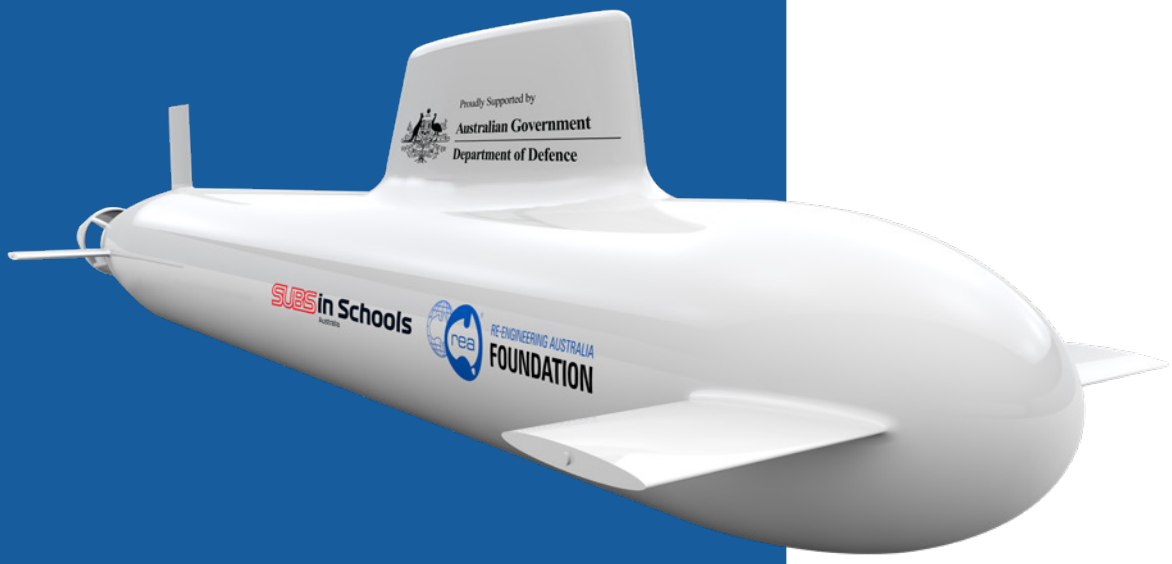
SUBS™ in Schools Australia

RE-ENGINEERING AUSTRALIA FOUNDATION



GETTING STARTED

A guide to running SUBS in Schools in Australia

Version 1.0

Re-Engineering Australia Foundation Ltd
U7, 20-22 Foundry Road
Seven Hills NSW 2147

1 300 204 476
(02) 9620 9944

www.rea.org.au
www.envizage.com.au

AUTHORISED AGENT

Re-Engineering Australia Foundation Ltd.
PO Box 136
Castle Hill NSW 1765

P: 61 2 9620 9944

F: 61 2 8079 0622

E: contact@rea.org.au
W: www.rea.org.au

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ABOUT REA

Re-Engineering Australia Foundation (REA) is a not-for-profit charity focusing on the implementation of a STEM 4.0 Life-long Learning platform which takes the concept of STEM education to another level. By focusing on the development of the analytical problem-solving capacity of students and by the development of their communication and collaboration skills, we help build resilience and character in students, preparing them for the world of work and their future careers.

REA's programs promote career relevance, supporting the transition of knowledge from primary school, through high school into university and directly into industry. We want students in primary school to start the process of developing a set of skills based on analytical problem-solving & communication that they can take with them and build on as they traverse high school and into university or a career.

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1. Introduction

SUBS in Schools is a high level STEM project where students have the opportunity to learn about complex engineering systems and build an operational Remotely Operated Vehicle (ROVs) or submarine.

Four levels (4) of participation exist within the SUBS in Schools program with each level designed to help students explore scientific, engineering, materials and manufacturing techniques, with each level focused on different levels of complexity.

The program allows students to learn about design processes, manufacturing, marketing, graphics, sponsorship, teamwork, communication, media, careers, finance and to bring all of these together practically and creatively to compete with their peers.

Underlying these activities is an educational pedagogy which develops employability skills (21st Century Skills) in students which will aid their transition to the world or work. These skills include communication, collaboration, presentation, teamwork and entrepreneurship. All of which are highly sought after by industry and invaluable in business environments subject to disruptive technologies.

The tasks faced by the students within SUBS in Schools are no less complex than that faced by engineers working on real marine projects and thus the opportunity to collaborate with industry, as a means of solving these problems, will help to develop the communication and collaboration skills of the students.

2. Brief Outline

Key Learnings

Schools running the program can create a set of internal rules and regulations but to compete outside of the school student teams must adhere to the Australian Technical and Competition regulations. The following are the key learning areas for students participating in SUBS in Schools.

- Teamwork: Students form a team of 3–5 members, develop a team name and assign roles and responsibilities within their team i.e. Team Manager, Manufacturing Engineer, Design Engineer, Graphic Designer and Resource Manager.
- Collaboration: Teams are encouraged to collaborate with industry to seek mentors and create business links which will help them develop an understanding of potential career pathways that align with their skills and motivations.
- Business and Sponsorship: Students plan and prepare a business plan, develop a budget and through collaboration with industry, raise sponsorship to fund their team. Having to raise funding to support their own team's activities helps the students gain an understanding of what it takes to build and fund a business and become entrepreneurs.
- Design: Using 3D Computer-Aided Design (CAD) software, students design their model to a set of specifications outlined in the Technical Regulations. They have the opportunity to use the same technology as used in industry by companies such as BOEING, Toyota & Tesla.
- Research: Students use a range of tools to expand their knowledge in areas such as buoyancy, electronics and pressure. Students will be driven by the real-world nature of the task to explore and seek out answers which they will not be able to find in the back of the book.
- Test: Students can physically test their design using a small pool or trough while considering how they can control variables and identify improvements, recording their findings as they develop. Students can also use CAD software (CFD & FEA) and systems-testing methods to analyse their design to maximise their chances of building an efficient and effective watercraft. .
- Make: Students get hands on and turn their ideas into reality utilising their creativity and CAD modelling skills incorporating industry-modelled manufacturing methods including CNC machining, 3D printing, laser cutting and beyond.

Technical & Competition Regulations

The SUBS in Schools competition requires competing teams to adhere to the regulations outlined in the official Australian competition documents. Competing teams must be aware of and comply with the competition & technical regulations. These regulations can be found on the REA website using the following link - https://rea.org.au/subs-in-schools/resources/

There are two documents, the Technical Regulations and the Competition Regulations available under the "Rules & Regulations" heading.

Competition Deliverables

The competition element of SUBS in Schools allows students to maximise their learning potential in an environment where they have the opportunity to interface with people from industry and gain a positioning of their knowledge against the expectations they will be facing when they move to the world of work.

Industry judges assess student work in the following areas:

- Scrutineering: The models must comply with a strict set of rules and regulations similar to what they would face in any industry. Models enter 'Parc Fermé where the judges measure every dimension to ensure they comply with the Technical Regulations.
- Engineering: Students take judges through the processes and methodologies they used to design their model. They interact with mentors from industry, sharing knowledge and experience.
- Project Portfolio: Students are required to produce an A3 project portfolio in two parts: an enterprise portfolio, documenting the business and marketing components of the project, and an engineering portfolio which documents the design, manufacturing and testing of their watercraft.
- Trade Display: To help build an understanding of the importance of marketing and communication, students create an informative display showing their work through all stages of the project, their team identity, marketing and management and present their display to a panel of judges.
- Verbal Presentation: Students prepare and deliver a presentation to a panel of judges focussing on collaboration, innovation and career development, which assists in building communications skills, self-confidence and self-efficacy.
- Trials: This is where the students manoeuver their designs in a pool and score points based on how well they can navigate an obstacle course with some additional challenges.

Competition is at several levels in Australia. Schools can run internal tournaments, and teams can go on to take part in State, and National and competitions.

Professional Class ROV Champions from Marryatville High School, SA (left) and Submarine Class Champions from Brighton Secondary College, SA (right).

3. Minimum Requirements

3.1 School Computers with CAD software

It is a requirement for students to use 3D software when designing elements of their watercraft models or accommodation space. There is a range of free CAD software currently available to schools. REA is offering free access to Dassault Systems 3D Experience software which includes apps for 3D Design, Computational Analysis, Project Management, Document management and collaboration. To access 3D Experience, schools must first register on the REA website and then with Dassault Systemes.

We encourage schools to use 3D Experience software, the same software used by BOEING, Toyota, Tesla and the Australian Future Submarine project. It will facilitate students developing skills in these areas which can translate directly into careers in industry, facilitating Life-Long STEM Learning. Schools who already have experience with CAD software will find the transition quite easy.

https://www.academy.3ds.com/en/challenges/3DEXPform

An alternative for Schools who participate in Level 3 - Spatial Design, is to use Sketch-up which is also available free to schools. Sketch-Up is available for download from the following schools' web page. This website also provides curriculum materials and tutorials specifically designed for students and the classroom. Students will be able to download a version of Sketch-Up for use at home to help develop their skills.

https://www.sketchup.com/education/sketchup-for-schools

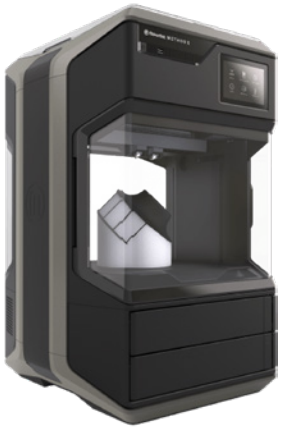
3.2 Access to a 3D Printer

The competition requires students to design some components of their ROV or submarine and then create a model using a 3D Printer. REA can supply a range of MakerBot 3D Printers which are ideal for SUBS in Schools. If schools are going to invest in a 3D-printer, our recommendation would be to invest in a robust 3D printer rather than a cheaper printer which can sometimes be challenging to manage and maintain and will produce inferior outcomes.

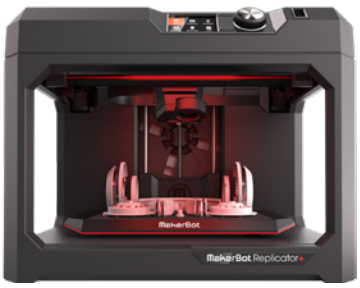
Schools without their own 3D Printer are still able to produce their components by outsourcing their manufacture. In most cases, schools can source 3D printing at reasonable or no cost via relationships with other local schools, TAFEs, universities and industries.

Some possible alternatives to 3D printing include CNC machining, vacuum forming and using carbon fibre.

MakerBot Replicator z18



MakerBot Method/Method X



MakerBot Replacator+

Equipment Purchase - www.envizage.com.au

Through its ENVIZAGE website, REA provides access to Denford CNC equipment, MakerBot 3D Printers, Roland Lasers as well as a range of other STEM project products.

REA supplied technologies are all suitable for use in school environments.

3.3 Access to Virtual Reality Software (Level 3 only)

Virtual Reality is a key component of Level 3 - Spatial Design. If schools would like to implement their own Virtual Reality (VR) environments REA can facilitate the equipment specification and access to software which would allow the school to undertake VR within the school. The software system which is recommended for the students to use during the competition is IrisVR software available from the following website.

https://irisvr.com/

The key advantages are:

- This is commercial software so it works very well
- Importing Sketch-Up models into the VR environment is incredibly simple and you do not need to know anything about VR programming.
- There are loads of real life demonstration resources available to inspire the students.
- The software can be run on a computer without a head set.

It is not a requirement of this challenge that students understand complexities behind the design of VR technology, only its use.

3.4 VR Head Set Hardware

The following link is to a page that list all of the different VR equipment platforms that are compatible with the Iris-VR software.

https://irisvr.com/supported-headsets/

At REA we use the HTC VIVE Pro.

Schools do not need to purchase multiple units and one unit will likely be enough for student use. The software is able to display what is happening inside the head set on a computer screen or projector so others can watch. Students should not spend more than 5 – 10 minutes max in the VR environment at an one time. Given that the design process takes place in the 3D software, much of the students time will be spent on the design process.

3.5 Computer hardware to run the VR equipment

Each head set provider will have their own requirements. Below are the minimum system requirements for the HTC Vive.

The key element is the Graphics card. The analogy of "The bigger the better" is appropriate when it comes to graphics cards. Again you will only need one PC with this specification

- GPU: Nvidia GeForce GTX 970, AMD Radeon R9 290 equivalent or better
- CPU: Intel i5-4590, AMD FX 8350 equivalent or better
- RAM: 4 GB or more
- Video Output: HDMI 1.4, DisplayPort 1.2 or newer
- USB Port: 1x USB 2.0 or better port
- Operating System: Windows 10

4. Resources

4.1 Kits

Kits are available to purchase for the following levels of the competition via REA's ENVIZAGE website.

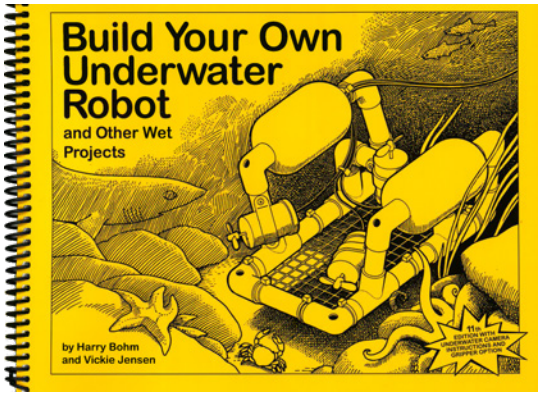
Level 1 - Mini ROV: Comes with workbook containing four lessons and six activities.

Level 2 - Large ROV (Development Class): Comes with the text book Build Your Own Underwater Robot.

Level 4 - Submarine: Includes all of the electrical components but some other components require teams to design and manufacture themselves. For a full parts list go to: http://www.envizage.com.au/subs-in-schools-submarine-kit/

4.2 Text Books

Build Your Own Underwater Robot (Harry Bohm, and Vickie Jensen)



This is the book that launched a thousand ROVs and started the "underwater robots in the classroom" revolution!

