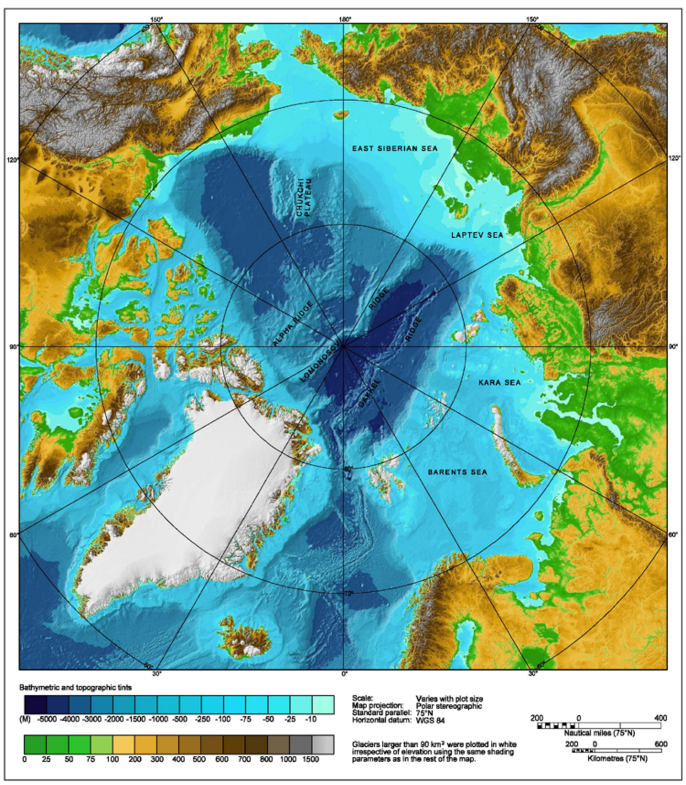
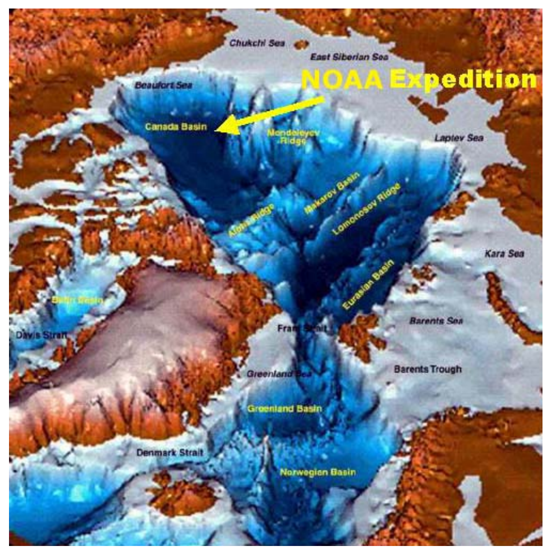
Mission #2 – ICE TANK

Science & technology under the ice: NOAA's "Hidden Ocean" arctic expedition
The Arctic Ocean is the smallest of the world's four ocean basins with a total area of about 1.4 million square kilometers (compare that to the Pacific, which has a total area of 179.7 million square kilometers). It is also the world's least explored ocean; its remoteness and harsh environmental conditions make accessing it, let alone working in it, an almost unfathomable challenge. Only scientists and explorers with the right research vessels, underwater technologies, and the determination to learn more about the polar frontier go to the extreme and venture there.

During the summer of 2005, a team of 45 scientists from the United States, Canada, China, and Russia went to the extreme with the right gear and the right attitude. This international team set out to explore and study the frigid depths of the Canada Basin, a 3.7-kilometer deep bowl adjacent to the Beaufort Sea, which is located north of the Northwest Territories, the Yukon, and Alaska and west of Canada's Arctic islands. Named "The Hidden Ocean" because this part of the Arctic is covered with sea ice for most of the year, the expedition was funded by NOAA's Office of Ocean Exploration.





The Arctic Ocean, highlighting the area of NOAA's "Hidden Ocean" expedition

The expedition operated onboard the U.S. Coast Guard (USCG) icebreaker *Healy*, the newest addition to the U.S. icebreaker fleet. The *Healy* is designed to break four feet of ice continuously at a speed of three knots and can operate in temperatures as low as

-45°C. Onboard the *Healy* supporting the expedition was the *Global Explorer*, an ROV capable of operating in the icy cold, deep waters.

