

## **SAUC-E Mission & Rules<sup>1</sup> (Version 02 – Nov 2010)**

### **Competition date: July 04 - July 10 2011**

The following teams participated in the SAUC-E '10

- ENSIETA, Brest
- University of Lubeck
- Cambridge University
- University of Southampton
- Heriot Watt University
- DFKI RIC Bremen
- University of Girona
- University of West England
- ESIEA, Paris

The University of Bath was unable to come at the last minute but committed to come for SAUC-E '11. We expect greater number of teams as some teams that did not compete before have contacted us and showed wiliness to participate. We look forward to another exciting competition.

#### **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.

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

**Schedule:**

The competition is planned to take place at the NATO Undersea Research Centre, (NURC) La Spezia, Italy, on July 4<sup>th</sup> – July 10<sup>th</sup> 2011. The facility is a sea water basin bound on three side and enclosed by a net on the fourth.

Day	Date	Events
1	Monday, July 04	<ul style="list-style-type: none"><li>• Teams arrival and registration</li><li>• Vehicle safety inspection</li><li>• 12-1pm lunch</li><li>• From 2pm - Mandatory familiarization meeting</li><li>• Welcome barbeque 7 – 9 pm</li></ul>
2	Tuesday, July 05	Practice runs – all day, start at 8 am <ul style="list-style-type: none"><li>• 7:30 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	Wednesday, July 06	Practice runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 7:30 am competitors arrive</li><li>• 5:45 – 6:00 pm daily debrief</li></ul>
4	Thursday, July 07	Qualifying runs – all day, arrival at 7:30 am, start at 8 am <ul style="list-style-type: none"><li>• 9-10 am Judges meeting</li><li>• 10:00 - 11:30 am Static Judging: 15 min. power point team presentation</li><li>• 5:45 – 6:00 pm daily debrief</li></ul>
5	Friday, July 08	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: 15 min. power point team presentation</li><li>• Media Day – all day</li><li>• 5:45 – 6:00 pm debrief</li></ul>
6	Saturday, July 09	Semi-Final runs –all day, arrival at 7:30 am, start at 8 am (until 6pm)
7	Sunday, July 10	Final runs – all day, arrival at 7:30 am, start at 8 am (closing 6pm) <ul style="list-style-type: none"><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. Each AUV will be tracked via acoustic positioning system. Therefore, each AUV must be able to accommodate a transducer. The transducer used will be approximately 30 mm in diameter, and 150 mm in length, and almost neutral in water. It will be using a 37 KHz frequency.

### Task 1

Move from launch/release point and submerge. The team can choose to initiate an autonomous mission from either Start 1 or Start 2 point. The teams will be allowed to specify vehicle's orientation. If Start 1 is chosen and the next task is completed the team would be awarded 100 extra points. If Start 2 is chosen the NURC's Autonomous Surface Vehicle (ASV), Figure 2, will be used to bring the AUV to the Start 2 location. The specifications of the catamaran ASV are the following: length 4.00 m, beam 1.96 m, and height 1.35 m. Each team needs to provide two hooks for the release mechanism that will be attached to the platform of the catamaran ASV. The hooks must be 4 cm of inner diameter separated by 30 cm.

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 4 metres from the validation gate. 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.**

### 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 to form a pipeline and are shown in Figure 3<sup>6</sup>. 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 follow the stationary structure while maintaining a 0.5 m stand-off distance from it. At that point Task 2 will be completed.

### Task 3

Free a mid-water target. A mid-water target will be tethered to the ground by a light rope - a fishing line with 1 mm diameter, 5 kg tension. The vehicles are required to find the target, go around it – perform obstacle avoidance manoeuvre, return to the initial approach heading (at that point 50 % of Task 3 will be completed) and then part (cut/melt/etc.)<sup>7</sup> the rope tether between the mid-water target and another orange buoy (located about 1 m from the floor)<sup>8</sup>. At that point second 50% of Task 3 will be

<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 at a controlled depth.

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

<sup>6</sup> Images of the pipe from SAUC-E '10 are also available on the competition web site.

<sup>7</sup> All cutting/melting devices must not pose a risk to the divers.

<sup>8</sup> Images /video of the target (orange buoy) and another orange buoy for aiding the competitors on a fishing line are available on the competition web site.

completed. 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.

