SAUC-E 2016 Mission & Rules[1] (Version 1.0 – March 2016)

Competition date: July 3- July 8 2016

Competition venue: Centre for Maritime Research and Experimentation (CMRE), Viale San Bartolomeo 400 19126, La Spezia, Italy.

We, as the Centre for Maritime Research and Experimentation (CMRE), formerly NATO Undersea Research Centre (NURC), are pleased to announce the Student Autonomous Underwater Vehicle Challenge – Europe (SAUC-E) 2016 that will be held from **July 3 to July 8, 2016** at the Centre' sea basin.

We build on the experience of last years SAUC-E editions and euRathlon 2014/2015 to organise SAUC-E 2016 challenge. SAUC-E 2015 was integrated in the euRathlon 2015 Grand Challenge Challenge. The competitors for SAUC-E'15 were teams of students. The following teams participated in SAUC-E'15:

- AVORA, Spain
- AUV Team TomKyle, Germany
- B.R.A.I.N. Robots, Germany
- ENSTA Bretagne Team 1, France
- ENSTA Bretagne Team 2, France
- Team Nessie, Heriott Watt University, UK.
- OUBOT, Obuda University, Hungary
- Robdos Team Underwater Robotics, Spain
- UNIFI, Italy
- Universitat de Girona, Spain

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.

[1] These rules are subject to change, refinement and development but will for sure be frozen starting the 1st day of the competition.

As in the past few years, in SAUC-E'16 we want to focus the team attention and effort on cooperation between vehicles. A second autonomous underwater or surface robot as a collaborator can therefore be included in the realization of some tasks and cooperation/collaboration between vehicles (also belonging to different teams) will be appreciated.

There will be five main tasks. However, several sub-tasks can bring points even if the entire task is not completed.

We require each team to provide **a one-page summary with the most important features of their robot (both hardware and software/algorithms) in a form of a table** (see the "Quick facts" form template on the SAUC-E website).

There will be dedicated time slots for Qualification session defined prior to the competition. This will be done on a first come, first serve basis. The entry that declares its will to compete and pay the relative deposit first, will be able to select first its time slot during the Qualification session.

The success of SAUC-E contributed to winning the EU funding for the euRathlon (http://eurathlon.eu/) project. This project organized the world's first multi-domain multi-robot search and rescue competition, the euRathlon Grand Challenge 2015. Last year, SAUC-E was part of euRathlon. Next year, there will be the second edition of euRathlon and the winner of SAUC-E 2016 will have a wild card to participate in euRathlon 2017.

Starting in 2012, the Centre for Maritime Research and Experimentation (CMRE), formerly NATO Undersea Research Centre (NURC), under the sponsorship of the Office of Naval Research (ONR) and ONR Global, formed the 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.
The NEST has set up an online forum/wiki site where the teams can collaborate, share codes, and post issues/solutions; has written documents especially addressing the challenges of the SAUC-E environment; and provides email, phone, and on-site support to the teams. NEST is open to suggestions from organizations interested in becoming actively involved in SAUC-E. NEST encourages, and will advise the judges to reward teams with members from multiple disciplines. Underwater robotics requires expertise from various engineering domains (mechanical, naval architecture, control engineering, communication, etc.). NEST discourages the advisors (professors) from actively participating in preparing particular tasks during the competition and will recommend the judges to penalize such actions.

