



Rules & Specifications



Njord Technical Team
October 2021

Contents

1	Summary	3
2	Njord's 2022 Autonomous Ship Challenge	
	2.1 The Digital Challenge	4
	2.2 The Physical Challenge	
3	Technical Specifications	
	3.1 Disclaimer	
	3.2 General Requirements.....	5
	3.2.1 Autonomy	
	3.2.2 Buoyancy and stability	
	3.2.3 Remote control capabilities	
	3.2.4 Launching	
	3.2.5 Kill switch	
	3.2.6 Marking	
	3.3 Hull Specification	6
	3.3.1 Main dimensions	
	3.3.2 Antenna	
	3.3.3 Visual indicators	
	3.3.4 Example hull	
	3.4 Propulsion Specification	7
	3.4.1 Battery	
	3.4.2 Speed	
4	Testing	
	4.1 Test prior to competition	
5	Time schedule.....	8
	5.1 Important deadlines	
	5.2 Intermediate Report	
	5.3 Check-ins	
	5.4 Webinar	
	5.5 Competition	
6	The Competition	9
	6.1 Maneuvering and Navigation	
	6.2 Collision Avoidance	
	6.3 Docking	10
	6.4 Technical Design Report	
	6.5 Weighting	
7	Registration of teams.....	11
	7.1 How to register	
	7.2 Deposit	

1 Summary

The requirements listed in this document must be fulfilled before the participant team is permitted to attempt the physical challenge. All participating ships will be inspected to ensure the listed requirements are satisfied. This is a working draft for the 2022 physical competition and is subject to change.



2 Njord's 2022 Autonomous Ship Challenge

Njord welcomes earlier participants of the digital competition in 2021 and new participants for the upcoming challenge in 2022. This year there will be two competitions run in parallel: a digital challenge, and the main physical competition. This document contains the guidelines for the 2022 physical competition.

2.1 The Digital Challenge

The digital challenge of 2022 will have similar features as the digital challenge in 2021. Teams will have to design a guidance system capable of collision avoidance and situational awareness. Further information regarding the digital challenge will be available at a later date.

2.2 The Physical Challenge



In Njord's first physical autonomous challenge teams will have to design and build a fully autonomous surface vessel. Njord will distribute a template hull for teams to help them get started. The teams will then have a choice to either use the template or make a design of their own which satisfies the technical specifications listed in this document. In the physical challenge we also encourage teams to make a digital twin of their physical vessel. The digital twin is to be implemented in the Gemini simulator in the same fashion as the digital challenge. For some of the simpler challenges we will test the deviation between the physical and digital run. We are really excited to take a leap into our first ever physical autonomous challenge!

3 Technical Specifications

3.1 Disclaimer

Any unfulfilled requirements or other deviations from the technical specifications and rules will be subject to the judgement of the jury, and may result in penalties or disqualification.

3.2 General Requirements

3.2.1 Autonomy

When competing in the different challenges teams will not be allowed to send any control information to and from the vessel. In other words, the vessel must be fully autonomous while competing in the different categories. The sole exceptions to this are when switching the vessel into 'autonomous mode', and when activating the killswitch in case of emergency.

3.2.2 Buoyancy and stability

The vessel must be positively buoyant and stable enough to be determined seaworthy.

3.2.3 Remote control capabilities

Participating ships must be able to be remotely controlled from land in case of a malfunction or emergency. The vessel will also be remotely operated during launch and recovery, as well as between challenges. All forms of propulsion and steering must be remotely controllable.

3.2.4 Launching

Participating ships must be able to be launched and recovered by crane. Therefore teams must clearly mark the centre of gravity on the hull to simplify the lifting operation, and have incorporated either anchor points or space for lifting slings.

3.2.5 Kill switch

Participating ships must have a clearly visible and accessible kill switch physically on board the ship, which disengages all motorized moving parts. Additionally, there must be a remotely controllable kill switch with the same function. Both kill switches must be wired in a circuit(s) separate to the main control system.

3.2.6 Marking

All sharp, pointy, moving or other sensitive parts must be covered and marked.



3.3 Hull Specification

3.3.1 Main dimensions

Dimension	[m]
Maximum length	1.85
Maximum width	1.85
Maximum height (including draught)	1.0

3.3.2 Antenna

Antennas are allowed to be built over the height limit as long as there are no sensors attached or built over the height limit.

