

Track 4: “Indoor Mobile Robot Positioning”

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1 Presentation

IPIN 2016 Indoor Competition-Track 4: Indoor mobile robot positioning is going to be held during the IPIN 2016 Conference, 4-7 October 2016, at the School of Engineering of the University of Alcalá, in Alcalá de Henares, Madrid (Spain). The competition includes four tracks, with the aim of bringing together the academic and industrial research communities the possibility of evaluating different approaches and put into practice their research for the indoor localization problem, for which no accepted standards do yet exist.

Specifically, in *Track 4: Indoor mobile robot positioning*, the goal is monitoring the trajectory followed by a mobile robot, along a predetermined track inside an indoor area, by using a localization system which can be installed by the competitors both in the navigation area and/or onboard the robot (without interaction with the mobile robot systems). Competitors will be provided with a map of the area, while the predefined path followed by the robot will not be disclosed. Final scores will be based on the accuracy of the position estimates provided by the competitors with a minimum framerate.

1. Request for admission

A "competitor" can be any individual or group of individuals working as a single team, associated to a single or a number of organizations. Competitors can apply for admission to the competition by providing a short (2 to 4 pages) technical description of their system, including details on algorithms and protocols. This document must be sent by e-mail to carmen@depeca.uah.es from 15th February to 15th July 2016. Any doubts prior to sending the "technical description" can be also solved by e-mail. The IPIN Track4 Organizing Committee will accept or refuse the application in a short time, based on technical feasibility and logistic constraints.

2. Registration for participation in the IPIN conference

After acceptance of the competitor's technical description, one member of the team is required to be full registered to the IPIN conference (during the process she/he will have to indicate that the registration is linked to a competition track). The full registration fee for the conference covers the submission of a paper describing the system and the allocated time, support and space for the competition.

Competitor teams are invited to submit a "regular paper" or "work in progress" to the conference through the 2016 IPIN Submission link (<http://www3.uah.es/ipin2016>). The paper will follow a peer review process. All accepted papers will be included in the conference proceedings and "regular papers" presented at the conference will be also published in IEEE Digital Xplore. Some competitors may prefer not to submit a paper to the IPIN conference; nevertheless **all competitors are required to make an oral presentation of their system during a dedicated session at the IPIN conference.**

3. Results publication

Results from the competition and the raw data results from the winner systems and all systems willing to disclose them will be published after the competition for the purpose of research and comparison. Winners of the competition will be announced during the conference.

4. Competition awards

The IPIN Track 4 award is a 1500€ cash prize to the best placed team. Depending on the number of participants and the technology used it would be possible to divide the prize in different categories, which will be announced in advance to the participants. The IPIN 2016 Indoor Competition is intended to be held in friendly, sporting and fair-play spirit. Refereeing decisions are pronounced with no possible recourse, except if an agreement between participants is made.

This version of the technical annex will be completed with the missing details and with additional information provided by the organizers, possibly with the help of feedback from the competitors. The IPIN Track 4 Organizing Committee reserves the right to modify the competition rules and parameters, should the needs of the competition require, warning the participants with time enough.

2 Rules of the competition and measurement procedure

A mobile robot will move along a predetermined track in an indoor environment, equal for all participants. It is a collision-free trajectory and will be executed by the robot only once for each competitor. The estimated time for the robot trajectory will be less than 5 minutes. The initial position and orientation of the robot will be provided. Competitors can install items of their positioning system both in the displacement area, in a set of aluminum profiles placed at the environment, and onboard the robot (without interaction with the robot systems). The profiles distribution guarantee that, within all the trajectory, the robot has direct line of sight with at least one of the aluminum profiles. Section 3.1 describes in more detail the navigation area, Section 3.2 details the profiles characteristics, and Section 3.3 explains the robot characteristics.

