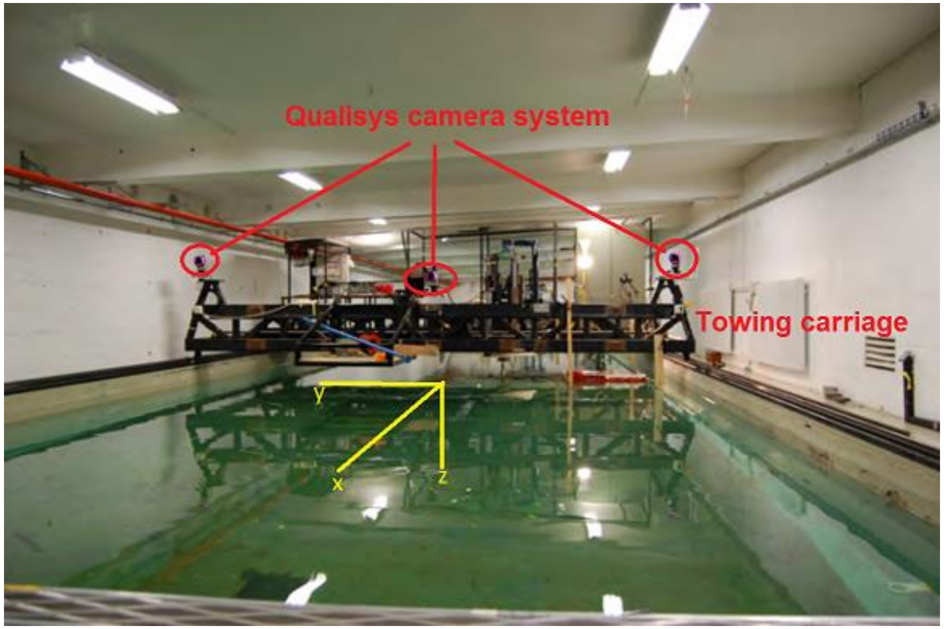
Laboratory for TMR4243: Marine Control Systems II 2019

Welcome



Teaching and student assistants

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You will work in three case studies.

- Case Study A: Thrust allocation and joystick control
- Case Study B: Observer design for sensors of the vessel
- Case Study C: Dynamic Positioning and maneuvering

- **Through the laboratory part of this course you will design control components, making the vessel able to perform dynamic positioning in the MC-Lab.**

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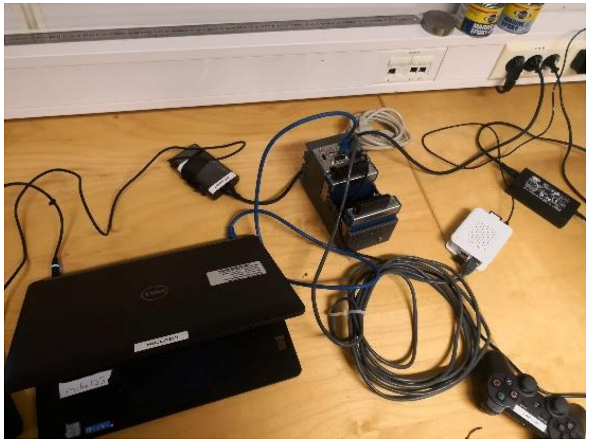
TMR4243: Organization of laboratory

- Each case study contains two parts:
    - **Theory and Simulation**
    - **Lab experiment**
- You can solve the theory and simulation whenever you want. You need to have the simulations running before the lab.
- For each lab-part you will write a progress-report which is not used for you grade (pass/no-pass). This is to ensure that all groups are ready for laboratory.
- Only the final report will receive a mark.

TMR4243: Theory and Simulations

- Before week 11, each group will answer theory questions as well as testing the control system through HIL testing.
- This work should make you ready for the laboratory tests.



Part I

Theory

1 Task: Path parametrization

1. Straight-line
   (a) Propose a straight-line parametrization for $p_d(s) = (x_d(s), y_d(s))$ with:
      - initial position $p_d(0) = p_{d,0} = (x_0, y_0)$, and
      - final position $p_d(1) = y_{d,1} = (x_1, y_1)$.

   (b) Derive the tangential velocity vector $p_d^s(s) = (x_d^s(s), y_d^s(s))$.

