Natural, Mathematical & Physical Sciences

17/1/2022

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4CCE1MCP: Design, Making a Connection

Week 22

Introduction to MCP

Image Source: The Ocean Clean-up

Learning Outcomes

- Explain the context, challenges and technologies involved in environmental clean-up for marine debris
- Explain how engineering design & autonomy can support technological solutions to major global challenges
- List the deliverables and dates required to successfully complete the module
- List the activities that will support skill development for the module
- Assign team roles & responsibilities for group work

Agenda

Making a Connection Project Theme

- Environmental Restoration
- Autonomous Systems Design

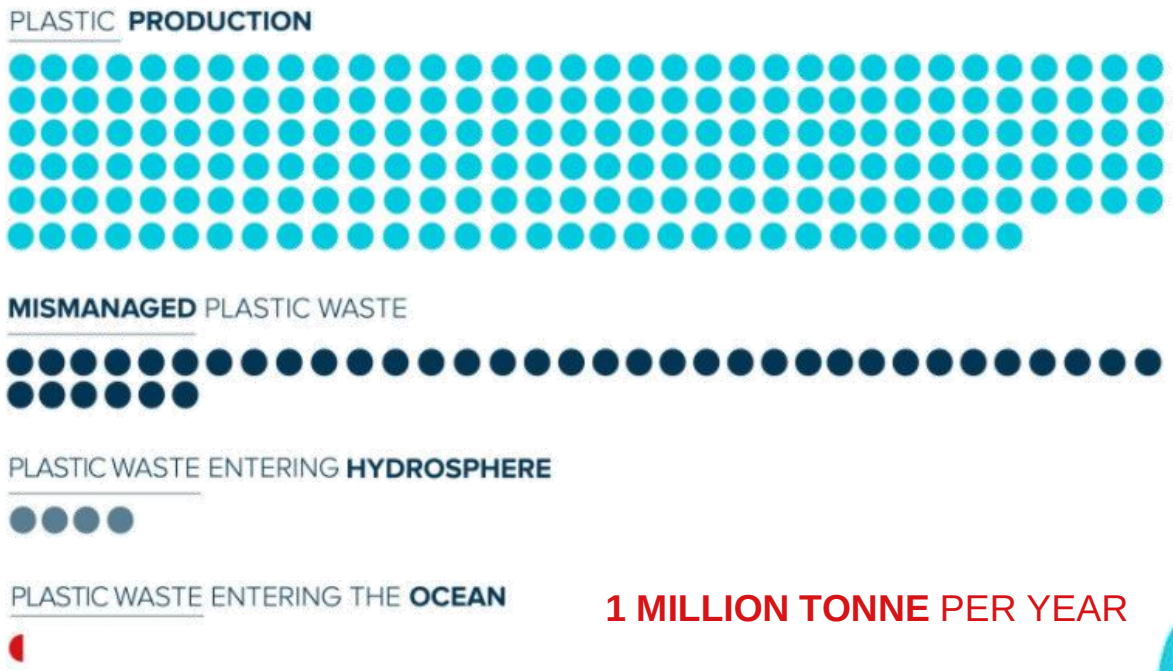
Assessment

- Individual Coursework
- Group Coursework

