



TASK 3: The Vertical Game: *MATE Floats! 2027*

MATE Floats! 2027 is inspired by the National Science Foundation (NSF)-funded [GO-BGC Project](#). The goal of GO-BGC is to build a global network of profiling floats with chemical and biological sensors to monitor circulation, chemistry, biology, and overall ocean health. Scientists, engineers, and technicians are using NSF grant funds to build and deploy 500 robotic ocean-monitoring floats around the globe. GO-BGC is over the 450 mark, with 457 out of the targeted 500 GO-BGC floats deployed and another 29 floats scheduled to be deployed from research vessels.

This year, *MATE Floats!* is challenging competitors to build a vertical profiling float capable of descending and maintaining position for a defined period of time, first in mid-water then at depth. As it ascends from depth to complete a vertical profile, the float is tasked with taking sensor readings at specified depths and transmitting that data to a shore-based receiver once it reaches the surface.

This task involves the following steps:

Design and construct an operational vertical profiling float

- **Game Plan:** Prior to the competition, design and construct a vertical profiling float – 5 points
- **Mic'd Up:** Float communicates with the station prior to descending – 5 points
- **Execute:** Float completes up to two vertical profiles
 - **Vertical profile 1**
 - Float completes first vertical profile using a buoyancy engine – 10 points
 - Float communicates first vertical profile data to the station – 5 points
 - Data verifies that the float maintains a depth of 2.0 meters for 30 seconds – 5 points
 - Data shows temperature and light measurements within expected range provided every 0.5 meters on ascent from 4.0 meters to 0.0 meters – 5 points
 - Float touches bottom of the pool – 5 point penalty
 - **Vertical profile 2**

- Float completes second vertical profile using a buoyancy engine – 10 points
- Float communicates second vertical profile data to the station – 5 points
- Data verifies that the float maintains a depth of 2.0 meters for 30 seconds – 5 points
- Data shows temperature and light measurements within expected range provided every 0.5 meters on ascent from 4.0 meters to 0.0 meters – 5 points
 - Float touches bottom of the pool – 5 point penalty
- Review the Play: Graph the data from the float
 - One vertical profile is graphed as temperature versus depth – 5 points
 - One vertical profile is graphed as light over depth – 5 points

OR

Company does not design and construct a vertical profiling float or float does not communicate data to the mission station.

- Temperature data provided by MATE is used to graph temperature versus depth – 5 points
- Light data provided by MATE is used to graph light versus depth – 5 points

Total points = 70 points

Product Demonstration Notes:

Prior to the competition, companies must build a float capable of completing a vertical profile (i.e., traveling from the surface to a depth of 2.0* meters, maintaining that depth for 30 seconds before descending to 4.0* meters, then ascending back to the surface) and collecting and communicating data to the mission station.

(*For regional competitions, depths may vary depending on the overall depth of the venue pool. [Contact your regional coordinator or visit your regional contest's website](#) to determine 1) the medium depth at which your vertical profiling float must maintain position and 2) the maximum depths at which your float should begin its ascent.)

Companies must design their float with a buoyancy engine. A [buoyancy engine](#) moves fluid from inside the float to outside the float, displacing seawater and changing the density of the float. Using motors to move air or liquid does constitute a buoyancy engine. Using motors as thrusters to directly move the float, by turning a propeller or emitting a jet of water, is not a buoyancy engine. The float must also be capable of communicating data to a receiving device (i.e., the receiver) located at the surface at the mission station. The company is responsible for designing and constructing both the transmitter on the float and the receiver that displays the data at the mission station.

Companies must submit a non-ROV device document outlining their float design, detailing its operation, and demonstrating that it does not violate any safety rules. This document must also detail the onboard battery design, fuse size for safe discharge of the current, and how the float communicates with the company's receiver at the mission station. See DOC-004 in the Competition Manual, and on pages 9-10 of this document, for more details. This non-ROV device document must be submitted in advance of the competition. Companies will receive 5 points for designing and building a float. Successfully designing and building a float is defined as submitting a non-ROV device document that meets the requirements of DOC-004, i.e., the float has a buoyancy engine to move the float vertically in the water column and transporting the float to the product demonstration station.