The scientific objectives of the voyage were to study the Canada Basin from the surface of the ice to the bottom of the deep sea, cataloging the organisms found throughout that range and trying to understand the linkages that exist between ice, water, and the seafloor. Information about water chemistry and circulation were also collected, in part to better understand the basin's links to the global ocean.

The expedition contributed to the Census of Marine Life, a 10-year international research effort to assess and explain the biodiversity, distribution, and abundance of organisms throughout the world's oceans. The census grew out of the need to better understand the oceans and how they are changing, as well as to better understand the implications of these changes on human life and our marine resources. Through 2010, scientists in more than 70 countries will gather information for the census. Like NOAA's Office of Ocean Exploration, the Census of Marine Life emphasizes field studies conducted in unknown and poorly studied habitats, such as the cold depths of arctic waters. Data, including photographs, collected during the Hidden Ocean expedition were entered into the census' inventory information system.

While NOAA's 2005 expedition resulted in a wealth of new information and discoveries, it also raised a number of new questions about the arctic marine ecosystem. It also instilled a new sense of urgency and the will to learn more about waters of the northern pole.

And this is where your mission begins.

Hidden Ocean science team and the USCG Healy crew on the sea ice in the Canada Basin
(photo credit Ian MacDonald, Texas A&M University)

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NOAA's Office of Ocean Exploration is organizing a return expedition to the "Hidden Ocean." In addition to the Canada Basin, the expedition's study area will include the adjacent Beaufort Sea. The scientific objectives are similar to those of the 2005 expedition and include documenting organisms for the Census of Marine Life.

Of particular interest is the species of benthic jellyfish found on the last voyage. *Crossota millsae* was a surprise to the scientists who viewed the specimen hovering above the seafloor in the video monitor of the *Global Explorer*. *C. millsae* was first discovered in the deep waters off of California and Hawaii; finding it in the Canada Basin put it well out its known geographic range. On this return expedition, scientists will collect samples of *C. millsae* in the hopes that studying it more closely will add pieces to the puzzle of this amazingly beautiful creature and shed light on how it fits within the polar ecosystem.

Crossota millsae ***(photo credit Kevin Raskoff, Monterey Peninsula College)***

Sampling algae that live on the "underside" of the ice cover is also part of the science plan. Large masses of algae exist at the ice-seawater interface, some forming filaments several meters long. On average, more than 50% of the primary productivity in the Arctic Ocean comes from unicellular algae that live near the ice-seawater junction, making this interface a critical part of the polar marine ecosystem. These algae can occur in such high abundances that the color of the ice is no longer white or blue, but instead "autumn" colors of brown, red, and orange. More than 200 algal species are known to exist in the Arctic sea ice, but, with additional sampling, many more species are likely to be described.

Also of particular interest is the population of bowhead whales, an endangered baleen whale found exclusively in arctic waters. Scientists are studying the distribution and migratory patterns of these whales in the hopes that it will lead to a better understanding of their role within the arctic ecosystem and, possibly, conservation measures that could save the species. The plan is to install a series of passive acoustic sensors at specified locations on the arctic seafloor. The passive acoustic sensors are essentially fixed hydrophones that will "listen" for the bowhead whale calls; communication cables will run from the sensors to stations on shore where the recorded sounds will be processed and, with the help of satellites, transmitted over the Internet to the offices of scientists involved in the study. Installing multiple acoustic sensors under the ice is an ambitious undertaking; this return expedition will test the concept by installing just one.

While the USCG *Healy* is available for the trip, the *Global Explorer* is not; it is currently on contract to support scientific studies at the opposite end of the earth, Antarctica. NOAA is searching for another vehicle equally as capable as the *Global Explorer* to operate in such extreme conditions. This ROV must be able to navigate under the ice in the deep, dark reaches of the Canada Basin. The vehicle must also be equipped to retrieve delicate organisms, such as the benthic jellyfish discovered during the last voyage, so that scientists can better understand the variety of life that inhabits this frozen habitat at the top of the world. Finally, the ROV must be able to deploy a passive acoustic sensor on the seafloor without damaging the communication cable that connects it to the shore-based research station.