Organisation & Housekeeping

- Lectures
- Computer Laboratories
- Workshops
- Groupwork

Plastic Pollution

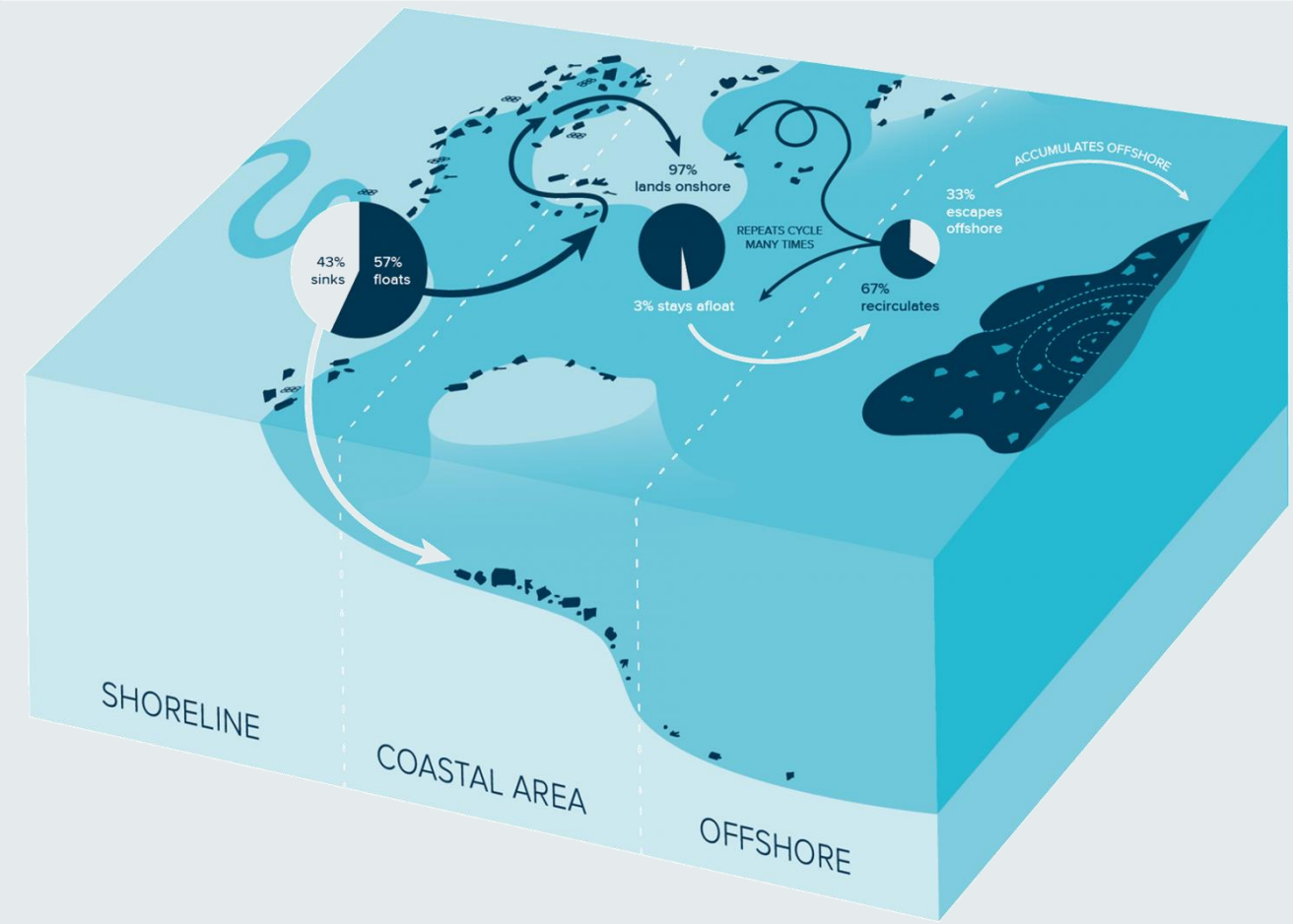


400 MILLION TONNES PER YEAR

1 MILLION TONNE PER YEAR

Image Source: The Ocean Clean-up

Marine Debris



Plastic waste accumulates in rivers and gets dispersed into the sea

Several **adverse environmental impacts**

- floating debris that collects on beaches
- plastic consumed by marine wildlife
- waste deposits on ocean floor

Image Source: The Ocean Clean-up

Waste Management Hierarchies vs. Environmental Restoration

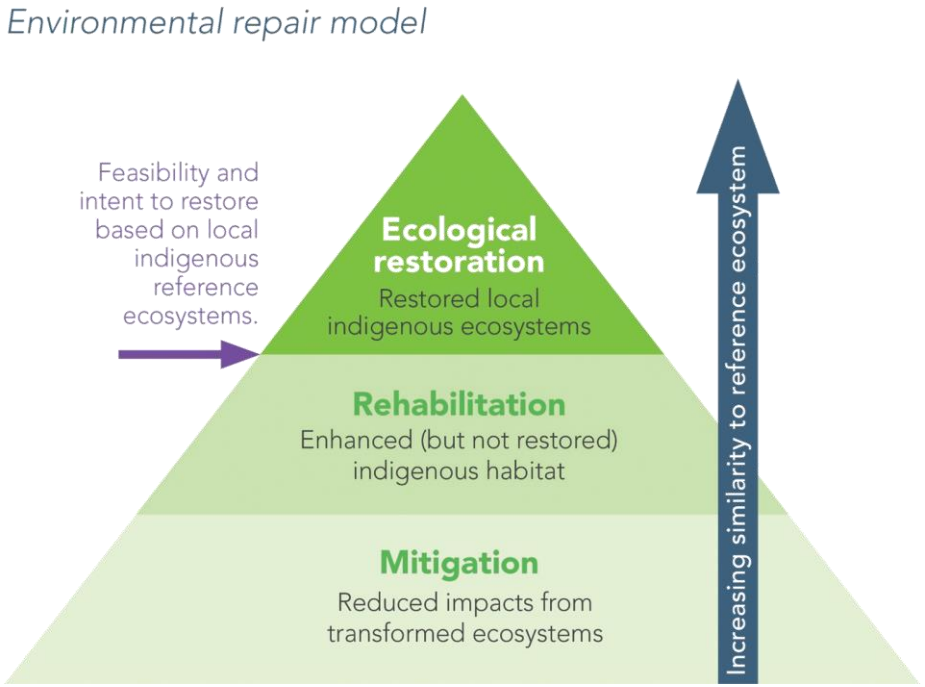


Image Sources: EU Waste Framework Directive left, McDonald et al. (2016) right

Clean-up Impact

Combining **waste management** and **restoration** strategies is becoming increasingly important for the future **health** of the planet

