

# SAUC-E Mission & Rules<sup>1</sup> (Version 01 – Feb 2012)

## Competition date: July 06 - July 13 2012

The following 10 teams participated in the SAUC-E '11.

- University of Lübeck (2011 Champion)
- University of Girona (2011 2nd place)
- DFKI Bremen (2011 3rd place)
- ENSTA – Ecole Nationale Supérieure de Techniques Avancées Bretagne (2011 4th place)
- ESIA - Ecole Supérieure D'Informatique Electronique Automatique-Ryujin Team
- University of West England
- Cambridge University
- University of Southampton and University of Birmingham (Combined Team)
- Heriot-Watt University
- ESIA - Ecole Supérieure D'Informatique Electronique Automatique-Aquatics Team

### Objective:

The goals of this competition are to advance the state-of-the-art of Autonomous Underwater Vehicles by challenging multi-disciplinary teams of students and engineers, to perform an autonomous mission in the underwater environment and to foster ties between young engineers and the organisations involved in AUV technologies. It is designed as a mini-grand challenge for the autonomous underwater community which will create a suitable environment for interdisciplinary interactions between academic researchers.

Starting in 2012, NATO Undersea Research Centre (NURC), under the sponsorship of Office of Naval Research (ONR) and ONR Global, has formed NATO Engineering Support Team (NEST) for SAUC-E. The objectives of the team are: to help raise the SAUC-E competition to the next level to go beyond the state of the art in AUV technology, Subject Matter Experts (SME) to provide additional guidance the students in the design of the AUVs that can perform well in realistic environments, encourage collaboration among teams and help the teams to spend their limited budgets wisely. NEST hopes to achieve these objectives by setting up an online forum/wiki site where the teams can collaborate, share code, and post issues/solutions; purchase the AUV components for the Hardware Library that the competitors can loan; write documents especially addressing the challenges of SAUC-E environment; and provide email, phone, and on-site support to the teams. This will hopefully result in improved SAUC-E competitors AUVs, increased students' interest in the competition, loaned sensors' integration software and data from in-water tests posted on the collaborative web page and be available to all the competitors. NEST is open to suggestions from organizations interested in becoming actively involved in SAUC-E. NEST encourages, and will advise the judges to award, multidisciplinary background of team members. Underwater robotics needs multidisciplinary from various engineering domains (mechanical, naval architecture, control engineering, communication, etc.). NEST discourages the advisors (professors) to be quite active in preparing the particular tasks during the competition and will advise the judges to penalize such actions.

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<sup>1</sup> These rules are subject to change, refinement and development.