Participants have to report the trajectory results through an email message to the contact address of this track (carmen@depeca.uah.es). All measurements have to be reported together in a single file with a maximum delay of 2 minutes after the end of the test with the robot. The submission report must be a plain text file (*.txt), with three columns, as follows: position x and y coordinates in millimeters with respect to the initial robot position and timestamp in milliseconds (see section 6.2 for an example). Each line in the text file will correspond to a new estimated position. The minimum framerate for the estimated positions is 0.1s.

At the beginning of each participant's turn, the competitor will have 30 minutes for the system set-up (notice, that the positioning systems of the competitors can only be installed onboard the robot- without interaction with the mobile robot systems- or in the provided aluminum profiles). Any technology can be used in the competition, provided that they fulfill the safety rules detailed in Section 5.3. Subsequently, the robot will start moving and the measurement will take place. During this phase, the competitors will not be allowed to apply reconfigurations of their systems.

All participants will have access to the competition area prior to the competition event, but will not be allowed to train/practice with the robot. Competitors will have a map of the navigating area in advance. Nevertheless, the predefined path followed by the robot will be disclosed at the time of competition. The path is equal for all participants, and can include loops, stops and partial or total occlusion in line of sight

from some of the strut profiles (as mentioned above, there will always be a direct line of sight from at least one of the profiles).

3 Competition set-up

3.1 Navigation area

The robot will move performing a specific route within a 12m x 6m area. Figure 1 is a plan of the hall where the robot navigation area will be placed, and <https://goo.gl/photos/JNwP2K7qmbE8XdQv5> is a 360-degree panoramic photo of the navigation area that participants can move and zoom. A set of 4 aluminum profiles will be placed within the navigation area, participants can install items of their positioning system in those profiles as indicated in Section 3.2.

Organizers commit themselves to detail the navigation area with as much detail as possible. Nevertheless, they reserve the right to some modifications if necessary. Eventual changes will be announced in advance on the IPIN 2016 website. No objections regarding differences will be taken into account.

