The HUNT for SIR NILS OLAV

Deep sea submarine salvage

Description, Rules and Procedures v0.2 20170320

Task Description

The project objective is to build a deep salvage system to raise the wreck of the *KNM Sir Nils Olav,* a prototype submarine lost at sea. The *Sir Nils Olav* is of an advanced design that employs non-ferrous, non-magnetic materials to reduce its radar and acoustic footprint, making it very difficult to detect. The missile cruiser *Polkovnik Gagarin* recorded the sounds of a submarine implosion in the vicinity of the Makaroff Deep, near St. Lucia, where the *Sir Nils Olav* was known to be patrolling. Audio analysis suggests the pressure hull failed at one or two hull fractures. The wreck is thought to contain highly valuable intelligence information including state-of-the-art armament, nuclear technology and intelligence ciphers. The wreck's location is only known approximately; it must be located, identified, and then raised with as many of its secrets recovered as possible.

The submarine contains the following items:

Hull sections: The bow, sail and stern of the *Sir Nils Olav* (dark grey).

Torpedos: Four horizontally-launched nuclear-tipped torpedos (blue); two in the bow and two in the stern.

ICBMs: Three vertically-launched missiles (white), stored in the sail.

Reactor modules: Two nuclear fission reactors (red); one in the mid-section and one in the stern.

Cipher machines: Four code cipher machines (yellow), stored in the sail.

The wreck is to be identified by returning a legible photograph of its sail markings (hull number TK-421) to the surface for verification. The integrity of recovered items is important, and it is highly desirable that the wreck be raised intact; items left on the sea floor will be considered lost.

All-up system testing will occur during scheduled demonstration sessions in week 13. There will also be incremental demos in weeks 7, 9 and 11, allowing partial functionality to be demonstrated. Be aware that this project specification **will** be updated through the course of the semester, with at least one guaranteed project specification change, requiring your design to be flexible to accommodate changes.

Testing Procedure

Each demonstration session will run for 25 minutes, during which students must complete all required setup, locate the wreck and conduct the salvage. After 25 minutes, the students must cease operations and will have 5 minutes to pack down and clear the tank and testing area, ready for the next team. The time-limits will be rigorously enforced. Build quality may be assessed at any time during the testing slot.

IMPORTANT NOTE: The testing tank is an enclosed, fluid-filled compartment and poses a potential hazard. Testing in the tank will only occur during normal scheduler practicals; do not expect access to the tank at any other time. If, during testing, any part of your system sinks, you cannot recover it yourself - it must be retrieved by a tutor or course coordinator. It is your own responsibility to build a system that will not sink or lose pieces during your testing. Any immersed parts of your system must be rinsed in clean water after use.

Scoring

Task performance will be assessed by a points system based on demonstrated performance and build quality. Refer to the separate build quality rubric and guidelines for build quality specifications. Only the performance of the overall system will be considered; no part will be considered separately.

Build Quality	**10/10 Points**

Basic functionality	**25/25 Points**
Return images of the sea floor to surface	10
Locate the wreck of *Sir Nils Olav*	10
Return image of sail markings to surface	5

Recovered items	**30/30 Points**
Torpedo	2 each
ICBM	2 each
Reactor module	4 each
Code cipher machine	2 each

Recovered hull sections	**35/35 Points**
One separate section	10
Two separate sections	15
Three separate sections	20
Two joined sections	25
Two joined sections, one separate section	30
Entire submarine intact	35

Bonus Functionality	**10/10 Points**
Sunken object recovery	3-4 points each

An item or hull section is considered “recovered” when it is transported to the surface by the salvage system, removed from the tank, and presented to the adjudicator (course coordinator or delegate). The adjudicator shall score the item in the condition in which it is presented to him or her; no consideration shall be given for damage sustained to the wreck between raising and scoring.

Three additional secret sunken objects may be discovered and recovered for bonus marks; no bonus marks shall be awarded unless all three hull sections are also recovered.