**OUTSIDE**  
**(Not to scale)**

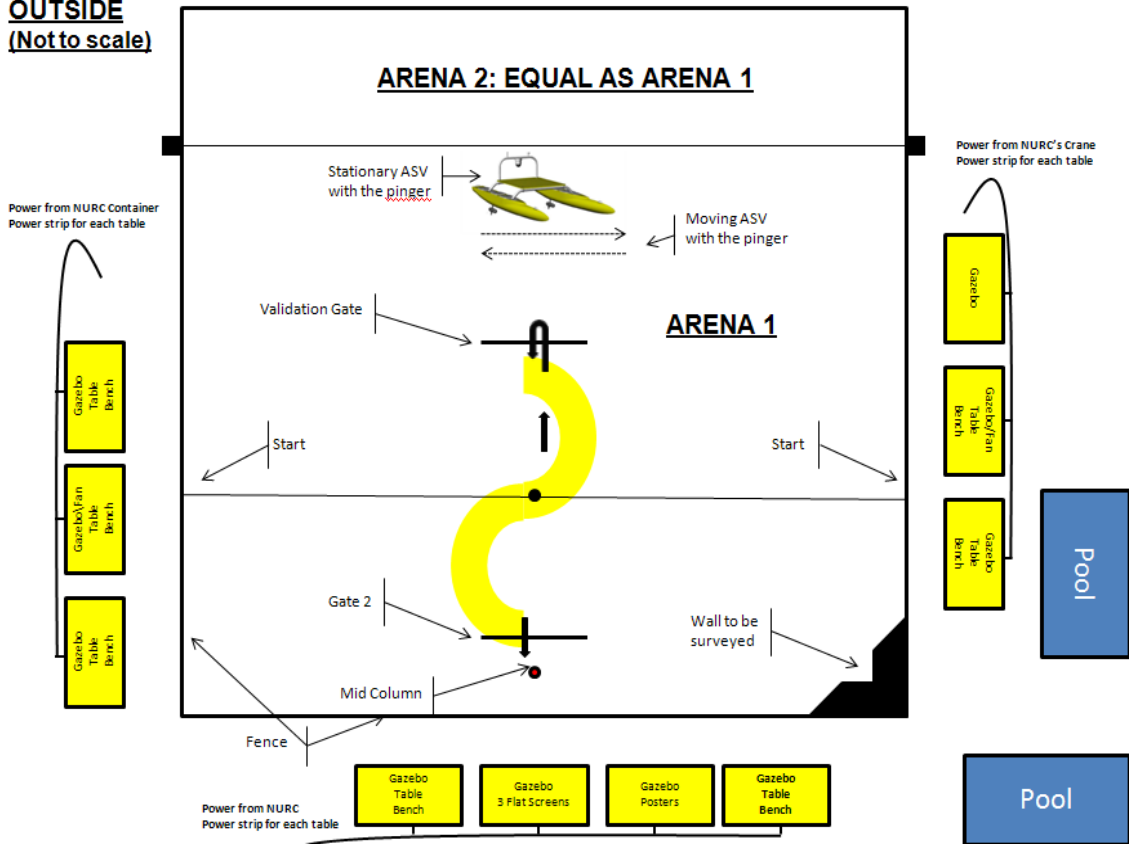


Figure 1: NURC's Sea Basin



Figure 2: NURC's Autonomous Surface Vehicle (ASV)

**Schedule:**

The competition is planned to take place at NURC, La Spezia, Italy, on July 6<sup>th</sup> – July 13<sup>th</sup> 2011. The facility is a sea water basin bounded on three sides by the wall and enclosed by a net on the fourth. For SAUC-E'12 the organizers are creating two equal arenas. Of course, Arena 2 will be bounded on two sides by the wall and two by the net, see Figure 1.

| Day | Date               | Events  |
|-----|--------------------|---|
| 1   | Friday, July 06    | <ul style="list-style-type: none"><li>• Teams arrival and registration</li><li>• Vehicle safety inspection</li><li>• From 2pm - Mandatory familiarization meeting</li><li>• Welcome barbeque 4 – 6 pm</li></ul>                         |
| 2   | Saturday, July 07  | Practice runs – all day, start at 8 am <ul style="list-style-type: none"><li>• 7:30 – 8:00 am competitors arrive</li><li>• Facilities for judges, observers, and media set-up finished</li><li>• 5:45 – 6:00 pm daily debrief</li></ul> |
| 3   | Sunday, July 08    | Practice runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 7:30 – 8:00 am competitors arrive</li><li>• 5:45 – 6:00 pm daily debrief</li></ul>   |
| 4   | Monday, July 09    | Practice runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 7:30 – 8:00 am competitors arrive</li><li>• 5:45 – 6:00 pm daily debrief</li></ul>   |
| 5   | Tuesday, July 10   | Practice runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 7:30 – 8:00 am competitors arrive</li><li>• 5:45 – 6:00 pm daily debrief</li></ul>   |
| 6   | Wednesday, July 11 | Qualifying runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 9:00 - 11:30 am Static Judging</li><li>• 5:45 – 6:00 pm debrief</li></ul>  |
| 6   | Thursday, July 14  | Qualifying runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 9:00 - 11:30 am Static Judging</li><li>• Media Day – all day</li><li>• 5:45 – 6:00 pm debrief</li></ul>                            |
| 7   | Friday, July 13    | Final runs – all day, arrival at 7:30 am, start at 8 am (closing 6pm) <ul style="list-style-type: none"><li>• Media Day – all day</li><li>• 7 pm Award Ceremony</li></ul>   |

## The Challenge:

The AUV must perform a series of tasks<sup>2</sup> autonomously, with no control, guidance, or communication from a person or from any off-board computer including the GPS<sup>3</sup> system, as illustrated in Figure 1.