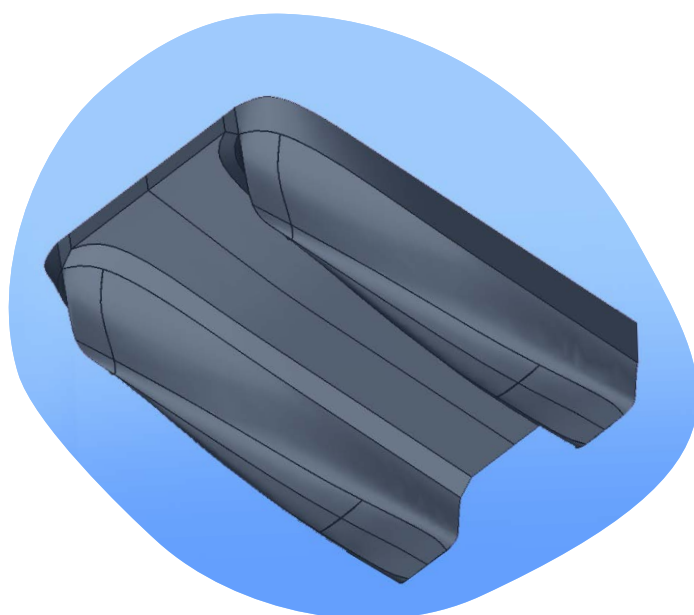
3.3.3 Visual indicators

Participating ships must be equipped with lights indicating its current operating state.

Indicators	Operational state
Red ●	Kill switch activated. Propulsion disabled.
Yellow ●	Remote operation.
Green ●	Autonomous operation.

All three lights must be visible from all directions.

3.3.4 Example hull



To encourage a focus on the autonomy component of the challenge, an example hull design is offered to teams which they are free to use or modify.

Teams are not required to utilize the example hull. However, creativity and innovation will be rewarded, so deviating from the example hull may be beneficial.

To the left you can see an illustration of the example hull which is provided by our bronze sponsor Sintef Ocean! This will be published as a digital CAD-file for teams at a later date.

3.4 Propulsion Specification

All forms of powered propulsion must be electrical.

3.4.1 Battery

All batteries must be sealed to reduce the hazard from acid or caustic electrolytes. The open circuit voltage may not exceed 60V [DC].

During the 2022 competition, Njord will be able to lend batteries to participating teams. The reason for this is to simplify the transport of the team's vessels to Trondheim, and to ensure that the batteries comply with safety standards.

The teams are not required to utilize the given batteries, but are responsible for ensuring that their chosen batteries are within safety standards.

There will be professional personnel present at the competition approving the teams' power supply arrangement before teams are allowed to compete. Specific details about the batteries Njord are offering will be published to teams closer to the competition.



3.4.2 Speed

At no point can the vessel exceed the speed limit, which is set to 5 knots.

4 Testing

4.1 Test prior to competition

Team's vessels are to be tested in the following before they are allowed to compete:

- Stability and Buoyancy
- Propulsion
- Steering
- Visual Indicators
- Power supply arrangement
- Kill switches
- And potentially other components...

5 Time schedule

5.1 Important deadlines

Deadlines

1. February	Registration of teams
1. April	Submission of intermediate report
1. August	Submission of technical report

5.2 Intermediate Report

The participating teams must submit a report within 1. April. The report will be divided into two sections, where the first is sent only to the Njord organizing team, and the second part is made publicly available to all teams. The first part will concern innovative elements of a team's design. This will help us prepare for the competition in terms of logistics. In the second part teams shall display their current status, including a brief explanation of the process so far, and the challenges the teams have faced. If teams fail to deliver the intermediate report by the deadline it will result in reduction of points for the final technical report. More detailed information regarding the intermediate report will come later.

5.3 Check-ins

Similarly like the 2021 competition, we will host bimonthly check-ins starting after the registration deadline in February. This is to get a better understanding of the team's current status and to answer any potential questions.

5.4 Webinar

We will host a webinar after the registration in February. This is to give further detail about the different categories in the 2022 competition.

5.5 Competition

The competition is set to be in week 33 in 2022 in Trondheim. All expenses regarding travel and stay must be covered by the teams.