Companies competing at a regional may or may not be required to submit float documentation. [Contact your regional coordinator or visit your regional contest's website](#) to determine if you must submit your float design document prior to the competition. IF REQUIRED BY THE REGIONAL COMPETITION, COMPANIES MUST SUBMIT THEIR FLOAT DOCUMENTATION OR THEY WILL NOT BE RECEIVE POINTS FOR BUILDING THE FLOAT.

At the World Championship the *MATE Floats!* task will take place separately from the other mission tasks, in a designated area of the diving well. **Two additional company members will be allowed on the pool deck** to launch their vertical profiling float and receive data. During the 5-minute set up period, these two company members can help to carry the ROV and other mission equipment to the station, but will then proceed with the float to the designated station at the diving well. These two company members will be responsible for the entire *MATE Floats!* mission task, including deploying the float and receiving data, and graphing the data received. During check-in, companies will receive separate *MATE Floats!* scoring sheets in their folder; they will need to provide these scoring sheets to the *MATE Floats!* mission station judges. While electricity (AC power) will be available at the *MATE Floats!* station, compressed air will not.

At regional competitions, the *MATE Floats!* task may or may not take place separately from the other mission tasks. [Contact your regional coordinator or visit your regional contest's website](#) for this information. The two additional company members will only be allowed if *MATE Floats!* is happening separately from the other tasks.

Companies may hand-launch the float at the side of the pool of the *MATE Floats!* station. Once deployed, the float must communicate with the mission station to receive points for communication. Deploying the float is defined as the float no longer in contact with any station personnel and floating on the surface. Once the float has been deployed, it must communicate to the receiver located on the surface at the shore station. Companies are responsible for constructing both the transmitter on the float and the receiver at the shore station.

The float must communicate (i.e., transmit) the following information to the mission station, referred to as the defined data packet:

- Company number (provided by MATE a few weeks prior to the competition)

- Time data (UTC or local or float time [float time would be time since float starts recording])
- Pressure data and/or depth data
- Water temperature
- Light data
- Any additional data as required by the company to complete this task

Pressure data must be displayed in pascals (pa) or kilopascals (kpa).

Depth data must be displayed in meters (m) or centimeters (cm).

Temperature data must be displayed in degrees Celsius.

Light data may be reported in a variety of units depending on the physical quantity being measured and the type of sensor used. Examples include irradiance (W/m^2), illuminance (lux), or a sensor-specific electrical output such as volts, millivolts, current, resistance, or digital counts.

Pressure/depth, temperature, and light data must correlate to a set time transmitted from the float. For example, a defined data packet from EXPLORER 01 could be:

EX01 1:51:42 UTC 9.8 kpa 1.00 meters 23.6°C 0.546 V

NOTE: MATE is requiring WHAT data is transmitted (i.e., company number, time, pressure/depth, temperature, and light). Companies must determine HOW to transmit that data and should consider that there will be other companies transmitting data at same time.

Companies will receive 5 points when their float is deployed into the water and successfully transmits the defined data packet to the receiver at the mission station upon deployment. Successfully transmitting the information is defined as the station judge seeing at least ONE defined data packet from the float on a screen or display at the mission station. The float only needs to transmit ONE defined data package prior to descending, but companies will not be penalized for sending additional defined data packets. The receiver should not receive transmissions from any source other than the float. The float must transmit the defined data packet before starting its first vertical profile. If the float does not transmit and has not started its first vertical profile, companies may recover the float and attempt repairs. If the float descends before transmitting, companies can continue with the remaining float tasks but will not receive points for transmitting before the first vertical profile.