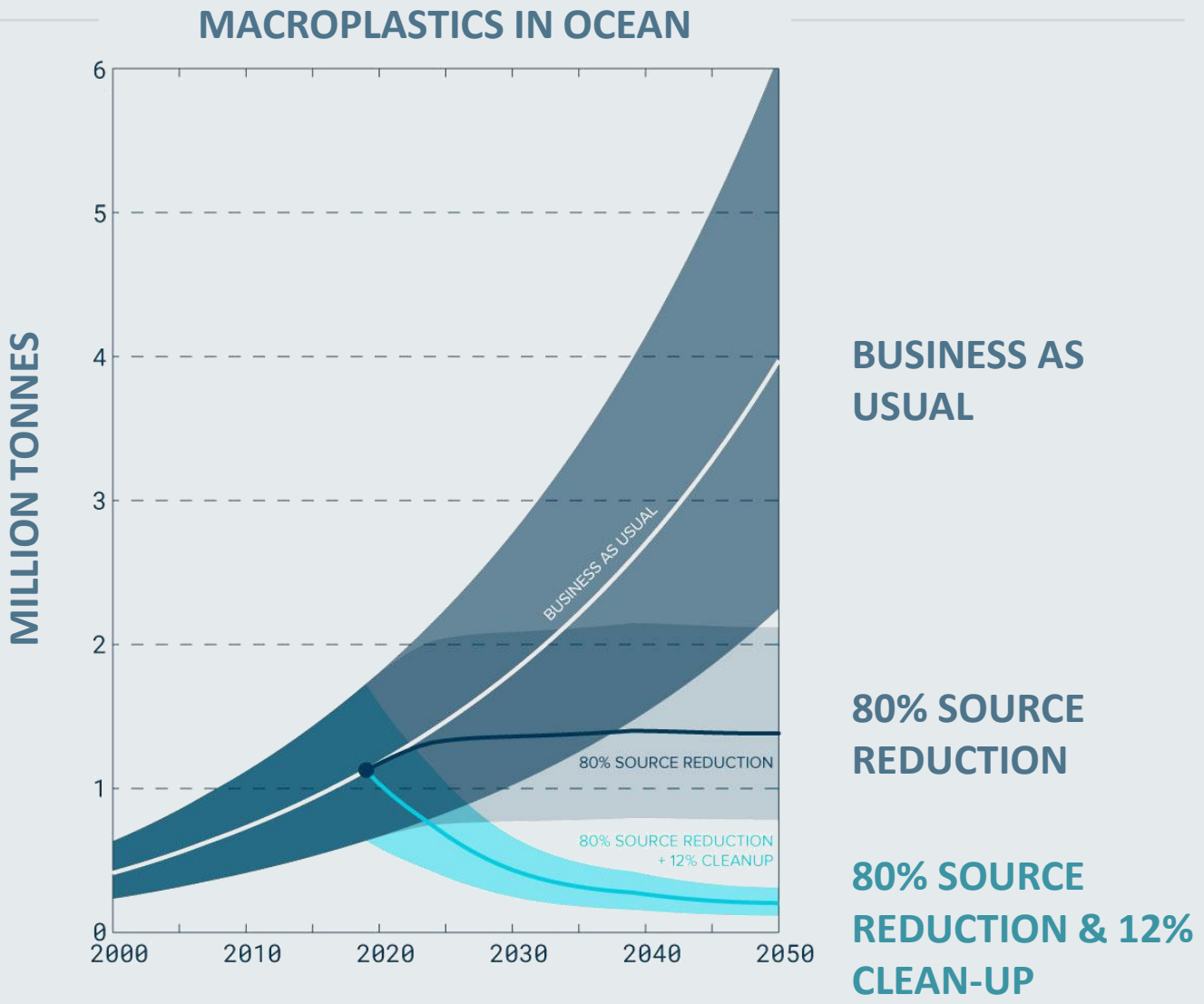


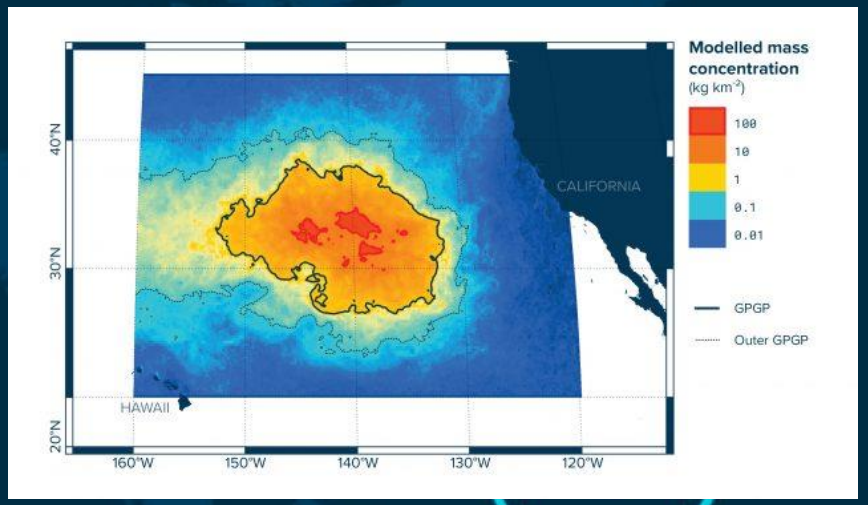
Image Source: The Ocean Clean-up

Technology Solutions for Restoration - Rivers

e.g. systems to collect and sort floating waste from river deltas

Image Source: The Ocean Clean-up

Technology Solutions for Restoration – Oceanic Garbage Patches



1

3

4

e.g. systems to collect and sort floating waste from oceanic gyres

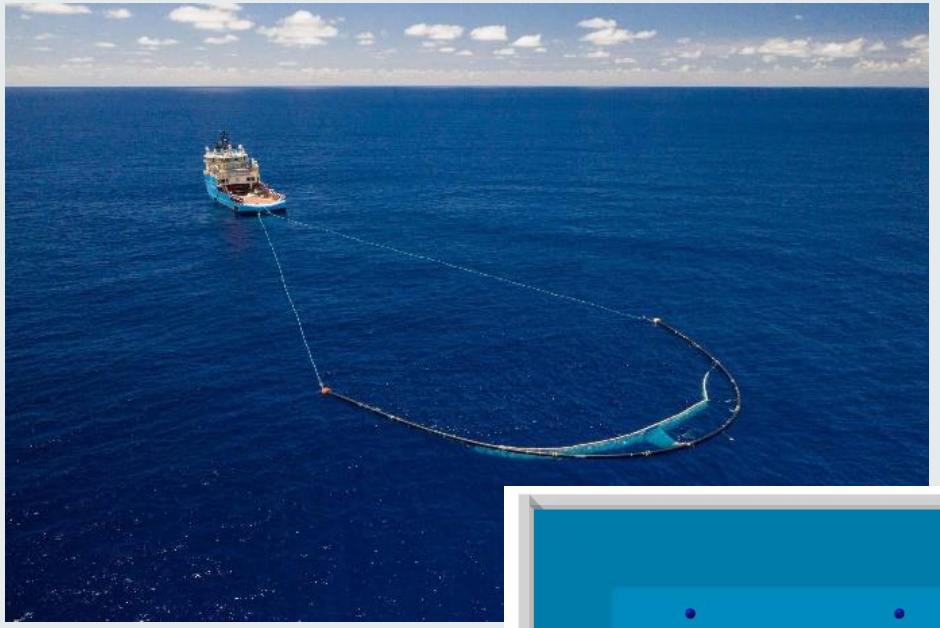
Image Source: The Ocean Clean-up

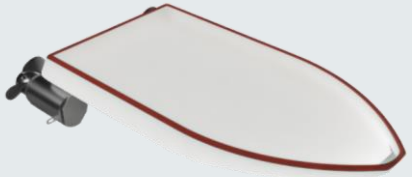
Autonomy in Environmental Restoration

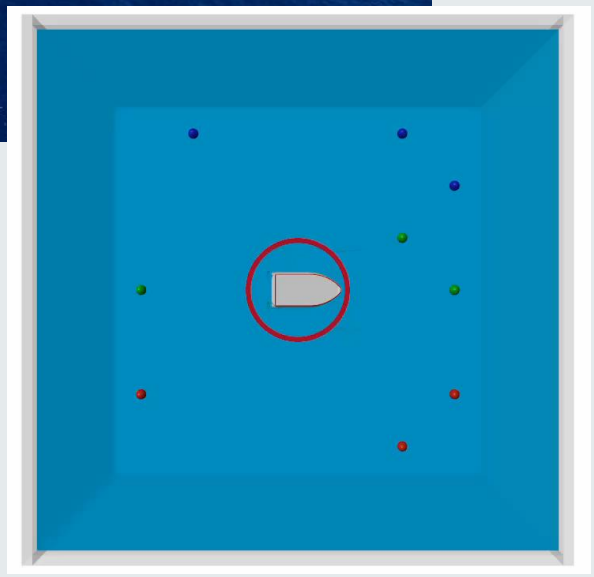
Autonomous Systems can replace humans for **dangerous**, **dirty**, **dull** and **difficult** tasks

