4th Annual Greater Philadelphia SeaGlide Competition

Executive Summary

The SeaGlide Competition is an Autonomous Underwater Vehicle (AUV) Science, Technology, Engineering, Art, and Mathematics (STEAM) educational program and competition. A SeaGlide is a miniature underwater glider that moves by changing its buoyancy, taking in or expelling water, and shifting its center of gravity so it may dive or rise in the water. As the glider completes its dive and rise cycles, its wings generate lift, propelling the glider forward. Full scale underwater gliders require very little energy and can be fully or partially autonomous, allowing them to deploy for months at a time to collect valuable data about the world's oceans. SeaGlide consists of an educational tool kit that centers on a curriculum-designed program that teaches students about the basics of naval architecture, marine engineering, computer programming and electrical circuits. The program is designed to provide students with the materials and knowledge to construct an AUV. The students are then encouraged to build upon that basic knowledge to innovate and create unique AUV designs to meet specific mission scenarios. The Greater Philadelphia SeaGlide Competition (GPSGC) will be held on April 23, 2021 with Temple University, in conjunction with the SeaPerch competition.

The 2021 GPSGC will take place virtually, with the culminating competition consisting of five sections and one optional section. Two of the five sections, the White Paper and Presentation, have been part of the competition for several years. The Vehicle Performance has also been a part of the competition, but is optional this year. Coding & Circuitry was introduced as a pilot last year and will be included this year. Find-the-Fix and Bug Hunt are two new sections being introduced this year.

The White Paper is submitted on a predetermined deadline for judging in advance of the competition date. It emphasizes the documentation of the design approaches, engineering processes used, an explanation of the final design, and future design plans from the problem statement defined in the Competition Scenario. The Presentation is the opportunity for the teams to compete against other teams for a fictional Navy contract. It consists of both a commercial and a slide presentation, in which students discuss and demonstrate their design and obstacles they overcame during the engineering process. Students should be prepared to answer questions afterward. The optional Vehicle Performance section may take place in any body of water that the team has access to that is 20 feet in length and 5 feet in width. The challenge is a straight speed run. The Circuitry & Coding is a 3-person team, live, timed competition using the SparkFun Inventor's Kit provided to each school. Teams will be given tasks that they will need to design, create and code circuits, and demonstrate that they work. The Find-the-Fix gives schools several weeks before the competition to design a specific upgrade for their SeaGlide. The schools are not expected to incorporate the upgrade into their SeaGlide, and will submit a brief report detailing their hardware design, circuitry schematics, code, and testing. The Bug Hunt is a 3-person team, live, timed competition where students will be provided virtual malfunctioning circuits and code that they must fix.

Specifications for all 2021 technical sections are outlined in the document below and can be found on phillynavalstem.com along with other resources to aid teams with building, practice, and test setups prior to competition.

The Competition Scenario

The United States Navy is interested in acquiring a fleet of underwater gliders with a variety of capabilities. The Navy recognizes that the autonomous nature and low energy usage of underwater gliders may provide cost savings to the US taxpayer. Furthermore, their small size makes them ideal for clandestine operations. The Navy is seeking to fund companies to design and produce underwater gliders that will be ready for deployment within the next few years. Your school is competing as a company seeking this funding. Companies are not expected to produce a working prototype that meets all of the Navy's requirements, but they are expected to present a functional underwater glider, as well as research and plans that indicate the company will be capable of meeting the Navy's requirements.

The capabilities of the gliders that the Navy eventually wishes to deploy can be divided into two types. First, the US Navy wants to locate, deactivate, and recover unexploded warheads on the ocean floor. It believes that underwater gliders could be used to locate them, and that the gliders' small size and lack of crew make them ideal for use in contested waters. The gliders should be capable of object avoidance, object recognition, detecting energy signatures, and communicating via satellite. Second, the US Navy, in conjunction with the National Oceanic and Atmospheric Administration, wishes to continuously gather data on the world's oceans. The gliders should be capable of object avoidance, measuring a variety of properties of the ocean water, and communicating via satellite.