The float should attempt to complete two vertical profiles. For this *MATE Floats!* task, the float should start on the surface and descend to 2.0 meters*, then maintain depth at 2.0 meters (+/- 0.33 meters) for 30 seconds. The top of the float should maintain depth at 2.0 meters. If the pressure/depth sensor is not at the top of the float, the company should program the float so that the top maintains depth at 2.0 meters. After maintaining depth, the float must descend to a depth of 4.0 meters*. The top of the float should reach 4.0 meters. Once the float has descended to 4.0 meters, it must ascend to the surface. During the ascent, the float must collect pressure/depth, temperature and light data every 0.5 meters until the float reaches the surface.

A float that touches the bottom of the pool at any time after descending will be penalized 5 points on that vertical profile. Companies can only get one penalty per vertical profile. If the float impacts the bottom multiple times during a vertical profile, only one penalty will be assessed.

Companies will receive 10 points for successfully completing their first vertical profile. Successfully completing a vertical profile is defined as any part of the float on or above the surface, descending in the water column to a depth of 4.0 (or more) meters, then ascending to and breaking the surface once again. For example, a float that descends to the bottom of the pool, then ascends to the surface would be considered to have completed a vertical profile. In this example the float did descend to 4.0 meters (and went beyond that), and then ascended to the surface. This float would not receive points for maintaining depth at 2.0 meters and would also be penalized for touching the bottom of the pool, but the float would be considered to have completed a vertical profile.

After completing the first vertical profile, companies must transmit data packets from that profile to the surface station. Companies will receive 5 points for successfully transmitting data packets to the surface station. Successfully transmitting data packets is defined as at least 10 data packets being transmitted. Companies must display at least 10 data packets from the first vertical profile on a screen for the station judge.

During the vertical profile, the float must maintain a depth of 2.0 meters for 30 seconds. Companies will receive 5 points for successfully maintaining a depth of 2.0 meters for 30 seconds. This is defined as the top of the float at 2.0 meters of depth (+/- 33 cm) for 30 seconds. The top of the float should be used for calculating this depth, i.e., the top of the float should be at 2.0 meters (+/- 33 cm). After the first vertical profile, when data is transmitted, the data packets should show seven (7) sequential data packets, 5 seconds apart, where the depth is 1.67 meters to 2.33 meters. Companies must display all data packets on a screen for the station judge; the company should point out the seven sequential data packets at the proper depth. If the float drifts outside of this range at any time during the 30 seconds, the float must return to the designated range for an entirely new 30 second period. For example, if the float maintains depth at 2.26 meters for 20 seconds but then descends to 2.41 meters (outside of the given range), the float must ascend back into the range for an entire 30 seconds, not just the remaining 10 seconds from the first attempt at maintaining of depth. If the float's depth/pressure sensor is not at the top of the float, communicate the offset to the station judge. For example, if the float's depth/pressure sensor is 25 cm below the top of the float, when the top of the float is at 2.0 meters, the pressure sensor would be at 2.25 meters. Thus, the proper range for the depth/pressure sensor would be 2.58 meters to 1.92 meters. Communicate that adjusted range to the judge prior to deployment.

After maintaining a depth of 2.0 meters, the float should descend to 4.0 meters. The top of the float should reach 4.0 meters. Once at depth, the float should surface, gathering sensor data every 0.5 meters. Sensor data should be gathered at 4.0 meters (+/- 20 cm), at 3.5 meters (+/- 20 cm), at 3.0 meters (+/- 20 cm), at 2.5 meters (+/- 20 cm), at 2.0 meters (+/- 20 cm), at 1.5 meters (+/- 20 cm), 1.0 meters (+/- 20 cm), at 0.5 meters (+/- 20 cm), and at the surface, 0.0 meters (+/- 20 cm).

Companies must determine water temperature and light levels at each depth. Companies will receive 5 points for successfully determining the temperature and light levels at each depth. Successfully determining the temperature is defined as showing the station judge nine data packets where the temperature is within 2.0°C of the true temperature, one from each of the required depths. MATE will supply a temperature readout in the pool practice area so companies can compare their temperature readout to the MATE benchmark.