### Task 1

Move and submerge from the Start point. The teams will be allowed to specify vehicle's orientation.

Pass through the validation gate<sup>4</sup> – without contacting any part of the 'structure'. The gate will be constructed of 2 orange buoys on a rope, 4 m apart (lights<sup>5</sup> will be added to the ropes to aid the competitors). The starting point of the vehicle will be located at least at 8 metres from the validation gate, as illustrated in Figure 1. The net which marks the end of the arena will be placed at least 5 meters from the gate. At that point Task 1 will be completed. **Failure to successfully negotiate the validation gate will result in the run being terminated. The negotiation of the validation gate will be the requirement for the final.**

### Task 2

Perform the “underwater structure” inspection. The structure will be constructed of 0.5 m diameter by 1.5 m cylinders as were used in SAUC-E '10 and SAUC-E '11 to form a pipeline like structure and are shown in Figure 3a. The structure will be consisting of cylinders but they will not form a straight pipeline but other irregular structure. The structure will be placed on the bottom but will be moved during the competition. The task is track (using real-time feedback from onboard sensors) the stationary structure while maintaining a 0.5 m stand-off distance from it. At that point Task 2 will be completed.

### Task 3

Perform the search and inform another autonomous vehicle about a “mid-water target”. The target will be a soft reflective object (both acoustically and optically) and will be a minimum size of 0.3m x 0.3m x 0.3m. The target will be of a distinctive colour and approximately spherical in shape. A mid-water target will be tethered to the ground by a light rope and have a strong white light source on top of it. The vehicles are required to find the target, go around it – perform a circular search manoeuvre, and return to the initial approach heading (at that point 40 % of Task 3 will be completed). At all time during the circular search, an AUV should send the message via an acoustic modem<sup>6</sup>, reporting its heading and the information if the light is on or off<sup>7</sup>. When the vehicle reaches its initial heading after the circular search is completed, the acoustic transmission should stop. When the vehicle reaches its initial heading for the second time the acoustic command will be sent to the vehicle by the judges (via the same

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<sup>2</sup> See definitions at the back of this document.

<sup>3</sup> GPS can be used while the vehicle is on the surface. The remote controller can be used to move the vehicle while on the surface in order to ease the job for the divers.

<sup>4</sup> The purpose of the validation gate is to show that the AUV can progress in a controlled manner, in a straight line, and turn when needed at a controlled depth.

<sup>5</sup> Images of the lights on the rope are available on the competition web site.

<sup>6</sup> A compact modem (two of them), 20-24kHz, will be available for a loan from the Hardware Library.

<sup>7</sup> An exact communication protocol will be provided by the organizers.

modem attached to NURC's ASV, see Figure 2) to orient itself to a heading that is distinctly different than its initial heading at the start of Task 3<sup>8</sup>. At that point 60% of Task 3 will be completed. Teams are encouraged to cooperate; a cooperative AUV can be used to send the command to the search vehicle instead of the judges. The command will be of the same form as the command sent by the judges and should be initiated when the search vehicle reaches its initial heading for the second time. The cooperative AUV can be placed anywhere in the Arena and will receive the bonus points only if the log shows that 1) it received the correct heading and the information about the light from the search vehicle at the appropriate time instant (2<sup>nd</sup> time the initial search heading occurs) and 2) it sent the valid command message at the appropriate time instant (2<sup>nd</sup> time the initial search heading occurs) while being submerged. **The teams should inform the judges prior to the run if they wish to cooperate.**

#### Task 4

A wall will need to be surveyed. The corner of the wall will be ~ 8 m from the mid-water target. The objective is to maintain a position  $\geq 2\text{m}$  and  $\leq 4\text{m}$  from the wall for the duration of the survey. At that point Task 4 will be completed. The AUV can use feedback from forward-looking sonar, altimeter, side mounted DVL, video camera, to name just a few sensors in order to maintain a constant standoff from the wall. The wall will not be straight.