The Navy is primarily interested that the company can build a simple functioning and autonomous underwater glider capable of traveling in a straight line. Additional capabilities, such as maneuverability, sensor data recording, and communication are greatly encouraged. The Navy expects the company to provide a White Paper that explains their design process and testing, but also includes detailed future plans for how they will meet at least some of the Navy's other requirements.

A) Program Structure and Format

I. Eligibility and Registration

a. Eligible Participants

The GPSGC is open to schools and youth organizations in the Pennsylvania, New Jersey, and Delaware tri-state area.

b. Registration and Fees

Team registration typically opens in early fall until capacity is reached. Only one team per school or organization will be accepted. There is no fee to register for the SeaGlide competition.

II. Timeline

a. Phase I – Program Kickoff

The program kickoff includes team registration, the delivery of the challenge mission, rules, and deliverables, and new advisor training. Typically, each school may have up to two teachers and two students attend a 2-day training session where each person may participate in either SeaGlide building or Arduino coding. Although this was cancelled for 2021, teams may still reach out for technical support at NSWCPD_STEM@navy.mil.

b. Phase II – Design, Build, and Test

This is the time between the program kickoff and the competition to learn, experiment, design, build, test, and practice. The AUV may be given multiple modifications to the original structure of the basic SeaGlide kit.

c. Phase III – Competition

There are three sections to the competition: White Paper, Presentation, and Vehicle Performance. The White Paper will be submitted prior to the competition day. The Presentation consists of two deliverables: a commercial and a slide presentation. The commercial and slide presentation will be submitted prior to the competition day, but will be presented and judged on the day of the competition. The Vehicle Performance will take place in a pool on the day of the competition. For more information, refer to the Technical Sections.

B) Technical Sections

I. White Paper

a. Overview

The white paper is a 3-to-5-page paper that states the purpose of the SeaGlide, provides background on the problems and solutions from the Competition Scenario section, and describes and justifies your current design and future plans. The white paper should include all of the following:

- An explanation of how specific scientific principles apply to your design
- Figures (i.e. photographs, diagrams, graphs) and/or tables
- Updated computer code (if any)

Figures and tables do not count toward the length of the white paper. Updated computer code should be included in the appendix and does not count toward the length of the white paper.

b. General notes

- It is expected that the paper submitted was written only by students and is original and unique for this competition year. Papers with substantial portions copied from previous years' submittals will be penalized or disqualified.
- Limit file size to 3 MB by appropriately compressing pictures.
- Papers should be saved as a PDF (preferred), Word document, or Google Doc with filename "<SCHOOLNAME> SeaGlide White Paper 2020". You *must* send the file- do *not* share access to a file storage website.
- Submit papers to SeaGlideNotebooks@gmail.com, using subject line "Submission: <SCHOOLNAME> SeaGlide White Paper 2020".

c. White Paper General Rubric

Section	Points	Details
Cover Page	5	School name, Team name (optional), Advisor name and contact information, School ID#
Introduction	10	Briefly describe the problem and how your SeaGlide design is a solution.
Background	10	Provide detailed historical and/or scientific background on the problem and solutions for it.
Design Process and Solution	35	Describe the process by which you proposed and decided on your design and rejected alternative designs. Include any research, calculations and testing.
Future Plans	20	Describe future plans for your design. Include any research, calculations and testing to support these plans.
Summary	10	Make your case as to why your team deserves a multi-year SeaGlide development contract. Include a cost breakdown (the cost of the basic kit may be listed as one item). Original 3D-printed components are to be valued at $0.05 per gram.
References	5	References should be cited throughout the document. Use the APA citation style.
Content/Organization	5	The white paper should have a professional appearance: section headings, page numbers, appropriate chart and figure titles with corresponding references in the text, appropriate use of references, and good organization.
Appendix A: SeaGlide Computer Code	0	This section should contain Arduino code that was newly developed for the SeaGlide. It should be clearly commented and indented. Do not include the basic buoyancy engine code unless it was modified, in which case only include the specific sections that were modified.
Total	100	