Is your team's vehicle up to the challenge?

MISSION TASKS – EXPLORER & RANGER

Teams will get one attempt at the mission. The time allotted to complete the mission (i.e., the mission performance period) is 20 minutes, plus 5 minutes to set up your system and 5 minutes to demobilize your equipment and exit the control shack.

Teams will receive a time bonus for successfully completing the mission tasks, returning their ROVs to the surface, and touching the side of the ice tank by the control shack before the mission performance period ends. ROVs do NOT need to return to the surface during the mission performance period.

Task 1: Collect one benthic jellyfish.

Your mission is to collect ONE jellyfish from the bottom of the ice tank and return it to the surface.

The mission task involves:

- **Collecting one jellyfish.**
- **Returning the jellyfish to the surface.**

Ten "O-balls" will be placed on the bottom of the ice tank within the specified mission area. For EXPLORER teams, this will be within 10 meters of the side of the tank at the control shack. For RANGER teams this will be within 6 meters of the side of the tank. If during the collection process an O-ball(s) is pushed or otherwise moved outside of the collection area, no additional O-balls will be provided.

Teams are only required to collect ONE O-ball. Teams can collect more than one O-ball; however, no extra points will be awarded.

Task 2: Collect one sample of algae.

Your mission is to collect ONE sample of algae from under the ice sheet.

The mission task involves:

- **Collecting one sample of algae.**
- **Returning the sample to the surface.**

Approximately 50 ping pong balls will distributed under the ice sheet within the specified mission area. For EXPLORER teams, this will be within 10 meters of the side of the tank at the control shack. For RANGER teams this will be within 6 meters of the side of the tank. If during the sampling process a ping pong ball(s) is pushed or otherwise moved outside of the sampling area, no additional ping pong balls will be provided.

Teams are only required to collect ONE ping pong ball. Teams can collect more than one ping pong ball; however, no extra points will be awarded.

Task 3: Deploy a passive acoustic sensor (PAS).
Your mission is to deploy a PAS with its attached communication cable within a designated area on the bottom of the ice tank.

The mission task involves:

- **Transporting the PAS to the designated area.**
- **Deploying the PAS within the designated area.**

The designated deployment area is 0.5m by 0.5m PVC square weighted to the bottom of the ice tank. Teams must place the PAS so that it remains completely within the designated area once it is released by their ROV. One student team member at the control shack is permitted to pay out the attached communication cable as the ROV deploys the PAS.

Scoring – 60 TOTAL points (no partial points will be given)

- 10 points – collect one jellyfish from the bottom of the ice tank so that it is under the control of your ROV and no longer in contact with the bottom.
- 10 points – return the jellyfish to the surface under the control of your ROV so that one team member can retrieve the jellyfish from the vehicle.
- 10 points – collect one sample of algae from under the ice sheet so that it is under the control of your ROV and no longer in contact with the ice sheet.
- 10 points – return the sample of algae to the surface until the control of your ROV so that one team member can retrieve the sample from the vehicle.
- 10 points – transport the PAS from the surface to the designated deployment area on bottom of the ice tank under the control of your ROV. Your ROV cannot use the communication cable as a means of transporting the PAS to the bottom. The PAS cannot dangle from the communication cable below your ROV as you transport it to the bottom.
- 10 points – deploy the PAS within the designated deployment area so that it remains within the designated area once your ROV has released it and mission control officials have confirmed it is successfully deployed. If your ROV accidentally (or on purpose) moves the PAS from the designated area once it has been successfully deployed, no points will be given.

Time bonus
Teams will receive 1 point for every minute and 0.01 point for every second under 20 minutes remaining. Your mission performance period ends when your ROV has successfully collected one benthic jellyfish and one sample of algae and deployed the PAS within the designated area. Time bonus points will be awarded accordingly.

MISSION PROP SPECIFICATIONS
Task 1: Collect one benthic jellyfish.

The jellyfish are simulated by "Original O-balls." O-balls are manufactured by Rhino Toys (http://www.rhinotoys.com/). O-balls are available for purchase at http://www.whatshebuys.com/rhi-1002-01.html and at numerous retail stores. Contact Rhino Toys for stores in your area.

The O-ball is made of plastic interlocking rings and is 11.43cm in diameter. It weighs less than 50 grams in water and will take less than 0.5 N to lift.