Successfully determining the light levels is defined as showing the station judge all nine light sensor readings, one from each of the required depths. There is no range limit for light readings; show the judge your voltage sensor readings. If either a reading is not from the proper depth or the temperature is not within range, companies will not receive points. For each data packet, the depth must be within 20 cm of the given depth. For example, for the 3.0 meter depth data packet, the data packet must show the depth between 3.20 and 2.80 m. To receive points, companies MUST show the depth within 20 cm, a temperature within 2.0°C, and a light measurement.

At the World Championship, the pool depth is 5.18 meters (17 feet deep). Regional competitions may happen in pools less than 5.18 meters deep. For shallower venue pools, the required depths will be adjusted accordingly. For example, if the pool venue is only 3 meters deep, companies may be required to maintain depth at 1.0 meters, descend to 2.0 meters, then ascend to the surface. In this example pool, companies will only be required to gather data at 2.0 meters, 1.5 meters, 1.0 meters, 0.5 meters and 0 meters. Companies would only display these five data packets to the station judge instead of nine data packets. [Contact your regional coordinator or visit your regional contest's website](#) to determine the depth of your venue pool, the depth level to maintain, and the depth levels at which to collect data.

The vertical profiling float should not touch the bottom of the pool. Floats that touch the bottom of the pool will be penalized 5 points.

The float should then attempt to complete a second vertical profile. Companies will receive 10 points for successfully completing a second vertical profile using a buoyancy engine. Successfully completing a vertical profile is defined as any part of the float on or above the surface, descending in the water column to a depth of 4.0 (or more) meters, then ascending to and breaking the surface once again.

After completing the second vertical profile, companies must transmit data packets from that profile to the surface station. Companies will receive 5 points for successfully transmitting data packets to the surface station. Successfully transmitting data packets is defined as at least 10 data packets being transmitted. Companies must display at least 10 data packets on a screen for the station judge from the first vertical profile.

During the vertical profile, the float must maintain a depth of 2.0 meters for 30 seconds. Companies will receive 5 points for successfully maintaining a depth of 2.0 meters for 30 seconds. This is defined as the top of the float at 2.0 meters of depth (+/- 33 cm) for 30 seconds. The top of the float should be used for calculating this depth, i.e., the top of the float should be at 2.0 meters

(± 33 cm). After the second vertical profile, when data is transmitted, the data packets should show seven (7) sequential data packets, 5 seconds apart, where the depth is 1.67 meters to 2.33 meters. Companies must display all data packets on a screen for the station judge; the company should point out the seven sequential data packets at the proper depth. If the float drifts outside of this range at any time during the 30 seconds, the float must return to the designated range for an entirely new 30 second period. If the float's depth/pressure sensor is not at the top of the float, communicate the offset to the station judge.

After maintaining a depth of 2.0 meters, the float should descend to 4.0 meters. The top of the float should reach 4.0 meters. Once at depth, the float should surface, gathering sensor data every 0.5 meters. Sensor data should be gathered at 4.0 meters (± 20 cm), at 3.5 meters (± 20 cm), at 3.0 meters (± 20 cm), at 2.5 meters (± 20 cm), at 2.0 meters (± 20 cm), at 1.5 meters (± 20 cm), 1.0 meters (± 20 cm), at 0.5 meters (± 20 cm), and at the surface, 0.0 meters (± 20 cm).

Companies must determine water temperature at each depth. Companies must determine the light levels at each depth. Companies will receive 5 points for successfully determining the temperature and the light levels at each depth. Successfully determining the temperature is defined showing the station judge nine data packets where the temperature is within 2.0°C of the true temperature, one from each of the required depths. Successfully determining the light levels is defined as showing the station judge all nine light sensor readings, one from each of the required depths. If one reading is not from the proper depth or the temperature is not within range, companies will not receive points. To receive points, companies MUST show the depth within 20 cm, must show a temperature within 2.0°C , and must show a light measurement.