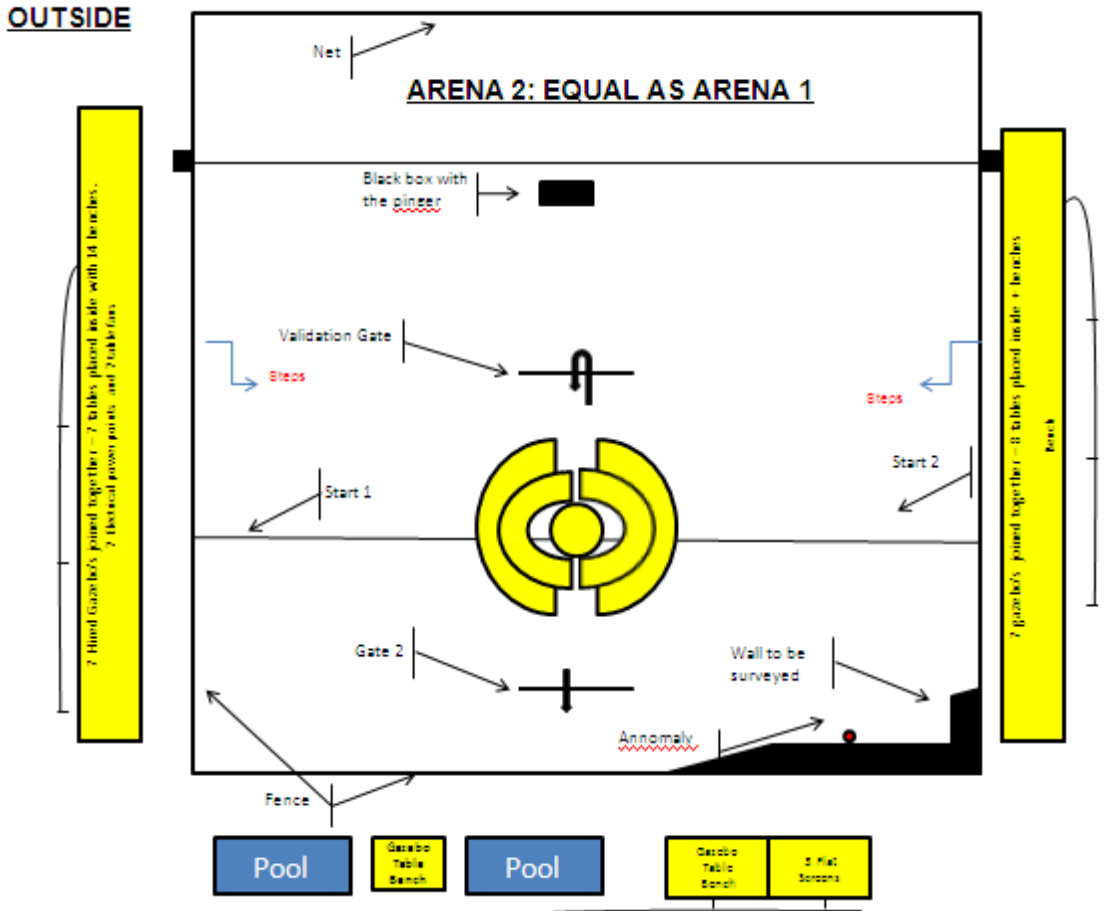

Figure 1: CMRE's Sea Basin.

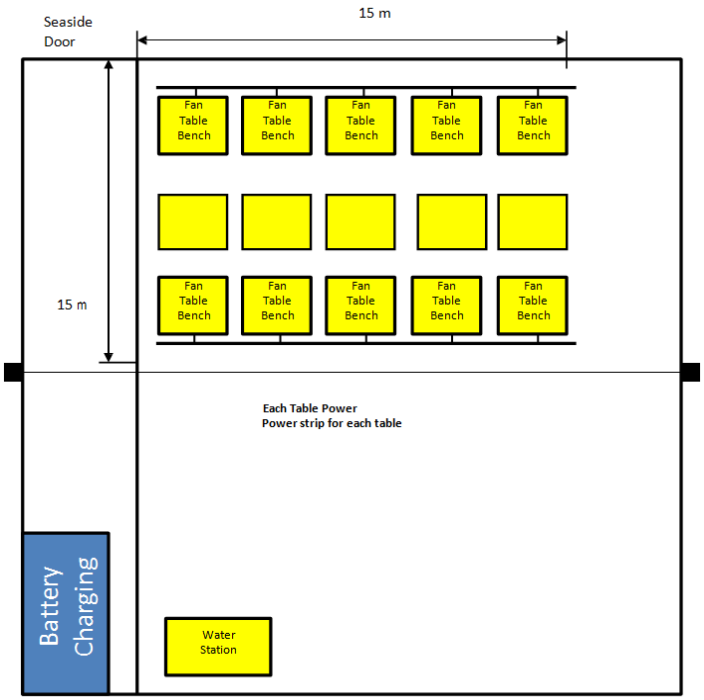

Figure 2: CMRE's Work area in B14.