#### Task 5

Perform tracking (below) of the moving NURC's ASV, shown in Figure 2, which will move (slowly) in the competition area. The specifications of the catamaran ASV are the following: length 4.00 m, beam 1.96 m, and height 1.35 m. An acoustic pinger will be placed at the center point of ASV about 1.0 m below it. The pinger will ping 1 pulse per second, at the frequency of 13 kHz, and will have the pulse length of 10 ms. The teams might choose to follow the ASV by either 1) detecting the pinger signal or 2) looking up with an onboard sensor. At that point Task 5 will be completed. Completing the task by both methods will result in bonus of 200 points.

#### Task 6

Surface in the surfacing zone – the surfacing zone location will be bounded by the NURC's ASV which will be stationary in the competition arena for this task. The teams might choose to find the ASV by either 1) detecting the pinger signal or 2) looking up with an onboard sensor. At that point Task 6 will be completed. **The surfacing zone must be attempted last.**

#### Task 7

For 2012 rules we decided to include "Impress the judges: mission task or system component". The competitors are encouraged to be creative and this serves as an opportunity for teams to demonstrate aspects of their system they are particularly proud of. The teams will be awarded for the performance/presentation of this task only during the final day. During the final day, if in-water performance, the finalists will be awarded the points for this task only after they successfully complete Task 1. For the competitors that do not qualify this does not apply and they can decide to perform this task at any time of the mission.

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<sup>8</sup> An exact communication protocol will be provided by the organizers.

Each team will produce a log file of the mission within around 10 minutes of the end of the run. The format of the log file will be a comma separated ASCII file of the format: Time, position, action, a comment between simple quotes. (SSSSS,XXX.x,YYY.y,ZZZ.z,AA.aa). Logged data will be plotted by plotting routine written by the organising committee. This will be used to score the log file. For acoustic modem task the additional file of AUV heading and light on/off data and cooperative AUV heading command will need to be provided. For the ASV tracking task the additional file of range and bearing data from the AUV to the pinger will need to be provided.

NOTES:

- Submerge and the validation gate MUST be undertaken first. The other tasks may be undertaken in any order.
- Tasks may be attempted individually from a start point requested by teams. Points can be collected for the successful completion of tasks throughout the practice days, qualification, and final<sup>9</sup>.
- For completing all the tasks in a single joined up mission, extra points will be awarded, see scoring section.
- Between subsequent entry runs the in-water targets may be moved in position and/or depth.
- The vehicle MUST remain fully submerged. **Surfacing at any time will result in termination of that mission.**



Figure 3a: SAUC-E 2011 Luebeck's pipeline following: detection, following the straight portion, and following the curved portion.



Figure 3b: SAUC-E 2011 Bremen's buoy servoing: detection, initial lock on it, final tracking and circling around it.

<sup>9</sup> Points for completing an individual task will only be awarded once for that task.

### Timing:

- Each team will be allocated a time slot for their in-water run(s). Twenty minutes before their allocated slot the team may move their vehicle to a specified position near to the launch point.
- At the beginning of their allocated slot the team may move their vehicle to the launch point.
- Each team will have a maximum of 50 minutes to perform the mission (In the Final 60 minutes). The first 10 minutes are the preparation period. The team may request that the vehicle is deployed in the water during this 10 minute preparation period. The officials may reissue tank time if the vehicle is not in the tank at the end of the preparation period.
- Only the judge can signal the start of operations. Only competition officials may deploy and recover the AUV. This is to prevent unsafe actions in an attempt to speed the deployment and recovery processes.
- A team may attempt multiple runs during the 50 minute operations period. Once a team has the officials deploy their vehicle, all points earned in previous runs (within this time slot) are lost. Only officials may retrieve a vehicle and return it to the dock.
- The mission ends when any of the following occur.
  - The 50 minute operations period ends.
  - The Judges order the end of the mission.
  - The Team leader requests the end of the mission.