Companies are permitted to use the light sensor of their choice to determine light levels at the various depths. Companies may measure spectral radiance, downwelling irradiance, total irradiance, or other measurement of light depending on their sensor. See [NASA - PACE EQUATION](#), for more information. Companies must report the physical quantity being measured (if known – Sensor dependent), and the units associated with the reported measurement. For example, a simple photoresistor would measure resistance, while an irradiance sensor would measure in Watts per square meter (W/m^2). DOC-004 must detail the type of light sensor used, including the units for that sensor.

The vertical profiling float should not touch the bottom of the pool during the 2nd vertical profile. Floats that touch the bottom of the pool will be penalized 5 points.

If the float fails to communicate to the mission station after its first or second vertical profile, it can continue to complete vertical profiles until it successfully transmits data. For example, if the float completes its first vertical profile but fails to communicate to the mission station before descending for its second vertical profile, companies will receive points for a vertical profile, but would not receive points for communication, maintaining depth, or determining temperature and light levels. After completing a second vertical profile, if the float communicates successfully with the surface station, companies will receive points for their second vertical profile and would receive points for communication, maintaining a depth, and receiving sensor information (if the data packets verify the required information). If the float then completes a third vertical profile and

successfully communicates to the mission station, companies will not receive any additional points for the third vertical profile, but they would receive points for the missed communication, maintaining a depth, and determining sensor data (if the data packets verify the information).

If a float communicates data to the mission station, but that data does not verify that the float maintained depth or determined sensor data, companies will still receive points for the tasks that they did complete during the vertical profile. If a subsequent vertical profile accomplishes additional tasks, the station judge will replace the lower score with the higher score. For example, if a float completes a vertical profile and transmits data packets, those data packets confirm the float maintained depth at 2.0 meters, but those data packets do not show sensor data, companies would receive points for completing a vertical profile, transmitting data, and maintaining depth, but would not receive points for determining sensor data at the various depths. After completing two vertical profiles, if a subsequent vertical profile is completed by the float, and that profile verifies maintaining depth and determining sensor data, companies would then receive points for data that verifies information missed in a previous vertical profile.

Companies MUST inform the station judge that their recent profile has additional points scored and show the station judge the data confirming a high score. The station judge is not responsible for tracking additional vertical profiles; a company member must show the judge the data verifying the additional points.

Companies will use the data packets received from one vertical profile to graph temperature versus depth. Data from either vertical profile can be used; companies will not receive additional points for graphing data from both vertical profiles. Companies will receive 5 points for successfully graphing temperature versus depth. Successfully graphing temperature versus depth is defined as showing the station judge a graph with temperature measurements from the float on the X axis and depth on the Y axis. Companies will also use the data packets received from the float to graph light versus depth. Companies will receive 5 points for successfully graphing light versus depth. Successfully graphing light versus depth is defined as showing the station judge a graph with light measurements from the float on the X axis and depth on the Y axis. For both graphs, companies must graph the data received from their vertical profiles, and teams must have data from every required depth point. If the float did not collect and transmit the required data, the company will not be able to graph its data and may instead elect to graph the data provided by MATE. Companies must use a computer or device to graph the data; companies may not draw a graph by hand. Data points may be entered (or cut and pasted) into a device by hand. Graphing of data must occur within the 15-minute product demonstration time.

Data will be available from MATE if the company does not build a float or if the float fails to communicate its data packets to the surface station. Likewise, if the float does not communicate sufficient data packets from the profile, or the sensor measurements are not correct, data will be available from MATE. Graphing MATE data replaces graphing profile data as well as the float communicating at least 10 data packets to the shore station and the data showing temperature and light data. Companies that graph MATE data may still earn points for completing vertical

profiles and maintaining depth at 2.0 meters, provided that the data shows the float maintaining depth.

Companies that choose to use MATE data should inform the station judge that they require this data. The judge will then provide a set of temperature versus depth data and a set of light versus depth data to the company. Once a company requests data from MATE, they forfeit the opportunity to receive points for communicating data packets to the station, taking sensor readings, and graphing data from their own float.