Image Source: HangarTech (2018)

Marine Debris Collection Project







In MCP, you will design strategies to **collect floating debris with a ship**

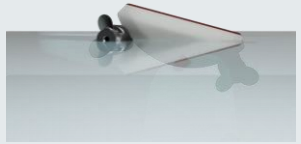
You will learn about

- System-level Design
- Project Management
- Design, Manufacturing & Testing
- Physical Computing, Mechatronics & Mechanisms
- Autonomous Control Design
- Communication Systems

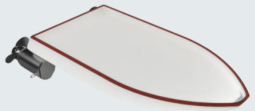
Image Source: The Ocean Clean-up

Model-based Design

Requirements

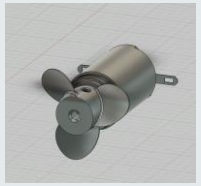


System
Integration & Test

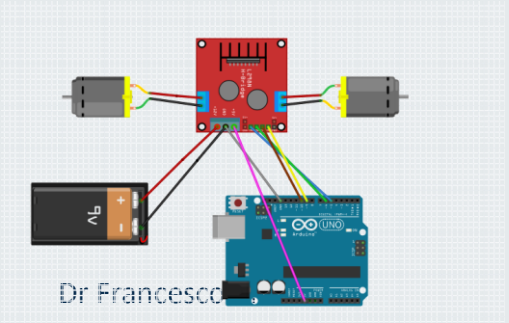


System Design

Component Integration &
Test



Component Design



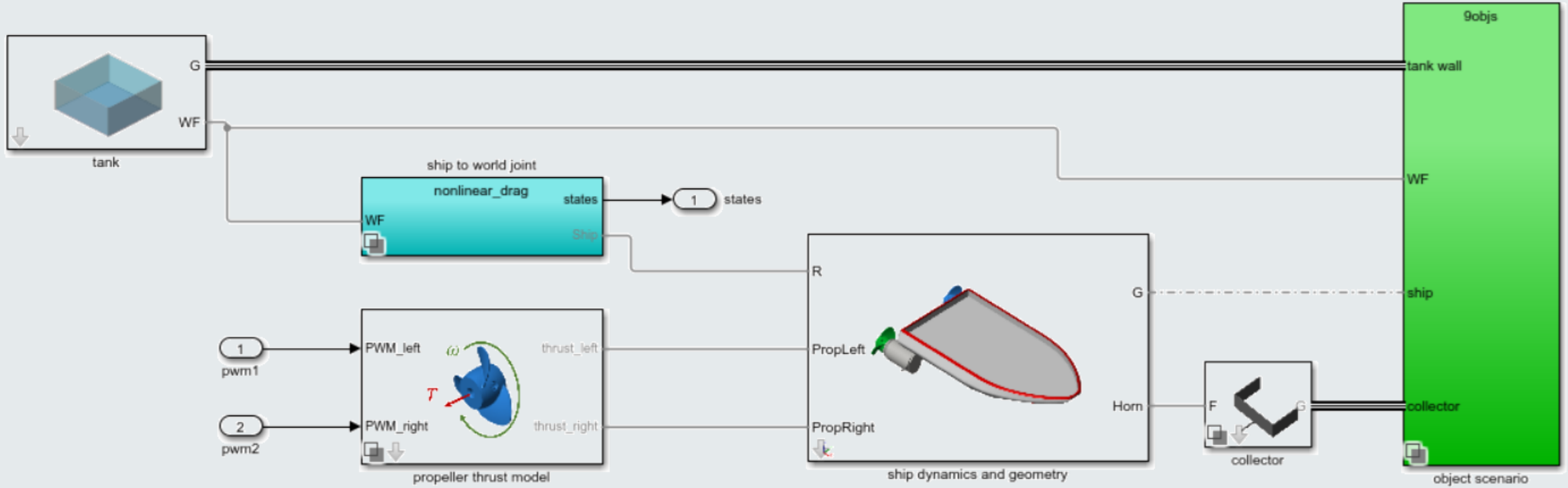
Component Implementation

Assessment

Deadline	Assessment	Deliverable(s)	Weight	Marking
Week 26	**Individual Coursework Submission**	Simulation Submission	**25%**	Individual
Week 28	**Mid-term Communication KEATS Quiz**	Quiz Completed	**10%**	Individual
Week 29	**1st Design Review**	Completed Prototype *10 min presentation + 5 min Q&A*	**Formative**	Sub-team
Week 31	**2nd Design Review**	Completed Build *10 min presentation + 5 min Q&A*	**Formative**	Sub-team
Week 32	**Group Project Demonstration**	Completed System Integration *15 min Live Demonstration*	**25%**	Group
Week 32	**Video log**	*5 min video summarising project*	**10%**	Group
Week 32	**Final Report**	*8-page report*	**30%**	Group