### Venue

The competition will take place in the tidal basin at the NURC, La Spezia. The area can be viewed in Google earth at 44.095842,9.864575

The basin is 120m long and 50m wide, the constant depth is 5.5 msw. The currents are negligible and the water clarity can be seen from the available images of the competition web site. The salinity can be measured and available to the competitors if required. For the information to the competitors close to the mid-water target there is a source of fresh water coming out of the wall simulating delta of the river. The AUV buoyancy compensation needs to be considered. Tidal range is approx 10 cm on a spring tide. Ambient water temp in June /July is approx 20° Celsius. The competition area will be 60m x 25m in the centre of the basin the centreline will be marked by a visible reference on the sea bed. Water visibility varies between 1 and 2 metres depending on weather conditions. Magnetic compass behaviour is indeterminate at this stage. However we expect magnetic compasses to be useable 1 meter away from any structure. More information will be provided to you shortly.

- Each team will be allocated a preparation space and the following resources:
  - ~6 square metres of clear floor space.
  - Workbench/table/work surface.
  - A tent to work outside
  - 220v mains electricity supply.

#### Notes:

The preparation area may be a tent, container or similar temporary structure/enclosure. If a team decides to provide their own 'structure' (eg container) they must notify the competition officials well in advance of the competition.

- The teams will have access to the following communal facilities:
  - Internet connection for computers
  - Arena 2 area for testing vehicles away from the competition arena.

Notes:

- Teams must provide their own consumables, hand tools, drill bits and test equipment etc.
- All team members must be skilled in the operation of all tools and equipment utilised.
- Only low voltage battery powered tools and equipment will be permitted within 2 metres of the pool.

## **RULES**

The official source for all information concerning rules, interpretations, and information updates for the 2012 Student Autonomous Underwater Challenge Europe are:

<http://www.sauc-europe.org/> and

[http://www.facebook.com/pages/SAUC-E/173111869367586?ref=tn\\_tnmn](http://www.facebook.com/pages/SAUC-E/173111869367586?ref=tn_tnmn).

Teams may comprise a combination of students, faculty, industrial partners, or government partners with a maximum of 10 people per team. Students may be undergraduate and/or postgraduate students. Inter-disciplinary teams are encouraged. Members from industry, government agencies (or universities, in the case of faculty) may participate, however full-time students must comprise at least 75 percent of each team. The student members of a joint team must make significant contributions to the development of their entry. One member of the team must be designated as the 'Team Leader'. The Team Leader, and only the Team Leader, will speak for the team during the competition.

An 'Intent to Compete' form is available on the web site. A refundable deposit of 500 euro is required to be submitted together with the form. The form should be submitted by **March 10, 2012**.

A formal 'Competition Registration' form will be available on the web site. This is due not later than **April 30, 2012**. The submission must be in English. The organiser's reserve the right to limit the total number of entries that are allowed to compete by declaring the competition closed to new entries before the due date above. As with all official information, this announcement (should it be necessary) will appear on the official web site.

### **Vehicles**

Each entry must be autonomous. Whilst carrying out the mission, no communication between the entry and any person or off-board computer is permitted. This includes the GPS system.

### **Weight in air and size constraints (tested at launch):**

Maximum dimensions: 2m long x 1m wide x 1m high.



The weight constraints are summarised in Table 1.

| <b>Weight</b>  | <b>Bonus</b>               | <b>Penalty</b>         |
|--|----------------------------|------------------------|
| AUV Weight > 70 kg                                     | Disqualification           | Disqualification       |
| $70 \text{ kg} \geq \text{AUV Weight} > 50 \text{ kg}$ | N/A                        | $60*(X \text{ kg}-50)$ |
| $50 \text{ kg} \geq \text{AUV Weight} > 35 \text{ kg}$ | $15*(50- X \text{ kg})$    | N/A                    |
| AUV Weight $\leq 35 \text{ kg}$                        | $225+9*(35- X \text{ kg})$ | N/A                    |

**Table 1: AUV weight point allocation**

Power constraints: All entries must be battery powered. All batteries must be sealed. The open circuit voltage of any battery in an entry may not exceed 60 Volts DC.

