

Engineering design is the process used to help develop new or improved products. It is a decision-making process that utilizes science, mathematics, and engineering in an effort to use resources optimally while accomplishing stated objectives. The design process begins with the establishment of objectives and criteria; followed by the formulation, analysis, construction, testing, and evaluation of a product. This process can be divided into ten major steps: identifying a need, defining the problem, conducting research, narrowing the research, analyzing set criteria, finding alternative solutions, analyzing possible solutions, making a decision, presenting the product/communicating results, and marketing of the product. In this 2-hour program, students will be introduced to engineering design as they are tasked to design and construct a mini-ROV (Remotely Operated Vehicle) while working in small groups. They then have the opportunity to test out their design, modify it, and present their final design to their classmates.

### **Background**

The first step in understanding any technology is to understand the reason why it exists. ROVs were developed because there is no other practical, safe and economically feasible way to perform deep-sea exploration and/or intervention.

Throughout history, man has explored the seas for such reasons as gathering food and salvaging cargo of sunken ships. To reach any significant depth or stay an extended length of time, the development of diving apparatus was required. The first use of such technology was recorded in the mid sixteenth century, when the first diving "helmet" was used. Since then, open water dives have been made to nearly 2,000 feet, a depth which involves an enormous amount of cost and risk to human life.

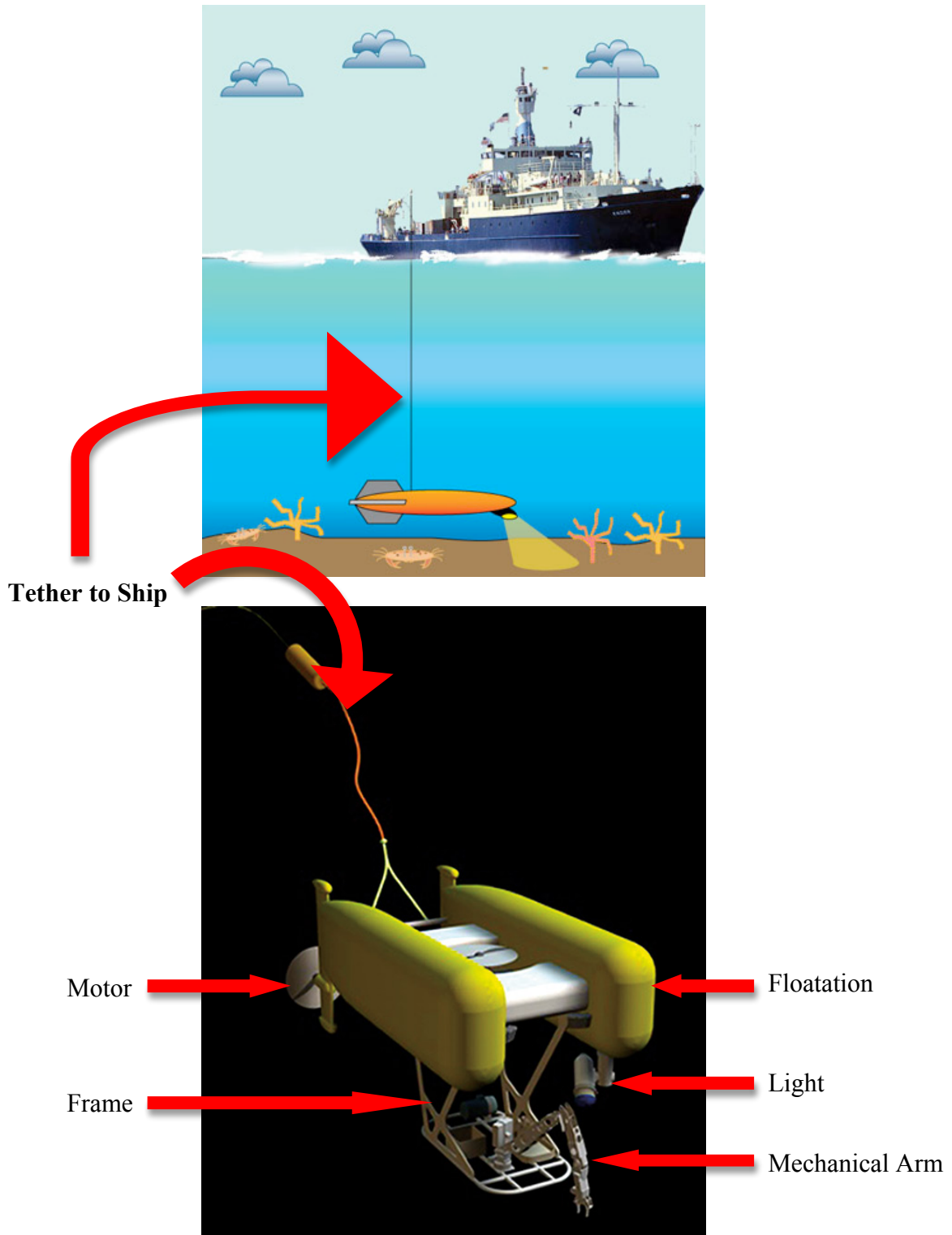
Manned submersibles were then developed for deepwater exploration. Unfortunately, these vessels still required substantial support from above and still put humans at risk of serious injury or death. In addition, they were slow to launch and recover and had limited bottom time, making them economically infeasible. The introduction of commercial ROVs in the mid-seventies has made manned submersibles virtually obsolete.