Companies that elect to use MATE data will receive 5 points for successfully graphing temperature versus depth. Successfully graphing temperature over depth is defined as showing the station judge a graph with temperature on the X axis and depth on the Y axis. Companies will receive 5 points for successfully graphing light versus depth. Successfully graphing light over depth is defined as showing the station judge a graph with light on the X axis and depth on the Y axis. Companies must use a computer or device to graph the data; companies may not draw a graph by hand. Data points may be entered into a device by hand.

Float Specifications:

New for 2027!!!

The float must be less than 60 cm in overall height.

The float must be less than 18 cm in diameter/length/width.

The float may not have an airline to the surface or a rope/line to the surface or the bottom.

The entire float must be less than 60 cm meter in length, including an antenna for broadcasting data.

The float must be less than 60 centimeters in length for the entire mission, it cannot have multiple compartments that separate, nor may it raise or lower any objects beyond the 60-centimeter limit.

The float must operate independently; it cannot be connected to the shore by a tether, and the ROV cannot interact with the float.

Any air used on the float must be stored on the float. Floats may not have an airline to the surface. All electrical power to the float MUST go through a single fuse. The float will operate as a non-ROV device (see 3.3.1 Non-ROV Device Power Specifications in the competition manual, and on pages 10-13 of this document, for additional rules on powering a non-ROV device). Small button batteries are allowed to power timing devices on the float. All other batteries must adhere to the non-ROV device battery rules.

DOC-004: Non-ROV device design document: Companies will be required to submit a written and photographic description of their non-ROV device. This document is limited to 2 pages in length.

Companies must measure the full load amps of the float device and determine their fuse size from this measurement. This non-ROV device design document must contain:

- A photo or diagram of the non-ROV device.
- The type of batteries used.
- A photo of all battery packs.
- A photo of the fuse(s) used on the ROV.
- Fuse determination showing the full load amps measurements for both waiting mode and buoyancy change mode. A photo should be shown of the amperage measurement readout at buoyancy change mode.

For the *2027 MATE Floats!* task, this document must also include:

- A description of the buoyancy engine used to complete vertical profiles.
- A description of how the float communicates with the shore side receiver. If any commands are given to the float after deployment, those communications must be described too.
- A description of how the battery pack was designed to safely fulfill the full load amps needs and the voltage requirements of the float device.
- **New for 2027!!!** A description of the mechanism to relieve pressure if pressure inside the canister is greater than the outside pressure.
- **New for 2027!!!** A description of the temperature sensor and light sensor used. For the light sensor, the description must include the sensor type (e.g. photoresistor, photodiode, irradiance sensor, illuminance sensor), the light-related quantity being measured (e.g. irradiance, illuminance, relative light level) and the reported units of measurement (e.g. W/m², lux, volts, millivolts, resistance, digital counts).

A SID of the non-ROV device document must be included with the non-ROV device design document. This SID must be one page in length and is in addition to the 2 pages required for the non-ROV device design document (i.e. DOC-004 can be a total of 3 pages, 2 pages for a description, one page for a SID). The SID must include:

- A fuse using a standard fuse symbol
- Full load amps fuse measurements

3.3.1 Non-ROV Devices

The vertical profiling float qualifies as a non-ROV device in 2027.

ELEC-NRD-001: The vertical profiling float cannot be powered from the surface. If the float is powered, it must use onboard batteries. Voltage is limited to **12 VDC maximum**; amperage is limited to **5 amps maximum**. All power for the non-ROV device must go through a single fuse (see ELEC-NRD-005).

ELEC-NRD-002: The vertical profiling float non-ROV device may not utilize thrusters nor include any cameras. Vertical profiling floats cannot use a camera onboard to take images or video of sensor data and transmit those images/videos to the surface station.

NOTE for 2027!!! New battery limitations are in place. Read the following information carefully!

ELEC-NRD-003: Onboard power is allowed for non-ROV devices. If onboard batteries are being used, the following specifications must be met.