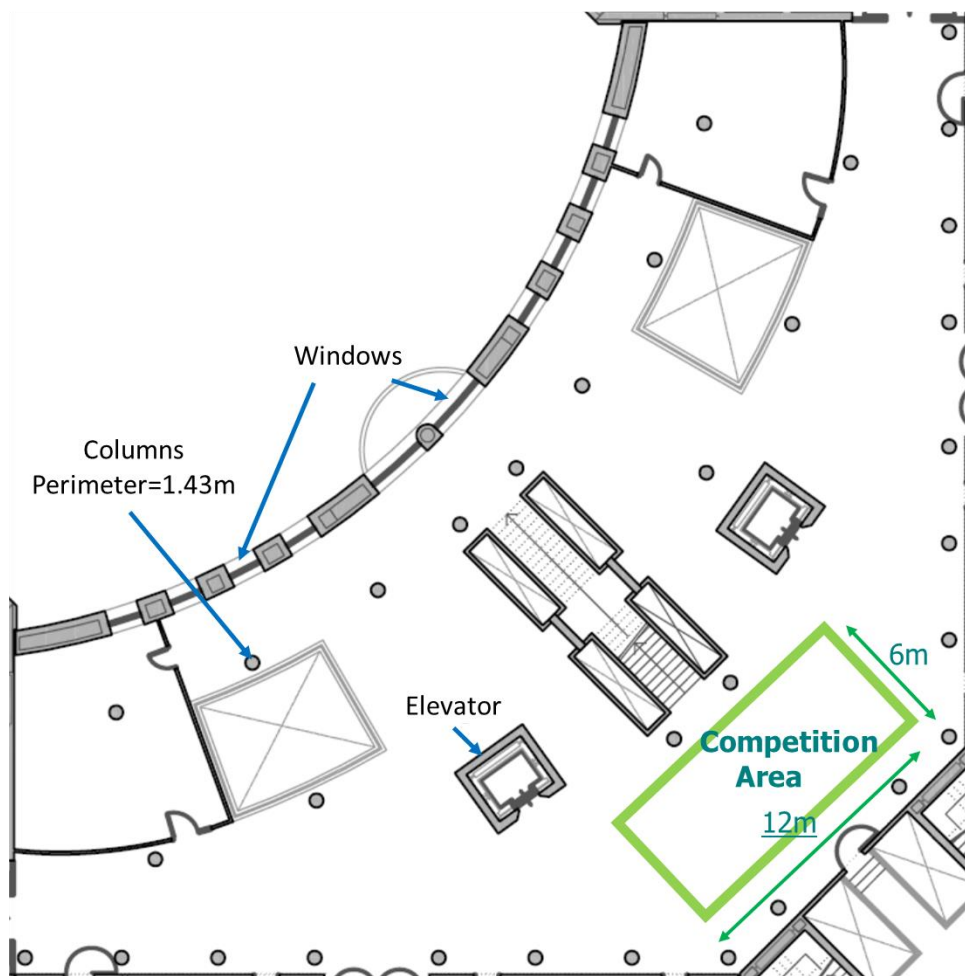


Figure 1. Overview of the University hall where the navigation area will be located.

3.2 Strut profiles

The four strut profiles in the navigation area are enough to ensure that within all the trajectory there is direct line of sight to the robot with at least one of them. Participants can use them to place parts of their positioning systems. All of them are 5cm width, with 8mm grooves, made from anodized aluminum and have a maximum height of 3.15m. Figure 2 represents the section of one of the strut profiles. Every profile includes a platform, adjustable in height that can be used by the participants for mounting their positioning systems (see Figure 3 for dimensions). Participants can also use other kind of non-permanent auxiliary holders, such as clamps. Maximum weight for the positioning systems to be hold in the strut profiles is 3Kg. In every strut profile there will be an electrical socket available.

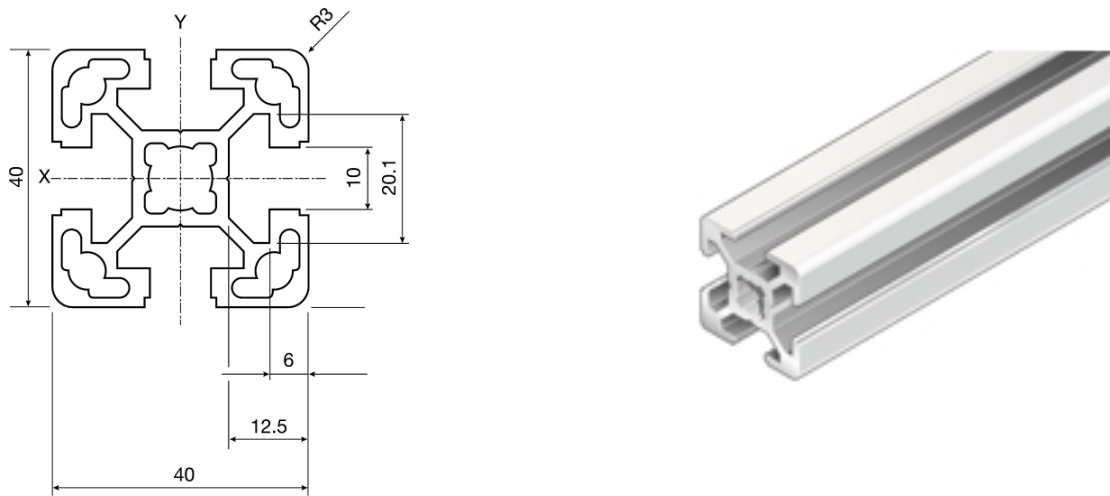


Figure 2: View of one individual profile.