II. Presentation

a. Commercial

Teams must produce a professional marketing commercial with a duration between 60 and 90 seconds. The commercial must focus on product features, product differentiation, and current and future design solutions. The commercial must encourage the Navy to fund the design, research and manufacture of your SeaGlide. It should also show other elements that cannot be demonstrated in the slide presentation (motion, development process, testing, and teamwork).

b. Commercial General Rubric

Section	Points	Details
5-second Splash Screen	1	School name, Team name (optional), School/Team logo, School ID#
Introduction	2	Briefly introduce your SeaGlide.
Product Features	5	Describe your SeaGlide's design features.
Design Process	5	Describe your team's design process.
Future Plans	5	Describe future plans for your design.
Summary	2	Make your case as to why your team deserves a multi-year SeaGlide development contract.
Graphics/Animation/Video	5	Demonstrate proper use of the video medium.
Content/Organization/Quality	5	The commercial should make good use of its time, be well-organized, and be clearly shot.
Total	30	

c. Slide Presentation

Teams must produce a slide presentation which they will present to judges. This slide presentation will contain more details than the commercial and last between six and eight minutes. Any number of teammates may act as presenters. The slide presentation should discuss the design process and obstacles the team overcame from the Competition Scenario section. It should also show elements that could not be demonstrated in the commercial (close-up photos, tables of data, lists of parts). Each team should discuss alternative designs that your team considered, the pros and cons of each, and ultimately why you chose your final design. Each presenter should have a speaking role during the presentation. Following the oral presentation will be a Q&A by the judges. Be prepared to answer questions regarding both your commercial and presentation.

*During the presentation and Q&A, the teacher/advisor and non-presenting teammates may observe, but may not contribute.

d. Slide Presentation General Rubric

Section	Points	Details
Cover Slide	5	School name, Team name (optional), School/Team logo, School ID#, Names of presenters
Introduction	5	Briefly describe the problem and how your SeaGlide design is a solution.
Design Process	20	Discuss your design process, including obstacles overcome and alternative designs that were considered.
Design Modifications	15	Discuss specific design modifications.
Data and/or Calculations	10	Present any data or calculations that were part of the design process.
Closing Remarks	5	Make your case as to why your team deserves a multi-year SeaGlide development contract.
Content/Organization/Quality	5	The slide presentation should make good use of its time and be well-organized. Graphics and photographs should be clear and properly sized.
Question & Answer	5	The presenters clearly answer all of the judges' questions.
Total	70	

III. Vehicle Performance (**Optional**)

a. Disclaimer

Due to many teams not having access to a pool and setup materials to test their SeaGlide vehicles, the Vehicle Performance challenge is optional.

b. Competition Overview

Teams that wish to participate must provide a video demonstration of in-water performance of their SeaGlide using the established requirements. This is the introductory level SeaGlide competition in which teams will compete with a basic SeaGlide kit and have a maximum budget of $50.00. The performance requirement is to glide a straight distance of 20 feet. Each team must build a testing area that meet the following requirements (reference diagram follows): The testing area is 20 feet long and 5 feet wide. There will be checkpoints at 5, 10 and 15 feet (Fig.1). The finish line will have red, yellow, and green target zones, each 1 foot in length. Leeway is provided regarding the construction of the testing area provided the objectives of the performance can be accurately observed.