Apparatus

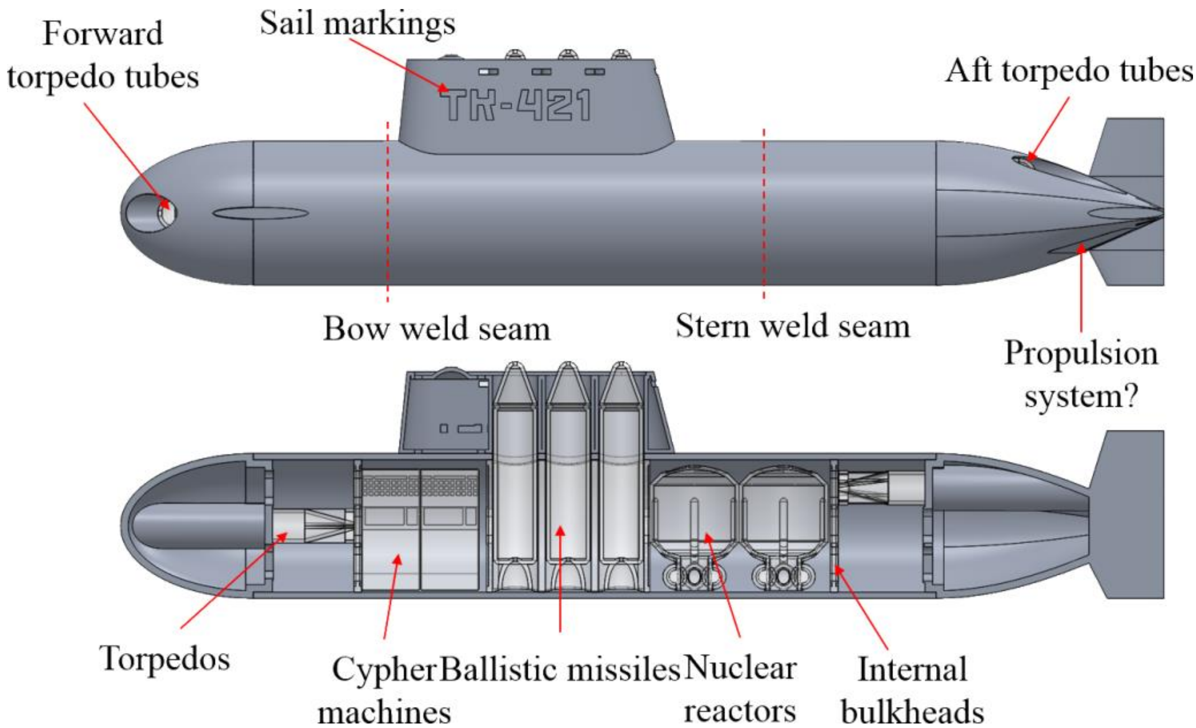
The search shall be conducted in a converted cylindrical rainwater tank with a removable top lid, approximately 2 m x 2 m. The tank shall be coated, painted or constructed in such a way that it admits little or no light internally. The water filling the tank may contain food colouring, dyes or some other colourant such that the water has reduced visibility. Within practicality, the water will be maintained to be pollutant-free and low-turbidity. The depth of water from the surface to the bottom shall be no less than 1.5 m.

The tank shall be fitted with a raiseable bottom which contains a model ocean floor. The ocean floor shall consist of small rocks, sand and silty material. The ocean floor may also include a variety of submarine terrain such as plinths, boulders, clefts ("rocks") and other sunken objects. Rocks shall be no larger than 100 mm across in any dimension, and weigh no more than 200 g each. Sunken objects geometries are intentionally unknown, but will be representative of artefacts found on the ocean floor. They shall have maximum dimensions of no more than 200 mm across in any dimension, and weigh no more than 100 g each. Sunken objects may incorporate magnetic or ferrous materials.