- NiMH (Nickel Metal Hydride) and AGM (Absorbed Glass-Mat) batteries only. **Alkaline batteries are not allowed.**
- NiMH battery packs consisting of 9-volt, AA, C or D cell batteries are allowed. **See table below for maximum amperage allowed for each battery type.** This includes battery packs with multiple small batteries wrapped in plastic.
- Larger NiMH and AGM (Absorbed Glass-Mat) 12-volt batteries are also allowed. This includes large (brick sized) batteries.
- No other size or chemical composition is allowed. 12-volt outdoor, re-chargeable batteries are not allowed. **Hi discharge LiPo batteries are not allowed.**
- Batteries are mounted in a manner that they are not loose inside the container.

All batteries are limited to the maximum allowed current shown in this table. Above this current, batteries will overheat.

Battery Type	Maximum Fuse Size
NiMH AA	2.0 A
NiMH C or D	5.0 A
NiMH 9-volt	200mA
NiMH* / AGM 12V	5.0 A

*The 5.0 amp maximum fuse size for NiMH 12 volt batteries refers only to the larger, brick sized batteries. 12-volt battery packs, consisting of multiple AA or 9-volt batteries wrapped in plastic, require the smaller fuse size for those batteries.

To determine a NiMH battery's maximum fuse size, see the individual battery's mAH (milliamp hours) rating. Divide that number by 1000. For example, if a NiMH AA battery has a rating of 2300 mAH, its maximum current would be 2.3 amps, requiring a 2-amp fuse. If a NiMH battery has a rating of only 1900 mAH, its maximum current would be 1.9 amps, requiring a 1-amp fuse.

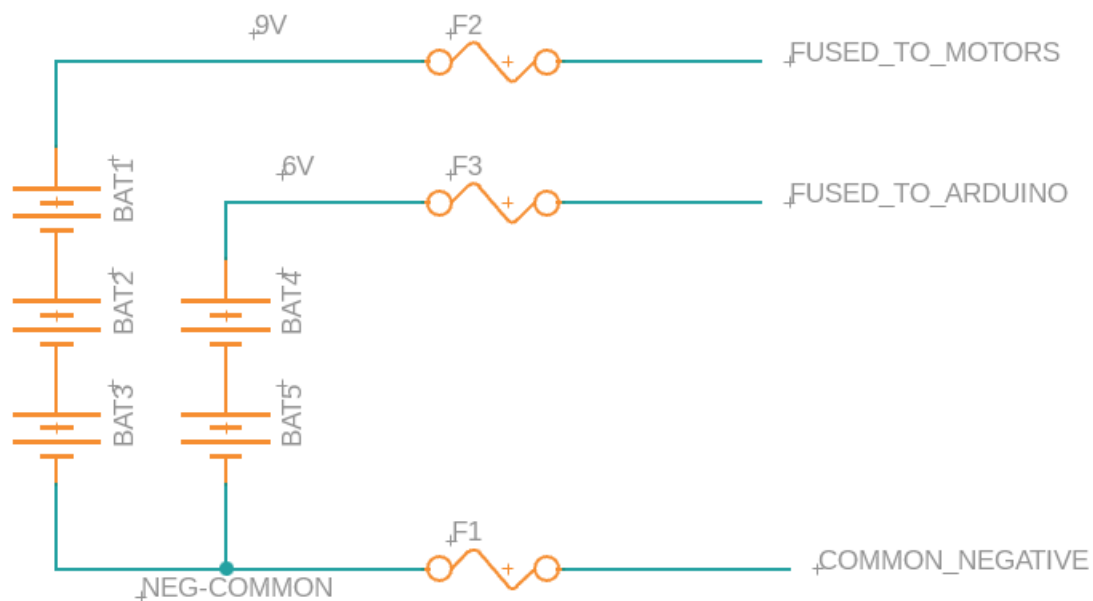
ELEC-NRD-004: Battery fusing for non-ROV devices is an important consideration and the following rules must be adhered to.