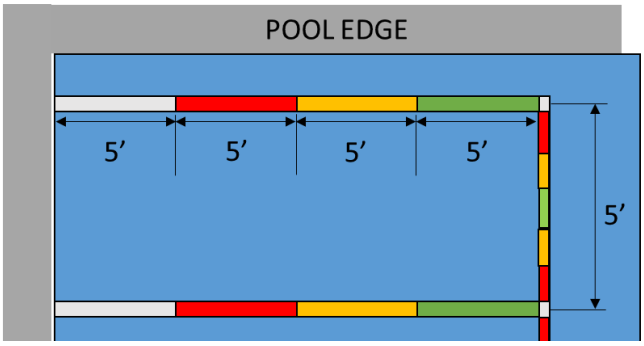

Figure 1. SeaGlide Course Dimensions

c. Recording
As with the live competition, teams are not limited to the number of attempts, but are additionally not limited to a fixed amount of time. Teams must provide video of their SeaGlide's best performance of the challenge. Position the camera at each checkpoint such that it is clear when the SeaGlide reaches that checkpoint. Due to refraction, poorly positioned cameras may make the timing of checkpoints difficult to determine and will result in intentional overestimation penalties.

d. Pool Restrictions
Nobody may be in the pool during the vehicle performance. Ensure that any water circulation jets are turned off. Water should be as calm as possible.

e. Scoring
Points are based on two parts: 1) the elapsed time it takes to reach each checkpoint and the finish line, and 2) how close the SeaGlide is to the center of the finish line.

f. Vehicle Performance Rubric

(T = elapsed time, B = best elapsed time for that distance)

Section	Points
Checkpoint 1	10(T÷B)
Checkpoint 2	15(T÷B)
Checkpoint 3	20(T÷B)
Finish Line (time)	30(T÷B)
Finish Line (best target)	Green: +25, Yellow: +15

C) 2021 Special Technical Sections

I. Find-the-Fix Design Challenge

a. Overview

The Find-the-Fix Design Challenge requires teams to act as In-Service Engineers to develop a detailed engineering solution and prototype concept to expand the capability of the SeaGlide vehicle to meet a need specified by the Navy. The challenge may include mechanical, electronic, and coding design.

b. Challenge Scenario

The Navy has been testing the prototype SeaGlide vehicles for applicability in oceanographic research. Following the initial testing, the Navy operators requested that your team, as the designers of the SeaGlide vehicle, include a sensor payload for monitoring noise and data logging daily statistics of the minimum, maximum, median, and first and third quartiles. The noise sensor must be externally mounted and enclosed in some manner of protective housing. The sensor is not required to utilize the existing Arduino microcontroller, and may be on a completely independent circuit.

c. Rules

1. Each team may use whatever resources are available to them to develop the engineering solution, but the design solution must be their own work.
2. Each team will provide a brief report demonstrating their solution.
3. The solution consists of three parts: housing assembly, circuit design, and code.
4. Each part is scored for each stage of its development as follows:
    a. Housing assembly: CAD design, prototype
    b. Circuit design: schematic, prototype
    c. Code: code, test results
5. Although it is desirable that each team both design and prototype their solution, it is absolutely acceptable for teams to submit a report if they were unable to prototype their design or test their code.
6. The report should be well-organized, and include figures and/or tables for each part.
7. Submit the report to SeaGlideNotebooks@gmail.com using the subject line "Submission: <SCHOOLNAME> SeaGlide Find-the-Fix 2021" by April 12, 2021.

Teams may use whatever software they like for CAD designs and schematics. Some suggested resources:

- www.autodesk.com/products/fusion-360/overview
- www.sketchup.com/try-sketchup#for-primary-and-secondary-education
- www.onshape.com/en
- www.tinkercad.com

d. Design Report (due by April 12)

The design report white paper is a 2-to-4-page paper that states the problem being addressed with the design modification to the SeaGlide, provides background on the problems, assumptions, solutions, and describes and justifies the design. The report should include all of the following:

- Rationale for sensor selection and why it is useful
- Figures (i.e. photographs, diagrams, graphs) and/or tables
- Microcontroller code

Figures and tables do not count toward the length of the white paper. Updated computer code should be included in the appendix and does not count toward the length of the white paper.