6 The Competition

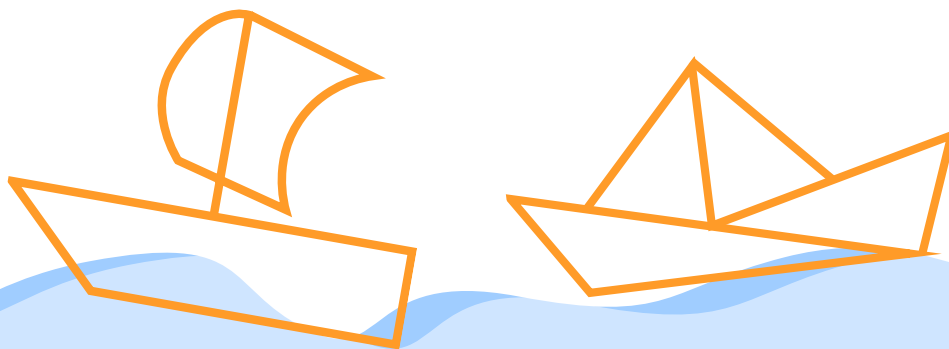
The 2022 physical competition will consist of 4 categories: maneuvering and navigation, collision avoidance, docking and a technical report. For the first three there will be different challenges with increasing degree of difficulty. As we also want to implement a digital twin for the 2022 physical competition, there will be some simple challenges testing the deviation between the digital run in the simulator and the physical run. Further details regarding challenges will be published closer to the competition.

6.1 Maneuvering and Navigation

The first category for the 2022 competition is maneuvering and navigation. The vessel will receive several check-points which the vessel must safely navigate to. In the more complex challenges the vessel must navigate the waters according to the COLREGs. Different types of navigational seamarkers will be utilized.

6.2 Collision Avoidance

The second category is collision avoidance. The vessel must reach a destination without colliding with realistic obstacles. Model-sized boats as well as smaller buoys will be used as obstacles. At a higher degree of difficulty teams must expect moving obstacles.



6.3 Docking

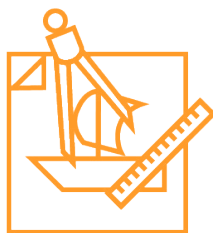
The third category is docking. The vessel must start off by safely docking in a berth with minimal impact. The level of difficulty will gradually increase by presenting multiple docks and using AR-tags which the vessel must interpret to find its allocated berth. Initially teams will dock with the bow facing the berth. In the more difficult challenges teams will have to dock in parallel to the berth.

6.4 Technical Design Report

The technical design report is a written report outlining design choices and considerations taken in creating the ship. The report is expected to include an overview of the components and systems onboard the ship, in addition to an increased focus on certain innovative aspects. This is an opportunity for teams to bring attention to and share the most ingenious, challenging areas of their design. The report should be written in a register fit for other interested university students. The jury will score the reports based on the following criteria:

- The report communicates a complete overview of the ship's components and systems, and their interaction.
- Major design choices are presented and well justified.
- 2-3 particularly innovative aspects are documented and presented in a fashion deemed inspiring to other students.
- The report contains visual aids (images, graphs and/or figures) as appropriate to supplement descriptions.

More detailed information regarding the technical report will come closer to competition.



6.5 Weighting

The 4 challenges will be equally weighted. Within each category there will be different weighting in regards to the difficulty level. As mentioned earlier teams will also get bonus points for innovation in their design.

7 Registration of teams

7.1 How to register

In order to join the competition, all of the team members must be enrolled in an undergraduate or graduate program. The team will also have to send in a form to Njord containing the team members (at least two), and a contact person from the university.

There is no upper limit for the number of members in a team, but we estimate that you will need at least 6 students. The challenge is intentionally multi-disciplinary, and we encourage teams to include members with varied backgrounds. Students studying cybernetics, computer science, electrical- or marine engineering could all be relevant to a team, amongst others.

To formally join the challenge, go to <https://www.njordchallenge.com/the-competition/join> and follow the given instructions.

7.2 Deposit

Teams will have to pay a deposit of 1000 NOK in order to register for the 2022 competition. Teams will have to deliver the technical report as a minimum effort to receive their deposit after the competition. Upon registration you will be sent the details regarding payment.



Njord, the Autonomous Ship Challenge



Njord Technical Team
October 2021