At the start of each test run, the bottom shall be raised and the *Sir Nils Olav* placed randomly on the ocean floor. The wreck may be partly buried in the silt and sand (but not under any rocks), and shall be placed intact, with all its equipment in position. The wreck may sit upright, on its side, or at some angle to the seabed, but shall not be placed upside down. The wreck may partially rest on rocks or other submarine terrain, provided it remains mechanically intact in that position. The wreck shall not be in contact with the edge of the tank; there shall be at least 150 mm clearance between the wreck and the tank wall.

The *Sir Nils Olav* is constructed from acrylic tube sections, with 3D printed parts and fittings. It consists of three hull sections joined by small magnets to provide limited structural integrity, and contains 3D printed representations of the internal systems of the submarine. The internal systems shall be weighted to be negatively buoyant, and painted according to an easily identifiable colour scheme. Vent holes will allow the majority of air to exit the wreck during set up. Each side of the sail of the submarine contains distinctive painted marking to be used to visually identify the submarine. Several versions of the wreck may be produced, with different fracture locations.

***Sir Nils Olav* (TK-421)** ballistic missile submarine
Displacement: 350 metric microtons (estimated)
Length: 275 millimetres
Beam: 38.4 millimetres
Propulsion: Two nuclear reactors powering an unknown silent propulsion unit



System Design Guidelines

Each team must construct a wreck salvage system and attendant support equipment using a limited budget. At least one component must be machined from metal, using milling, turning, water-jet cutting or any combination thereof. At least one custom PCB must be produced. The adjudicator shall be the final arbiter of whether any part of the system, or the system as a whole, is legal within the guidelines. Students may provide their own laptops or desktop computers, which do not count towards size or budget limits.

Construction

Dimensions

The salvage system, including all support equipment (except laptop/desktop computers), must fit inside a typical shoebox for final submission. The system may be partly deconstructed to fit in the shoebox, with the understanding that students must reconstruct it during the strictly time-limited testing slot for the final demo.

Control

The salvage system does not need to be autonomous; teleoperation from a control station is allowed. However, no wired links between the seafaring parts of the system and the control station shall be permitted. There shall be no physical or direct visual contact between the operators and the seafaring salvage system except to place the system in the testing tank, or remove it (and any recovered material) from the tank. Computer mice and keyboards are considered part of the computer system provision and do not count towards the budget; handheld control interface components such as joysticks, gamepads or space mice are not considered part of the computer, and must be accounted for.

The team must provide a real-time visual datafeed (VGA or HDMI) from any onboard camera systems; if there are no onboard cameras, then the datafeed should instead display data telemetry from the ocean-going system. These datafeeds will be displayed on a provided large screen monitor on testing day for use by the adjudicator and observers.

Power Sources

Stored energy in the seafaring parts of the salvage system is limited to charged electrical devices and stored gravitational energy systems. No kinetic, nuclear or thermal energy systems may be used. Exceptions may be granted by the course coordinator on a case-by-case basis. Elastic energy storage may be used, provided the specific system proposed is approved by the adjudicator. **Li-poly batteries may total no more than 15 kJ maximum energy capacity.** Tethered power to any part of the system from outside the tank is forbidden.

Processors and programming

Pre-fabricated processor and computer modules may be used. However, due to abuse by previous students, no Atmega 328 processors may be used, and Arduino software (IDE, scripts etc) is strictly prohibited. Exceptions may be granted by the course coordinator on a case-by-case basis (for example, a commercial product that incorporates a 328P processor, but which is non-reprogrammable). It is strongly recommended that teams program using C.

Budget

The total cost of materials, parts and components incorporated in the product shall be no more than $200 (excluding laptop/desktop computers). Regardless of actual cost to construct, the team must demonstrate that the product produced *could* be constructed from parts costing less than or equal to $200. Up to $200 will be provided for purchase orders through ETSG. **Reimbursements will *not* be permitted.**

Cost of parts shall be calculated on a per-item basis; parts that are purchased in multiple units may be costed per unit – e.g. a bag of 10 nails for $10 may be charged at $1 per nail used. Bulk unit discounts from suppliers may be applied, provided the quantity of items used in the product is sufficient to earn the discount. Items sourced for free (i.e. not paid for) may be costed at half the market purchase price. Circuit boards must be purchased via ETSG in order to be paid out of budget.