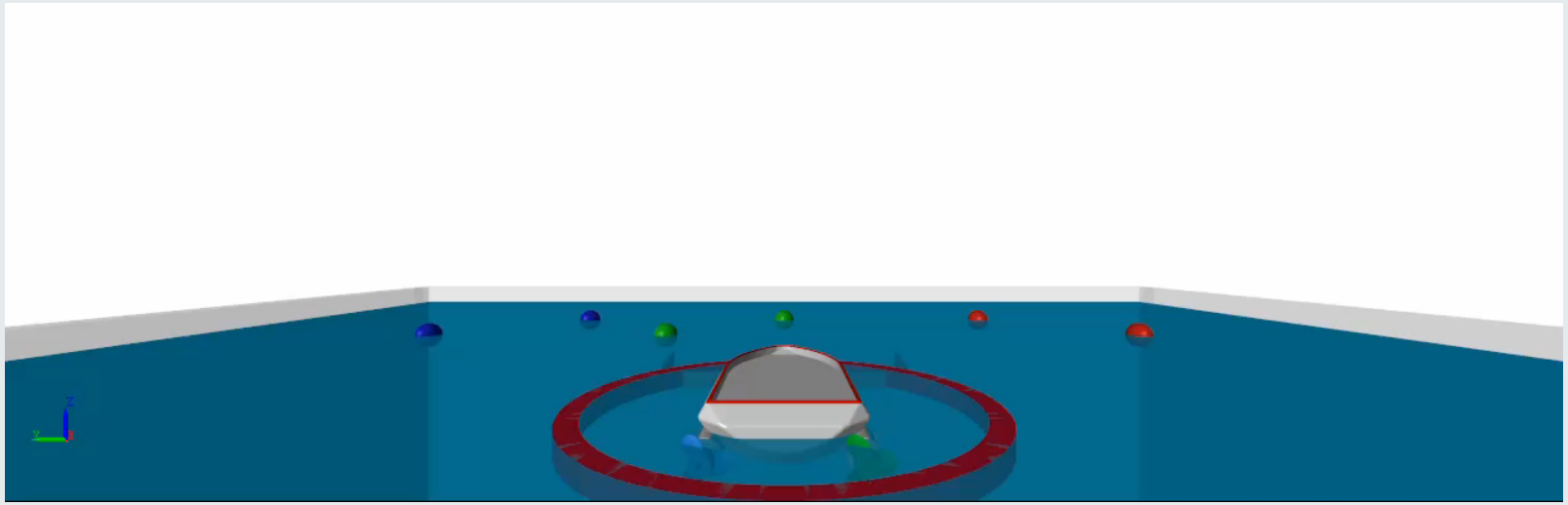
Individual Coursework

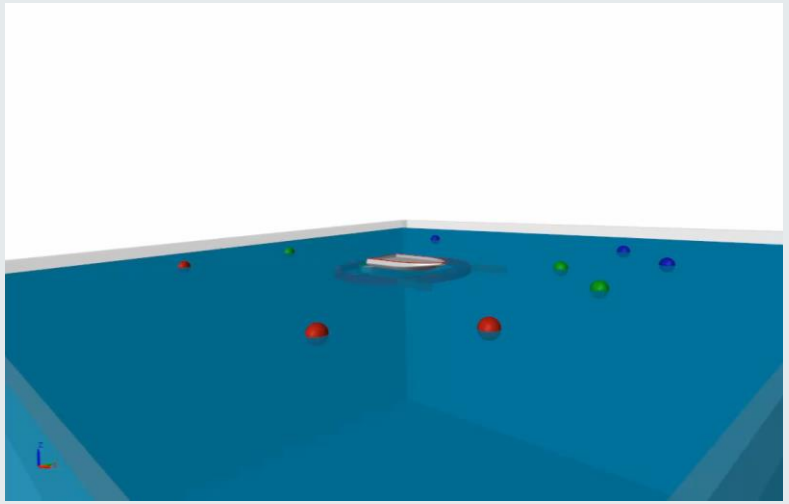
Autonomous Control System Design in Simulink on a Multibody simulation of a Ship with a Collection System



Individual Coursework

You will be judged on how quickly you managed to complete the scenario provided in the simulation template, measured in simulated time.





Group project

Design, build & test an RC ship model and demonstrate operation in water tank

Teams of 8-9 members with sub-teams for

- System Design, Project Management and Integration
- Control Design & Teleoperation
- Mechatronics, Drivetrain & Embedded Programming
- Ship and Collector design

Team Allocation

Team members and project managers have been pre-allocated

See KEATS for team lists and other guidance

First activity: Breakout rooms to meet your team (5 min)

1. Come up with a "*nautical*", sea or ship-themed, **team name** that starts with your Group's Letter
2. Upload your team name to this **Padlet** <- link shared in chat

Confluence Team Page

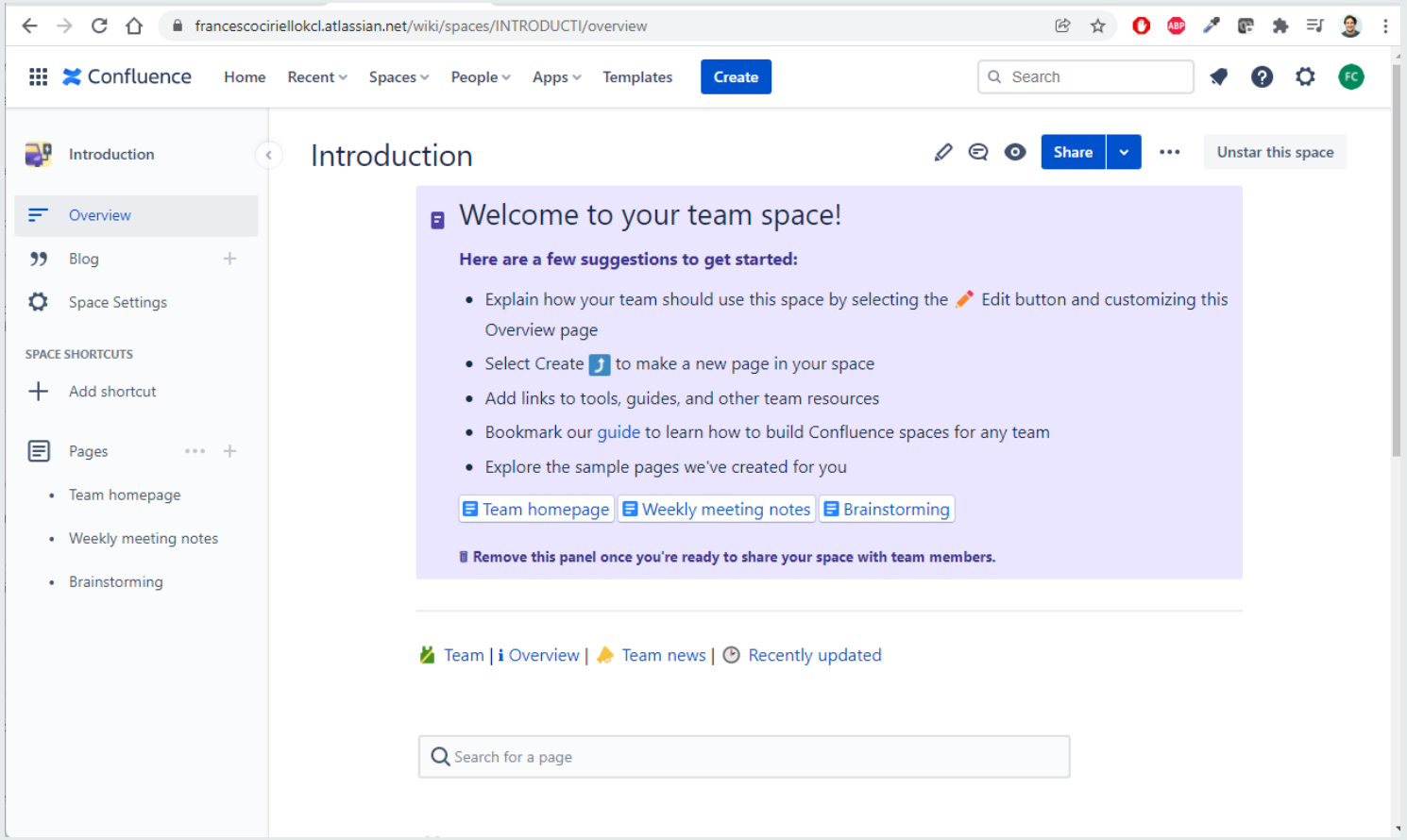
Create a **confluence page** to manage your team