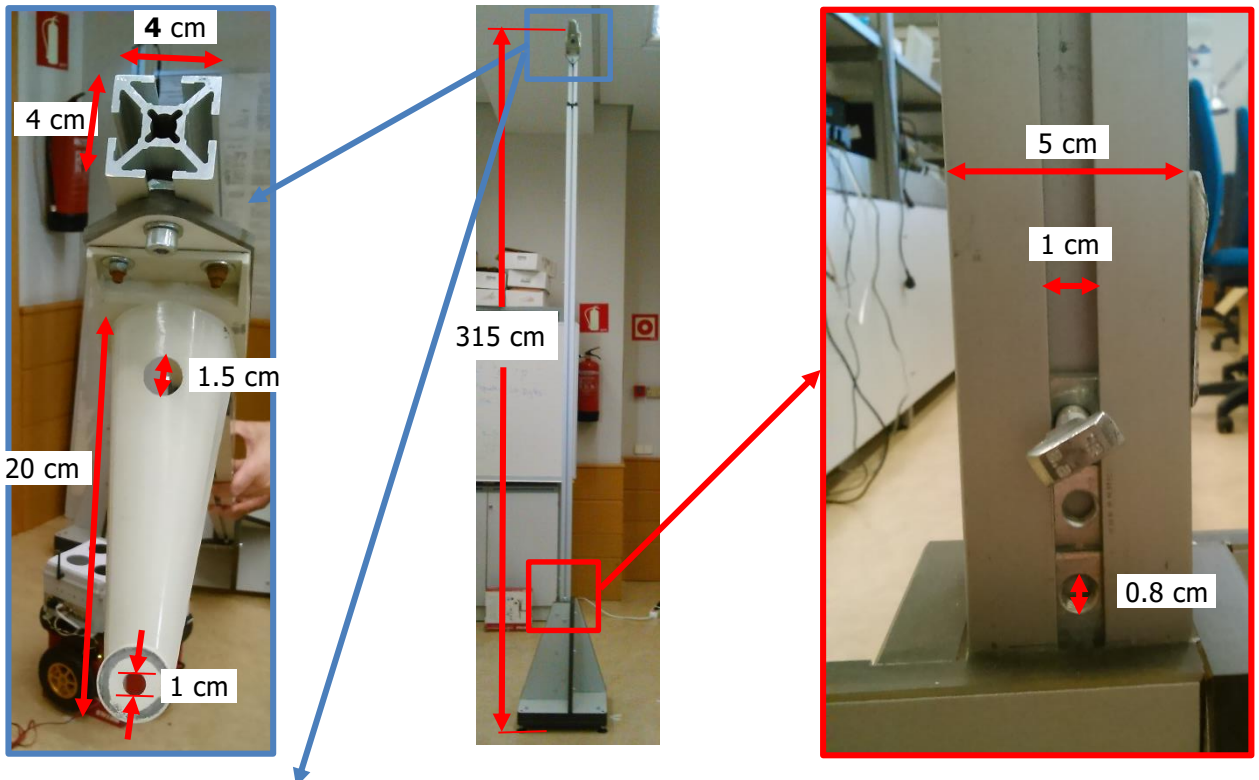




Figure 3: Example of profiles and platform coupled to them for better emplacement of the participants positioning systems.

3.3 The robot

The mobile robot whose position along the trajectory has to be accurately identified is a Standard EASYBOT of ASTI. Figure 4 shows the robot size. In Figure 5 two photos of the robot can be observed. In each side of the robot there is a hooking system with predrilled holes of 8mm of diameter, uniformly distributed around a rectangle of 9x94cm. Items to be mounted on the hooking system cannot exceed neither 3kg weight nor 30cm height and the robot dimensions.

The robot speed will not exceed 0.5m/s during the competition.