   (c) Formulate the desired pose $\eta_d(s)$, including $p_d(s)$ together with 1) a constant reference heading $\psi_d(s) = \psi_{ref}$, and 2) desired heading $\psi_d(s)$ tangential to the path.

   (d) Derive expressions for $\eta_d^s(s)$ and $\eta_d^{s^2}(s)$ for the two cases.

   (e) Propose a speed assignment $U_s(s,t)$ for $\dot{s}$ that makes the vessel follow the path at constant reference speed U_{ref} [m/s]. Note that U_{ref} may take both positive and negative values for forward and backwards motion along the path.

2. Ellipsoidal path
   (a) Propose an ellipsoidal parametrization for $p_d(s) = (x_d(s), y_d(s))$ with:
      - center in (c_x, c_y), and
      - radii (r_x, r_y).

   (b) Derive the tangential velocity vector $p_d^s(s) = (x_d^s(s), y_d^s(s))$.

   (c) Formulate the desired pose $\eta_d(s)$, including $p_d(s)$ together with 1) a constant reference heading $\psi_d(s) = \psi_{ref}$, and 2) desired heading $\psi_d(s)$ tangential to the path.

   (d) Derive expressions for $\eta_d^s(s)$ and $\eta_d^{s^2}(s)$ for the two cases.

   (e) Propose a speed assignment $U_s(s,t)$ for $\dot{s}$ that makes the vessel follow the path at constant reference speed U_{ref} [m/s].

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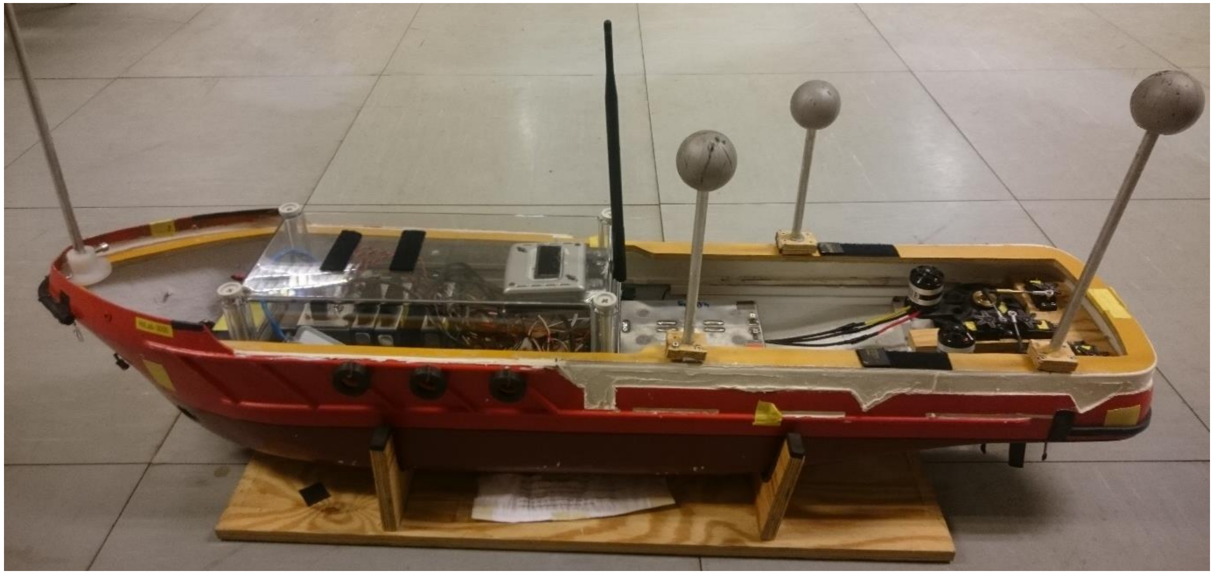
TMR4243: Lab experiments

- In week 11-13, each group will conduct the lab experiments of all three cases in MCLab.
- We will arrange a schedule for use of the lab, but be aware that in these weeks the workload in TMR4243 may be quite high