Although many groups have been involved in the evolution of ROV technology, the United States Navy is credited with advancing the technology to an operational state in its quest to develop robots to recover underwater ordnance lost during at-sea tests. Since then, ROVs have been used for everything from rescue and recovery efforts of downed planes to the observation and repair of subsea oil rigs, in addition to deep sea exploration.



*An example of an ROV being deployed to explore the Antarctic sea floor and collect samples.*

ROVs come in all shapes and sizes depending on what they are designed to do but all ROVs have a few structures in common. ROVs have a rigid frame that must withstand high pressure and extreme temperatures as deepsea temperatures can range from near freezing to over 400 degrees Celsius. Mounted to the frame are motors to provide propulsion, floatation and ballast that combine to provide neutral buoyancy, and a tether or umbilical cord linked to the ship that provides power and is used to control movement. Other equipment such as lights, cameras, sensors, and collecting devices are often attached as well.



## **Suggested Pre- or Post-Visit Activities and Resources**

Have students research the deep-sea environment. What is it like in terms of light, temperature, pressure, bathymetry (bottom structure)? Discuss how the environment might affect the way you would build an ROV.

Have students research the history, development and use of ROVs. What are some of the ways they are utilized? How does the particular use affect the design?

Website with video footage of Oregon Underwater Volcanoes captured by ROVs

<http://www.pmel.noaa.gov/vents/>

NOAA Ocean Explorer Website with lesson plans, video footage, and photos of ROV exploration

<http://oceanexplorer.noaa.gov/explorations/explorations.html>

Labeled Diagram of a ROV from Monterey Bay Aquarium Research Institute

<http://www.mbari.org/expeditions/ridges2005/images/tiburonLabeled.jpg>

Other ROV Related Lesson Plans

[http://www.uncw.edu/aquarius/education/lessons/habitat\\_design.pdf](http://www.uncw.edu/aquarius/education/lessons/habitat_design.pdf)

<http://www.uncw.edu/aquarius/education/lessons/Aq%20Dive%20In.pdf>

<http://www.uncw.edu/aquarius/education/lessons/Aq%20AUV.pdf>

[www.pbs.org/saf/1207/teaching/teaching2.htm](http://www.pbs.org/saf/1207/teaching/teaching2.htm)

## **Correlation to Oregon Science Education Standards**

### **Grade 6**

6.4 Engineering Design: **Engineering design is a process of identifying needs, defining problems, developing solutions, and evaluating proposed solutions.**

6.4D.1 Define a problem that addresses a need and identify science principles that may be related to possible solutions.

6.4D.2 Design, construct, and test a possible solution to a defined problem using appropriate tools and materials. Evaluate proposed engineering design solutions to the defined problem.

6.4D.3 Describe examples of how engineers have created inventions that address human needs and aspirations.

### **Grade 7**

7.4 Engineering Design: **Engineering design is a process of identifying needs, defining problems, identifying constraints, developing solutions, and evaluating proposed solutions.**

7.4D.1 Define a problem that addresses a need and identify constraints that may be related to possible solutions.

7.4D.2 Design, construct, and test a possible solution using appropriate tools and materials. Evaluate the proposed solutions to identify how design constraints are addressed.

7.4D.3 Explain how new scientific knowledge can be used to develop new technologies and how new technologies can be used to generate new scientific knowledge.

### **Grade 8**

8.4 Engineering Design: **Engineering design is a process of identifying needs, defining**

**problems, identifying design criteria and constraints, developing solutions, and evaluating proposed solutions.**

8.4D.1 Define a problem that addresses a need, and using relevant science principles investigate possible solutions given specified criteria, constraints, priorities, and trade-offs.

8.4D.2 Design, construct, and test a proposed engineering design solution and collect relevant data. Evaluate a proposed design solution in terms of design and performance criteria, constraints, priorities, and trade-offs. Identify possible design improvements.

8.4D.3 Explain how creating a new technology requires considering societal goals, costs, priorities and trade-offs.

### **High School**

**H.4 Engineering Design: Engineering design is a process of formulating problem statements, identifying criteria and constraints, proposing and testing possible solutions, incorporating modifications based on test data, and communicating the recommendations.**

H.4D.1 Define a problem and specify criteria for a solution within specific constraints or limits based on science principles. Generate several possible solutions to a problem and use the concept of trade-offs to compare them in terms of criteria and constraints.

H.4D.2 Create and test or otherwise analyze at least one of the more promising solutions. Collect and process relevant data. Incorporate modifications based on data from testing or other analysis.

H.4D.4 Recommend a proposed solution, identify its strengths and weaknesses, and describe how it is better than alternative designs. Identify further engineering that might be done to refine the recommendations.

H.4D.5 Describe how new technologies enable new lines of scientific inquiry and are largely responsible for changes in how people live and work.