Task 2: Collect a sample of algae.
The algae are simulated by orange-colored ping pong balls. The ping pong balls are 3.7cm in diameter. The balls are positively buoyant and will therefore float on the underside of the ice sheet.

Task 3: Deploy a passive acoustic sensor (PAS).
The PAS is simulated by ABS pipe, PVC end caps, a chain, and a dive weight. It consists of two parts: a base unit and the instrument.

The base unit is constructed of a 30cm length of 3-inch black ABS pipe. A 2-lb dive weight is attached to the bottom of the base unit via cable ties. The dive weight functions to anchor and stabilize the unit on the bottom of the ice tank when the PAS is deployed. Attached to the dive weight is a 20m length of 22-gauge wire. This wire simulates the communication cable that links the PAS to the shore-based science station.

The instrument is constructed of 3-inch black ABS pipe with white PVC end caps on each end. The length of the instrument, including the end caps, is approximately 30cm. Holes drilled in both the end caps and the ABS pipe will allow water to fill the instrument. Flotation inside the ABS pipe will provide buoyancy and allow the instrument to float above the base unit. The instrument is attached to the base unit by 30cm of #100 décor oblong black chain.

For **EXPLORER** class teams, the PAS, including the base unit, the instrument, and the cable to the surface, weighs ~4N in water. For **RANGER** class teams, the PAS, including the base unit, the instrument, and the cable to the surface, weighs ~2N in water.

The chain was purchased at Orchard Supply Hardware. The part number is: 265-7260

Note: Photos of the jellyfish, algae, and PAS are included at the end of this document. Assemblies and drawings of the PAS were created in SolidWorks and are also included at the end of this document.

ENVIRONMENTAL CONDITIONS
While this part of the Arctic Ocean is covered in ice for much of the year, the time of its seasonal melt is happening sooner, while the time that it freezes over after ice-free summer months is happening later. At the time of your return expedition, the ice cover is present. In addition to the presence of ice, the Canada Basin and adjacent waters are achingly cold; water temperatures seldom rise above 0°C. Air temperatures, hovering

well below 0°C during the winter months, are exacerbated by strong winds of cold, dry air from the descending jet stream.

Your team should prepare to operate your ROV in the simulated environmental conditions described in the **Operating Environments – Ice Tank** section of the **Design & Building Specifications and Competition Rules** document. Note that EXPLORER and RANGER class teams will face similar environmental conditions.

References:

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Photos
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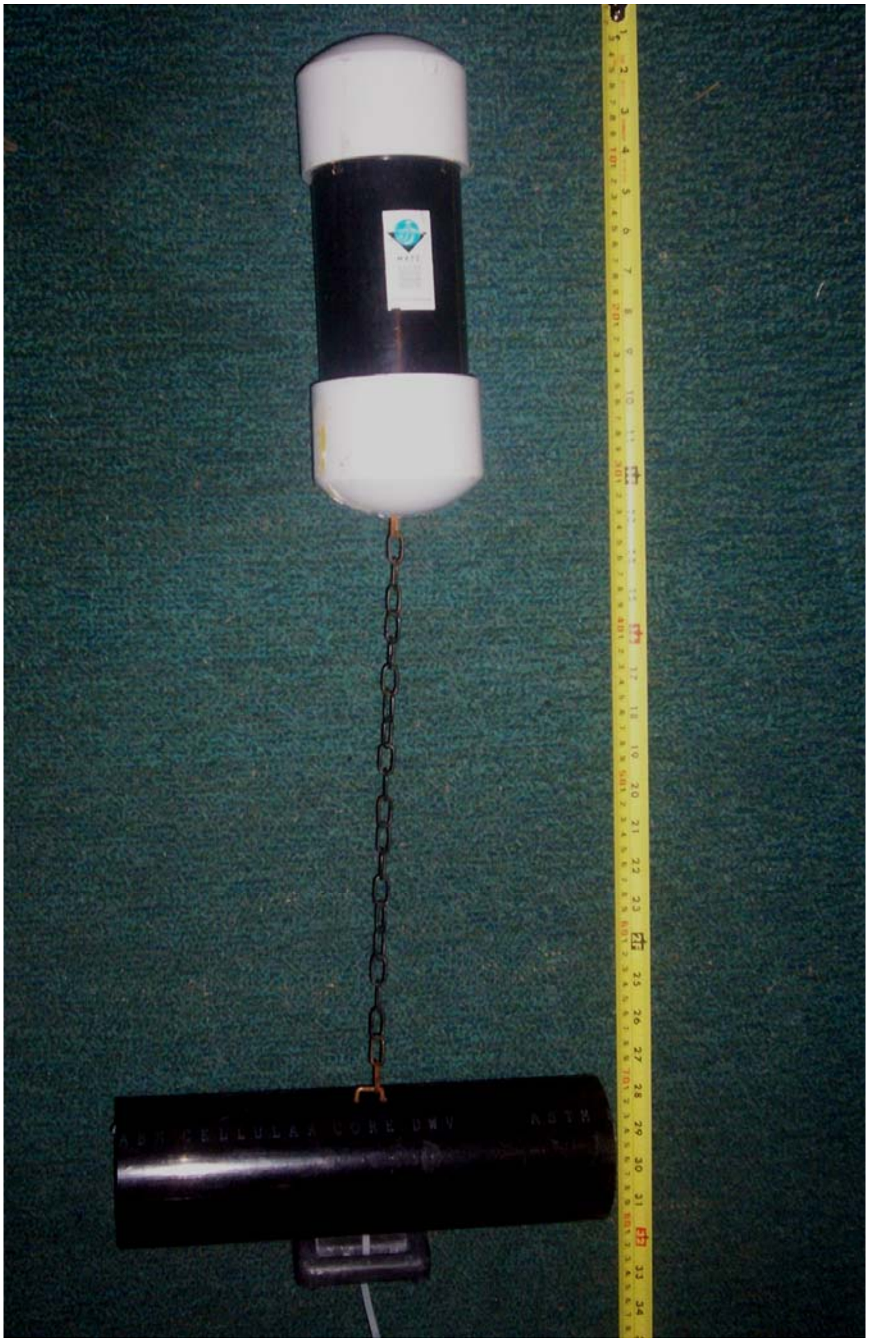
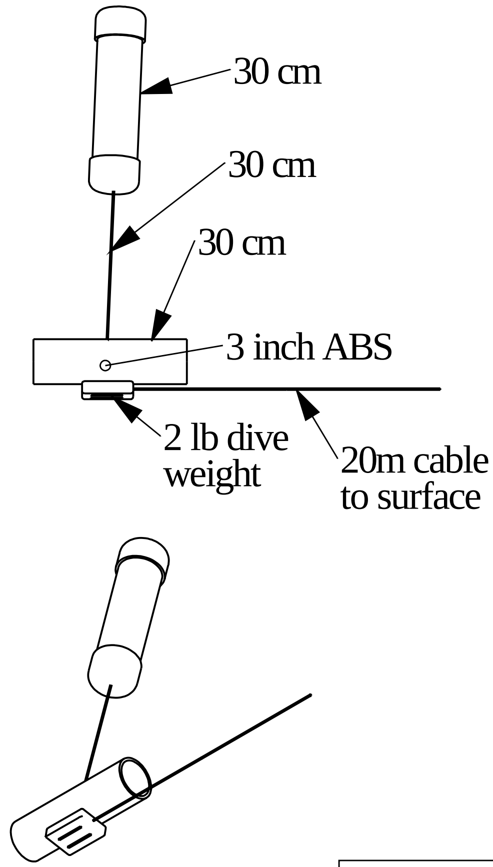
Benthic jellyfish

Algae



Passive acoustic sensor



Mission #2: Ice Tank

<u>Passive acoustic sensor (PAS) instrument</u>
- Constructed of 3-inch ABS pipe
- 3-inch endcaps on both ends
- Total length: 30 cm

<u>PAS chain</u>
- Constructed of #100 decor oblong black chain
- Total length: 30 cm
- Connected to instrument and base module with U-nail

<u>PAS base</u>
- Constructed of 3-inch ABS pipe
- Total length: 30 cm

<u>PAS weight</u>
- 2 lb dive weight
- 8.5 cm x 7 cm x 2 cm
- Cable tied to bottom of PAS base

<u>PAS cable</u>
- Total length: 20 meters
- Constructed of 22 gauge speaker wire