No materials (except for compressed air) may be released by the entry into the waters of the Arena. Any vehicle leaking a fluid will be deemed unsafe.

All vehicles must carry a clearly legible 'label' showing the vehicle weight in air.

All vehicles must have 2, 3 or 4 clearly identified lifting points onto which standard commercial lifting slings may be easily attached / detached – on land or in the water – in a safe manner.

All vehicles will be required to install strobe lights.

All entries must bear a clearly marked OFF switch that a diver can readily activate. The switch must disconnect the batteries from all propulsion components and devices in the AUV. Note, this does not have to kill the computer. Upon reactivation, the vehicle must return to a safe state (props do not start spinning). All entries must be positively buoyant by at least one half of one percent of their mass when they have been shut off through the OFF switch.

Competition officials will be responsible for recovering lost entries.

The officials will suspend the operation of a vehicle at any time they deem that such action is required by safety or security considerations.

Teams will be required to submit technical descriptions of their entries to the officials in advance of the competition, with the goal of identifying potential safety concerns well in advance. When requested, such technical information submitted to the judges will be held in confidence until the end of the competition.

**Any vehicle deemed unsafe by the competition officials will be disqualified.**

### **Journal Paper**

Each team is required to submit a Journal Paper that describes the design of their entry and the rationale behind their design choices. This paper may be no more than **20 pages** (including all figures, references, and appendices but excluding Resumes). The

paper must include the following sections:

- Executive Summary
- Introduction
- Description (Physical, autonomy and mission planning)
- Innovation
- Financial summary (1 page on income and expenditure)
- Risk Assessment

The paper must be provided in electronic format (pdf preferred). The format shall be printable on A4 sheets, margins of at least 25mm all sides, 10 point font or larger. Journal papers will be collated into SAUC-E proceedings which will be made available on the SAUC-E web site. The Journal Paper will be evaluated as described in the section on scoring.

A video diary will be accepted as a supplement to the journal paper. The video diary should focus on significant events during your preparations for the event. For example, team meetings, designing, building, testing etc. The video will be collated to form part of a competition video and / or displayed during the event.

**The paper must be received not later than June 20, 2011. Teams that do not meet the submission deadline will not be allowed to participate in the competition.**

Resumes of all student team members should be appended to the journal paper.

### **Static Judging**

Each entry will be subject to static judging. Each team will be requested to give a 15 minute presentation which will be followed by questions. The presentations should be delivered by the student component of the team. The judges will evaluate each entry on technical merit, safety and craftsmanship, as described below in the section on scoring. These presentations will be scheduled in advance. Teams are also strongly encouraged to make a poster describing the entry. Representatives of the press and of other organisations will be encouraged to visit each team.

## Scoring

Entries will be scored on performance measures and on subjective measures, these are detailed in Table 2. Points for attempting tasks in multiple missions can be acquired throughout the week. Points for a single multitask mission will only be allocated during the final.