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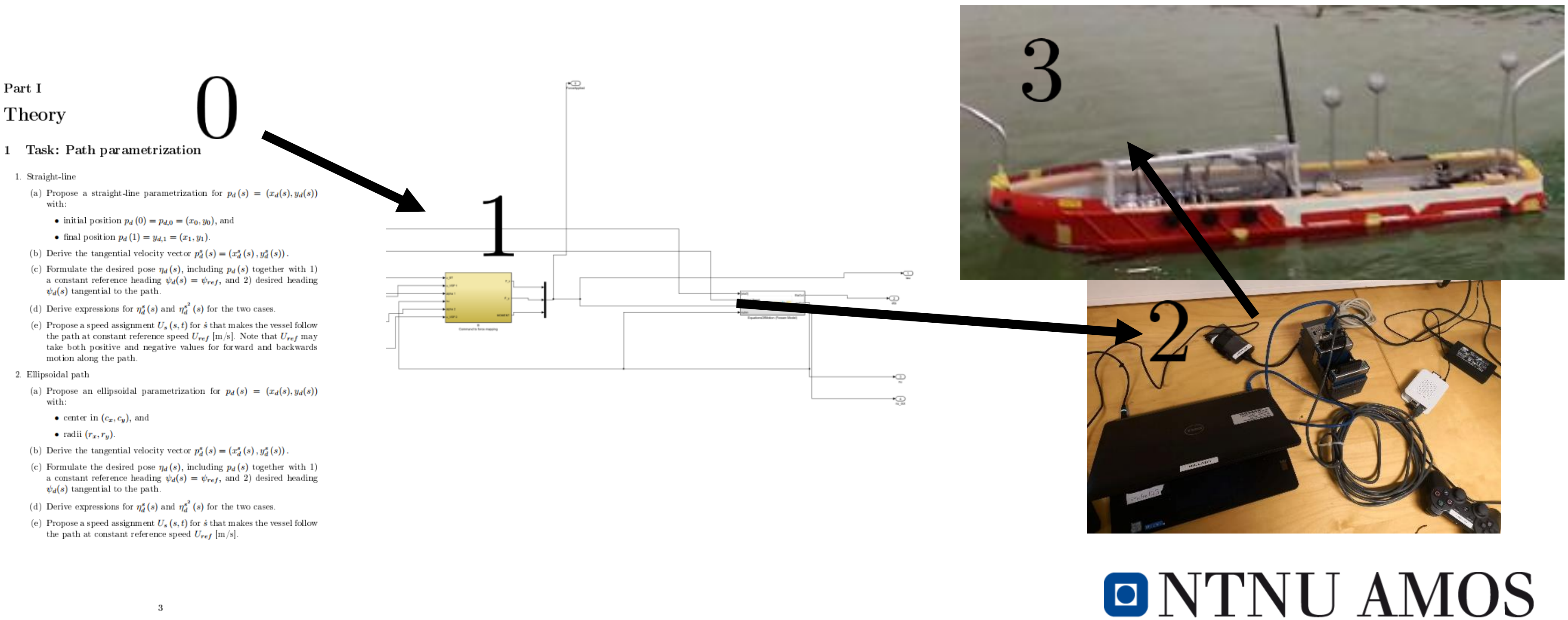
TMR4243: Suggested workflow

0. Do theory part and get familiar with the tasks.
1. Simulink, which has a similar simulation model as we use in HIL-testing.
2. HIL- testing, which has a similar interface as Lab.
3. Model- Scale testing in the Laboratory.



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TMR4243: Transitioning between Simulink and HIL boxes.

- Same simulation model in Simulink and HiL-boxes.
- Simulink is great for development, rapid prototyping and testing.
- Details in lab-text.

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TMR4243: Transitioning between HIL boxes and model-scale

- Hil-boxes: same software + partly hardware as model scale ship.
- HIL boxes eliminates errors. However, *expect new to appear in lab.*
- You control component should help should handle these discrepancies.
- May be smart to

-Consider robustness to modeling errors in your simulations

-Allow variables to be re-tuned in the graphical interface.

- Further details in lab-text.

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TMR4243: Lab experiments- Progress reports

- Mandatory, but in any way used for grading.
- Each part: Deliver 1-3 computer written pages addressing theory questions and 1-2 pages addressing HIL test tasks.

