of the design, build and test. The video should be a maximum of 5 minutes long;
- a final report presenting your project for review.

Learning objectives

- Design a system by using a combination of modelling and experimentation.
- Produce a CAD model of the ship to instruct for manufacture.
- Choose appropriate materials and methods for manufacture.
- Deploy a control system to embedded hardware.
- Implement a robust remote-control solution for a real-time system
- Work effectively as an independent contributor of an engineering team
- Deliver a project within a tight set of deadlines and requirements
- Communicate effectively with sub-teams from different domains using requirements, system specifications and a testing framework.

Marking Criteria

Group project work accounts for 65% of module grade. Assessment will be staged in three sessions, which include:

- Video log, 10%
- Final demonstration, 25%
- Final report, 30%

Overall marking Criteria

Marks will be awarded to groups based on their merits in six core learning areas;

Area	Actions
Science & Mathematics	Justify design approach Interpret design performance using mathematical and statistical techniques Critique choice for component characteristics and technology
Engineering Analysis	Apply engineering tools to solve the design task Conduct critical analysis to identify, classify and describe system performance compared to benchmark Adopt systems approach to improve on design Extract and evaluate pertinent data to solve unfamiliar problems
Engineering Design	Evaluate user needs and requirements Identify and work with design constraints and unknowns Communicate to a technical audience Deliver efficient, effective and robust design
Engineering Context	Identify and mitigate areas of risk Appreciate the environmental and social context for the engineering project
Engineering Practice	Demonstrate design effectiveness in the context in which the system is applied Work effectively as an independent member of an engineering team
Additional General skills	Demonstrate effectiveness, clarity and originality of communication

Final demonstration day

Marks awarded on pass / fail basis for the following requirements. This rubric has been developed for easy and objective marking on the demonstration day, and to encourage you to deliver a functioning system.

Total marks 100 to scale to 25% of module grade

Marks	Requirement	Pass or Fail
Total 20	**Project & Systems**	
5	Group attends session and project ready for demonstration	
5	Ship system successfully collects at least one object in allocated time	
5	Ship system successfully collects at least three objects in allocated time	
5	Ship system successfully collects all objects in allocated time	
Total 20	**Ship design & manufacture**	
5	Ship is intact / does not miss components	
5	Ship floats	
5	Ship is stable	
5	Electronic components safe from splashing or water ingress	
Total 20	**Control & Communication System**	
5	Ship can move forward	
5	Ship can steer	
5	Remote control works	
5	Ship can approach floating objects	
Total 20	**Mechatronics**	
5	Ship propellers spin	
5	Propulsion system drives ship	
5	Collector system catches objects	
5	Collector system keeps collected objects	
Total 20	**Competition**	
	Marks awarded as a distribution of performance with respect to other teams*	

**Performance will be marked with respect to the number of objects collected in the allocated collection time (max 10 minutes). If all objects are collected, the quickest time of collection will be considered to rank performances.*

Video log Marking Scheme

Take this opportunity to share your design. The video log submission must be of less than 5 minutes in length.

Total marks 10

Area	Actions	Marks
Engineering Design **(3 marks)**	Communicate to a technical audience	• Use appropriate technical language to describe design, **3 marks**
Engineering Practice **(3 marks)**	Demonstrate design effectiveness in the context in which the system is applied	• Demonstrate how the ship works, **3 marks**
Additional General skills **(4 marks)**	Demonstrate effectiveness, clarity and originality of communication	• Use media and graphics effectively to communicate your design, **2 marks** • Clear and concise voiceover, **1 mark** • Original presentation, **1 mark**

Final Report Criteria

You are expected to produce an 8-page report (excluding figures, appendices and technical drawings) to present your final design & build for review.

The submission of the report is the responsibility of the project manager. Each sub-team is expected to work on an individual section of the report.

The report must include the following sections:

Contributor	Title	Length
Project Manager, System Architect & Quality Control	*Scope of report and list of deliverables*	max ½ page
	System Architecture & Quality Control Process	max ½ page
Ship Design & Build	*Ship Hull Design & Analysis*	max ½ page
	Ship Manufacturing & Build	max ½ page
Mechanical Engineer, Control Engineer, Quality Engineer	*Ship Collector Design & Analysis*	max 1 page
Propulsion Engineer, Control Engineer	*Ship Propulsion & Steering Design & Analysis*	max 1 page
Communication, Control Engineer, Quality Engineer	*Remote Control System Design & analysis*	max 1 page
Led by System Architect, All	*Reflection on new technology development and implications for Oceanic Clean-up*	max ½ page
Led by PM, All	*Reflection on group project delivery and new lessons learnt*	max ½ page

Suggested figures and appendix items

- Project timeline
- List of requirements
- List of tests
- Technical drawing of ship hull
- Technical drawing of ship drivetrain
- Technical drawing of ship collector
- Step by step instructions on how to build for reproducibility
- Model diagram for control system, e.g. Simulink model
- Communication diagram