Figure 3: Gate lights.

Schedule:
The competition is planned to take place at CMRE, La Spezia, Italy, from July 3rd to July 8th 2016. The facility is a sea water basin bounded on three sides by a wall and enclosed by a net on the fourth side. As in previous editions of SAUC-E, the organizers are once again creating two arenas. Of course, Arena 2 will be bounded on two sides by the wall and two by the net, see Figure 1. The Teams will be based in Building 14 in a cleared area to the left of the seaward entrance, see Figure 2. Each team will be provided with tables and benches to work on a 220V power and multiple sockets and with Internet access.

Day	Date	Events
1	Sunday, July 3	• Teams arrival and registration • Facilities for judges, observers, and media set-up finished • First practice runs in the pools if the teams are ready.
3	Monday, July 4	• Vehicle safety inspection • Mandatory familiarization meeting Practice runs – all day, arrival at 7:30 am, start at 8 am • 7:30 – 8:00 am competitors arrive • 5:45 – 6:00 pm daily debrief
4	Tuesday, July 5	Practice runs – all day, arrival at 7:30 am, start at 8 am • 7:30 – 8:00 am competitors arrive • 5:45 – 6:00 pm daily debrief
5	Wednesday, July 6	Qualifying runs – all day, arrival at 7:30 am, start at 8 am • 9:00 - 11:30 am Static Judging • 5:45 – 6:00 pm debrief
6	Thursday, July 7	Qualifying runs – all day, arrival at 7:30 am, start at 8 am • 9:00 - 11:30 am Static Judging • 5:45 – 6:00 pm debrief
7	Friday, July 8	Final runs – all day, arrival at 7:30 am, start at 8 am (closing 6pm) • Media Day – all day • 7 pm Award Ceremony

The Challenge:

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

Task 1 (100%, all or none) **– Pass through the gate**

Submerge and move from the Start point 1 or 2. The teams will be allowed to specify vehicle's orientation. Pass through the validation gate[4] – without contacting any part of the 'structure'. The gate will be constructed by 2 orange buoys on a rope, 2m apart (lights will be added to the ropes to aid the competitors, see Figure 3). The task is to traverse at the controlled depth towards the centre of the Arena, make a 90 degrees turn, and pass through the validation gate. All teams must start from the South or North wall of the basin. The starting point of the vehicle will be located at least at 8 metres from the validation gate, as illustrated in Figure 1. 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 and can be achieved both in Practice and Qualification sessions.** At that time the points for the first task will be awarded. A video log of the AUV passing through the gate must be provided. The gate will be marked by the two buoys (detectable both by the sonar and video camera), spaced 2 metres apart, and an anchoring line. The line will be illuminated by the lights, placed in a tube. Due to the low visibility in the basin the lights will be visible only from a close (1-2 m) distance but these conditions constantly change according to the weather (lighting conditions, sea state, water turbidity). In the centre of the Arena there will be a large landmark (made out of the yellow tubes used in the previous years to form the pipeline). The top of the landmark will be aligned with the gate. Thus, the top of the landmark can be used as a good point to make the 90 degrees turn. The organizers reserve the right to change the size (length, width, and height) of the landmark during the competition.

Task 2 (33%, 33%, 33%) **–** ***Underwater*** **structure inspection**

Perform the "underwater structure" inspection. The piping assembly will consist of cylindrical shapes, yellow in color, OD (outer diameter)=0.5 m by Length=1.5 m (shown in Fig. 5), arranged to form a 3D structure. The cylinders could be placed in the assembly

2 See definitions at the end of this document.

3 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.