<u>PAS total wet weight</u>
- Explorer class: 4 Newton
- Ranger class: 2 Newton

NEXT ASSY | USED ON
APPLICATION

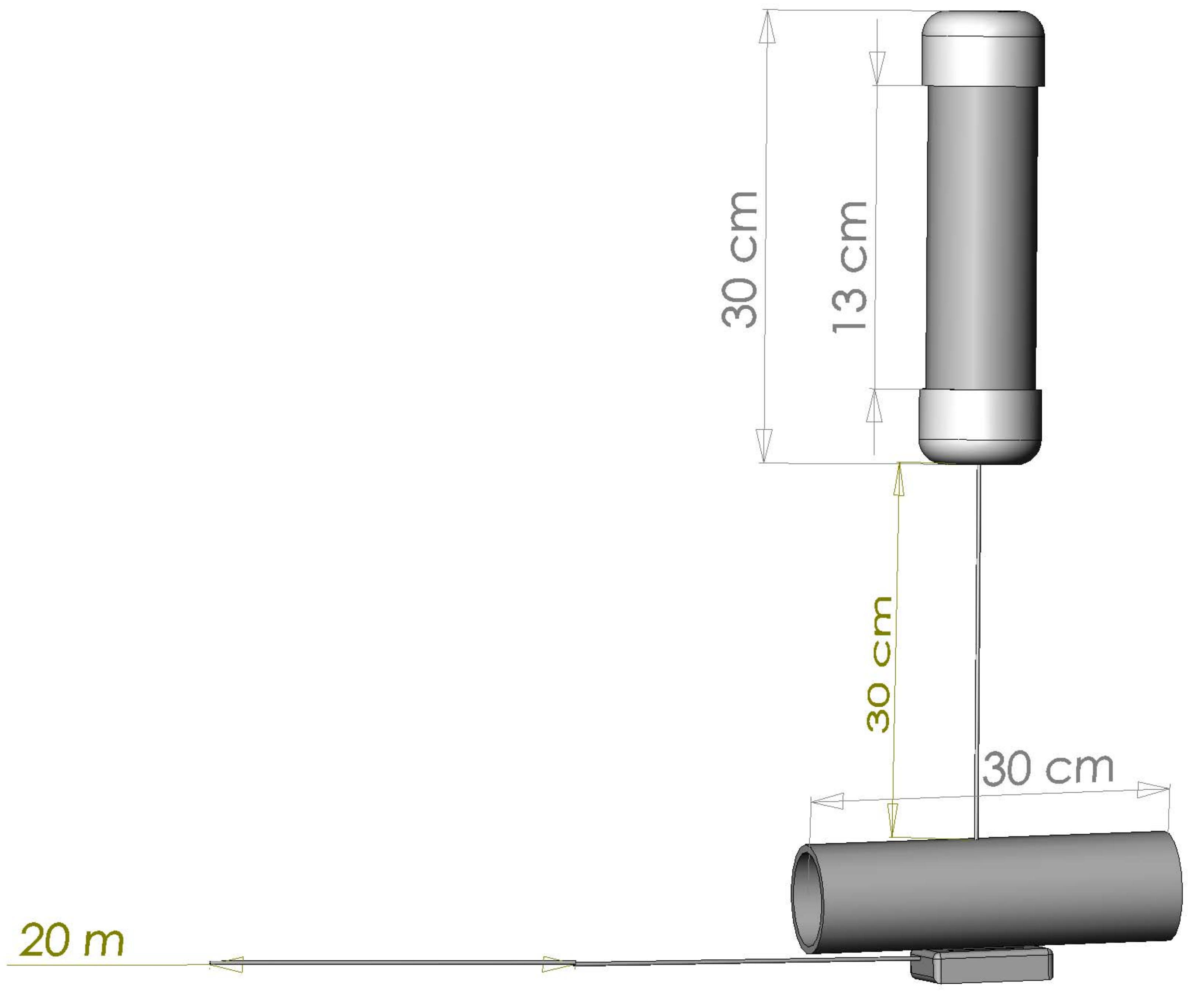
DIMENSIONS ARE IN CM
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
MATERIAL --
FINISH --
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

MATE ROV

SIZE A | DWG. NO. | REV.
SCALE:1:10 | WEIGHT: | SHEET 1 OF 1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13 cm
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