Detailed Final Report Mark scheme

Total marks 100 to scale to 30% of module grade

Area	Actions	Marks
Science & Mathematics (20 marks) *Mark based on sub-team performance*	Justify design approach Interpret design performance using mathematical and statistical techniques Critique choice for actuator and sensor characteristics and technology	*Project Management & System Engineering Team* • Provide evidence of project delivery and well-defined project management strategies (milestones and deliverables), **5 marks** • Implement a system architecture and justify the choice of components, **5 marks** • Provide evidence of quality control process (tests & verification), **5 marks** • Demonstrate one-to-one mapping between tests and requirements, *e.g.* using a table or diagram, **5 marks** *Ship Design & Build Team* • Inform design decisions from a model of ship dynamics, **4 marks** • Perform flotation analysis to specify ship payload, **4 marks** • Discuss design measures to ensure ship stability about the heel and trim, **4 marks** • Design ship hull and other floating systems to reduce drag, **3 marks** • Appropriate choice of materials and manufacturing methods, **5 marks** *Control & Communication Team* • Implement an appropriate controller for ship motion and steering, **7 marks** • Deploy control system to hardware and comment on fixed rate performance, **3 marks** • Implement and present a communication network diagram, **2 marks** • Implement and present the design of a remote controller, **4 marks** • Discuss how you designed the communication system to robustly handle issues of latency and quality of service, **4 marks** *Mechatronics Team* • Design an appropriate load transfer mechanism between the motor shaft(s) and the propeller(s) and demonstrate how your design was informed by models and experimentation**, 6 marks**

		• Design an appropriate steering mechanism and demonstrate how your design was informed by models and experimentation, **7 marks** • Design an appropriate collector system and demonstrate how your design was informed by models and experimentation, **7 marks**
Engineering Analysis (20 marks) *Mark based on sub-team performance*	Apply engineering tools to solve the design task Conduct critical analysis to identify, classify and describe system performance compared to benchmark Adopt systems approach to improve on design Extract and evaluate pertinent data to solve unfamiliar problems	*Project Management & System Engineering Team* • Provide a system architecture diagram, **4 marks** • Analyse performance of team using qualitative and quantitative means, **4 marks** • Provide requirements (in appendix) passed on to design teams, **4 marks** • Implement appropriate testing framework to measure ship performance, **4 marks** • Run and report tests run on ship, **4 marks** *Ship Design & Build Team* • Report on technical drawings and models for the ship, **4 marks** • Demonstrate performance improvements compared to a benchmark initial prototype, **4 marks** • Demonstrate attempts to optimise system-level performance through modelling and experimentation, **4 marks** • Provide images of build to demonstrate appropriate use of manufacturing technology for build and joints, **4 marks** *Control & Communication Team* • Define a benchmark or target performance, **4 marks** • Demonstrate attempts of improving control performance relative to an initial prototype through appropriate tuning methods, **4 marks** • Demonstrate attempts of improving communication performance relative to an initial prototype, **4 marks** *Mechatronics Team* • Report on technical drawings and models for the drivetrain, steering mechanism and collector, **4 marks**

		• Reference data to justify design, **4 marks** • Consider weight and thrust of components used, **4 marks** • Provide evidence of data collection & analysis from ship build and test, **4 marks**
Engineering Design (20 marks) *Mark based on team performance*	Evaluate user needs and requirements Identify and work with design constraints and unknowns Communicate to a technical audience Deliver efficient, effective and robust design	• Identify and evaluate trade-offs for ship weight and propulsion, **8 marks** • Identify and evaluate trade-offs for collector system, **5 marks** • Use appropriate technical language and engineering schematics to communicate design, **3 marks** • Demonstrate attempts at optimising system performance using physical intuition, **2 marks** • Demonstrate Attempts to improve mechanical parameters for design, **2 marks**
Engineering Context (18 marks) *Mark based on team performance*	Identify and mitigate areas of risk Appreciate the environmental and social context for the engineering project	• Identify risk of sinking and demonstrate a risk mitigation strategy, **2 marks** • Identify risk of cap sizing and demonstrate a risk mitigation strategy, **2 marks** • Identify risk of water ingress and demonstrate a risk mitigation strategy, **2 marks** • Identify risk of poor manoeuvrability and demonstrate a risk mitigation strategy, **2 marks** • Identify risk of communication failure and demonstrate a risk mitigation strategy, **2 marks** • Acknowledge weight of components and attempt to minimise cost**, 2 marks** • Discuss implications of new technology development to Oceanic clean-up, **6 marks**
Engineering Practice (12 marks) *Mark based on team performance*	Demonstrate design effectiveness in the context in which the system is applied Work effectively as an independent member of an engineering team	• Address requirements provided in brief and by systems engineer, **2 mark** • Report on system-level performance test(s) from hardware implementation, **5 marks** • List key design parameters using a table or engineering drawing, **3 marks** • Demonstrate attempts of system integration and optimisation across sub-team domains, **2 marks**

Additional General skills (10 marks) *Mark based on team performance*	Demonstrate effectiveness, clarity and originality of communication	• Report within eight pages and with less than 20 **grammatical errors, 5 marks** • Provide high quality schematics (diagrams, plots, or equivalent) to support your arguments, **5 marks**