The case studies- Handouts

- Case Study A: Thrust allocation and joystick control (07.02)
- Case Study B: Observer design for sensors of the vessel (18.02)
- Case Study C: Dynamic Positioning and maneuvering (25.02)

The case studies- Progress-report deadline*

- Case Study A: Thrust allocation and joystick control (21.02)
- Case Study B: Observer design for sensors of the vessel (28.02)
- Case Study C: Dynamic Positioning and maneuvering (07.03)

*The progress-report deadlines are flexible. Send an email if you need an extension.

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TMR4243: Lab experiments- Final Report

- Mandatory delivered as a group.
- Account for 40 percent of grade in course.
- The report shall document the answers to the theory in the lab (questions and your own derivations), work methods, and test results
- If there are faults and discrepancies in the lab setups that you are not responsible for, this shall not affect your grade. (You can still make a good report, but explain what went wrong and if possible why). However, if the issues are due to design errors from your side, it may affect the grade.

TMR4243: Lab experiments- Final Report

- When addressing tasks, we want you to incorporate the answers to tasks into your report, with a flow between questions rather than listing the questions one after another.
- The project report should be a maximum of 18 pages not including appendixes. Appendix in the report is not mandatory, and is only read/used for grading if something is unclear in the main part of your report.
- You shall include an electronic appendix where your project files are posted.

- * Full assignment information will be posted as a separate PDF at a later date.

TMR4243: Lab experiments- Final Report

Project report outline (you should use this):

- **Introduction**
- *(Introduce project. Also discuss how well model worked. Was there any faults in the ship/HIL-boxes, that made it difficult to perform tests? What worked and what did not work?**)***
- *Project objective*
- ***Project scope***
- **Project Part A: DP Thrust Allocation and Joystick Control**
  - **Theoretical development. (**Through this section you chronologically address **all** numbered theory-question. (A, Part I)
  - **Simulink and model scale testing. (**Through this section you chronologically address **all** numbered HIL (A, Part II and Part III**).**
  - **Part A : Discussion of Results.**
- **Project Part B: DP Observer design – State estimation and filtering**
  - **Theoretical development. (**Through this section you chronologically address **all** numbered theory-question. (B, Part I)
  - **Simulink and model scale testing. (**Through this section you chronologically address **all** numbered HIL (B, Part II and Part III**).**
  - **Part B : Discussion of Results.**
- **Project Part C: DP feedback control and maneuvering**
  - **Theoretical development. (**Through this section you chronologically address **all** numbered theory-question. (C, Part I)
  - **Simulink and model scale testing. (**Through this section you chronologically address **all** numbered HIL (C, Part II and Part III**).**
  - **Part C : Discussion of Results.**
- **Project Conclusions.**

Borrowing HIL-Boxes

You are either in group A or group B

Date	Group
13.feb Wednesday	A
14.feb Thursday	B
15.feb Friday	A
18.feb Monday	B
19.feb Tuesday	A
20.feb Wednesday	B
21.feb Thursday	A
22.feb Friday	B
25.feb Monday	A
26.feb Tuesday	B
27.feb Wednesday	A
28.feb Thursday	B

Group 1-3, in Block B.
Group 4-5, in Block A.

After 28^{th} of February: You should be more or less ready to go to lab. (Further schedule to be announced)
Note: It may happen that some of the HiL-Boxes are “down” for maintenance. If this happens, we will arrange as good as possible to compensate you with extra time.