Record

- meeting notes
- project plan
- research and design notes

to document your progress

Confluence pages will be regularly reviewed by assessors and used to support marking in final demonstration



Design Reviews

Present Design to Academic Staff

You are expected to produce a maximum of 5 slides per review, including

- Engineering Drawings and Diagrams
- Model & Simulation Analysis
- Pictures of Build

Sub-teams address questions in each domain

Demonstration Day

Compete in the final day of term by running your RC Ship system in water tanks

Dimensions of tank and objects

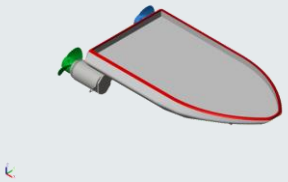
- Tank is ~ 1 x 1 m^2
- Collect spherical objects, 20 mm diameter
- 15 min total demo time
- Fastest collection time wins

Video log of Design & Build

You will need to submit a 5 min video of your design, build and test activities

Remember to record pictures, video, diagrams, etc. throughout term

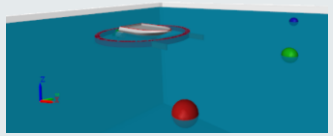
Roles & Responsibilities



Design Team

Ship Designer

Ship Builder

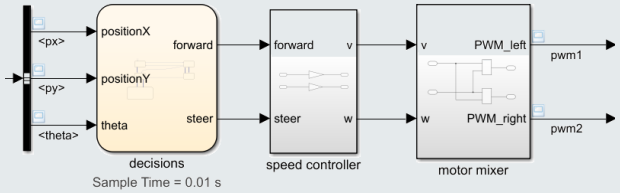


Systems Team

Project Manager

System Architect & Integration

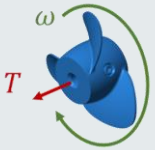
Quality Control Engineer



Control Team

Control Engineer

Communication Engineer

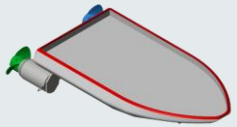


Mechatronics Team

Robotic Engineer

Propulsion Engineer

Ship Design Team



Design Team

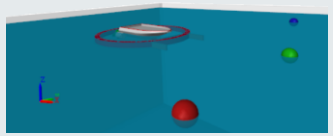
Ship Designer

Ship Builder

Requirements

- Ensure ship flotation & stability
- Design & manufacture ship hull
- Design & manufacture housing for on-board equipment and propulsion system
- Waterproof on-board equipment

Ship Systems Team



Systems Team

Project Manager

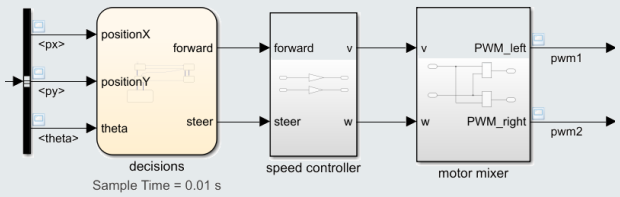
System Architect & Integration

Quality Control Engineer

Requirements

- Manage project delivery, including scheduling and chairing team meetings, setting milestones for design reviews and delivery
- Lead design reviews
- Draft requirements and specifications to hand down to other teams
- Specify system architecture
- Write tests to be verified by design teams
- Demonstrate project at end of term

Ship Control Team



Control Team

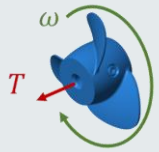
Control Engineer

Communication Engineer

Requirements

- Design decision-making system
- Design remote controller and operator interface
- Design steering controller to ensure adequate ship manoeuvrability
- Deploy remote control communication, including server-client setup using WiFi or BLE
- Manage sample times and latency for control and communication

Ship Mechatronics Team



Mechatronics Team

Robotic Engineer

Propulsion & Drivetrain Engineer

Requirements

- Design motor to propeller mechanisms, including load transfer and propulsion drivetrain
- Implement low-level controllers for DC motor(s)
- Design floating waste collection system
- Design steering system, e.g. rudder or other control surfaces
- Design calibration system
- Deploy control algorithm to microcontroller

Lessons learnt from KEP

Second activity: Formal lessons learnt with team

(10 min)

Instructions in the handout shared in chat

Pluses *What worked well?*	**Deltas** *What did not work well?*
Puzzles *What was uncomfortable?*	**Considerations** *What was noteworthy?*

Report back - Lessons learnt from KEP

Report back Padlet

Groups

- **A-F:** Share a Plus
- **G-L:** Share a Delta
- **M-R:** Share a puzzle
- **S-X:** Share a consideration

Pluses *What worked well?*	**Deltas** *What did not work well?*
Puzzles *What was uncomfortable?*	**Considerations** *What was noteworthy?*