Each team will be provided with 500 g of 3D printer filament in a specified colour. Once this material has been exhausted, no further filament will be provided or nor may be purchased with the build budget. Only the provided filament may be used in submitted work.

Specific Prohibitions

- **No additional off-board sensing**
  Sensors may only be mounted on the seafaring part of the salvage system. No FLIr, ground-penetrating radar, or other such remote imaging systems may be operated outside the tank.
- **No outside markers, attachments or alterations**
  No signs, structures, markers, radio beacons may be installed outside of the tank; such items may be deployed inside the tank by the salvage system, but may these not be manually installed ahead of time. No alterations may be made to the tank or other apparatus. You may not deliberately touch the top or sides of the tank in anyway; resting on the ocean floor is ok, but no adhesives or permanent attachments are permitted. Systems that cause damage to the apparatus will be prohibited from operating. The water volume of the tank may not be altered.
- **No internet connection**
  No part of the salvage system, support equipment or off-board processing facility may be connected to the Internet. Where WiFi or similar wireless protocols are used to connect between seafaring system and another computer, it must be demonstrated that no computer on its network is connected to the Internet. The instructor may elect to have the connection status of any input device demonstrated prior to testing. The instructor shall be the final arbiter of whether a connection constitutes connection to the Internet.

The Aim of the Project and the Spirit of the Rules

Without a doubt, engineering students are extremely creative and talented at finding clever solutions to difficult problems. This project aims to teach you about the practical trade-offs encountered by engineers when facing a multi-faceted challenge with broad scope and many possible solutions. It is recognised that no set of rules could cover every possible edge-case without becoming cumbersome fodder for ‘rules lawyers’.

Thus, the two cardinal rules are:
1. The instructor’s decision is final.
2. Stay within the spirit of the problem.

If you think what you are attempting might not be in accordance with the spirit of the rules, there is no harm in asking! The instructor will rule whether a particular approach is permissible. Obviously, it is best to ask these sorts of questions early in the semester and before committing to a particular solution!

Other Miscellanea

By-laws, clarifications and addenda go here. This used to be a short section, but previous years' students have shown that it is *depressingly* necessary to spell-out exactly what you should not be doing. But you're going to be smarter and better dressed than them, *right*? ☺

1. All OH&S inductions and procedures *must* be adhered to. You **WILL** be ejected from the lab if you are unsafe or in violation of footwear requirements. Repeat offenders will be barred from the teaching labs for the remainder of the semester.

2. It is the responsibility of all students to keep the teaching labs in clean, functioning condition. Lab cleanliness will be arbitrated by a warning system, as posted on the class blackboard site and class website.
    a. The lab status starts at GREEN.
    b. If the condition of the labs deteriorates and becomes messy, status will change to YELLOW, indicating that a clean-up is needed.
    c. If conditions do not improve or deteriorate further, the status will be changed to RED and the labs will be set to fixed-hours, with after-hours access prohibited.
    d. If conditions still do not improve or deteriorate further, the status will be changed to BLACK and the labs will be locked to students until the next practical session, whereupon the labs must be completely cleaned before any non-cleaning work may resume.

3. The following are specifically prohibited inside the lab:
    a. Eating or drinking in the lab (including water), or having food or drink outside of a backpack or bag.
    b. Sleeping in the lab
    c. Leaving the lab door open (all students have access cards)
    d. Giving non-enrolled students/non-students access to the lab
    e. Non-work related activities (e.g. computer games)

    Students found to be violating these rules will have lab access revoked.

4. Under no circumstances may project infrastructure, test equipment, tools, supplies, furniture, etc. be removed from the teaching labs. 'Vegas rules' are in effect: what happens in c404 *stays* in c404. Transgressors will be barred from the teaching labs for the remainder of semester.

5. No grade will be awarded until all assigned tools and equipment are returned and accounted for. Students are separately and collectively responsible for their group's tools.