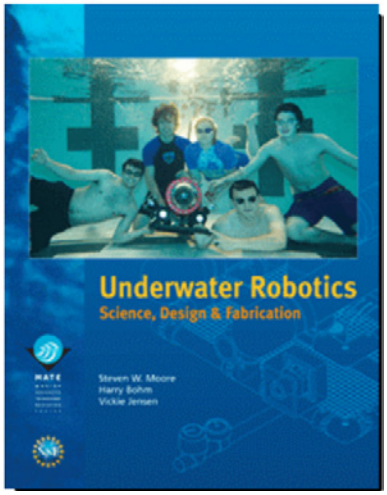
Inside the latest 11th edition of this reader-friendly resource you'll find:

- Easy-to-follow plans and illustrations for a variety of projects
- Plans for waterproofing a camera to create an "eyeball ROV"
- New instructions for adding a hydraulic gripper to your ROV
- Helpful construction tips, types of tools, and safety advice
- Information on the exciting history of sub-sea exploration and modern underwater vehicles
- A section on useful facts and an index

BUILD YOUR OWN UNDERWATER ROBOT helped the Marine Advanced Technology Education Centre (MATE) create the MATE's International ROV Competition. It also served as the backbone for MATE's UNDERWATER ROBOTICS: Science, Design and Fabrication, which contains more advanced coverage of these topics.

This amazing book also inspired the SeaPerch Remotely Operated Vehicle (ROV) educational program, set up by the Massachusetts Institute of Technology Sea Grant (MITSG) College Program.

Underwater Robotics (Dr. Steven W. Moore, Harry Bohm, and Vickie Jensen)



Format: 770 pages with hundreds of photos, illustrations, and diagrams of underwater vehicles; appendices, glossary, index.

UNDERWATER ROBOTICS introduces students, educators, and other aspiring inventors to sub-sea technology. This exciting resource provides the information needed to design and build underwater vehicles. It also encourages bright young minds to consider a career in the world of underwater robotics.

This textbook is written for advanced high school classes or college and university entry-level courses. Each chapter begins with a true scenario that sets the stage for the ocean science, physics, math, electronics, and engineering concepts that follow.

The 770-page informative text is enhanced by hundreds of photos, illustrations, and diagrams of underwater vehicles. In addition, the textbook includes a discussion of sub-sea vehicle development, resource appendices, an extensive glossary, and a complete index.

Textbooks are available at http://www.envizage.com.au/subs-in-schools/

5. Implementation

Running the program at your school

SUBS in Schools is student-centred, and it's up to the students to plan and develop their ideas. The role of the teachers is one of coach and facilitator, the challenge being the time required to devote to assisting students. If you're reading this document, then it's very likely you have what is needed to take on SUBS in Schools at your school.

Schools run the program in a variety of ways. Some will run SUBS in Schools outside school hours as an extra-curricular activity. Many others run the program as a part of their curriculum, integrating it into Design and Technology, Science classes or in dedicated Engineering, STEM or "SUBS in Schools" elective classes. There is no ideal way to run the program, but you should consider what is most practical and sustainable in your school's context. It might take some trial and error to find what works best.

Teachers who consistently do well in the program guide their teams and poke and prod them in the right direction. It's not a program especially designed around specific material or work plans but rather an open-ended approach to exploring knowledge to determine how it fits within an analytical problem-solving environment. While SUBS in Schools provides the flexibility required to help students develop and refine their ideas, access to a wealth of knowledge and training material is made available to teachers around which they can structure classes.

Working knowledge of CAD design or access to staff members with these skills is fairly crucial for running the program successfully. While 3D printing and other aspects can be outsourced, it is an advantage if students have hands-on experience of the manufacturing process and leverage the knowledge of teachers at the school.

Scheduling Suggestions

Teachers should use their professional judgement to decide how the program should operate within a school as every environment is different. With an understanding of the school's context and by gauging the broader support from other staff and faculties, STEM teachers (regardless of faculty) should think of implementing SUBS in Schools in a way that will work for their students at their school. Below are some suggestions based on observations from schools currently running SUBS in Schools.

After School as an extra-curricula activity

Many schools run the program outside school hours as an extracurricular activity. A dedicated day every week where students can spend time in their team groups with supervision goes a long way. When it comes around to competitions, teams might need to spend more days after school or their lunchtime working on the project.

As an in-class activity

Many schools will run the program within their teaching faculties. For example, a Technology faculty might make one of their junior projects the SUBS in Schools program and all students in the cohort will form groups to design and build a watercraft. The program has a natural fit as a cross-curricular teaching platform as it fits comfortably with Design, Art, Science and Maths. Cross-faculty collaboration however, can be challenging to achieve but the benefits for the students are numerous.

For students to succeed in competitions, being able to collaborate is an essential skill and a mandatory task. If they can work in an environment where they see teachers collaborating, it can be inspiring for the students. Students taking on the program do much better when they drive decision making via collaboration.

Running a dedicated subject

Running the program as a dedicated subject is something that has been taken up by several schools. Fortunately, some schools are moving away from the siloed style of education and recognise that showing the practical applications of STEM subjects benefits students when they go back into individual subject lessons. Cross-curricular education can be a challenge and requires a broader school commitment to the program for timetabling.

Note: The WA School Curriculum and Standards Authority has endorsed REA's SUBS in Schools STEM Challenge and students completing this program from 2020 can count this learning towards their Western Australian Certificate of Education (WACE) and have the achievement reported on their WA Statement of Students Achievement .

6. Student & School Outcomes

Student Outcomes

Students who participate in the program come out the other side very different. There are a range of tangible learning outcomes that students can achieve, but these are secondary to building character and opening their minds to the possibilities in the world around them. The REA website contains numerous stories of student success.

Through our competitions, students interact with industry mentors and learn about STEM concepts but equally as important, students learn about themselves, their strengths and weaknesses and are encouraged to grow as individuals. Students are motivated to move out of their comfort zone and delve into the unknown.

In addition to increased understanding of technical concepts, students:

- Build confidence and develop interpersonal skills,
- Develop an understanding of the design and manufacturing process which produces much of what they interact with daily,
- Develop an understanding of different careers and job opportunities available beyond school,
- Bring together concepts which are generally taught in siloed lessons,
- Follow a proven process to produce a finished product they can touch and feel,
- Are given an opportunity to network with industry and their peers beyond the walls of their school.

School Outcomes

Schools that participate in SUBS in Schools can say with confidence that they are implementing a tried-and-tested STEM learning program. Participating in SUBS in Schools offers an opportunity for students to represent their school on a state and national stage.

All-encompassing STEM programs are challenging to find, and SUBS in Schools covers many bases that one would hope are already present in a school's plan. At a time where schools are required to demonstrate their active involvement in broadening their student's understanding of STEM and careers, the SUBS in Schools program is a great solution.

School benefits include:

- Local industry interaction and support,
- Engagement with other schools and educational institutions including feeder schools and tertiary institutions,
- Publicity in their local community as well as the opportunity to be represented on a state, national and international level,
- Development of career-focused and well-equipped students,
- The provision of educational and career-advancing opportunities for staff,
- Increased confidence of parents by providing proven educational programs which prepare students for the world of work,
- Collaboration between faculties to highlight student achievement,
- Engagement for academically disengaged students,
- Providing an open-ended, limitless project for high-performing students

More on Learning Outcomes

Quantifying all outcomes achieved by the program is challenging. There are some STEM concepts which students must cover, such as CAD design, design processes, testing, analysis and manufacturing; however, the program is open-ended, and innovation is encouraged.

Schools have run seminars on more profound concepts such as Bernoulli's Principle, pressure or propulsion, but learning about these concepts, and including them in final submissions is up to each team. Students may find they want to go in an unconventional route and dive into different ideas - perhaps in areas such as statistics or coding.

Through Subs in Schools students are encouraged to take ownership of their learning and collaborate with industry to secure their futures at an early age.

7. Changing Perspectives

7.1 Changing Attitudes in Students and Teachers

Over the past 14 years, REA has been undertaking a longitudinal research project into the Motivational Drivers of Childrens Career Decision Choices and the effectiveness of its programs. We use this research to continually modify and improve our approach to engaging students.

Whilst our alumni have gone on to take up careers as diverse as becoming orthopaedic surgeons to engineers in companies like AIRBUS, changing student and teacher attitudes towards education is as much of an achievement as individual success stories.

We have always looked to foster an attitude of learning and growth within both students and teachers. We do this by putting much effort into our planning and events - allowing opportunities for our industry-based judges to interact with staff and students who attend. Networking and peer-learning are just some of the ways we look to facilitate growth.

Anecdotally we have seen teachers completely shift in their attitude towards education through engaging in our programs. We're proud that we can reach the people in charge of creating Australia's future.

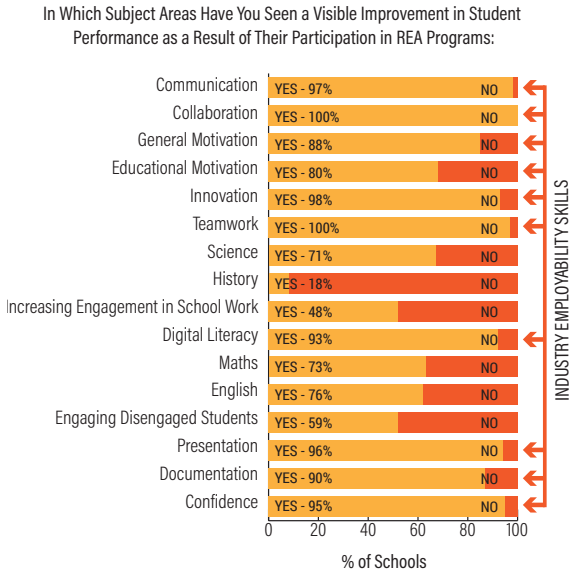
7.2 Teacher Testimonials

"Last year was our first entry into the Subs in School Technology Challenge, and what an adventure it was. My students decided to enter the Submarine (Level 4) Division, and instantly became absorbed in the challenge of building and testing a remotely operated sub. The degree of engineering engagement provided through this competition far exceeded anything deliverable through the normal high school curriculum. Upon returning from the National Finals last year, my students were already talking about the new innovations they would incorporate into this year's competition entry. This eagerness to pursue continuous improvement, as an end in itself, empowers our young people to become the leaders that can take our nation forward."

Dave Bonzo, St Philips Christian School, Newcastle Campus

"SUBS in Schools is the foundation and key innovation focus in our STEM program. It's taught as a curriculum subject with some 150 students taking part each year. Teachers in all subject disciplines contribute to the program, promoting true STEM ideals."

Stephen Read: Former Lead STEM teacher, Brighton Secondary School



Educational Outcomes Report

REA is consistently chasing up feedback and data from students and staff participating in REA programs. Our Educational Outcomes Report displays data acquired over many years of research into STEM and education. The full report can be found under the "Education Outcomes Research" heading using the link below.

https://rea.org.au/for-students-and-teachers/

8. Subs in Schools Levels

SUBS in Schools is a multi-disciplinary challenge in which teams of school students in years 5 - 12 have the opportunity to design and build mini remotely operated Vehicles (ROV's) and submarines. The programs have been designed in a number of stages with each stage facilitating an increase in student's interaction with the concepts involved in under water vehicles allowing them to grow their knowledge and understanding over time.

Each level of the program, while having specific outcomes, is designed not to be overly prescriptive in terms of implementation. Teachers are encouraged to implement learning processes that work within their own educational environment.

SUBS in Schools Level		Brief overview and a look at student learnings
SUBS in Schools (non-competitive)	5-12	Schools are able to adapt SUBS in Schools into their own STEM program as they wish. The learning outcomes and guidelines can be determined by schools internally and we encourage basing these off REA official regulations. Non-competing schools are still required to register on the REA website and REA is able to support non-competing schools on their STEM journey. Learning outcomes will be similar to those listed in the competitive classes below.
Level 1 - Mini ROV (non-competitive except in WA where a competition pathway exists)	5-8	Used as an introduction to STEM and underwater vehicle operation, students build and operate a simple underwater ROV using a supplied kit whilst learning about the principles of buoyancy, propulsion and control. Students are required to conduct their own research and present their overall project results and findings in a verbal presentation and stripped back trade display.
Level 2 - Large ROV Development Class	5-9	Students are required to build a larger scale ROV from a supplied kit but must research, design and manufacture ancillary items such as cameras, robot arms and probes to undertake specific tasks as part of water trials. Students must develop and demonstrate a good understanding of CAD as well as producing evidence of their design process and design decisions and an understanding of scientific principles in an Engineering Portfolio. In addition to their research into STEM concepts, students have to demonstrate within an Enterprise Portfolio, an understanding of project management, marketing, finance and careers and deliver a verbal presentation and a reduced trade display.
Level 2 - Large ROV Professional Class	6-12	Requirements are very similar to the Large ROV Development Class above however teams are not required to use a standard kit and have the freedom to design, develop and build their own Large ROV. Students have no restrictions when it comes to manufacturing, and innovation in any area of the competition (whether in engineering or enterprise) is rewarded through the judging process. This level requires a more significant commitment from students as they work on producing two portfolios slightly longer and more detailed than that of the development class and a full trade display. Students are required to undertake more extensive industry collaboration and document their design and decision-making processes.
Level 3 - Spatial Design	7 -12	For schools who do not have access to a technology workshop, this level requires students to design an accommodation space (kitchen galley or berth) for a submarine. Students will be required to walk the judges through their design and its features using VR technologies supplied by REA at a competition event. As for level 2, teams will need to submit an Engineering and Enterprise Portfolio, Verbal Presentation and trade display
Level 4 - Submarine	7-12	Students take on the task of designing an operational scale submarine from scratch or by using an REA supplied kit that is capable of diving, maneuvering and performing required tasks as part of the water trials. Teams will need to manufacture items such as the fin/sail, fore and aft caps, control surfaces and propeller cover. Teams also need to develop and build the Submarine's electronics. At level 4, teams will need to submit an Engineering and Enterprise Portfolio, Verbal Presentation and trade display

8.1 Level 1 - Mini ROV

Team Membership: 1 - 3 members

Divisions

- Primary: Years 5 & 6
- Secondary: Years 7 & 8

Project Intent

- To have students at this early age become excited about STEM activities and to realise that STEM is about cross curricular activities, not just maths and science.
- Allow students to take their first steps to becoming entrepreneurs as they learn how to market and promote their ideas and their team. If students wish to explore much broader components of ROV design it is recommended that they undertake Level 2 of SUBS in Schools which focuses much more on the application of engineering content and techniques.

