Overview: (minimum 4 hours over 4 days) This activity will expose the world of ROVs to students and then ask them to create their own designs and solutions to challenges associated with deep sea missions. Then students will construct an actual ROV and test it. This can be done at nearly every learning level. This lesson presented as a 2-day engineering activity can be expanded in many ways, and resources are available below to explore for yourself. Many science principles can be covered to many levels of complexity: including buoyancy, weight, force, torque, pressure, and even electrical principles like voltage, current, and resistance, and there is great potential to extrapolate on the history of submersibles through warfare and exploration as well as economic relationships and funding challenges.

Focus Question(s):  What are ROVs good for?
Who funds ROVs? How does ROV exploration fit into local and global economies?
What are some challenges to deep sea exploration?
Why is it important to improve technology and techniques for deep water ROV maneuvering?

Activity: DAY 1
Focus Question:  What are ROVs good for?

Engagement:  (10 min) In small groups, students brainstorm what they could use an ROV for. Call on students to share out.

Exploration: (20 min) Provide a reading 'Background Oil Spill Cleanup' (provided by MATE 2012). Discuss why ROVs are important for this.

Explanation: (25 min) Show slide show of various ROVs, discussing the definition of an ROV compared to SCUBA, submersibles, submarines, etc. Discuss reasons for various sizes, shapes and tools.

Elaboration: Give students a handout with an ROV template. Instruct the students to draw the forces that they think would act on a submerged ROV.
Use the iTest PowerPoint presentation (provided by MATE—you may skip through and select relevant slides) to help synthesize ideas of forces, balanced and unbalanced, to help students in the construction of their ROVs. Then instruct students to design an ROV, focusing on the placement of 3 propellers.

Evaluation: Have students complete an exit ticket recalling or expanding on principles from today. (Example: list 3 challenges with deep sea exploration)
Activity: DAY 2

Focus question: What are some challenges to deep sea exploration?

Engagement: (10 min) Show ROV video on ROV missions—some are available at discovery education online, ex: 'Dive to the Bottom'

Exploration: (45 min) Students use this brief foundation to build their own ROV frame out of PVC. Group the students into teams of 2-4, depending on class size and ROV kit availability. Students will discuss their ideas and designs, and settle on a design they want to build together. Remind students to think about balance between buoyancy and weight as well as balance along the various axes of the craft.

Elaboration: (7-10 min) Take a break half way into the exploration and have students walk through the room and observe other ROVs and discuss problems/solutions with other groups.

Evaluation: (formative, self-assessment) Have a container available for groups to submerge their ROV in to test buoyancy. Is it neutrally buoyant?

Activity: DAY 3

Engagement: Tell groups that their crafts will be tested for balance.

Exploration: (15 min) Handout diagnostics sheet on which students will evaluate characteristics of their ROV and make suggestions for improvements. Have students complete questions on ROVs.

Explanation: (10 min) Discuss with students the importance of periodically and scientifically testing their technology.

Evaluation: (30 min): Test the buoyancy of each ROV. This does not require as large a tank as the final dive. This needs to be large enough just to submerge the ROV without touching the bottom or sides of the tank. Students can then watch as their craft may twist, float, or move in unexpected ways. Remind students to record these observations on their diagnostics sheet. Groups will work at different rates, so this is a good time to allow some groups to work while others test.

Elaboration: (10 min, overlapped) Students are given time to adjust/finish their ROV in preparation for the big dive tomorrow. Remind students that their diagnostics sheet must be completed to participate in the big dive tomorrow.

Activity: DAY 4

Have arrangements ready to access a pool or large tank for the evaluation.

Engagement: (15 min) It is the day of the big dive. Have a banner or other exciting graphic ready as a reminder. Remind students of the important missions that need to be completed today. Then have students retrieve their ROVs and give 10 minutes for final tune-ups and preparations.

Exploration: (45 min) You should run this competition how you like. Provide teams equal time to complete missions and to keep track of their own data within each mission (ex: how many corral were picked up? How many lift bags were lifted?) Provide students a space on the other side of their diagnostics sheet to record data. This time will vary and may require a second class period for completion.
**Explanation:** (15 min) Students share successes and improvements they would make. They also share their data so that a class set of data can be recorded. An extra day may be required for this. Once data is shared, students will have time to complete their own evaluation sheet (as seen below) and the remaining time can be used to show the rest of the ROV video you started on DAY 2.

**Evaluation:** Give students time to complete the diagnostics and dive day sheets.

**Materials Needed:**

**Student Handouts:** Notes to follow presentations, ROV templates, Background Oil Spill reading, Assessment/challenge scores

**Items for Groups Display:** PowerPoint (MATE mission, iTest), video (Discovery Education online)

**Material Items:** ROV kit, tools, battery, tank, challenge pieces, PVC lengths and joints (1/2” recommended), handouts. Pieces for the challenge-- corral made of PVC and pipecleaners, a 'T' PVC 'oil' piece, a lift bag (pipe with 2 lb weight, and plastic tube attached to a bike pump). *To participate in the MATE competition in late spring, students must wire the props to the control box and connect the tether themselves. This requires more tools and time, but is highly recommended.

**Facility/Equipment Requirements:** A large tank or pool that will hold water. Recommended dimensions are a minimum height of 3 feet, and diameter or minimum width of 4 feet. This can be a challenge, but another option is to plan a field trip to Hatfield Marine Science Center in Newport, OR where you can arrange to use their tanks for testing, or coordinate with a local pool.

**Vocabulary:** ROV, buoyancy, force, thrust, weight, pressure, submersible

**Teacher Preparation:** (1-2 hrs) Review the resources, but most of your time will be spent gathering and organizing equipment.

**Curricular Connections:**
Covers many of the engineering and inquiry standards for middle school science, can easily be adapted to cover Physics standards on pressure, Newtonian physics, electronics, as well as Earth Science standards on systems and human interactions. The curriculum could also focus on history and economics.

**MATE competition:** Whether you plan to participate in a MATE event or not, the annual theme makes a good guideline for curriculum. The missions are related to real world problems and material is provided for reading, research, and challenges.

In 2012 the theme was shipwrecks. A reading provided by MATE discussed historical sinkings and current estimates of numbers of shipwrecks sitting on the Ocean floor, amount of fuel trapped. There are three levels of participation--Scout, Ranger, and Explorer. Scout is the only class that allows direct viewing of the ROV. Ranger and Explorer class missions are more involved and complex and require use of an underwater camera and screen. To participate in any MATE class, students must build their own ROV ‘from scratch’, wiring the control box, motors, and power supply. More information and tutorial are available on the iTest PowerPoint.