4 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.

both with horizontal and vertical axis, and could be stacked to increase the overall height. The assembly will be placed on the bottom, will not be moved during the competition (even if its position will be unknown until the time-slot of the first participant team). The top of it will be aligned with the validation gate. Thus, this structure can be used to make a 90 degrees turn to be able to pass through the gate for Task1.

Task 2 is to inspect this structure with an imaging sensor while maintaining a required stand-off distance from it. At that point Task 2 will be completed.

In the case the teams are performing the tasks in sequence (see later in the document for the detailed rules about chaining the tasks), after the AUV passes the validation gate it needs to go back to the underwater structure of Task 2 and inspect it. The AUV can take any path to the landmark.

Task 2 objective is to thoroughly inspect the underwater structure. The AUV might start from any point of the structure, may maintain any distance from it (to be decided by the team based on the inspection sensors available, any sensors are allowed as long as they supply good quality data), and any path planning algorithm for moving around the structure will be allowed.

The points will be awarded based on the quality of the inspection data. 100 % coverage of the structure is desired and the inspection data from any sensor (team's choice) will be accepted. If equipped with the sonar, the sonar mosaic or 3D structure reconstruction could provide a very good inspection product. If equipped only with the video camera, in order to get a good quality inspection data of the entire structure, the team might need to perform several circles around the landmark at different depths. The accuracy of the AUV motion and the field of view of the sensor will be crucial to obtain a good data mosaic, 2.5 D photo mosaic, or a 3D image reconstruction of the structure.

The points will be awarded as such:

1) 1/3 of the total task points if the AUV performs a search around the structure while maintaining the structure in the FOV of a sensor (even one 360 degrees pass will be sufficient to get this partial credit). The structure will have a mark (detectable both by sonar or video) in order for the judges to be certain that the inspection was performed around the entire structure,

2) 2/3 of the total points if the AUV performs the inspection such that the 100 % coverage of the structure is obtained, and,

3) Up to full credit will be awarded if the mosaic and/or 3D reconstructed image of the structure is produced and depending on the quality of the mosaic/reconstruction.

The data must be provided to the judges within one hour from the end of the team's slot to encourage the teams to push their system to produce good quality data if not in real-time as close to real time as possible.

Task 3 (25%, 25%, 25%, 25%) **- Inspect the wall, find an anomaly, and call a friend to further inspect the anomaly)**

The East wall of the basin must be followed. The objective is to maintain a position between 2 and 4 meters (<=4m and >=2m) from the wall for the duration of the survey. 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.
An anomalous object (orange buoy with a light on top of it) will be placed close to the North and East end of the basin wall, as shown in Figure 1, at a depth not exceeding 1.5 m. The target will be a soft reflective object (both acoustically and optically) and will be of a minimum size of 0.3m x 0.3m x 0.3m, shown in Figure 4b. The target will be of a distinctive colour and approximately spherical in shape. The 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 light will be turned on and off in intervals of not less than 10 sec., as was done for a mid-water target in SAUC-E'14.

The main vehicle in the task is the so-called search AUV. The search AUV is the first vehicle to move and has to follow the wall and if the anomaly is detected it will send an acoustic signal[5] to the so-called inspection-collaborator AUV (or ASV) to come and take a closer look at it and report on it.
The inspection-collaborator AUV/ASV (initially positioned at Start 1, see Figure 1) must have a sensor that will be able to detect the buoy-anomaly and if the light (on top of the buoy-anomaly) is on or off and **report this information to the search AUV during the rest of the Task 3**.
During that time the search AUV will continue to send the information about the anomaly position (*different message from the invitation message*) until this message is acknowledged by the inspection-collaborator AUV/ASV (the teams can decide their own communication policy). These messages can help the inspection-collaborator AUV/ASV navigation until it finds the anomaly.
An inspection-collaborator AUV/ASV can be equipped with sensors and algorithms to detect the anomaly and might consider re-acquiring the anomaly (that can be moved by judges but it will be placed in the general area attached to the two walls as shown in Figure 1). In that case only the initial "invitation" trigger is needed by the search AUV. If an ASV is considered for the task a mechanism might be needed to be designed to bring the ASV's sensor close to the light source.