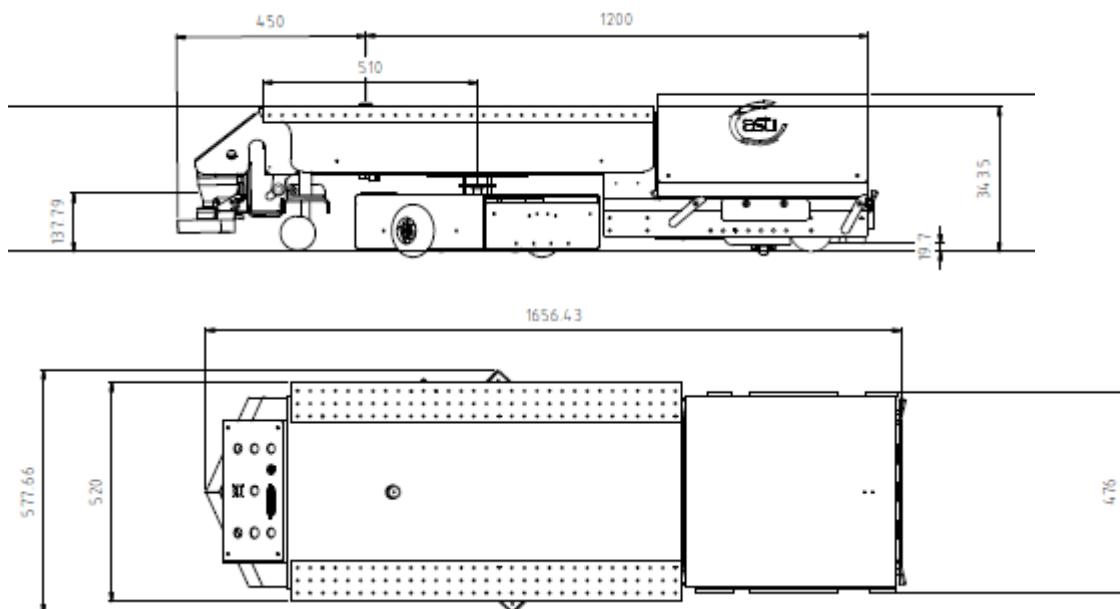


Figure 4: Standard EASYBOT measurements (in millimeters).



Figure 5. Photo of the robot, including the predrilled platform and the pattern that indicates the reference point to be localized.

4 Evaluation criterion

4.1 Approval

Prior to the competition, the positioning system used by the participants needs to be approved by a referee. In the pre-approval, the referee verifies that the positioning system complies with the rules (safety, dimensions and weight). If the positioning system passes the test, it will be declared as approved and will be allowed to participate in the competition.

If significant changes are made to the positioning system after the approval and before the competition, the referee must be informed, and the approval tests have to be done again. If significant changes are applied without reporting them, the participants will be disqualified.

4.2 The contest

The accuracy score will be based on the differences from the ground truth trajectory and the one obtained by the participants. The metric will be computed as the third quartile of the localization errors. The localization error is the Euclidean distance between the estimated positions and the ground truth trajectory.

Final scores will be disclosed at the end of the competition, and the competing systems ranked according to their final score. Also, the raw data from all systems willing to disclose them will be published after the competition with the purpose of research and comparison.

Exceptionally, the jury reserves the right to declare the prize void.

5 Design and constraints

In order to obtain the position and orientation of the mobile robot, competitors can install their own devices both onboard the robot (without interaction with the robot electronics and mobile system) and in the displacement area (using the available aluminum profiles).

5.1 Energy sources

Since the system onboard the robot should not interact with the robot electronics and mobile system, it has to include its own energy source. The battery life should be enough for all the trajectory.

In general, all forms of energy sources are allowed, except those using chemical reactions like combustion or pyrotechnic processes, for safety reasons. Any corrosive products or other liquids that can splash are also forbidden for the same reason.

If you have any doubts about an unusual energy source, please ask the referees in time and share with them the corresponding datasheets.

Regarding the devices allocated in the displacement area, they can include their own energy source (with the same restrictions than the onboard system), or be plugged into the available sockets that will be available next to each profile. There will be one socket per profile.