The Mini ROV competition is designed as an introduction to STEM and underwater vehicle operation for students working with a remotely operated vehicle and experiencing a subset of the competition elements which make up the Large ROV and Submarine competition components of the SUBS in Schools STEM Challenge.

The task is to build and operate a mini ROV with the focus being on learning the principles of buoyancy, propulsion and control. Small ROV model kits, together with instructions and a workbook, can be purchased via http://www.envizage.com.au/subs-in-schools/

Internal or External Competition

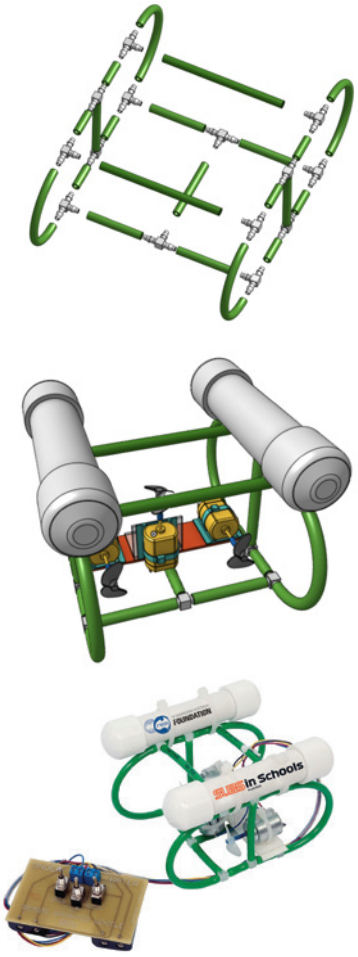
The Mini ROV runs as a State Final competition in Western Australia **ONLY** and does not have a pathway to the National Final. Teachers from competing schools in WA should thoroughly read and ensure compliance with the Competition Regulations downloadable from the REA Subs in Schools website.

Schools from other states can run this project as an internal school competition and high schools running SUBS in Schools can use this project as a way to connect and develop valuable partnerships with their feeder primary schools.

The activity is based on the use of a standard Mini ROV kit with the focus of the competition being around three major elements.

- Water Craft Trials - Traversing a set of "courses". Each course will test a different manoeuvering or navigating skill
- Project Verbal Presentation
- Marketing Display.

Within the competition, engineering is not the major focus of the evaluation process as all students **MUST** use the same ROV kit model. Students are permitted to innovate in terms of the controlling hand set and the wiring but the body of the ROV **MUST** remain unchanged.



Level 1 - Mini ROV

8.2 Level 2 - Large ROV

Team Membership: 3-5 members

Divisions

- Development: Years 5 - 9
- Professional: Years 7 - 12

Project Intent

Level 2 - Large ROV involves a much larger component of design and construction. Students must focus on buoyancy, performance and are required to build a larger scale ROV that is capable of supporting ancillary items such as cameras, robot arms, probes and the like, and be able to undertake specific underwater tasks.

At this level the students will be required to extend their understanding of the maths and science around underwater operation together with robotic control.

This SUBS in Schools level is divided into two classes as follows:

Development Class Entry Requirements

- Student in years 5 - 9 may only compete in the Development Class if they are competing in the competition for the very first time with the exception of Year 5 students who can reregister in this class in Year 6.
- Students **MUST** build their ROV from an REA supplied standard development class kit. Kits can be purchased via: http://www.envizage.com.au/subs-in-schools/.
- Teams **MUST** use the standard controller supplied with the Development Class Kit and use only 3 motors on the ROV.
- Teams **MUST** restrict their Engineering and Enterprise Portfolios to 7 printed pages and comply with certain Trade Display restrictions for State Finals.

Professional Class Entry Requirements

Professional class is an open design category where students have the freedom to design and build their own ROV in compliance with the Technical Regulations.

- Student in years 7 - 12 are eligible to compete in this class of the competition
- Students **MAY** participate in this class multiple times.

No other restrictions apply to the Professional Class

Competition Requirements

The Large ROV runs as a State Final competition around Australia and does have a pathway to the National Final. Teams and teachers should thoroughly read and ensure compliance with the Competition Regulations downloadable from the Subs in Schools page on REA's website.

At a competition, teams will be expected to present the following project elements for assessment:

- Large ROV model built to comply with the Australian Technical Regulations
- Project Verbal Presentation
- Marketing Trade Display
- Engineering and Enterprise Portfolios

8.3 Level 3 - Spatial Design

Team Membership: 3-5 members

Divisions

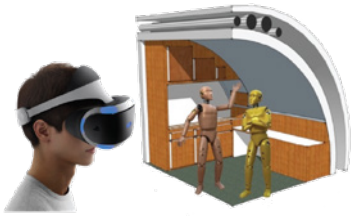
- Open Class: Years 7 - 12

Project Intent

The SUBS in Schools Spatial Design project challenges students to design and build a virtual galley or berth environment for a submarine. The program aims to create an exciting and fun learning environment for students. If time permits, students are encouraged to go beyond the manual, be creative and innovative extending the process.

Some of the problems students will face when designing a virtual environment will be similar to challenges faced by engineers building a full-scale submarine.

The task is to form a virtual design company, which will make a bid for the design of an accommodation space on-board a future submarine project. The students will then bring this design into a virtual reality environment to demonstrate their design. This level is ideal for schools who do not have a significant workshop facility.



Level 3 - Spatial Design

Class Entry Requirements

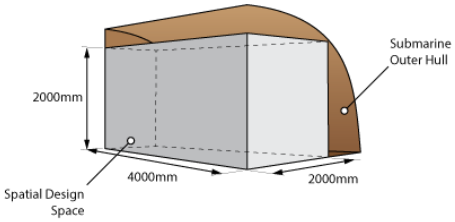
This is an open design category where students have the freedom to design their own accommodation space in compliance with the Technical Regulations.

- Student in years 7 - 12 are eligible to compete in this class of the competition
- Students **MAY** participate in this class multiple times.

No other restrictions apply to this class

Competition Requirements

Level 3 - Spatial Design runs as a State Final competition around Australia and does have a pathway to the National Final. Teams and teachers should thoroughly read and ensure compliance with the Design Brief and the Competition Regulations downloadable from the Subs in Schools page on REA's website.



At a competition, teams will be expected to present the following project elements for assessment:

- 3D virtual model built to comply with the Australian Technical Regulations
- Project Verbal Presentation
- Marketing Trade Display
- Engineering and Enterprise Portfolios

8.4 Level 4 - Submarine

Team Membership: 3-5 members

Divisions

- Open Class: Years 7 - 12

Project Description

At Level 4, students take on the design of an operating scale submarine. The task is to form a new design company to design and build a new remotely operated submarine. The submarine must work within an operating environment defined by a set of rules.

In the first year the schools would be encouraged to reconstruct an existing design of a model submarine. In the subsequent years the schools would be able to innovate on the existing designs to improve their submarines.

Students form a new design company making a bid for the design of a new remotely controlled submersible vehicle. There are special design specifications for this vehicle and parameters teams must work within. To succeed in the challenge students will need to work with modern design, manufacturing and virtual reality technologies.

This submarine will have to be able to dive, maneuver and carry out a number of tasks within a set of time constraints and will have to meet a number of design limitations set by the rules. It will also have to be remotely operated and be able to communicate with the driver (captain) who will be located on land.

Class Entry Requirements

- Student in years 7 - 12 are eligible to compete in this class of the competition .
- Students **MAY** participate in this class multiple times.

No other restrictions apply to this class other than those outlined in the Australian Competition Regulations.

This is an open design category where students have the freedom to design a submarine in compliance with the Technical Regulations or use the REA submarine kit purchasable via http://www.envizage.com.au/subs-in-schools/.

Submarine Kit - The kit includes all of the electronic components but few of the mechanical components which will need to be manufactured by the students. A Build Manual for the REA kit submarine is available via https://rea.org.au/subs-in-schools/resources-2/.

One kit per school is suggested in the first year as the design of the submarine can be broken up between a number of students or teams of students each working on a different facet of the construction i.e.

- Electrical
- External Shape
- Propulsion
- Controls etc

To complete the construction, you will need access to a 3D printer to be able to manufacture some of the body elements. As the schools will be allowed to take existing models and modify them in ongoing years this cost to the schools in subsequent years will be significantly reduced.

Competition Requirements

Level 4 - Submarine runs as a State Final competition around Australia and also has a pathway to the National Final. Teams and teachers should thoroughly read and ensure compliance with the Competition Regulations downloadable from the REA Subs in Schools website.

At a competition, teams will be expected to present the following project elements for assessment:

- Scale Submarine model built to comply with the Australian Technical Regulations
- Project Verbal Presentation
- Marketing Trade Display
- Engineering and Enterprise Portfolios

9. The SUBS in Schools Process

The process which students follow is: design, analyse, make, test, trial and review.

Over time the process relies on the students learning from each other, from teachers and former competitors. The classroom becomes an environment where knowledge is shared between students and across teams as an ideal way to ensure students get the most out of the program.

Throughout the process, described in the following pages, students will continuously be making improvements. Perhaps they will need to cycle through the design to review process a few times before they get the hang of it.

On the first attempt, students might be still figuring out how CAD works. A few tries later, the CAD functionality will become second nature, and perhaps they will be able to improve on other aspects of the competition. Overall, the SUBS in Schools program is designed to be a learning process. As students work through each competition level, they will find that they have spent many hundreds of hours on the project, and by the end they should have produced a range of quality material to look back on and also to call on if required in a job or tertiary study interview.

Allowing students to see their own progress through the program is excellent for building their confidence and understanding of how projects work in the real world and how what they learn at school can be applied to the world outside of school.

The SUBS in Schools program differentiates for students using the 'class structure' for competitions. Students will come from different backgrounds and may come with some level of prior knowledge. It's essential for staff to recognise student level and allow students to grow and progress at their own pace.

Each step in the design, analyse, make, trial and review process is discussed in the following pages. Some aspects are only relevant to specific classes, but generally, the concepts involved will also work for teams that aren't competing at all. Elements such as trade booths are only relevant to competing teams, and even then, are only applicable to specific classes of competing teams. For new schools, determining student classes is something that can be decided after students start developing a foundation of understanding.

It's essential to keep in mind that the competition has comprehensive rules and regulations which competing teams must adhere to. There are technical regulations and competition regulations described in slightly more detail in this document with current versions available on the REA website. If running an internal competition, schools are encouraged to use REA regulations as a template for simplified judging criteria. Students might design a few ROVs before deciding they will compete and move on to other aspects of the competition, such as trade booths and portfolios.

Regulation Documents

There are two regulations documents. The Technical Regulations relate to the specifications required for the model design and manufacture. There are different rules for different classes, teams must read the regulations well and are familiar with what is permitted.

Competition Regulations contain information about the competition itself. It includes information on team membership, compliance with competition process, submitting project elements for judging, trials and watercraft repair regulations, as well as information on all of the assessable criteria such as CAD, manufacturing, portfolios, marketing and verbal presentations, including access to all of the scorecards by which teams are assessed.

Critical Regulations

Critical Regulations appear in the Technical Regulations document. Failing to adhere to the Critical Regulations will incur hard-hitting time penalties (as well as point penalties). The Critical Regulations are indicated with a yellow triangle & exclamation mark.

10. Design

Model Design and CAD package selection

Students must develop an understanding of CAD software. Initially, when designing models, students should be given a walkthrough of the particular CAD package used at the school and directed to tutorial videos if necessary. Designing

There are a range of CAD packages suitable for SUBS in Schools. REA recommends using Dassault Systemes 3DExperience platform, which is available free to schools registered for REA programs and includes CATIA CAD software. After signing up at the following link https://academy.3ds.com/en/challenges/3DEXPform students and teachers can access online tutorials and videos to assist with designing their own submarine.

You first need to register with REA at this link https://rea.org.au/school-registration-form/ before attempting to download the software. There are no costs involved with these registrations.

Other CAD packages include but are not limited to Solidworks, Autodesk's Inventor & Fusion 360. If staff are already familiar with a particular CAD package then that is the best to use what is familiar if new to SUBS in Schools.

On the REA website, students can find supporting documents for Submarine Kit STL files saving the students having to design these elements. There is also a Submarine Wiring Diagram as well as instructions on an Analogue or Digital Controller. Assistance from teachers familiar with CAD will be beneficial in the early stages of designing.

Technical Regulations

Teams entering competitions must consider the "Australian Technical Regulations" document when designing their models. Teams may miss critical information, which will lead to penalties during the event. While this is a warning for new teams, experienced teams will often also make errors when students are careless or feel that they're beyond checking the regulations against their design and final model.

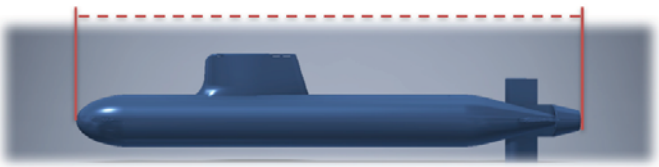
Ensure students take note of the critical regulations which attract a time penalty. The first steps in designing for new teams would be to consider which CAD package is most suitable to use within the school context. If competing, then teams should also be given (or directed to) the official REA SUBS in Schools Technical Regulations - these are updated year-to-year, and it's good practice to consider the Technical Regulations early on in the design process.