In this task points can be awarded to the search AUV and to the inspection-collaborator AUV/ASV.

[5] A compact modem (two of them), 20-24kHz, will be available for a loan from the Hardware Library. If this modem is used the judges will be able to listen to the messages. If any other modem is used, in order to get the points in case the collaboration fails, a team must supply a copy of the modem and software to the organizers.

In the following a superscript *SV* will indicate points assigned to the search AUV and *IV* to state they are awarded to the inspection-collaborator vehicle.
The point scheme and the sequence of sub-tasks is as follows:
1) 25 % of the total points^{SV} if the search AUV *follows the wall and finds an anomaly* – correctly stops and images, maintains a distance from the anomaly (as done relative to the mid-water target in SAUC-E 10-14). These points are only given to the search AUV.
2) Other 25 % of the total points^{SV} if the search AUV *signals (the invitation message)* the collaborator (another modem will be placed in the arena and the judges will be able to listen and verify the modem messages and/or proved by the logs).

- If the inspection-collaborator arrives in the location around the anomaly (within 3 metres) or close to the search AUV (within 3 metres) upon the invitation of the search AUV it gets 25% of total points^{IV} – the collaborator bonus points in the scoring table. From logs it has to be clear which was the destination for the inspection-collaborator (if the received position of the search AUV or the received position of the anomaly). Even if the anomaly position is not correctly sent by the search AUV, but the inspection-collaborator reaches that position, the points to the inspection-collaborator are awarded. However, logs must show the correctness of the inspection-collaborator navigation, that is, evidence has to be proved that the inspection-collaborator reached the received point.

Thus, to get the credit for this sub-task and all other follow-on Subtasks an inspection-collaborator AUV/ASV depends on the search AUV as it must start its mission after it correctly receives the invitation message.
3) Other 25 % of the total points^{SV} are awarded if the search AUV sends a message via an acoustic modem, reporting anomaly's x, y, z coordinates (*different message from the invitation message*) to help inspection-collaborator finding the anomaly. Thus the search AUV does not inspect the light and will get this credit even if the inspection-collaborator does not achieve its goal as long as the position of the anomaly is correctly reported (anomaly position message sent and received by judge's modem).

- If the inspection-collaborator *reacquires the anomaly* (in order to save time and avoid collisions the teams might decide to send the appropriate information but vacate the area with the search AUV) – correctly stops and images, maintains a distance from the anomaly it gets another 25% of the total score^{IV}.

Thus, at this point, if all of the required functionalities are performed by the search AUV it can get 75% of the total points for this task. At this point, the inspection-collaborator AUV/ASV can get 50 % of the total points for this task.
4) The data about the light being on or off correctly received and stored by the search AUV will result in the rest of the points awarded to the search AUV (other 25 % of the total points^{SV}) leading to the full credit for this task. The inspection-collaborator AUV should

report via modem the information if the light is on or off to get other 25 % of the total points[IV].