| <b>Performance Measures</b>   |             | <b>Multi mission Task Success</b> | <b>Single Mission Points For Attempt** (From file / From Judges)</b> | <b>Single Mission Task Success</b> |
|---|-------------|-----------------------------------|--|------------------------------------|
| Weight  | See Table 1 |                                   |  |                                    |
| Pass through Validation Gate  |             | 150                               | 150  | 150                                |
| Structure Inspection  |             | 250                               | 200 / 50 (250 max )  | 600                                |
| Avoid Mid-Water + Report and Act                                    |             | 500 (200 + 300)                   | 450 / 50 (500 max )  | 1000                               |
| Follow Wall   |             | 300                               | 250 / 50 (300 max)   | 600                                |
| ASV Tracking  |             | 500                               | 450 / 50 (500 max )  | 1000                               |
| Surface   |             | 400                               | 350 / 50 (400 max )  | 800                                |
| Bonus - Collaborator  |             |                                   |  | 300                                |
| Bonus - Dual Tracking   |             |                                   |  | 200                                |
| <b>Subjective Measures</b>  |             | <b>Max. Points</b>                |  |                                    |
| Journal Paper (J) + Video (V)                                       |             |                                   | 200 (J)<br>100 (V)   |                                    |
| Technical Merit (From Journal Paper, Static Judging + Observations) |             |                                   | 500  |                                    |
| Craftsmanship (From Journal Paper, Static Judging )                 |             |                                   | 500  |                                    |
| Safety of Design (From Journal Paper, Static Judging )              |             |                                   | 500  |                                    |
| Innovation (From Journal Paper, Static Judging )                    |             |                                   | 500  |                                    |
| Impress the judges  |             |                                   | 500  |                                    |
| Discretionary Points (Awarded After Last Competition Run)           |             |                                   | 300  |                                    |

**Table 2: Scoring Matrix**

\*\*Note that an 'attempt' must appear in the Log file or, in the opinion of the judges, be an obvious attempt to complete that part of the mission.

The Log file points will be allocated after the run when the log file of the vehicle is used to replay the mission in simulation and evidence of autonomous decision making (i.e. not luck) is demonstrated.

*Journal Paper*, These points are for the production of the journal paper, ensuring all sections are included and the amount of thought and care that has gone into its production.

*Technical Merit*, The vehicle will be assessed on overall design, software algorithms, mission planning, design choices addressing the problem and construction.

*Craftsmanship*, These considerations will account for any components of the design that are or could be (in the judges opinion) commercially available or do not include a significant contribution by team members. In other words, if you use a well-built, well-designed, off-the-shelf computer, your team does not get points for the computer's good technical design, etc. You will get points in the Technical merit section for selecting a computer that is well-suited to the engineering needs of the design, in the opinion of the judges. Efficient and novel use of cheap 'every day items' will also gain points.

*Safety of Design*, Points will be awarded for knowledge and resolution of potential hazards in the vehicle's design. Judges will be looking for the teams recognition of potential hazards and how these hazards have been removed or managed in both the design choices and final vehicle.

*Innovation* What makes your vehicle unique? This section is looking for the new ideas, be it something built specifically for the competition or a novel use of existing equipment.

## **Sequence of Events during the Competition**

*Static Display Period*. Each team will receive a scheduled time during day 2 or 3 of the competition for static judging. In addition, judges, members of the public, the press, and representatives of other organisations will also view the entries and talk with team members throughout the event.

*Practice Runs*. Practice time slots will be scheduled to achieve maximum utilisation of the tank. The size of the Ocean Basin is such to permit multiple courses. Each entry must be approved by the judges before it will be allowed into the Arena. Our objective is to provide as much practice time in the water as is practical. We expect to allow several entries in the tank simultaneously, on the condition that they do not interfere (May want to take this part out?) with each other. It is anticipated that each team should have approximately 6 hours of practice time.

*Competition*. Each team will be assigned a time slot for their preliminary/elimination run. This is planned to be the afternoon of the 4<sup>th</sup> day. The final runs, envisaged to take place on the last day, may be restricted in numbers – dependent upon time available.

### **Awards**

TBC

### **Definitions**

**Mission** – A mission is defined as an attempt at completing one or all of the predefined tasks. A mission is started when the vehicle submerges and ends when the vehicle surfaces.

**Tasks** – Tasks are a specific challenge; go through the validation gate or dock in the docking station are two individual tasks.

**LIABILITIES & RESPONSIBILITIES:** The organizers of SAUCE '12 assume no liability for the competitors. The organizers will perform the safety inspection of the competition area with the organization's safety officer prior to the competition. The competitors will not be allowed to dive.