Submit Lessons Learnt & Team Roles by this Friday

Project manager responsible for

1. scheduling kick-off meeting
2. creating a Confluence page
3. sharing with team
4. creating Lessons Learnt from KEP and Team Roles page
5. sharing with assessor

Support Structure

You will be mentored through term with:

- Lectures
- Computer-based Laboratories
- Workshop & Making Sessions
- Design Consultations & Reviews

Lecture Schedule

Lectures are delivered Live Online, access by MS Teams link in KEATS

Date	Topic	Lecturer	Duration
Week 22	Introduction to MCP	Prof Barbara Shollock	1hr
Week 23	Modelling Engineering Components	Dr Francesco Ciriello	1hr
Week 24	Control System Design	Dr Francesco Ciriello	1hr
Week 25	Hardware Interfacing	Dr Francesco Ciriello	1hr
Week 26	Case study	Dr Julia Li	1hr
Week 26	Group Project Introduction	Prof Barbara Shollock	1hr
Week 28	Communication Technologies	Prof Vassilis Friderikos	2hr

Computer Laboratories

Computer labs are supervised practical sessions in which you will get you started with modelling, control and hardware interfacing needed for the group design project

Date	Topic	Lecturer	Duration
Week 22	Introduction to Simulink	Dr Francesco Ciriello	2hr
Week 23	Modelling in Simulink	Dr Francesco Ciriello	2hr
Week 24	Control Design in Simulink	Dr Francesco Ciriello	2hr
Week 25	Arduino Programming in Simulink	Dr Francesco Ciriello	2hr

Workshop Sessions

Workshop sessions are scheduled for each team to build the ship and collection system

Date	Topic	Lecturer	Duration
Week 26	Group Planning Meeting	Self-organised	1hr
Week 27, 30	Expert Design Consultation Breakouts	Mixed academic staff	15 min
Week 27, 28, 29, 30, 31	Making Session	Dr Kamalanathan Kajan	3hr

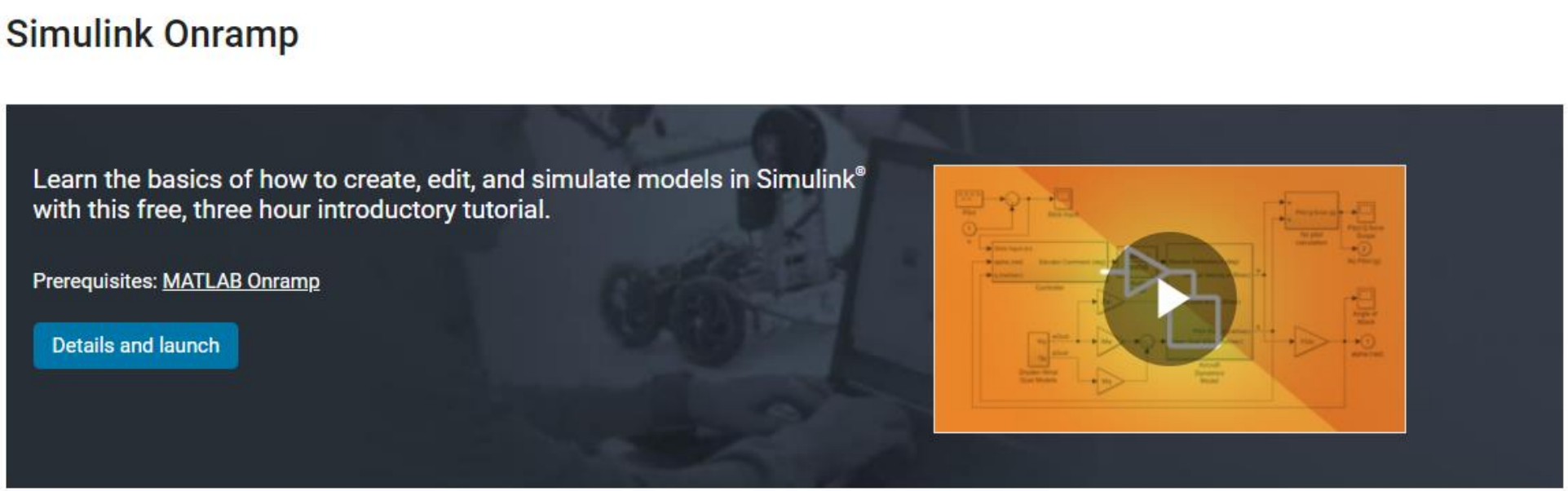
Make sure to reach making sessions, starting on Week 27, with a clear plan on how to manufacture your system

Next Steps

- Attend all support sessions (lectures, computer labs, workshops)
- Set aside **regular team meeting times** in your calendar, including
  - 30 min **kick-off meeting** to be held before this Friday
  - 15 min **stand-up meeting** at beginning of each week
  - 30 min **sub-team planning** meeting each week
  - 30 min **full team planning** meeting every two weeks
- Use kick-off meeting to assign roles based on individual preferences
  - submit team roles & confluence page link by this Friday