For scoring purposes (See Table 2: Scoring Matrix) this means that the search AUV can get **750 out of 1000 points (1500 if Tasks 1-3 performed in a continuous sequence during the Finals, see later in the rules)** for Task 3 even if the full product regarding the collaboration fails – the reporting on light being on or off is not correct, as long as the acoustic messages are received at the correct time by the inspection-collaborator AUV/ASV (verified by the judges). Thus, only for Subtask 4 the search AUV depends on the collaborator and will not be awarded points if the inspection-collaborator does not fulfill the message sending assignment. Similarly, the inspection-collaborator vehicle **can get a maximum of 750 out of 1000 as long as the search AUV does not fail to send the invitation message**. *The correct anomaly position is not necessary if the inspection robot can reacquire it in the general area*.
It is ok to use GPS navigation for the ASV at all times. You need to be "invited" by the search AUV and then you can go to the general area using GPS navigation. Buoy with light might be moved during the competition but it will be in the general area so your ASV can perform the search for it.
If a team collaborates with another team that uses a different type of modem, it would be acceptable to have a *shore-based relay-station*, which is simply a laptop with two modems attached that passes on messages between the different modems. This relay-station would also be used by the judges to monitor messages. It will also be acceptable to use the acoustic modem to remotely command a mission abort during the Practice and/or Qualification phases. Each team is allowed to participate in Task 3 twice, once as a search vehicle and once as an inspection vehicle. And therefore a team can get up to 1750 points in total (when doing Task 3 as a separate mission – 1000 as a search vehicle if the complete task is done and 750 as collaborator). Task 3 performed with the single AUV (no collaborator) means there is nobody to report on the light being ON or OFF to you as you are alone, so there is no chance that you can store the data that does not exist and you can get 750 points max.
The teams should inform the judges prior to the run if they wish to cooperate. It should be noted that the judges will be able to listen to the modem messages ensuring that the points are awarded to either search or inspection robot or both. Again, 75% of all the points will be awarded even if your collaborator completely fails in its mission as long as the search AUV meets all the requirements.
Cooperation is allowed between different teams or between vehicles of the same teams. Points are awarded to the team owner of the vehicles. For instance, if a team uses two cooperating robots it will get in the same mission the points both from the search AUV and the inspection-collaborator vehicle.

Task 4 (33%, 33%, 33%) **– Survey and find a black box**

Task 4 consists of three Subtasks:

1) Build a map of the environment (33% of the total points). Points can be earned for producing the map (33% of the total points) if the vehicle surfaces anywhere within the time limit. The quality of the map is taken into account while assigning the points.
2) Find a stationary black box, which may be placed anywhere in the arena (33% of the total points). The black box will emit a ping and will be placed in a camera- or sonar-detectable housing. The AUV can choose how to search for the box (detecting the pings or surveying the area with a camera or sonar sensor). If it both completes the survey and detects the pinger (uses both methods), it is eligible for a 250 point bonus.
The omnidirectional pinger will ping 1 pulse per second, at the frequency of 15 kHz, will have the pulse length of 10 ms, and will have a power output of 153.5db at 1m.
3) Surface in the surfacing zone within 3 meters of the black box (33% of the total points).

Thus, one third of the points is assigned if the map is created, one third will be given if the black box is found, and one third if the surfacing above the black box is performed.
For Task 4, in the single-mission run in the final, the teams do have to perform the search using both methods to gain the bonus points. You can get these bonus points if you complete the search by both methods in separate missions as well. To complete the search by both methods in sequence, after the first time the AUV localizes the black box it has to return to the start point (within 5 meters) and stays at that location for a certain time agreed with the judges. During this time, the black box is moved. The AUV can then try to find it again with the other method.
In general, the black box can be moved at any time during the AUV mission.
The surfacing must be attempted last.

Task 5 (25%, 75%) **– Find a missing person**

Task 5 consists of two Sub-tasks:

1) Find a missing person represented by a mannequin. The mannequin can be in any place of the arena and will be moved from run to run whenever a team finds it. It can be in supine or prone position and it will be dressed in bright orange clothes.
2) Survey and reconstruct the mannequin. Both sonar and optical 2D and 3D reconstructions will be accepted (e.g. mosaics, point clouds). The number of points will be awarded depending on the quality of the reconstruction up to a maximum of 75% points of the total amount for this Task.

Logs:

Each team will produce a log file of the mission within around 60 minutes of the end of the run (unless additional available time explicitly stated in the rules, e.g. in Task 2). The format of the log file will be KML including time and actions of the vehicles. This is the required info:

(TIME, LAT, LONG, DEPTH, ACTION).
Where:
TIME is the time in seconds from the beginning of the mission;
LAT is the latitude in decimal degrees. E.g. 44.2456;
LONG is the longitude in decimal degrees;
DEPTH is the depth of the vehicle in meters;
ACTION is a string communicating the action/state the vehicle is performing.
For Task 2, Task 4 and 5 additional data about the mapping are required while for Task 3 the additional file with light on/off data and the sent-received acoustic messages have to be provided.