The mains electricity in Spain is 230VAC/50Hz, and the available plugs and sockets are type C (<http://www.iec.ch/worldplugs/typeC.htm>) and F (<http://www.iec.ch/worldplugs/typeF.htm>), shown in Figure 6. In case the participants plugs are different, they should use their own plug adapter.



(a)

(b)

Figure 6: View of the available plugs (a) Type C, (b) Type F.

5.2 Sources of interferences

It is recommended to encode all communications to avoid interferences between the signals of different teams, as well as other external electronic devices.

Attention should be paid to the ambient light (which can include direct sun light through the windows) during the event, especially when using infrared or other optical devices. Furthermore, this light may vary during the competition time.

5.3 Safety

All systems should comply with current national and European safety regulations. They must not put at risk either the participants or the audience during competition, as well as the stands and backstage.

The use of liquids, corrosives, pyrotechnics and living components is strictly prohibited.

Only considerations based on the laser class definition “EN 60825-1:2007, Edition 2 -Safety of laser products– Part 1: Equipment classification and requirements” will be taken into account.

Teams using a laser have to provide either the classification notice of the equipment or the laser component data sheet. Not being able to provide such a document will prevent the positioning system from being approved.

Based on this classification, lasers of classes:

- 1 and 1M are allowed without any restrictions
- 2 are tolerated if the projected spot is never projected outside the competition area
- 2M, 3R, 3B and 4 are strictly prohibited

Caution: A laser device consists of the laser source, its electronics and the optics. Disassembling or modifying any of those components often leads to a change of classification. Only commercial products with unaltered components can be approved for the competition.

In case of use a powerful light, light intensity shall not be dangerous for the human eye in case of direct spot exposition. Be aware that some kind of LED provide warnings.

If any doubt, organization has the right to ask for manufacturer specification to verify that the lighting system is not dangerous.

Any device or system considered as potentially dangerous by the referees will be rejected. It must be removed from the system prior to the competition, or will result in the team's disqualification.

6 Appendix

6.1 Contact points and information

- Main contact points: María del Carmen Pérez Rubio (carmen@depeca.uah.es) and Cristina Losada Gutiérrez (losada@depeca.uah.es), Department of Electronics, University of Alcalá, Madrid, Spain.
- There is also the option to use the contest@evaal.aaloo.org mailing list to suggest ideas or ask for clarifications related to all tracks.

6.2 Plain text file format for positioning results

Participants have to report the trajectory: robot position and timestamp at least every 0.1 seconds (minimum frame-rate). All measurements have to be reported together with a maximum delay of 2 minutes after the end of the team participation. Measurements presented after the deadlines will not be considered. The measurement report must be a plain text file (*.txt), with four columns, as follows:

- position x and y coordinates in millimeters with respect to the initial robot position
- timestamp in milliseconds with respect to the movement starting time

Each line in the text file will correspond to a new estimated position

An example, in which the results are given every 5ms, is shown below.

X coordinate (millimeters)	Y coordinate (millimeters)	Timestamp (milliseconds)	
00000.0	00000.0	000000	→ Position estimation 1
00025.0	00000.0	000050	→ Position estimation 2
00050.0	00000.0	000100	
00075.0	00000.0	000150	
00100.0	00001.4	000200	
00124.8	00004.2	000250	
00149.5	00008.4	000300	
00173.8	00014.0	000350	
00197.8	00020.9	000400	
00221.4	00029.1	000450	
00244.5	00038.7	000500	
00267.1	00049.5	000550	
00288.9	00061.6	000600	
00310.1	00074.9	000650	
00330.5	00089.4	000700	
00350.0	00105.0	000750	

6.3 Frequently Asked Questions (FAQ)

(Q1) Is there any limitation on the number of receivers that we can set in one profile?

(A1) There is no limitation in the number of receivers to be placed in each profile. Note however that in every profile there will be only one platform like the one of figure 3. We can add an auxiliary mounting bracket for a second anchor, or you can use your own non-permanent auxiliary holders if you need more.