- A single fuse must be utilized that will shut down all power sources in the non-ROV device if the fuse blows.
- A fuse (5 amps max) must be installed within 5 cm of the battery positive terminal.
- All fuses, when installed, must be able to be visibly inspected for amperage through a clear housing or immediately after an opaque NRD device housing is removed without the need to uncover the fuse.
- **Note for 2027!!!** Cartridge, ATO type blade fuses or MINI blade fuses CAN be used for fusing NiMH and AGM batteries. The fuses to select from are 1A, 2A, 3A, 4A and 5A fuses. These fuses provide easy visual inspection for amperage using industry standard color codes.

Fuse Reference: [ATO fuse](#) [MINI fuse](#)

These fuses are all rated for 32VDC and are color coded for amperage.

- All blade fuses MUST correspond to the standardized color codes listed on the fuse links above. All cartridge fuses must be readily accessible and have the current stamped on the end of the fuse. Minimum DC voltage for the fuse must be 32 volts.
- The maximum distance from a battery pack to any fuse is 5 cm.
- Batteries in Series: No voltage over a nominal 12V is allowed. This means no more than eight 1.5V alkaline batteries in series.
- Batteries in Parallel: Batteries may be placed in parallel to increase the current available to the system within the following limits:
 - In no case shall the current from the pack exceed 5A.
 - The number of series strings in parallel is used as a multiplier to determine the fuse size. For example, using AA batteries, the maximum fuse size is 2.0 amps. If two battery strings are placed in parallel, the maximum fuse size is 2 amps ($2 * 2.0A = 4.0$ Amps).
- **Note for 2027!!!** For systems with multiple battery packs, the battery packs should be connected to the negative terminals with the fuse (5 amps max) located off of the common negative terminal connection. Each individual battery pack should also be fused with the properly sized fuse for that battery pack. Note that a single battery wired in parallel is considered a battery pack. For example, five NiMH 9-volt batteries wired in parallel, the maximum fuse size is 1 amp ($5 * 0.2A = 1.0$ A). Each 9-volt battery would need to be individually fused at 0.2A as well.



ELEC-NRD-005: Full Load Amps Value. Companies MUST measure the full load amps (FLA) of their device during waiting mode (motors off) AND during buoyancy change mode (motors on). The type of battery pack allowed for their system can be determined using the full load amps measurement (See ELEC-008E in the competition manual for more information).

Using the non-ROV device full load amps values, companies should select the standard fuse closest to their FLA.

ELEC-NRD-006: If using a housing for onboard batteries, the enclosure housing must be designed so that it will open if the pressure inside the housing is greater than the outside pressure.

There are two allowable methods for pressure relief:

1. The enclosure is built in a manner that an end cap will pop off if under pressure. This can be an internal or external cap with O-rings to provide sealing. The sealing diameter of the end cap must be 2.5 cm in diameter or greater (this limits the smallest ID of an enclosure to 2.5 cm).
2. **New for 2027!!!** An approved commercial, off-the-shelf pressure relief valve may be used provided it is set to a maximum of 15 PSI. Companies planning to use a pressure relief valve must forward the specifications for the valve to the [Competition Technical Manager](#) by May 1st, 2027, or at least 2 weeks prior to their regional competition. The specifications must show the pressure release rating of the valve. Companies are REQUIRED to bring the pressure release valve specification to their safety inspection. This may be as a digital copy or a printed copy made available to the safety inspectors.

Additional notes:

- Under no condition should the housing be built with fasteners to hold the housing together. There must be at least one 2.5 cm or larger opening that serves as a pressure release.
- Pop-off end caps that utilize a tightening mechanism (hose clamp, Twist-Tite) are not allowed.
- Companies may use other pressure relief devices as a secondary type of pressure relief, but must institute one of the primary methods to pass the safety inspection.
- **New for 2027!!!** A hole filled with a rubber stopper is no longer acceptable as a primary pressure relief mechanism. Companies may use a rubber stopper as a secondary pressure relief system but must have one of the two acceptable primary pressure relief mechanisms in place.

ELEC-NRD-007: A SID must be submitted for any non-ROV device that uses electrical power