Example Technical Regulation

This example shows the requirements of the designed submarine's body length. Scrutineers will measure the submarine and if in violation, the team will lose points and, in this case, incur a 30 second time penalty in the sea trials. The yellow triangle indicates that this is a critical regulation. ROV's or Submarines deemed unsafe, or that fail some critical rules won't be allowed to trial until brought into compliance. The Specifications Scorecard that scrutineer judges use is available in the competition regulations document.

T3.1 Overall Length [30 Time Penalty | 4pt Penalty]

The overall length of the complete submarine measured between the longitudinal extremes of the submarine product, including all components, **MUST NOT** exceed 1200mm.



Parc-Ferme/Scrutineering/Rectification/Repairs

In competitions, ROV's and Submarines along with an Engineering Compliance Booklet, are submitted into Parc-Ferme for scrutineering immediately before trials take place. The scrutineers will ensure that each operational model is compliant with the technical regulations and teams will be penalised for any errors either through a point penalty or a time penalty or both. Teams will have an opportunity to rectify violations of critical regulations only, and unsafe models will not be permitted to trial until they are made safe. It's essential for competing teams to make sure their models comply with the regulations and that they have access to current versions of the official REA Technical and Competition regulations.

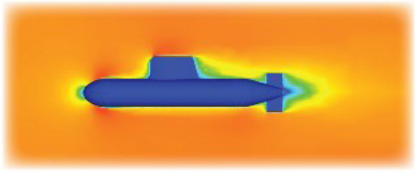
During trials, if an ROV or Submarine breaks or fails, students are given time to make repairs, so it's essential to consider the design of the model is robust and capable in the water. Testing leading up to a competition is key. Models that break often will likely lose some performance and models that break beyond repair will not be allowed in the water, resulting in a loss of points.

11. Analysis &Testing

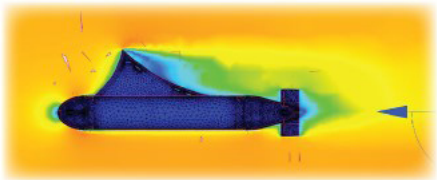
Computational fluid dynamics (CFD) analysis is a great place to start when it comes to analysing a design before going to manufacture. Finite element analysis (FEA) is also possible on most CAD packages which identify the forces acting on a particular model. Students can discover a lot about their model and design both before and after manufacturing their components.

All testing should be documented in student workbooks and engineering portfolios with explanations of how improvements were achieved and how ideas were built upon throughout the process of designing, analysing, manufacturing and testing.

Examples of CFD analysis

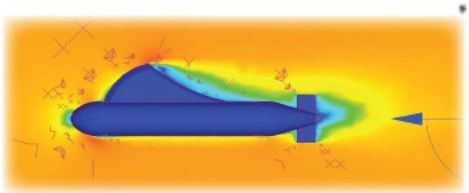


AUTODESK CFD FIGURE 11 - CFD Image of REA kit Sail

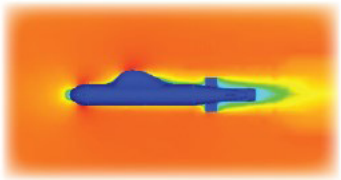


AUTODESK CFD FIGURE 13 - CFD Image of Iteration 2 sail

The Buoys, 2019 National Final CFD testing of Sail



AUTODESK CFD FIGURE 15 - CFD Image of Propulsion sail



AUTODESK CFD FIGURE 17 - CFD Image of National Final Sail (current)

The Buoys, 2019 National Final CFD testing of Sail

Virtual Wind Tunnel

REA can offer Virtual Wind Tunnel (VWT) software. The easy-to-use software accepts an STL file and will give students a good idea of how effective their model will be when manoeuvering through water. Using software such as this can very efficiently point out flaws in a design before the manufacturing process. Students must consider the cost of production in their plans and manufacture designs which they already feel will produce a robust and effective watercraft.

Testing vs. Analysis

While the process of SUBS in Schools is built on design, analyse, make, test, trial and review, there is a clear relationship between testing and analysing. The question of when to go to manufacture should be decided as a group after students feel enough virtual and theoretic analysis has taken place. There is no point in producing a model that is expected to have poor results.

At the same time, analysis can be confusing and inaccurate. Using computer simulations has many advantages but also some shortfalls. It's up to teams to find the right balance between resource allocation and data acquisition. There is much learning students can glean out of this process - comparing modelled results to what happens in the real world can be an excellent way to validate the effectiveness of individual components.

Pool Testing

Students will eventually need to test their completed watercraft in a pool. This will be the true test of a watercraft's buoyancy, maneuverability and effective operation of all components. Gaining access to a public pool or even a student's own backyard pool will be valuable as they determine which design changes are effective and which are not. For more information go to Article 13. Trials and Results.

12. Manufacture

Creativity meets Creation

Depending on the level of competition students are given many opportunities to get hands-on and innovative. Understanding the link between their design on paper and their design in real life is a key element of the competition which allows for student growth.

In all classes students will need to develop an understanding of electronic components and how they will work together in an underwater environment. The ability to create electrical circuits which serve specific purposes and to build and test these using basic and complex manufacturing processes is key to success. With every watercraft students will need to have an understanding of electronics and soldering. Further opportunities using both well-established and emerging technologies such as CNC Machining, vacuum forming, 3D printing, hydraulics, hand-sanding and many others can all be utilised throughout Subs in Schools.

3D Printing & Additive Manufacturing

Components of the Large ROV and Submarine can be 3D printed such as: the front and end caps, the sail and many of the internal components.

Large ROV: Cameras, robot arms and probes .

Submarine: Fin/sail, fore and aft caps, control surfaces and propellor cover.

When competing, it's essential to check the finished design complies with the regulations. While 3D printing may be allowed in certain classes, it is not a mandatory requirement. Other methods can include using carbon fibre and outsourcing production.

Assembly

Assembly can be achieved in several ways. Teams are encouraged to think about how components will fit together in the design and manufacturing stages. It is important that teams take great care in attaching components to model bodies to ensure the finished result achieves the required clearances and overall dimensions in accordance with the Technical Regulations.

Schools that aren't competing should consider avoiding making permanent changes to kits in order to use them in subsequent years. For example, avoiding glue with the REA ROV kits will make them easy to disassemble and reuse for following years.

Finishing

Form and finish can impact a large part of the appearance of the watercraft and models are judged in these two areas. Students are required to paint their models, and this should be carried out with consideration of their team's overall branding.

In competitions, teams must take note of the advertising requirements using the correct decals, as stated in the regulations.

Notes:

- Manufacturing is very much an iterative process. Things will go wrong, and designs won't turn out exactly as they appear on a CAD screen. To maximise learning outcomes and short circuit any problems it's best if students can get hands-on experience of manufacturing by using in-house tools and resources rather than outsourcing.
- Students often make the mistake of thinking that their manufactured model will have the same dimensions as their CAD design. Manufacturing tolerance is a lesson they should learn early on.
- Designing an easy-to-assemble model or one that has pieces that fit together nicely will be highly regarded by the engineering judges.
- Students must document their errors and refinements. Learning about the relationship between their first concept and their final product is very much a part of the SUBS in Schools journey and can be useful during judging.
- Students must consider the model's requirements in their design and manufacture. Poor design and manufacturing can lead to breakages that can have a significant effect on a team's performance, a well-engineered model should not break.

13. Trials & Results

Watercraft trialing is always fun for students and pool testing before a competition can be very beneficial for teams. In general, organising a trial-day where students can compete is a great way to use competition to fuel student drive to improve on their designs and processes.

The SUBS in Schools trials are time limited events in which teams will be required to perform certain tasks or manoeuvres with their water craft in order to score points. Teams will be scheduled with one or more time slots in order to complete their Trials. Trials are expected to be conducted in swimming pools with maximum depths of approximately 2 metres.

ROV Trial Procedure

For level 2 competition, the ROV will be required to travel underneath the surface of the water and perform a series of tasks. The ROV **SHOULD** be designed in order to competently complete these tasks.

- Flotation and Water Column Positioning Trial (4 minute maximum)
- Submerged Manoeuvring Trial (4 minute maximum)
- Retrieval Voyage Trial (Timed)

Submarine Trial Procedure

For level 4 competition, the submarine will be required to perform a number of trials and then manoeuvre around a set course on a voyage. Teams will progress through the four trials in the order listed.

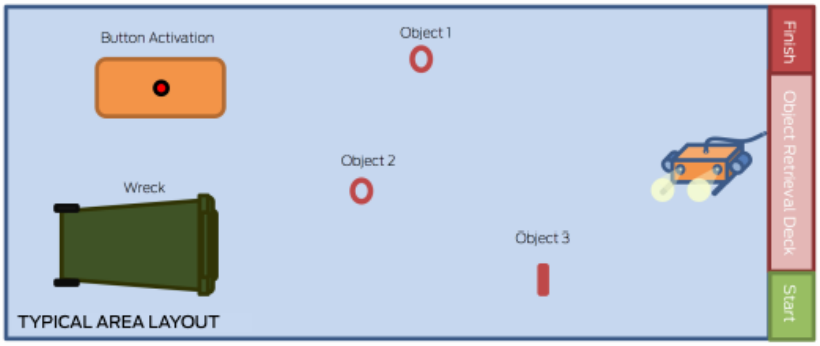
- Surface Manoeuvring Trial
- Flotation And Ballasting Trial
- Submerged Manoeuvring Trial
- Timed Way point Voyage

An example - Level 2 Sea Trials "Retrival Voyage "

The image below is taken from the Competition Regulations document and outlines what a typical sea trial might look like for Level 2 - ROVs. Teams are judged on both their ability to complete tasks and the time taken to do so. The table below is an example of what the points allocation might look like for a sea trial in an REA competition.

Sample Ranking

Team	Tasks Completed	Trial Time	Rank	Points
Team 1	5	7:20	1	60
Team 2	5	7:30	2	50
Team 3	4	7:00	3	45
Team 4	4	7:15	4	40
Team 5	4	7:35	5	35
Team 6	4	7:50	6	30
Team 7	3	6:00	7	30
Team 8	3	6:35	8	30
Team 9	3	7:00	9	30
Team 10	3	DNF	10	10



14. Portfolios

Teams competing in the Levels 2, 3 and 4 of the competition are required to submit multiple copies of A3 sized enterprise and engineering portfolios outlining their progress as well as an engineering compliance booklet. Even if schools aren't planning on competing, students must learn to document their work and processes as a part of their SUBS in Schools journey so they can get the most out of the program. Often in the real world, the process of decision making and development is just as important as a useful final product.

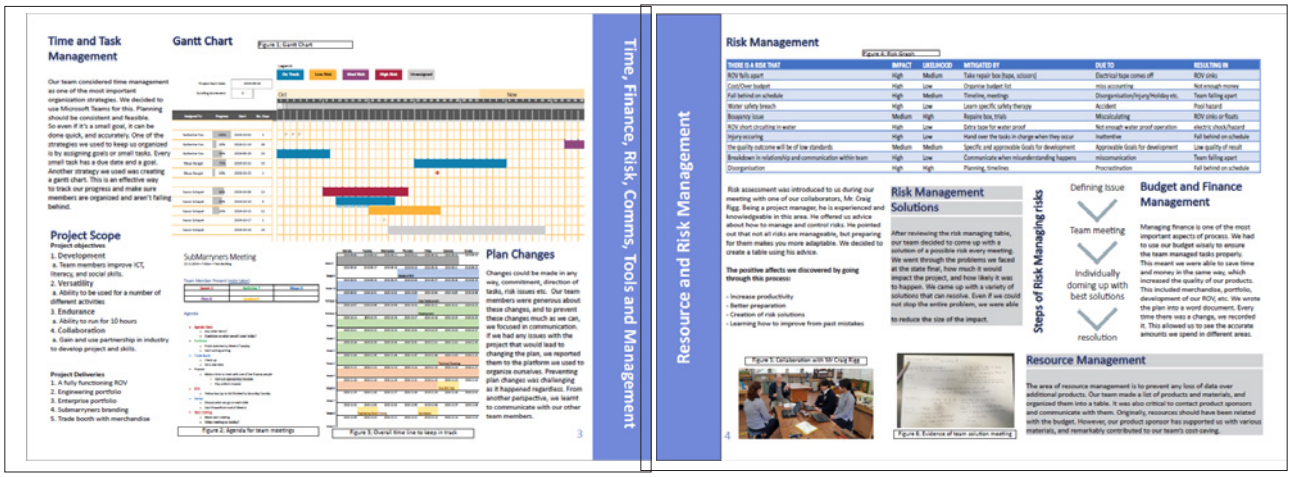
There is no requirement for portfolios in Level 1 Mini ROV.

Enterprise Portfolio

A team's enterprise portfolio outlines its processes for team management, communication, career relevance, marketing and collaborations. The enterprise portfolio includes information on the teams' processes for:

- Project Management including roles, responsibilities and timeline,
- Stakeholder engagement, collaborations and partnerships,
- Finance and budget considerations,
- Brand development, marketing and social media,
- Career development,
- Trade booth and uniform development and execution.

A significant takeaway for students is an understanding that a large project has many components which need to be managed to achieve a result. As in any project, documenting progress and justifying why specific approaches were taken is critical in demonstrating understanding of the decisions which have been chosen and also an understanding of the errors which may have been encountered.



SubMarryners, Marryatville High School SA -2019 SUBS in Schools National Final Enterprise Portfolio

Engineering Portfolio

The engineering portfolio outlines a team's design process, research, model development, manufacturing and testing. Teams must record their issues and challenges early on and maintain a habit of recording their progress and choices. Note there is no requirement for manufacturing within Level 3 Spatial Desgin although teams can optionally create a scaled physical model of their design if they choose.