NOTES:

- **Tasks can be attempted individually from a start point requested by teams and agreed with the organization. Points can be collected for the successful completion of tasks throughout the Practice days, Qualification, and Finals.** Two trial sessions are defined: Practice/Qualification and Finals[6].
- Submerge and the validation gate MUST be undertaken first. The other tasks may be undertaken in any order. **Success in Task 1**, "Passing through the gate", during Practice and Qualification **qualifies the team to compete during the Finals session**.
- **Only teams qualified to Finals are eligible to be awarded with a podium position (first three prizes).**
- Points for achieved tasks are **counted separately in Practice/Qualification and Finals sessions**. The final score for a team is the sum of the scores achieved in the Practice/Qualification session and Finals sessions, the score achieved in the Subjective measure and the bonus/penalty for the weight (see later).
- In Practice/Qualification sessions, teams can try in different missions the same task (with different subtasks). The highest achieved score is awarded to the team for that task. In case of failing of the attempt to fulfill one task, the old score (so far highest score) is maintained.
- The difference between Practice and Qualification is the distribution of the sea time. During Practice, more time slots will be given to the teams to allow them to exercise with the proposed tasks. In the Qualification one time-slot will be given to each team on the base of a first come, first serve basis (based on the registration time to the competition). The entry that declares its will to compete and pay the relative deposit first will be able to preempt its time slot deciding when to run its Qualification session.
- Tasks can be chained in single missions. During Practice/Qualification there is no bonus in fulfilling chained tasks. Chained tasks are encouraged as preparation to the Finals.
- For completing chained tasks in a single joined up mission in the Finals, extra points will be awarded, see Table 2: Scoring Matrix.
- In the Finals a multi-task mission has to be attempted. After the mission ends, the team

[6] Points for completing an individual task will only be awarded once for that task inside a certain session (two sessions are considered: Practice/Qualifications and Finals).

can decide to repeat. At that point previous points achieved during the Finals session **are cancelled**.

- Examples of scoring: a team completed Task 1 during Practice/Qualification (150 pts), Task 1 (150) + Task 2 (with bonus) during Finals (600 pts) will result in a total score of 900 pts for sea trials. To this they have to be added the Subjective Measures (for instance 1000) and the weight bonus (for instance 100).
  The final team score is therefore 2000 pts.
- 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. The only exception is Task 4 during a multi-task mission. In that case, after the resurfacing close to the black-box the AUV has to immediately submerge to start executing the next task.**

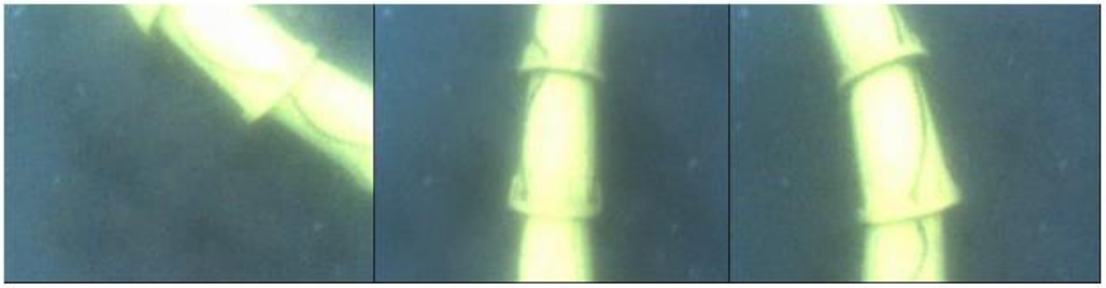

Figure 4a: SAUC-E 2011 Luebeck's pipeline following: detection, following the straight portion, and following the curved portion.

Figure 4b: SAUC-E 2011 Bremen's buoy servoing: detection, initial lock on it, final tracking and circling around it. This will be an anomaly for Task 3 in SAUC-E'16.

Fig. 5. Piping assembly structure used in SAUC-E 2016. (Left) Frontal view. (Right) Lateral view. The structure, composed of yellow pipes, has the following dimensions: 2 m (front area) x 3 m x 1.8 m (height).