#### Task 4

A wall will need to be surveyed. The wall will be ~ 10 m from the mid-water target. The objective is to maintain a position > 2m 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, ADCP, 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 which will move (slowly) in the competition area. An acoustic pinger will be placed at the center point of ASV about 1.5 m below it. The pinger will ping at the rate of 1 Hz and the frequency of 12 kHz. 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 sent from the NURC's ASV via an acoustic signal (20 – 24 kHz). A compact modem will be given to each of teams. The teams will be required to accommodate the modem of 76 mm length and 56 mm diameter, provide power to it and write software to be able to receive modem commands per Interface Control Document (ICD) written by NURC (will be available on the competition web). At that point Task 6 will be completed. **The surfacing zone must be attempted last.**

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 ASV tracking task the additional file of range and bearing data from the AUV to the pinger will need to be provided.

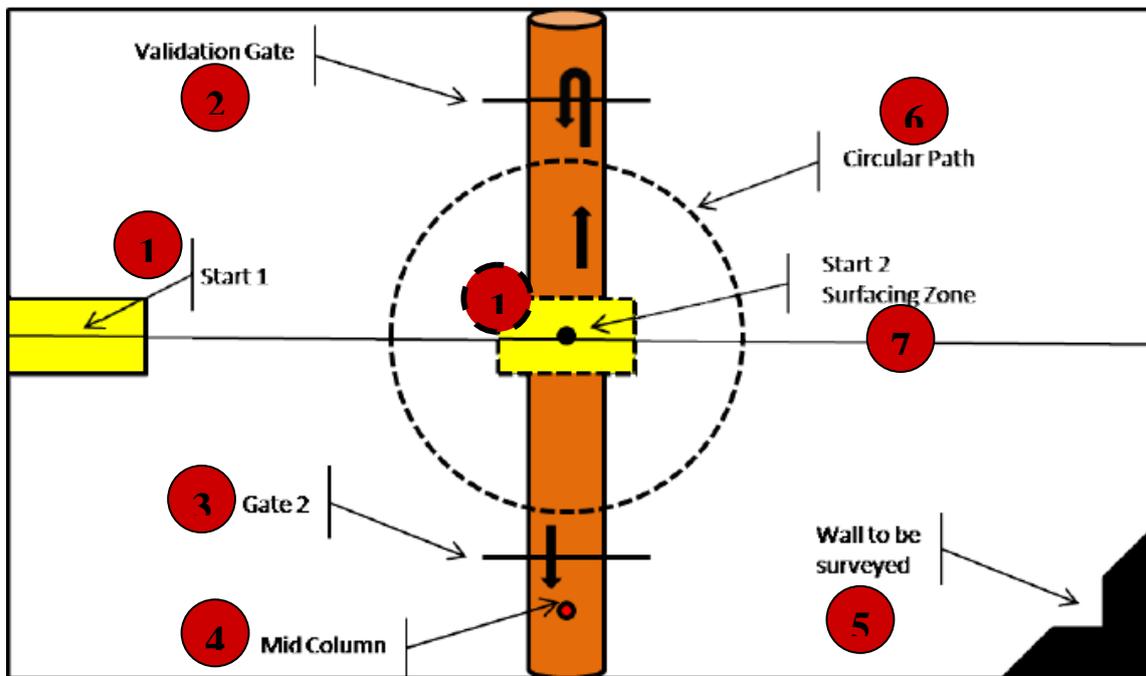


Figure 1: Mission Illustration (Will be updated to reflect 2011 Rules)

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, semi-final 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.**

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



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



Figure 3 : Underwater Structure

**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

- A shallow area for testing vehicles away from the competition arena.<sup>10</sup>

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 2011 Student Autonomous Underwater Challenge Europe are:

<http://www.sauc-europe.org/> and  
<http://www.facebook.com/pages/SAUCE10/190283629180>.

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 February 10, 2011.

A formal 'Competition Registration' form will be available on the web site. This is due not later than 1<sup>st</sup> April 2011. 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.

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<sup>10</sup> The shallow area will be ~ 1-3 m deep.

**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 kg > AUV Weight > 50 kg	N/A	60*(X kg-50)
50 kg > AUV Weight > 35 kg	15*(50- X kg)	N/A
AUV Weight <= 35 kg	225+9*(35- X 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 carry an acoustic positioning transponder supplied by the competition body.

All entries must bear a clearly marked OFF switch that a diver can readily activate. This switch must disconnect the batteries from all electrical and electronic components and devices in the AUV. 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		300	250 / 50 (300 max )	600
Avoid / Release Ball		425	375 / 50 (425 max )	850
Follow Wall		300	250 / 50 (300 max)	600
ASV Tracking		300	250 / 50 (300 max )	600
Surface		400	350 / 50 (300 max )	800
Start 1 Bonus				100
<b>Subjective Measures</b>			<b>Max. Points</b>	
Journal Paper (J) + Video (V)			200 (J) 50 (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	
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 '11 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.