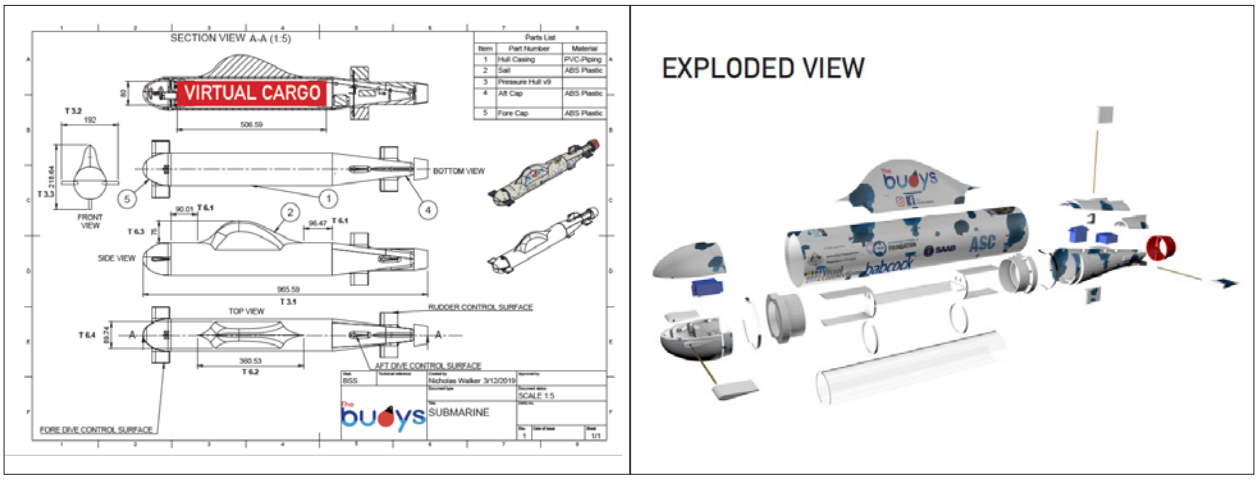
It's useful to document all errors and adjustments and while not everything must be included in the final portfolio, being able to draw from a range of information is a great way to impress judges and is an essential part of the learning process for students. The engineering portfolio includes information on:

- Model design research, ideas and development,
- Innovations and design analysis,
- Manufacturing and finishing processes,
- Evaluation and testing of design.

The Orcas, Newton Moore Senior High School - 2019 National Final Engineering Portfolio

Engineering Compliance Booklet

The compliance booklet is used for engineering judging and contains CAD models, technical drawings and photorealistic renders of submitted models. A third party should be able to pick up a team's compliance book and be able to manufacture the physical model using only the information contained.



The Buoys, Brighton Secondary School, SA, 2019 National Final Engineering Compliance Booklet

15. Marketing: Branding & Trade Displays

Marketing

For teams competing at all levels, an understanding of marketing and branding is a large part of the competition and is an excellent introduction to students on the multi-faceted requirements of most successful organisations. Having a fantastic product or solution is one thing but understanding how to communicate that product or idea is also critical to success.

An understanding of marketing is also a great way to engage sponsors and stakeholders - a well thought out brand incorporation strategy can go a long way when students are cold calling local industry for support and sponsorship. This applies to the team as they look to make a good impression and also to what they're offering any organisation they choose to approach.

Marketing is often a challenge for students, and by including it in the program, we hope that students will learn the importance of presentation and imagery. While marketing does stand on its own as a judging criterion, students may be able to identify a link between how they market their team and their ability to win sponsorship and industry collaboration opportunities. Something as simple as dressing well or having a uniform can make a big difference when canvassing for support.

Competing teams are required to use accurate branding for REA and affiliated organisations as stated on the REA website and competition documents.

Trade Display

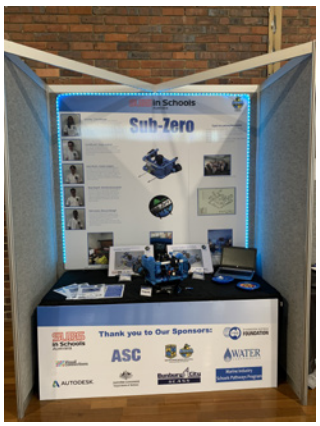
In competitions, teams from all levels are required to plan, prepare and set-up a complete trade display strictly in accordance with the terms and conditions as outlined in the Australian Competition Regulations with an emphasis on portable, compact, pop up displays which are easily transportable, sustainable and have re-usable frameworks.

A trade display is to visually 'sell' the team's most important key messages in snapshot form for assessment and event promotion. The Marketing judges will assess a team's trade display content and structure. Specific areas to be assessed are:

- Trade Display Design Development
- Watercraft Display
- Information Design
- Use of ICTs
- Visual Design & Impact
- Structural Design
- Materials Selection & Use
- Sustainability

Teams in levels 2, 3 and 4 should design the display using 3D CAD. The design must facilitate set up without teacher or adult help in a limited 2 hour time frame. The standard dimensions of trade booths are outlined in the competition regulations, and teams are encouraged to use their creativity to come up with innovative and unique displays.

Some restrictions are placed on Mini ROV and Development ROV trade displays for State Finals so it's important that teams adhere to these otherwise penalties are applied.



Sub-Zero, Newton Moore Senior High School, WA
ROV Development Class, 2019 WA State Final

Osprey, St John's Grammar School, SA
ROV Professional Class, 2019 National Final

The Buoys, Brighton Secondary School, SA
Submarine Class, 2019 National Final

16. Sponsorship & Fund Raising

Raising Funds

Students are required to raise the funds needed to resource their project at all stages of the competition. This can be a challenge for students, but it can also be enriching. In many cases, sponsors are happy to help a keen group of students, especially when teams can outline how they will be looking to benefit their sponsors.

Going for local sponsors is a great way to get communities behind successful SUBS in Schools teams. In the past teams have been able to get support from many local industries and can strategically offer sponsorship opportunities which are mutually beneficial to sponsors. For example, students might be able to get a local shirt printing company to make their team shirts for free or with some branding recognition.

Many teams have raised funds through their local Bunnings sausage sizzle days but you need to book well ahead.

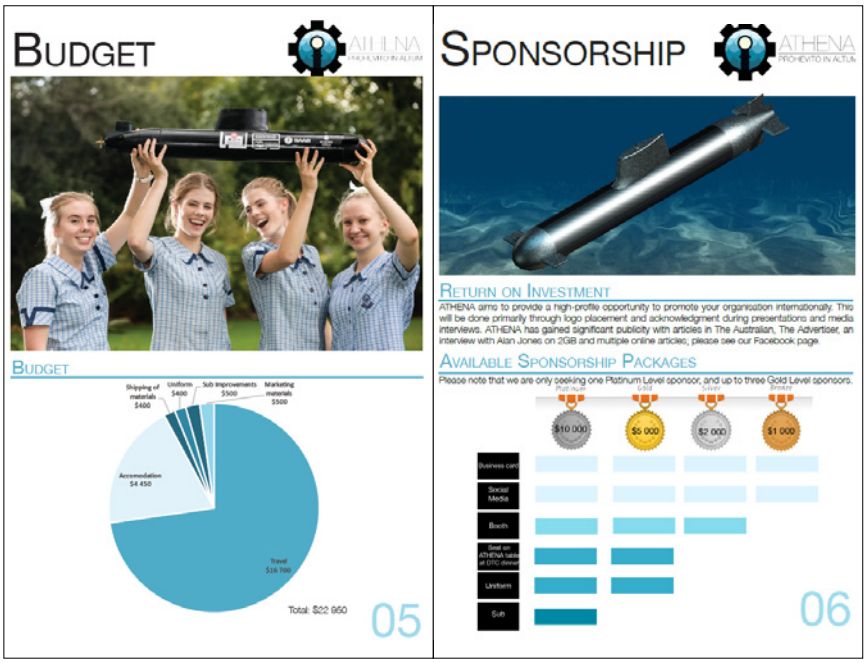
Using Trade Displays to Generate Funds and Awareness - An Example

Students are often able to come up with creative ways to raise funds. An F1 in Schools team from Mount View High School in NSW was able to raise funds by leveraging a student's parents store in the local community. In the shop front, the team set up some branding material and a short letter to passers-by on what was involved in their project. The team displayed their models, parts of their trade booth and several trophies they had won - in doing so they were able to receive contributions which helped get them to the 2019 F1 in Schools World Final.

Using trade displays to generate attention is a great way to raise funds. Some stores have spaces for community projects to be advertised. Investing in a good trade display, the framework for which can be re-used, has some other benefits too. Many schools will set up past team trade displays in school libraries or hallways to display for students who aren't competing and also for new students and parents on school open days.

Sponsorship Prospectus

Many competing teams will produce a prospectus which outlines an ROI for sponsors. These don't have to be complicated, but it doesn't hurt with marketing judges and in the fundraising process. In the past teams have been able to gather support from local businesses, whether they be large companies or local fast-food chains. In some cases, students might spend time mustering up the courage to knock on a door or phone a business but winning support is very rewarding for students and allows them to grow in confidence, an example of the many unique learning opportunities the SUBS in Schools program provides.



Athena, St Peter's Girls' School, SA, 2016 SUBS in Schools National Champions
Sponsorship Prospectus excerpts to attend 2016 MATE ROV Competition, Houston - Texas USA

Government Grants

Applying for grants is an option when starting to raise funding for the team. Each State Government is likely to have funding options in place to support student projects. Local Government Councils also provide access to community grants.

A grant that has benefited competing students in the past by the Australian Federal Government's Department of Industry, Innovation and Science is the grant for Student Science Engagement and International Competitions which can be found at -

https://www.business.gov.au/sgseic

Persistence is Key

In many cases, students will need to get a list of organisations and start calling. It's a difficult task for students, but it does allow them to learn a lot about how they sell themselves and their project.

In some cases, students will be denied any opportunities, but we do find that when students are well prepared, companies and organisations will look for ways they can contribute - whether with direct financial contributions or through products or services they offer.

Some businesses are happy to donate goods or services that can be auctioned off as prizes at fundraising events or school fetes. Even if students are knocked back being able to present a strategy and a list of their attempts will be beneficial in judging. Students might need to think outside the box, teams which approach companies without a plan and ask for a blank cheque are very unlikely to produce a positive outcome.

17. Verbal Presentation

Students in all levels of the competition will be required to deliver a verbal presentation about their project and experience in the SUBS in Schools program. At competitions judging panels are sourced from industry as much as possible, and students are judged on both their presentation technique and presentation content based on the judging criteria.

As with all judging, students must check the scorecards as they develop their responses to make sure the criteria is being addressed. In presentations, students will have access to an data projector or large monitor to which they can connect their computers to play a media presentation and videos if required. Each student must contribute to the presentation. Presentations are limited to 10 minutes and judges will stop students when the time limit is reached. Judges may ask clarifying questions following presentations, and they also may offer feedback immediately after the presentation.

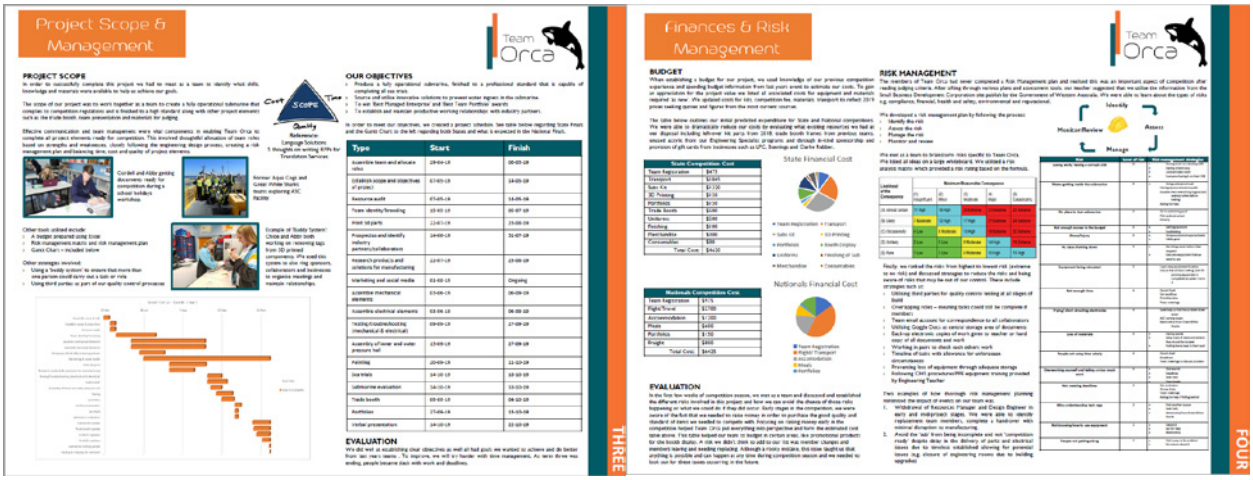
18. Project Management

Project management is a critical component when it comes to success in SUBS in Schools. When managing the project, it's essential that students consider all aspects of the competition and what might be required. They will find that throughout the process things might not work out as expected but starting with a plan is essential.

Project management is a component of judging so students must document their process for management in all aspects of the competition which may include how they raised funds, managed time & risks, developed as a team and communicated with industry.

The Australian Institute of Project Management (AIPM) and the Australian Government Department of Defence (DoD) have combined their efforts to produce a Project Management Guide to assist students which can be downloaded from the Resources area of the SUBS in Schools webpages.

In addition to this, teams must read Criteria 5 Project Management scorecard and address all of the Key Performance Indicators outlined in the advanced range for each of the criteria.



The Orcas,

Newton Moore Senior High School - 2019 National Final Enterprise Portfolio

18.1 Team Roles and Tasks

When it comes to roles, teams must consider the requirements of the program. There are no rules regarding roles, but they should be allocated based on each student's skills, experience and interests as well as the required project tasks. By considering different aspects of Engineering and Enterprise judging, teams should form their team into functional roles as they see fit. It might be a good idea to flip through some past portfolios to gain insight into how other groups have assigned roles in the past.

Below are some aspects of the competition and some roles that might match. Again, there are no strict rules on roles, and there will be plenty of overlap. Each team will have it's own unique set up where students are responsible for certain aspects of the project. Combining roles and creating new roles is always an option for teams.