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 time-slots if the vehicle is not in the sea at the end of the preparation period.
- Only a 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 time-slot operations period.
  Once a team has the officials deploy their vehicle, during Finals all points earned in previous runs (within this time slot) are lost. During Qualifications the highest achieved points during one task are considered. Only officials may retrieve a vehicle and return it to the dock.

- The mission ends when any of the following occur.
  - The 50/60 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 CMRE, 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 made 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 the delta of a river. The AUV buoyancy compensation needs to be considered. Tidal range is approx 10 cm on a spring tide. Ambient water temp in September 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.

- 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’ (e.g. 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 2016 Student Autonomous Underwater Challenge Europe are: http://www.sauc-europe.org/ and 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.

Registration:

Detailed information about the registration procedure can be found at http://www.sauc-europe.org/.

An 'Intent to Compete' form is available on the web site. A deposit of 500 euro is required to be submitted together with the form. The deposits will contribute to the prizes. **The form should be submitted by April 15, 2016.**

The submission must be in English. The organisers 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: 4m long x 1m wide x 1m high.

A weight based on the total system weight will be considered for the bonus/penalty computation. This means the following:

- If one team attempts tasks not involving the collaboration the considered weight is that of the vehicle;

- In the case of the search AUV collaborating with the collaborator-inspection AUV/ASV, if the collaborator-inspection AUV/ASV is lighter than the search AUV the average weight of the two vehicles can be considered. This happens only if the inspection AUV/ASV gets some points during the competition proving it is a vehicle capable of some autonomous operations. If the inspection AUV/ASV does not get points, the weight of the search AUV is considered.
- In the case that the collaborator-inspection AUV/ASV is heavier, the weight of the search AUV is considered.

With this rule, *an AUV can lower its weight penalty (or increase the bonus) by collaboration with a lighter vehicle (e.g. an ASV).* Therefore, collaborator vehicle can be built or searched from another team also on the base of weight considerations. The weight bonus/penalty to be considered is reported in Tab.1.

Weight	**Bonus**	**Penalty**
System Weight > 90 kg	Disqualification	Disqualification
90 kg $\geq$ System Weight > 70 kg	N/A	60*(X kg-70)
70 kg $\geq$ System Weight > 45 kg	9*(70- X kg)	N/A
System Weight ≤ 45 kg	225+9*(45- X kg)	N/A

Table 1: System 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 that this does not have to kill the computer. Upon reactivation, the vehicle must return to a safe state (propellers 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 **15 pages** (including all figures, references, and appendices but excluding Resumes). The paper must include the following sections:

- One page Robot Description (the sample will be posted on the web)
- Executive Summary
- Introduction
- Description (Physical, autonomy and mission planning)
- Innovation

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/video must be received not later than 1 June, 2016. 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.

Judging Team

The Judging Team is a group of officials designated by the organizers as such. The Judging Team is the final authority on all matters referred to in the rules and on all matters affecting the operations of SAUC-E.

The Judging Team may revise the schedule of the trials and provide interpretation of the rules at any time and in any manner that is required. The Judging Team's decisions regarding the rules are based on a number of factors, such as safety, legal compliance, fairness, trial goals, environmental protection and efficient operations. Decisions of the Judging Team are final.

Scoring

Entries will be scored on performance measures and on subjective measures, the complete scoring sheet will be published soon. **Points for attempting tasks in multiple missions can be acquired throughout the week (Practice and Qualification). Points for a single multitask mission will only be allocated**

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 with each other. It is anticipated that each team should have approximately 6 hours of practice time.

Competition. Each team will be assigned one time slot (or more on the base of the available time and participant teams) for their Qualifications run. This is planned to be the afternoon of the 4th and 5th day. The Finals runs, envisaged to take place on the last day, may be restricted in numbers – dependent upon time available.

Awards

TBD

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.

Contacts:

For any questions, please contact:

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LIABILITIES & RESPONSIBILITIES: The organizers of SAUCE '16 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.