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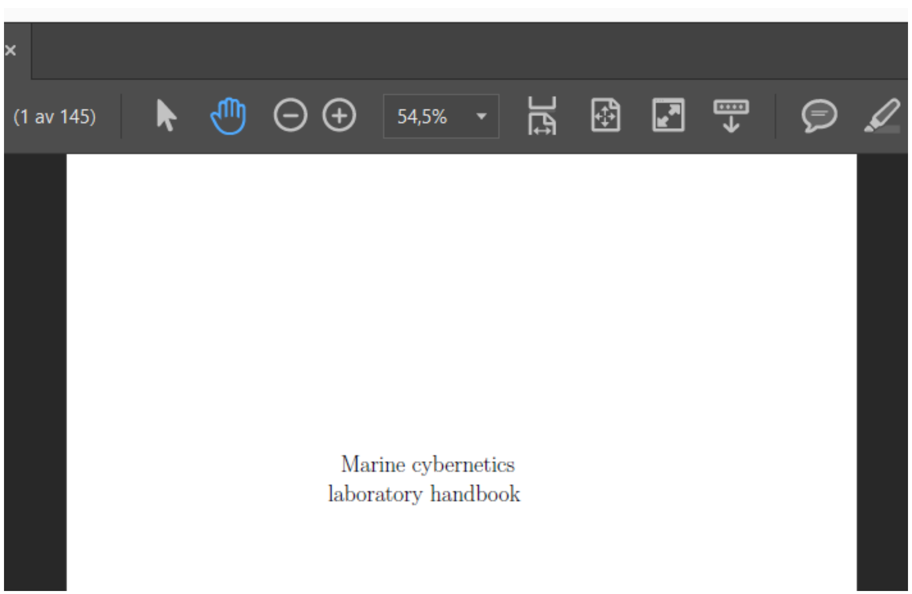
Transition between groups (HIL-boxes)

- The **HIL** box availability is limited. You should spend a lot of time with these also early on! (not everyone in the group need to work on the same simultaneously)
- Collect the boxes at office C.2095 or C2.105 from 09:15.
- When you have the boxes, you are required to deliver the boxes to either office C.2095 or C2.105 before 17:00 in the evening. However, you may (if you ask for permission) work in the evenings, take it home and deliver them between 09:00 and 09:15 next day).
- Do not leave the boxes unattended in the evenings (If you have them in evenings you should take them home with you).
- If any hardware does not work, this should be reported.
- Take care of equipment, it is quite expensive
- If you do not deliver the boxes in time, you may receive a penalty in the form of less time with the boxes in the future.

TMR4243: The manual

- **You get two manuals, which really explain everything!!!**
- **It saves you a lot of time, tears and troubles.**

  Read appendix and go through the examples prestened there.



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Consultation for TMR4243: Marine Control Systems II 2019

TMR4243: Consultation

Need help?

- Ask in the **discussion forum**(!)
- **Office hours** are to be quite frequent, so it is expected that you use office hours for consultation rather than dropping by at random.
- *Always good: **Write an e-mail** and explain your problem before visiting us. That way we can prepare a solution for you.*

-**Hardware failure/bug in the HIL-boxes and Veristand :**

Previous years indicate that the HIL setup is not very robust. In particular, there might be unexplainable bugs that is not due to errors from you.
*When stuck on this, it is expected that you spend some time, both following the troubleshooting guide and on Google before asking for help. However some problems are difficult to solve. If you are still stuck with these types of problems, and do not wish to wait until next consultation hours send an email to **Einar Ueland and/or*** **Henrik Schmidt-Didlaukies** *and we will try to resolve it as quick as possible.*

-Remember:

You can ask in the discussion forum at any time. We will try to answer frequently.

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TMR4243: Consultation of exercises

- Regular exercises are not mandatory. Solutions will be posted the following week. (We expect you do them anyway)
- Student/teaching assistants main focus is to be well prepared for laboratory exercises. However you can of course also ask about regular-exercises.
- Ask in the forum!

Office hours-plan.

- **Exercise hours:**

-Every Monday: 11:30-13:00 in T7. (Here may ask about both lab-exercises and regular-exercises).

- **Office hours**:

- Tuesdays: 11:30-13:00 in G.2196. (Here may ask about both lab-exercises and regular-exercises).
- Wednesday-Friday (14:15-15:00) and Monday-Friday (16:30-17:00) in room C.2099 , AMOS (but if we are not there, check our offices (C2.105) or (C2.95).

- Try to use the office hours rather than dropping by at random times. If needed, we will add more office hours.
- If you have questions about the regular-exercises, you are adviced to use the exercise hours rather than the office hours.

- **Office hours are subject to changes, please follow latest updates on Blackboard).**

TMR4243: to do list

- ✓ Work on the project regularly
- ✓ Send in the status reports according to deadlines
- ✓ Become familiar with HIL-boxes early on.
- ✓ Be prepared for frustrating bugs/errors.
- ✓ Start writing your report early
- ✓ Follow schedule for borrowing the the HIL-boxes, and prepare well for lab-exercises
- ✓ Read the manuals

Charles M. Schulz

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