In addition to the report, teams will also provide separate file for the following deliverables in the overall compressed .zip file:

- Drawings/Models
  - Sensor Housing / Assembly engineering drawing(s) (*.pdf*)
  - Sensor Housing / Assembly 3D model(s) (*.stl*)
- Circuit Illustration (*.pdf with TinkerCAD URL hyperlink included*)
- Microcontroller code (*.txt* or *.docx*)

e. Find-the-Fix Report Rubric:

Section	Points	Details
Cover Page	5	School name, Team name (optional), Advisor name and contact information, School ID#
Introduction (1 paragraph)	10	Briefly describe the problem being addressed and how your SeaGlide sensor design modification is a solution. Include design assumptions
Housing Assembly CAD Design (2 paragraph)	15	Brief description of the process used to develop the sensor housing design
Housing Assembly Prototype	10	Figures with description of the sensor housing design
Circuit Design Schematic (2 paragraphs)	15	Brief description of the circuit design and figure of circuit schematic
Circuit Design Prototype	10	Figure of the circuit the sensor housing assembly
Code	15	Fully commented supplemental sensor code
Test Results (1 paragraph)	10	Description of test methodology and results
Summary (1 paragraph)	10	Describe the process by which your team developed the final design, including considerations for future efforts
Total	100	

II. Circuitry and Coding

a. Overview

The Circuitry and Coding section is a 90-minute race where 3-person teams compose and program multiple circuits using the SparkFun Inventor's Kit. The competition consists of multiple, unrelated tasks that are scored separately. Some tasks have bonus tasks that will require additional circuitry and/or code.

b. Rules

1. Each school may have one team consisting of no more than three students.
2. Each team must supply their own computer, preloaded with the Arduino IDE. Each team is restricted to Arduino coding on one computer.
3. Each team will use the SparkFun Inventor's Kit, which contains the Arduino microcontroller and all of the necessary components and accessories. This is the same kit that schools received at the two-day build training event. Teams may not provide any of their own additional materials. However, some tasks may require you to provide a common office supply (i.e. a sheet of paper). SparkFun Inventor's Kit information: (https://www.sparkfun.com/products/15267)
4. Each team may prepare a PDF document of notes, such as circuit diagrams and code snippets. Teams may access this document on their computer, as well as have their own hard copies. The document is limited to two pages (or one two-sided page) and must be a PDF. Teams may not access any resources besides their PDF and any resources provided by the judges. Teams may have blank paper and writing implements for planning purposes.
5. Each team will be provided with a list of separate circuitry and coding tasks. Each task will specify the expected outcomes, which may include component and/or serial monitor output. Neither a circuit diagram nor code will be provided. A task may include bonus tasks, which will require additional circuitry and/or code.
6. The competition will take place online by video conference. Each team must demonstrate that they are secluded during the competition, though an adult chaperone may be present. Successfully completed tasks will be demonstrated on camera, according to the judge's instructions.

c. Rubric

The rubric will be provided at the competition, and will vary depending on the number and difficulty of the tasks and bonus tasks. Each successfully completed task and bonus task will be worth a set number of points. Ties will be broken based on the time required by each team to complete their tasks.

d. Suggestions

1. Teams should have completed every project in the SparkFun Inventor's Kit or have sufficient experience developing circuits and programming with the Arduino microcontroller. They should understand how the circuits work and how the code works.

2. Teams should devise and complete their own small projects with the SparkFun Inventor's Kit, or similar Arduino starter kit.
3. The PDF should have important and/or common code snippets that can be quickly copy-and-pasted into the Arduino IDE, and then modified.
4. Make sure that the computer you will be using can connect to the SparkFun Inventor's Kit and that basic code can be successfully compiled, uploaded, and executed.