In each of the levels in this program there are many tasks that must be mastered. Students will need to form teams of 3-5 students. Students can make up their roles and titles. The following are example roles that the students can assume as part of their team to complete the project:

Team Manager

This person would be responsible for managing the team, ensuring that all resources and the work of all team members comes together seamlessly and on schedule. The Team Manager works closely with other members, guiding and implementing management strategies, team meetings etc. whilst offering assistance where necessary.

Design Engineer

The Design Engineer has primary responsibility for the design, styling and hydrodynamic performance of the ROV or Submarine. The Design Engineer will be responsible for developing the 3D CAD model of the design and will need to liaise with the Manufacturing Engineer to ensure that all components are manufactured to meet the design criteria. The Design Engineer will need to have a good understanding of the rules and regulations.

Resources Manager

The Resources Manager manages time, materials and equipment for design and manufacture of the ROV or Submarine. They may also be responsible for developing ideas regarding team marketing and industry links. The Resources Manager will need to liaise with all members to check tasks are progressing on time and offer additional help, if needed.

Manufacturing Engineer

This person is usually responsible for the construction of the ROV or Sub and in particular the manufacture or 3D printing of all components. The Manufacturing Engineer will need to liaise with the Design Engineer to report and help solve issues with manufacturing of the ROV or Submarine.

Graphics Designer

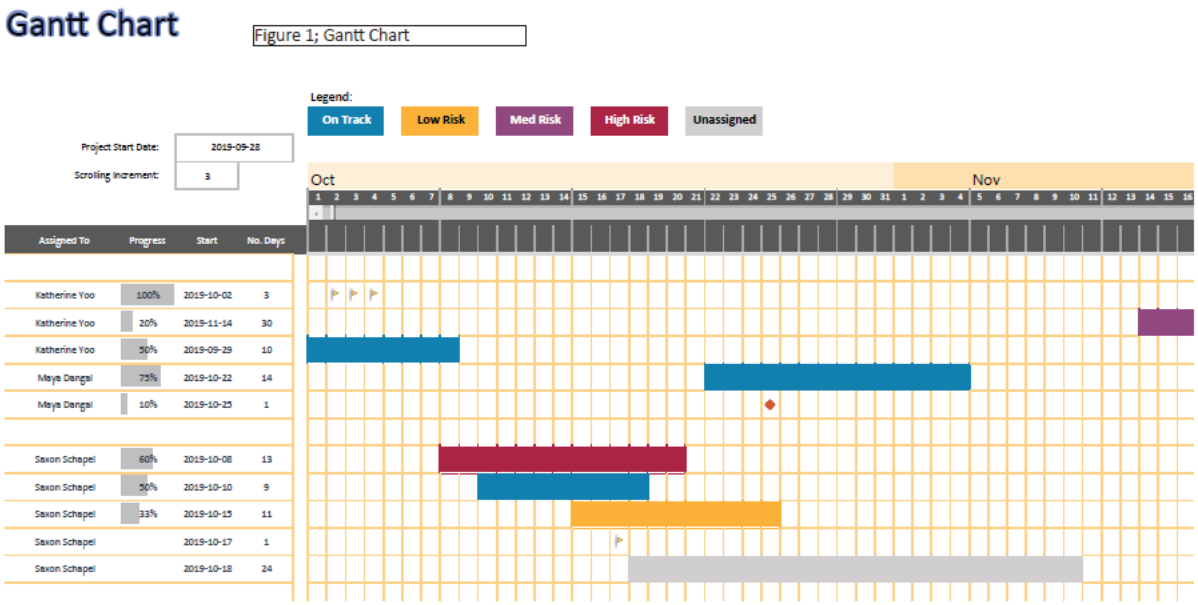
This person would be responsible for producing graphical concepts for team identity as applied across the project, including layout of documents and displays, together with the final graphic renderings and any additional team marketing materials.

18.2 Time Management

Below is a Gantt chart taken from an example portfolio. This chart was likely created after a lot of the actual work was done, but students must have a plan for how they'll manage their time and keep track of their progress.

Often students will struggle to adhere to or create deadlines and teachers might be able to push and prod students in the right direction. As with most high school projects, leaving things to the last minute does occur with SUBS in Schools teams and will often lead to problems.

Teams may work on the project for a couple of terms but fail to complete important elements in time for the competition. Time management is critical and an important concept for students to get their head around early in their SUBS in Schools journey.



SubMarryners, Marryatville High School, SA - Gantt Chart

19. Collaboration & Mentorship

Industry collaboration is critical to success in SUBS in Schools and greatly encouraged. In fact, it accounts for some significant points within the Verbal Presentation Content scorecard. A large part of the program is opening up opportunities with industry for students to gain a better understanding of current best practice. Students have a lot to learn from involving experts in various fields, whether in engineering disciplines, communication or design and graphics.

It might take students a few days or weeks to gain the confidence to contact a company and ask for help or to organise a meeting. This very much is a part of the program, and the confidence gained from successful partnerships is a huge opportunity for students. For students, it is by no means is an easy task to gain industry support, but in our experience, we find that many companies respond positively to student contact.

It's best to consider your local industries and to encourage the students to get involved. Taking advantage of any existing relationships the school may already have is a great place to start.

Contacting REA is also a good option if your students are struggling for industry collaboration but pushing students to make more calls can also be quite useful.

Creating Partnerships

Creating partnerships with other organisations is a great way to generate a foundation for SUBS in Schools at your school. This may involve a broader commitment from school executives to the program but in the long-run, will make collaboration easier for teams at the school.

In Adelaide, SAAB Australia has developed a fantastic partnership with about six schools at the time of writing. Saab graciously gives time for its graduate engineers to mentor and collaborate with teams and students taking on the SUBS in Schools competition.

In WA, schools in the past have been able to work with graphics artists who have supported REA competitions. "AndyK Graphic Artist" in Beechboro WA has supported the competition and collaborated with many teams over many years. Andy has supported the competition through mentoring and judging.

REA has a long-standing relationship with Visual Connections, who is a significant sponsor of REA. Visual Connections is the governing body for the print and sign industry and have offered to locate printers and signwriters which have been useful for competing teams in the past. Use the link below or contact REA for more information on industry partners through Visual Connections.

We strongly encourage schools and students to forge relationships in their local community. A great by-product of SUBS in Schools is the ability to bring communities together to support the growth and development of students in their area. REA will assist as much as possible to create partnerships with industry, but the onus should be on students attempting the competition as they have the most to gain out of understanding how corporate relationships work and forging partnerships for themselves. Please contact REA for more information or use the link below to submit a request for mentors or industry partners.

- https://rea.org.au/industry-mentoring-request-form/

Judging Panels & Feedback

Judging panels are sourced from industry wherever possible. Judges are an invaluable resource to competing teams as they assess student work. They benchmark team submissions and after each competition students are given feedback in the form of judges scores and comments.

During competitions, we encourage students to do their best to approach judges floating around the complex to ask them questions that are relevant to the judge's area of expertise. Students can talk to judges about what the judge does for work, whom they're representing, and if they have any tips or suggestions for their team.

20. Process Timeline

The Journey

Schools can create their own SUBS in Schools Journey, but there is a specific path which is required to reach the national final. New schools shouldn't worry about the road to the national finals until they can set up a strong system for STEM within the school but there are often teams who do extremely well in their first attempt and make it through to a national final in the same year.

Schools should focus on implementing the program for all students, not just those who will be looking to advance and compete. Within a school, it makes sense to run yearly cycles for STEM in which SUBS in Schools can be a significant program.

The timeline below is the general outline for how a team may progress through to the National Finals. Below is a general guide for which terms the events take place but the actual dates must be checked using the information posted on the REA website and may be different to the guide below. For example, a State final may be held later in term two or early term four depending on circumstances but will generally be in or around term 3.

Term 1 - Get started, introduce students to the concept of SUBS in Schools competitions and begin to work towards internal school competitions. This can be a yearly competition coordinated by STEM teachers and also offers an opportunity for students who previously took part in SUBS in Schools to share their learnings with new teams and students.

- *Register your school with REA as early as possible. This is an annual requirement and has no cost involved.*

Term 2 - Complete the development of some models and hold an internal competition to select the best teams who will represent their school at a state final. Success at a state final is a requirement before a team can advance to a National Final.

- *Ensure any teams looking to compete are registered by their TEACHER. This is separate to school registration and should be one of the first things teachers do after teams are formed.*

Term 3 - Get involved in REA competitions in your State. State Final dates can be found on the REA website, and the REA team can be contacted if you need any guidance or support. Not all states have state finals. Generally these only run in SA and WA with teams registered in other states moving straight to a national final. This will change as the competition grows around Australia.

- *Teams are not guaranteed to progress past the State finals and for many teams this will be the end of their SUBS in Schools competition journey and will need to try again the following year.*

Top placing teams continue through the process.

Term 4 - Prepare for national final using learnings from State Finals. Teams will often require a more comprehensive approach to the national final. Feedback from State Finals should be applied to improve aspects of student submissions where possible.

- *Teams can register the following year in the same or another level of the competition depending on the restrictions imposed. Teams should once again take their learnings from the national final and build on their knowledge and experience.*

21. Reflect & Refine

Team Evolution

Building a culture of growth within a school goes hand-in-hand with running a successful STEM program for students. Most schools will run SUBS in Schools consistently every year and have teams "coming up through the ranks". Using older students to mentor younger teams is a great way to help students grow and learn - in some cases students learn more from other students than from teachers.

Teams themselves are often chopping and changing. From year-to-year groups may change and re-form with changes in the team name and some group members. Having a whole-school plan for STEM and allowing students to compete in consecutive years will ensure students get the most out of SUBS in Schools.

REA asks that all schools taking on SUBS in Schools register on the REA website. Schools with teams looking to compete must also register their specific teams as early as possible on the REA website - https://rea.org.au/SUBS-in-schools/fees-and-registration/

School Registration - https://rea.org.au/SUBS-in-schools/school-registration-form

Team Registration - https://rea.org.au/SUBS-in-schools/team-registration-form

Event Scheduling - https://rea.org.au/events-calendar-and-information/

22. Competing

Who should compete?

Staff should use their professional judgement as teams decide whether or not they want to compete. While teams will benefit immensely from competing, judges are generally from industry and volunteering time from their job or business to contribute their expertise in judging student submissions and presentations. If students put forward poor submissions, they will receive poor results.

A balance between using the event as a learning opportunity and motivating students by using an incentive of a podium finish is ideal. There is no limit on how many teams can be put forward by a school but REA may ask schools to whittle down their entries to ensure that all schools in an area are given an opportunity to be represented.

SUBS in Schools Competition Regulations

Just like any competition, the SUBS in Schools program requires teams to follow guidelines in the production of their model and documentation. Competitions run according to the rules and regulations documents. The competition regulations can be found on the REA website, which are updated from year-to-year. Giving students a copy of the regulations early on is very important in ensuring they know the full scope of what's allowed and what's required in the program. The regulations documents can be found using this link - https://rea.org.au/SUBS-in-schools/resources/ under the "Rules & Regulations" heading.

- *Teams will need to be aware of two regulation documents. The Technical Regulations and the Competition Regulations.*

Not Sure if you should Compete?

The process at first for students should be similar whether they're competing or not. For REA competitions, students must document and keep track of their progress so that it can be used in their portfolios and verbal presentation. Documentation of student work is good classroom practice. Our research has shown that the hands-on components of the program rate highly with students, this suggests that students might not have an interest in competing until they start producing a final product. In levels 2, 3 and 4, students are required to submit two portfolios, one for their engineering processes and one for their enterprise process. Students are also required to put together a verbal presentation and trade booth display, so record-keeping and planning are a must.

Throughout the CAD process, it's good to let students play and figure out how CAD works before giving them the technical regulations. Students can work on the project and should be able to transition from a non-competing team to a competing team quite easily if they have a good understanding of each of the elements of the program and understand the importance of time management. Awareness of registration deadlines and competition dates is also vital for teams early on in the process of their journey.

Regulation Documents

Competing teams should be given the regulation documents as early as possible with the understanding that the documents are updated every year. There are two regulation documents, the Technical Regulations and the Competition regulations, both available from the resources page on the REA website under the "Rules & Regulations" heading - https://rea.org.au/SUBS-in-schools/resources/

23. First Steps

Register on the REA Website

Whether entering a competition or not, the first step is that schools register on the REA website. This will allow REA to monitor school progress and open the line of communication with the school. Deadlines apply. There is no cost to register and registration is via the 'fees and registration' page on the REA website - https://rea.org.au/SUBS-in-schools/fees-and-registration/.

A 'Team Registration' is required once teams are formed and looking to compete in Regional or State Competitions. Deadlines apply.

Engaging Students

Schools might like to introduce students to the program before encouraging them to commit. The program can be promoted within a school at an assembly, through a newsletter or subject selection evening. REA has a lot of promotional videos available on its website, on YouTube and has a PodCast channel 'Above and Beyond' which includes interviews with teachers, past students and industry. The videos of the most recent State or National Final can be a good starting point. Some links are listed below

Videos

- https://rea.org.au/category/subs-in-schools/
- https://www.youtube.com/c/ReEngineeringAustraliaFoundation/videos

Podcasts

Whooshkaa (Includes Apple and Spotify Links)

- https://player.whooshkaa.com/shows/above-and-beyond

REA

- https://www.rea.org.au/above-and-beyond

Google

- https://podcasts.google.com/search/REA%20above%20%26%20beyond

Deezer

- https://www.deezer.com/show/1589052

Meeting Times

Once students commit to the program, the next step is to consider when the team will be meeting. Teams can chop and change quite a bit in the early stages, but students need to document their process from the get-go for their learning and possible later use in portfolios.

It's up to the students to plan and organise their time, but supporting staff can certainly point them in the right direction. If schools are running the program across an entire cohort, there might not be a need to organise additional sessions.