(Q2) Is it possible to put large scale posters on the aluminium profiles? (e.g. to be detected by the equipment on the robot)

(A2) Yes, large scale posters can be included on the aluminum profiles, as long as they do not exceed the maximum allowed weight (3kg).

(Q3) Will the position of the profiles be known in advance?

(A3) We will give you the (0,0) coordinates of the reference system, this way you can use it to calibrate your sensorial system independently of how many sensors and profiles you have chosen. You will have 30 minutes for the system set-up and calibration before your turn.

(Q4) Can we connect all anchors by cables?

(A4) Yes, you can connect all anchors by cables. Notice that all cables, including the connections between your equipment or to the strut profiles, must be provided by the participants. In every strut there will be an electrical socket available.

(Q5) How will the area (12mx6m) be covered? Are there solid constructions around the playground, e.g., until 1m height? Can people stand directly at the boarder of the playground?

(A5) The area is free of obstacles and of people circulation. The area will be covered by means of four aluminum profiles (see Section 3.2 for further details regarding the strut profiles and Figure 1 for a map of the competition area where you can observe the elements outside the competition area). As mentioned before, people cannot stand inside the competition area, but can observe the robot navigation from outside.

(Q6) Are there some obstacles in the competition area which can block the direct line of sight of the robot?

(A6) Partial or total occlusion in direct line of sight between the robot and some of the strut profiles may occur, however within all the trajectory there will be always direct line of sight with at least one of the aluminum profiles.

(Q7) Are there any slope or inclined surface in the competition area?

(A7) No, there is no slopes or inclined surface in the competition area.

(Q8).- Do you have WiFi in the area?

(A8).- Regarding to the internet connection, we do have free WiFi in the competition area. Nevertheless, in case of fail of the WiFi connection, the data can be deliver through a portable external hard disk or pen drive (USB connection).

(Q9) Is remote processing allowed?

(A9) Yes, remote processing is allowed, as long as Track 4 rules are followed (see Track 4-Call for Competition-Section 6.2 for further details).

(Q10) What is the allowed height of equipment on the 20x30cm area on the robot?

(A10) The allowed height is up to 30 cm.

(Q11) Can screws be applied to fix the equipment?

(A11) Yes, screws can be applied to fix the equipment.

(Q12) Is there a power source on the robot to power equipment?

(A12) No, there cannot be any connection with the robot systems, so the equipment to be placed on the robot must be autonomous.

(Q13) The minimum frame rate of 0.1 seconds means that no delay between positions larger than 0.1 seconds will be allowed?

(A13) Yes, that is, a new measurement should be given at least every 0.1s.

(Q14) Where is the link for the measurements of the trajectory? (e.g. the center of the robot, the center of the top plate)

(A14) A pattern on the robot is provided to identify reference point of the mobile robot (see Section 3.3 for more details regarding its location).

(Q15) How can we provide a time stamp, if no communication with the robot is possible?

(A15) At least manual synchronism will be provided.

(Q16) The instruction mentioned "Attention should be paid to the strong ambient light". Is there a direct sunlight? Is it possible for us to know the approximate light intensity (in lux) over the area?

(A16) Light conditions can vary during the day, in Figure 1 you can see the distance of the competition area from the windows. There are also fluorescent lightings (leds). As a reference, in normal conditions, the approximate light intensity is about 320 luxes (50 luxes without artificial light). Nevertheless, during the competition additional artificial lighting can be included (consider 2000 luxes in certain zones).

(Q17) Are you planning to have only 2D competition or 3D as well?

(A17) We are asking for 2D positioning.

(Q18) Is LIDAR allowed?

(A18) The sensors used are a decision of the competitors, provided that they fulfil the safety restrictions.

(Q19) What accuracy are you expecting from competitors to archive?

(A19) The measurements accuracy depend on the competitors. We have not included any threshold to discard competitors. As a reference, we expect that some systems can achieve accuracies bellow 10cm.