III. Bug Hunt

a. Overview

The Bug Hunt section is a 90 minute race where three person teams identify and correct a number of deliberately placed mistakes ("bugs") in a simulated Arduino circuit. The bugs may be errors in the Arduino code, or they may be physical misconfigurations in the wiring of the circuit.

b. Rules

1. Each school may have one team consisting of no more than three students.
2. Each team will provide their own, internet-connected computer.
3. Each team will be given a link to a TinkerCad webpage that contains the "buggy" Arduino circuit simulation and its associated sketch.
4. Each team will be given a document that describes the intended function of the circuit and provides a set of operational requirements. In addition, each team will be provided a short video clip of the circuit operating as intended.
5. The competition will take place online by video conference. Each team must demonstrate that they are secluded during the competition, though an adult chaperone may be present. The team will share their screen so that judges can observe the team's progress.
6. The team will be given 90 minutes to identify as many of the deliberately placed bugs they can, and to demonstrate that they can reproduce the behavior indicated in the video clip provided in (d) above.
7. Each team will be given a log sheet to keep track of the bugs they've identified and the corrective actions they've taken. This log will be used to assign points; bugs that are identified and corrected in the circuit, but are not reflected on the log sheet may not be scored appropriately.
8. Teams are welcome to use online references for the Arduino language and for the components used in the circuit. These references should be identified on the log sheet in the designated section.

c. Rubric

The rubric will be provided at the competition and will assign points to the bugs known to be in the circuit based on the subtlety of the error and its impact on the circuit's operation.

Points will be awarded for bugs identified (and their associated corrective actions) on the provided log sheet.

Bonus points will be awarded for restoring broken circuit features to their required operational behavior.

d. Suggestions
   1. All components in the bug hunt are included in the SparkFun Inventor's Kit provided as part of the SeaGlide materials. Although this exercise is conducted entirely virtually (so that the kit and its components are not necessary),understanding the projects in the kit will be invaluable in completing the Bug Hunt.
   2. When feasible, do not simply copy and paste the code for the Arduino sketches when building the projects in the kit. Manually typing in the sketch code will invariably introduce bugs; the same techniques needed to identify and correct these bugs will be useful in the Bug Hunt.
   3. Develop good coding habits when building and extending the kit projects. Adding comments to code and using meaningful names for variables and constants greatly simplifies the troubleshooting process.
      4. The TinkerCad Arduino simulator is available at https://www.tinkercad.com/learn/project-gallery;collectionId=OMOZACHJ9IR8LRE . Many of the projects described in the SparkFun Inventor's Kit can be replicated in the simulator. Completing those projects virtually as well as physically will provide useful practice and experience using the simulator tool.

F) SeaGlide Mentor Program

I. What is the Mentor Program?

The mentor program is an important part of the GPSGC. Bringing engineers and students together in a classroom environment is increasing student interest in math, science, and engineering. It increases awareness of Naval Engineering and Naval Architecture as career fields. Benefits of the mentor program include:

- Helping students prepare for college level work
- Provides students with the opportunities to:
  - work in a collaborative environment
  - experience a major university campus
  - participate in a realistic business and technical scenario
  - interface with industry, academia, and government engineers

Working with a mentor enhances a team's experience and provides the teacher/advisor with a greater chance of success.

II. How is the Mentor Relationship Established?

SeaGlide teams register online and it is at that time they can request partnership with a mentor. Once the request is received for a mentor one may be assigned to you. Every effort is made to find the best fit between the school and the mentor. A returning team may specifically request a mentor they have had in a previous

competition. Once a mentor is assigned, an email is sent to the mentor and the team advisor containing email and telephone number contact information. It is up to the advisor and/or mentor to establish and maintain connection after the first introductory e-mail is sent.

III. Meeting with the Mentor

The mentor meets with their SeaGlide team throughout the Design and Build phase. The first meeting is a great introductory opportunity for the mentor to discuss their career, the fields of science and math and share the fun aspects of math and science. The mentor can provide examples of how they use science and engineering every day. Subsequent meeting times are established where the students engage in the design of the SeaGlide and then on to the building phase.