Roles and Responsibilities

Once teams form, everybody on a team must know their role. Students will have different interests. Some will want to design using CAD and others will want to be involved in manufacturing, management or marketing.

It's essential to explain to students that different roles will help the project come together to produce a final product. It's a good idea to show them what the end product might look like - there are example portfolios available on the REA website and REA competition videos on YouTube will give students an idea of what's involved. Visiting an event before competing can also be beneficial.

It's also crucial that the students are on the same page. While not all students will have the same responsibilities there is a lot of overlap and working together will benefit the team overall. As an example, team judging takes place in several areas and while students can manage who answers specific questions, it will come across better in the judging process if all team members have at least some understanding of all aspects of the design, test, manufacture and review process, even if they aren't directly responsible for that process within the team.

Competing teams should be directed to the SUBS in Schools Technical and Competition Regulations documents with the onus being on students to adhere to the rules outlined.

24. Competition Events

There is no requirement to enter into any competition. Schools may wish to compete internally within the school or even on a class-by-class basis. Competition can be a great incentive for students to work towards and offer further learning outcomes for students beyond internal competitions.

If teams do wish to compete, the first level of competition in SA and WA is a State Final, for which a cost is involved for each team. The State Finals include a large number of teams and are usually coordinated by REA directly in consultation with the SUBS in Schools regional coordinators. For all other states, there is not yet a requirement for a state final but this is expected to change in the coming years.

If successful at a State Final, teams are then invited to attend the Australian National Final which involves schools from all across Australia. SUBS in Schools is an Australian-led program and is not yet a global competition but with the UK taking on Subs in Schools and international interest from other Asia-Pacific countries, it's only a matter of time before we stage a world final.

Summary of Australian Competition Levels

Intra-school	State Finals	National Final
If you don't think your students are ready for a competition or if you're new to the program you can run SUBS in Schools within your school. Dropping in to an REA event will give staff an idea of what's involved and can be useful.	These are held around term 3 and are REA organised events. Teams from across the state compete for a shot at the National Finals. Dates can be found on the REA website when available.	Most recently this has been held in Perth or Adelaide in term 4. It's a huge event with a lot of peer and industry networking opportunities.

25. Competition Levels

The levels of the competition provide a series of stepping stones students can use to increase their skills and competencies. These classes are Level 2 Large ROV, Development and Professional Class, Level 3 Spatial Design and Level 4 Submarine. The different classes have different Technical Regulations but share the same Competition Regulations. The complexity increases between the Large ROV Development and Professional Class and teams will need to be aware of these differences.

Teams may only reach an intra-school level which would not involve any external competitions, or they may progress through all the levels of official competitions, starting at a State Final and then a National Final. To participate at the higher levels of competition teams need to achieve a high placing at previous levels or are offered a wildcard invitation.

Class Structure

Difficulty Level	Level/Class
Low Difficulty	No-Class (within the school only)
	Mini ROV (WA only)
	Level 2 - Large ROV (Development Class)
Moderate Difficulty	Level 2 - Large ROV (Professional Class)
	Level 3 - Spatial Design
High Difficulty	Level 4 - Submarine

26. Frequently Asked Questions

Do all students have to be in the same year level?

Students don't all have to be in the same grade. Teams will need to complete at the level allowed based on the oldest student or form new teams depending on the level of competition they want to enter. The eligibility requirements for certain levels of the competition follows:

- Mini ROV: Years 5 -9 only
- Large ROV (Development Class): Years 6 - 9 only
- Large ROV (Professional Class): years 7 - 12 only
- Spatial Design: Years 7 - 12 only
- Submarine: Years 7 - 12 only

For example, a team with two year 8 students and a year 10 student will have to compete in a class or level which allows students in year 10 and above.

Can students enter the same level multiple times?

In the case of the Large ROV Development Class, secondary students can only enter this class once . However primary school students can enter both in Year 5 & 6.

In the Large ROV Professional Class, Spatial Design and Submarine Class students can enter as many times as they like.

Can my school enter multiple teams into the competitions?

Schools can enter as many teams as they like. Teams must, however, be able to demonstrate a capacity to deal with the competition. Merely entering a team because they have a completed model isn't always a good idea. In some cases, REA may ask schools to reduce the number of teams entered to ensure all schools have an opportunity to be represented.

I have a group of keen students in year 7, can they enter the more complex Level 4 Submarine Class?

Yes, they can but Year 7's may struggle to compete against older students. If competing for the first time, starting at the Large ROV - Development Class level would likely be better so students can compete with others their age.

What are the costs involved in the program?

Schools can run internal competitions at no cost, we do ask the schools register if they are running competitions internally which is free.

Other costs include the costs of components. REA is able to offer equipment through www.envizage.com.au. The kits available are all customisable and offer a solid base for students to work from. In the ROV Professional Class and Submarine Class students can source and build their own parts at their own cost. The development class kits start at $550.

Registration for REA events also has a cost involved for each team ranging from approximately $500 at State Finals and up to $1000 for National Finals. Competing students will also need to fund their projects as it relates to printing portfolios and building their trade displays.

What equipment do I need?

Equipment required depends on the level entered. In general, schools will need a 3D printer to create their own accessories and to comply with the rules however it is not critical. For example, propeller covers are required on the ROVs, ideally teams will design and build these covers using a 3D printer however physically covering the propeller with a mesh barrier using elastic bands can be used as a propeller cover. Students should consider how engineering judges will view their work and avoid "hack" solutions.

In the Submarine Class a 3D printer is required to print certain parts but this can be outsourced if necessary.

Other equipment that will be required are basic workshop equipment. Things like a soldering iron and solder are critical. Other basic tools such as a multimeter to test circuits and continuity can be very useful.

Is access to a pool critical?

Pool access is not critical but very useful when it comes to trailing a craft. The majority of schools don't have a pool or access to a pool and are able to use repurposed fish tanks or reinforced plastic tubs to test their watercraft. That being said, access to a pool for testing should be something students prioritise as they develop their plan for competition.

27. Competition Activities

REA is responsible for running the SUBS in Schools State and National Final competition events within Australia. Each event has it's own schedule and specific requirements but in general most events will run over 2 - 3 days and have the following components.

1. Registration & Element Submission

At the beginning of each event teams will register their arrival and submit the different components of their project to REA staff. It's critical that teams are aware of what's involved in their submission according the competition regulations for their class. Teams will submit the following (with the exception of mini-ROV in WA):

- One fully functional Large ROV or Submarine with required decals (Decals are provided on the day),
- Two identical enterprise portfolios,
- Three identical engineering portfolios,
- One engineering compliance book.

About 1-2 weeks prior to the event, teams will also be required to submit electronic copies of CAD design files, portfolios, compliance booklet and all forms.

2. Trade Display Set-Up

After event registration, teams are given two hours to complete the setup of their trade display. The two hour limit encourages teams to be practical in their trade booth designs. No non-team member is permitted to help. The set-up may be scheduled as one session or teams divided over two sessions depending on space and timing available. The display dimensions are outlined in the competition regulations document.

3. Scheduled Judging Events

Throughout the days teams will be scheduled for judging at certain times. Judging times may be scattered throughout the day and it's up to the teams to keep track of their schedule. Maps of judging locations are physically posted around the event and explained during the opening ceremony. Maps and schedules will be sent ahead of the event but it's important to keep in mind that there might be last minute changes in which case updates will be sent to teams.

All team submissions are judged including portfolios and models. All team members speak with judging teams when undertaking:

- Trade display interviews,
- Engineering CAD and manufacturing interviews
- Their verbal presentation.

4. Scheduled Trials

Trials of watercraft are also scheduled throughout the day. Teams will have at least two attempts to navigate their watercraft through their required tasks as per the Competition Regulations. Points are allocated based on the tasks successfully completed and the time taken to complete the course. Timing points are only granted to teams who complete a minimum of 3 tasks in the case of a Large ROV and 3 gates for a Submarine.

5. Awards Presentation

Throughout the event days, judges update their results online after deliberating with their fellow judges. Each panel of judges is responsible for judging a detailed category of student submissions. Judging criteria used in competitions is identical to the criteria found on the last pages of the Competition Regulations. Judging results are combined with trial results and the winners are announced for each level and class. In addition to 1st, 2nd and 3rd placings, there are also category awards which consider more specific aspects of student submissions, these can be found on the following page.

Participation Certificates

At REA competitions all competing students are providied with a certificate for their participation and at national finals, this also includes a medallion.

28. Awards and Recognition

Awards & Prizes

Awards are allocated based on performance in specified categories. All categories which contribute to awards are outlined in the Competition Regulations document within the Awards Matrix.

The results for 1st, 2nd and 3rd are produced from the sum of overall score across all marking criteria. Other awards listed below are selected from specific judging criteria which are highlighted in the competition regulations document.

Overall Awards

Based on the overall scores, teams are awarded 1st, 2nd and 3rd. Points are based on an accumulation of all judging categories.

The full assessment criteria can be found on the last pages of the competition regulations document. It's important to point your students to the scorecards as students will often miss easy marks because they don't look at the criteria - just like with their regular school assignments.

Category Awards

Students are recognised for their achievements even if they don't place on the podium. Certain judging criteria contribute to the awards below and are highlighted in the judging criteria available in the regulations documents. It is possible for podium teams to also be awarded multiple awards and there is no guarantee that teams will win awards beyond participation.

Award Name	Level 1 (WA)	Level 2 (Dev)	Level 2 (Pro)	Level 3	Level 4
Best Trial	.	.	.		.
Best Engineered		.	.		.
Best Engineering CAD		.	.		.
Best Virtual 3D Model				.	
Best Manufactured ROV/Submarine		.	.		.
Best Team Portfolio		.	.	.	.
Best Graphic Design		.	.	.	.
Best Managed Enterprise		.	.	.	.
Best Team Marketing		.	.	.	.
Best Team Trade Display	.	.	.	.	.
Outstanding Industry Collaboration	.	.	.	.	.
Best Team Verbal Presentation	.	.	.	.	.
Innovation	.	.	.	.	.
Chair of Judges Recognition	.	.	.	.	.
Best Newcomer (National Final Only)		.	.	.	.

Progression

Champions in individual levels and class categories automatically progress to the next level of competition. At REA managed finals, some teams will be offered wildcard invitations. These invitations are at the discretion of REA staff and are not necessarily based on final rankings of teams.

29. More on Competitions

What to expect from your students

Often students will be a mixture of nervous and excited for competitions. It can be a reasonably high-pressure situation for students, especially at first, but as students move to higher levels of the competition they will often find themselves having much fun.

In Australia, competitions are always friendly, and while some healthy rivalries form, this is considered part of the competition and students learn to deal with the pressures involved. Overall, the competitions are a great learning experience for students and teams are encouraged to network with each other and share ideas to improve.

What's allowed and what isn't

During each competition, teacher involvement in the judging and assessment process is not permitted. Of course, they can speak with their students and must make sure they're behaving safely at all times. Staff can give hints and tips at specific points, but when it comes to rectification, trade displays and judging panels, teachers are not permitted to intervene. One teacher is permitted to sit at the back of judging to observe but cannot interact with the students or the judges whatsoever.

Students are allowed to rectify and work on their models in the designated periods and are allowed to borrow equipment from other teams as long as they are given permission. While it is a competition, it's common to see teams helping each other out with suggestions and equipment such as glue and tooling

Students must have media consent forms submitted with REA before any event. This is a part of the standard event registration process which registered teams will be reminded of before competitions. Students refusing to submit a signed Media Consent will not be permitted to attend an REA managed competition event.

Watercraft and controllers that are deemed unsafe by scrutineers and/or the chair of judges will not be permitted to trial.

Managing Expectations

The competition is all-encompassing in terms of the STEM outcomes. Students have to develop ideas, learn new concepts and apply them. All this while managing how they'll be acquiring sponsorship and meeting deadlines.

Expectations of students will be related to how you run the program. If you're running SUBS in Schools across an entire cohort, then it might be appropriate to not overwhelm students at the start with the intricacies of the project and the work involved. With students who struggle to get motivated, once they're in the swing of things and if they're designing and producing good work, they will develop the motivation to find sponsorship and be proactive when they set their eyes on the competition.

On the other hand, if running SUBS in Schools for students who are explicitly aiming to win a competition, that's great. With a smaller group of motivated students, it's a great idea to let them know the complete path and what's involved early on in the process.

It's really up to staff professional judgement when working with students within a school's individual context but managing expectations and determining realistic goals is certainly something to consider early on. Due to the nature of competitions, there can only be one winner, and it's important students (and teachers) learn to deal with this gracefully.

Sample Competition Results

Final results and awards are announced at all events. Following competitions, teams are provided with a full report on how they performed. In addition to the overall points summary, teams are given specific feedback from the judges on each of the judging areas.

As with all school assignments, it's very useful for teams to be aware of the judging criteria ahead of the competition. The following is an example taken from the result sheet provided to teams.

Judging Category	Low	Median	High	Your Score
Specifications	30	62	78	**65/80**
Engineering CAD	5	34	54	**54/65**
Engineering CAM	27	33	51	**51/65**
Engineering Design Process	18	43	59	**44/70**
Marketing - Project Management	6	46	64	**50/80**
Marketing - Portfolio Design	13	37	48	**37/50**
Marketing - Branding	25	41	56	**56/60**

30. Competition Costs

Trade Booth

In all competition levels, teams must organise and set up a trade booth to display their work. The cost can vary from $200 to $2000+, and it's really up to teams how they go about it this and how far they take their design.

Judges don't consider the costs involved in building the display but will examine how the students applied creativity and practicality to the set-up. Of particular importance are issues of sustainability and use of recycled products in the construction.

Roebling, Wilderness School, SA, 2019 National Final

SubMarryners, Marryatville High School, SA, 2019 National Final

Team Uniform

Teams competing in Levels 2, 3 and 4 need to include in their marketing the development of a team uniform. Teams struggling to raise money to fund this might consider wearing their school uniform or integrating affordable screen printed shirts with their school trousers, shorts or skirts. At state and national competitions, team uniforms play an important role in differentiating teams. They also provide an opportunity to display sponsors logos and bond the team together. Uniforms are usually outsourced and can cost from $30 per item.