Lab Preview – Week 22

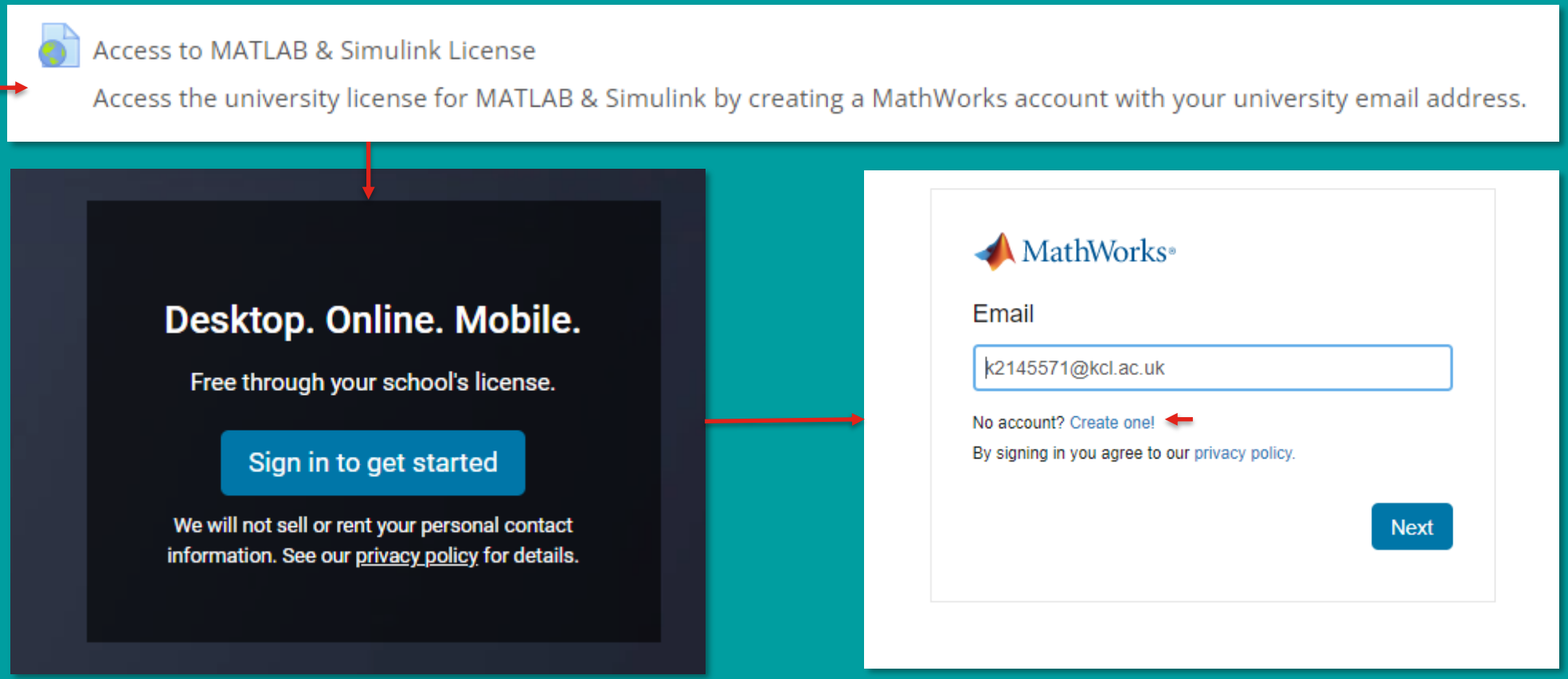
In the first lab, you will get started with using Simulink as a design tool, by completing a self-paced short-course:



Before Computer Lab – Week 22

1. **Create a MathWorks account under your university license**
2. **Install MATLAB R2021b**

Links in KEATS



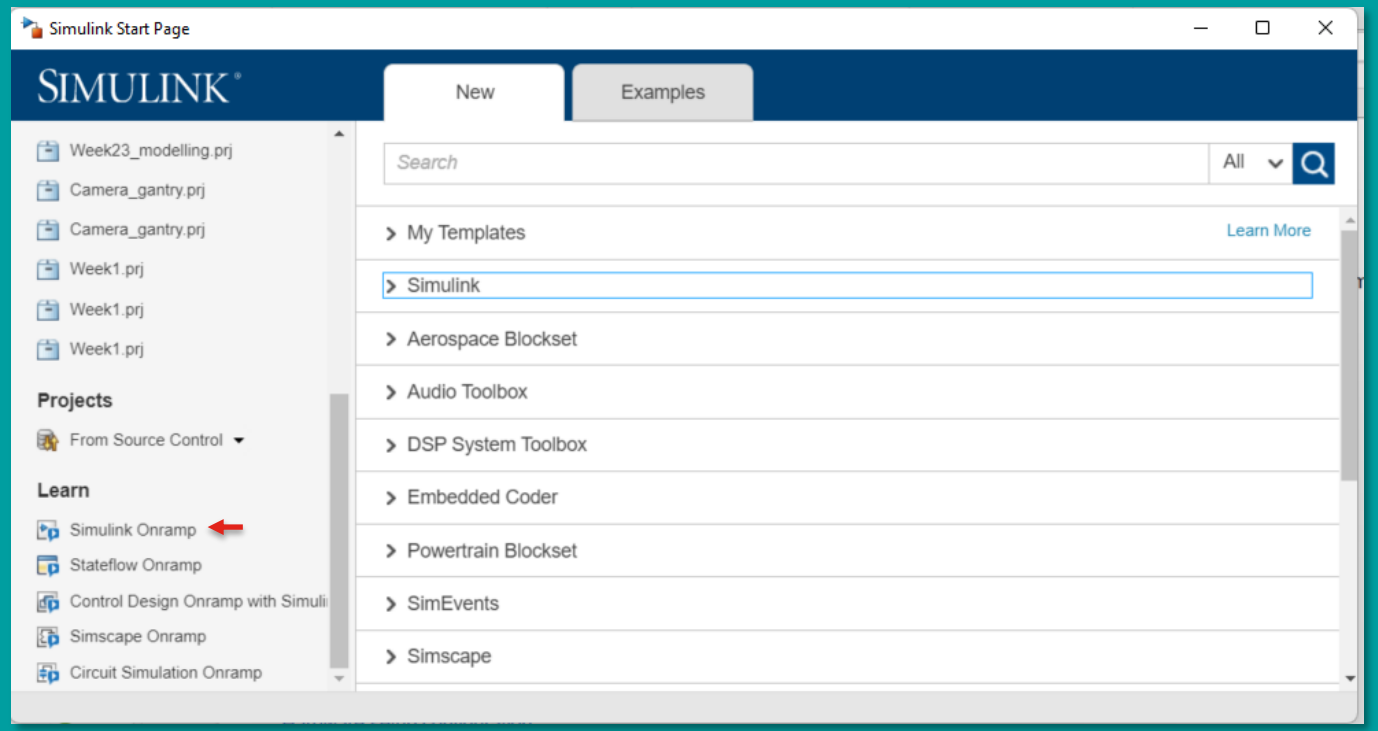
During Computer Lab – Week 22

Labs held in Bush House (S)7.01/2 (Lab)

Recommended: Bring your own laptop to run the tutorial on MATLAB Desktop

Launch MATLAB

Open Simulink from HOME menu in MATLAB toolstrip



Launch Simulink OnRamp course from the **Learn** menu (LHS)