Portfolios

Levels 2, 3 and 4 are required to produce team portfolios. Portfolios can be printed inhouse or outsourced to an organisation like Officeworks. Portfolio printing can cost anywhere from $100 to $400+ depending on the quality and number printed. .

Vanguard, Large ROV Development Class, Trinity Gardens Primary School, SA, 2019 National Final Enterprise Portfolio

Ex-cursions/Industry Visits

Mentoring of students by industry adds value to the knowledge the students can discuss with judges. We recommend that teams arrange site visits to industry to help build their knowledge and understanding of the world of work. REA can assist any school who would like to visit industry which provides support to the Defence Industry via our relationship with the Department of Defence. In the past, we have seen teams work with a wide range of exciting and sometimes obscure industries and organisations. Collaborating with industry is an invaluable source of knowledge, and can open opportunities for sponsorship.

31. Competing Team Costs

State & National Final Registration Fees

Costs are involved in the State, National, and World Finals to cover the provision of display booths and event costs. When teams are ready for these levels of competition, they should have a plan to raise money and manage these costs on their own. Describing how they manage project costs is a component of their enterprise portfolio. The cost of team transport and relief teachers would also need to be considered by the school to allow attendance at these more significant events. The cost involved in participation is available on the REA website: https://rea.org.au/SUBS-in-schools/fees-and-registration/.

The following are an estimate of the participation costs for a State & National Final:

- State Finals (Mini ROV - WA only) - $200
- State Finals (Large ROV, Spatial Design, Submarine levels) - $475
- National Finals - (Large ROV, Spatial Design, Submarine levels) - $975

If your school is taking on SUBS in Schools for the first time or if you have a large number of students, it would be a good idea to whittle down the teams within your school who will attend State level competitions. .

Costs and Involvement of Time

SUBS in Schools is an extensive program in terms of the possible learning pathways which may come from involvement. There is no upper limit to the learning process and teams will need to produce a large amount of content to comply with the judging criteria. They will look to access knowledge from many areas including engaging with industry, Universities and TAFE along the way. Chasing sponsors can also be a time-consuming activity. The students should manage the additional financial resources needed to undertake these activities.

Funding and Sponsorship

Fundraising is scary work which is not usually within the vocabulary of teachers or students. Fundraising requires persistence, determination and resilience. There will be many knockbacks, but these should feed the desire to try again.

Students will need to take responsibility for raising the funds they need for their project which might involve making an application with the school's P&C, running fundraising activities, a BBQ at a Bunnings or applying for a grant from the Federal or State Government. It's up to students to chase down sponsorship and develop relationships with local organisations.

To assist with the process of fundraising, teams should develop a prospectus outlining the Return On Investment (ROI) that sponsors will receive from their investment. This document should be relevant to the industries they will be approaching and the local environment.

NOTES:

- From our experience, it is remarkable how easily students can attract sponsors. Each year we take four teams to the F1 in Schools World Finals, and the cost of this can be as high at $60,000. We have never had a team that was not able to attract sufficient sponsors. In some cases, they have attracted over $90,000 per team in sponsorship which has allowed the school to use the additional support for the purchase of equipment.
- Success at SUBS in Schools can help lift the image of the school, assisting schools to develop long term relationships with industry, attract industry as sponsors and mentors to guide students career pathways.

32. Creating a STEM HUB

Why Create a STEM HUB?

Fostering a culture of collaboration, learning and understanding is one of the best outcomes that the SUBS in Schools program has to offer schools. Providing students with the tools and opportunity to create and produce will empower students to see the world differently and look through a lens of creativity and innovation. It will provide students with the wherewithal to become producers rather than consumers in the world we live in today.

Creating a STEM Hub won't suddenly turn students into engineering experts, but it will allow both students and teachers to push their limits and allow them to grow without the barrier of accessibility.

What is a STEM HUB?

A STEM HUB is a modern-day industrial design workshop: a creativity factory where student ideas can come to life. Students might be creating a simple new toy for themselves or a sibling or a well-engineered solution to a problem. Regardless of what they want to produce, a STEM hub allows students to use the tools they learn from different subject areas across the school and to apply them into a finished product.

A STEM HUB will allow them to create a tangible solution from a concept that originated in their mind. Students can be working towards a specific goal or freely innovating. As with most learning, a hands-on STEM experience will also allow students to make mistakes and develop a greater understanding of what exactly goes into producing any designed solution.

STEM HUB Equipment

A stem hub can contain a range of technologies which will allow students to design and create almost anything.

3D Printers

More recently, 3D printing has been recognised as providing learning outcomes by placing in the students' hands what was in their minds. 3D printing is only one of the steps in the design process along the way to producing an outcome. Using 3D printing in industry started 25 years ago where its use was as a design aid and not a result. While learning outcomes can come from 3D printers, they are still subject to bad data in = wrong model out.

Ideally, an excellent 3D printer will be a part of a STEM Hub, but it should only be one of many elements that make up a STEM hub.

CNC Routers and Lathes

For a school looking to implement SUBS in Schools, a quality CNC router is an ideal addition to a STEM Hub. REA offers Denford CNC equipment to Australian schools. A CNC Router is perfect for any STEM Hub as it produces designed solutions via subtractive manufacturing techniques, as used in industry, consistently and reliably. Denford CNC Equipment is designed specifically for schools - the software is easy to use, and the machines are very robust. The Denford Routers machine with precision and speed, which is ideal for in-class use for projects beyond SUBS in Schools.

When it comes to Subs in Schools a router can be useful in creating parts for the sub and moulds which can be used for vacuum forming. A router can also be used to machine PCB boards which house the electronics required for watercraft depending on how students decide to design their watercraft.

Laser Cutter

Laser Cutters are very versatile and have many uses in a school context. Laser cutters are a simple way to bring any design to life, they are easy to use and can accommodate a range of projects and student levels. When it comes to subs in schools a laser cutter is a valuable tool in cutting material to size and incorporating design ideas into a final model.

In competitions laser cutters are very valuable in the creation of trade displays and marketing material

Vacuum Former

Vacuum formers are a great compliment for the items listed above. A vacuum former is an effective way to produce strong plastic shells using a mould.

33. Subs in Schools Kits and Resource Costs

Mini-ROV Kit

The Mini-ROV Kit is sourced from North America and provides an affordable entry-level kit for primary schools and younger high school years. The mini-ROV kits are easy to set up and can be re-used if de-soldered.

At the time of writing the kits cost $175 + Shipping.

Development Class ROV

The Development Class ROV kit is a complete kit which will have students working in water in no time. The kit is straight forward and easy to put together. In competitions students are required to produce their own additions, improvements and creativity to the kit in order to address the competition requirements.

The Development Class ROV Kits cost $550 + shipping.

Additional Accessories

Additional Accessories include cameras and robotic arms which students will need to source or build themselves. Additions don't have to be expensive but they do have to be functional. It's up to students how they build-in accessories and the amount of cost which can be expended. Many accessories are likely already available to students, for example, adding camera functionality can be done in many ways - it's likely students will already have access to a go-pro through the school which can be incorporated as the watercrafts camera functionality.

Submarine Kit

REA is currently developing a new Submarine Kit which will be available to schools in 2021. The kit is a complete kit and will build a functional submarine with the required addition of 3D printed parts. The kit has been designed to be robust and uses premium components to limit the risks inherently involved with building a submarine. Schools are encouraged to re-use the submarine from year-to-year and, if not the whole submarine, components of the submarine should certainly be kept in order to facilitate future Subs in Schools groups.

The kits are expected to cost around $2,500-$3,000.

Text Books

Text books can be an ideal resource depending on how teachers structure their classes. A yellow textbook titled "Build your own underwater robot and other water projects" is included with a Development Class ROV kit and can also be purchased for $33 + shipping.

A more comprehensive textbook is also available for students and teachers which has extensive information on underwater projects. The blue "Underwater Robotics: Science, Design and Fabrication" textbook can be purchased for $165 + Shipping and is an ideal resource for schools taking on Subs in Schools.

JoyStick Controllers

Further kits which allow for greater control and programming functionality are also available from REA. In general, these kits are great for Professional Class ROV teams but can also be adapted in other classes. The joystick controllers come as a plug-and-play kit for $1,300 + shipping or with an Arduino processor for $1,700 + Shipping

Premium 3D Printers

A good 3D printer is a necessity for schools taking on level 4 but can also be very useful in other classes and in other school projects. At REA we recommend MakerBot 3D printers and have a range available starting with the MakerBot Replicator+ at $4839 through to a MakerBot Method which starts at around $13750.

34. Teacher Feedback

The following feedback comments were provided by participating teachers in response to questions posed in an annual survey implemented by REA

1. **Have REA programs changed the perception of STEM education in your School? If yes, in which way?**

- It is a very comprehensive program, gives a real experience on deadlines and teamwork. Students can see how these skills relate to the real world. (Wesley College, WA)
- Being a low socio-economic school with a high rate of refugee students, it has become a wonderful program to open their minds to the possibilities. (Balga Senior High School, WA)
- It broadens students horizons. One student has actively changed his career direction because of SUBS in schools. Students realise that stem education has an engineering component which has high status in the community. (The King David School, VIC)
- It has changed the perception of staff that subjects should operate as isolated silos, to being a perception that subjects need to be inter-related and collaborative. (Gold Coast Christian College, QLD)
- It is great to have very clear structure to project-based learning projects. The different levels allow us to cater to different needs. (Provides) real-world problems and skills not just paddle pop sticks. (Ulladulla High School)

2. **Have REA programs increased the adoption of STEM and/or engineering studies at your school? If yes, in what ways has it brought about a change?**

- (Through implenting SUBS in Schools, our) current stage five and six engineering studies student (numbers are the) highest in years. (Plumpton High School)
- The majority of students studying science or engineering at HSC level have completed REA programs in year nine and 10. (Ulladulla High School)
- It's hard to pinpoint in statistics, but students engaged in STEM and REA events are more involved and enjoy their studies more. (Parramatta Marist College)
- It is the most comprehensive STEM project. Students enjoy all the different aspects. We try and make stem projects comprehensive like the SUBS in Schools program. (Wesley College, WA)

3. **What are the learning outcomes for the students as a result of participating in REA's Programs?**

- Huge learning outcomes, students are working within a rigourous criteria on a broad range of lifelong skills. (Alamanda K-9 College, VIC)
- To develop teamwork to deliver a project based on inquiry and relative to real life. To develop skills for life long learning. To acquire manufacturing and have skills developing and demonstrating their knowledge of technology. To utilise numeracy and literacy skills to enhance their project. (Albert Park College, VIC)
- Dynamic problem-solving skills, time and resource management, teamwork, leadership qualities. (Port Hacking High School, NSW)
- It's hard to put this into a little box, however, my view is that students need to understand that REA program, SUBS in schools, is their opportunity to be their best. They have a great chance to represent the school in a healthy atmosphere of competition and success. Wonderful pathway to their adulthood. (The King David School, VIC)

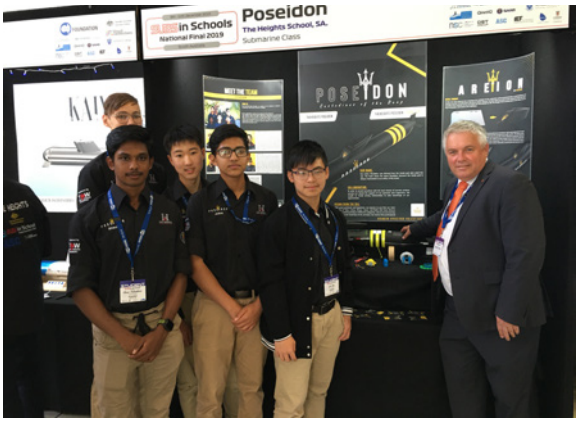
4. **What are the positive aspects of REA Programs which stand out for you?**

- You are technology. CAD, allows students to extend themselves, allows students with different skill sets to participate to a high level. (Adelaide High School, SA)
- The fact there is a role for all students, regardless of where they lie on the technical, people centred spectrum. (Blue Mountains Grammar School, NSW)
- SUBS in Schools really helps students to mature and helps them understand the skills that they will need for the future. It encourages collaboration, communication and develops lifelong learning skills in a positive (way). (Albert Park College, VI)

Gallery - 2019 National Final at St Peters College, SA

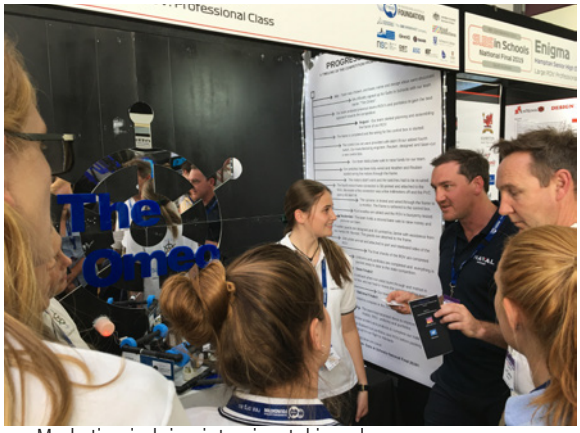
Main Foyer, competing teams and trade booths.

SubMarryners, Marryatville HS, SA showing off their ROV with Senator Rex Patrick



Poseidon, The Heights High School, SA team and trade display with Senator Rex Patrick

Awards Presentation Audience



Marketing judging interview taking place.

Submarine Class Podium

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Re-Engineering Australia Foundation Ltd
ABN: 12 095 876 323
Unit 7/20-22 Foundry Road
Seven Hills NSW 2147 Australia
PO Box 136, Castle Hill NSW 1765
Phone: +61 (02) 9620 9944 Int. Facsimile: +61 (02) 8079 0622 Email: contact@rea.org.au
Internet: www.rea.org.au