MINESWEEPERS
TOWARDS A LANDMINE-FREE WORLD

UNIVERSIDAD AUTÓNOMA
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El presente lo escribimos juntos

LATIN
AMERICAN

MINESWEEPERS

TOWARDS A LANDMINE-FREE WORLD

TARIJA 2019

RULEBOOK

September 30, October 01-02
at Campus Universitario de la Zona el Tejar

LANDMINEFREEORG

8TH YEAR

Official qualifying round for world competition, China 2019

MINESWEEPERS
TOWARDS A LANDMINE-FREE WORLD

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1. About the competition

Detection and removal of antipersonnel landmines is, at the present time, a serious problem of political, economic, environmental and humanitarian dimension. The humanitarian demining activities carried-out to remove landmines and UXOs from the vast contaminated areas in the world are not on the same level of the problem. Robotics systems can provide efficient, reliable, adaptive and cost effective solution for the problem of landmines and unexploded ordnances (UXOs) contamination [IEEE-RAM2015]. Minesweepers: Towards a Landmine-free World is the first international robotic competition on humanitarian demining established in 2012. This competition aims at raising public awareness of the seriousness of landmines and unexploded ordnances (UXOs) contamination and fostering robotics research and its applications in the area of humanitarian demining in the world. In this competition, each participating team constructs a teleoperated/autonomous unmanned ground/aerial vehicle that must be able to search for buried and surface-laid anti-personnel landmines and UXOs. The position and the type of each detected object are visualized and overlaid on a minefield map. The robot must be able to navigate through rough terrain in an indoor arena that mimics a real minefield. More than 400 robots by 3000 competitors from 15 countries and 70 universities have participated in the previous seven edition of the competition. The ultimate goal of the Minesweepers competition is to put into practice the strategic mission of IEEE, "…to foster technological innovation and excellence for the benefit of humanity" and to serve as an educational and a research forum to provide efficient, reliable, adaptive and cost-effective solutions for the serious problem of humanitarian demining in many affected countries in the world. Moreover, the applicability of the robotic systems presented in this competition can be extended to a wide range of other applications such as security and surveillance, search and rescue, health monitoring of civil infrastructure and environment monitoring.

2019 comes with new challenges in the city of inventions, Macau, China. At the community of genius people, technology geeks and industrial culture, Minesweepers competition is starting a new chapter in its journey towards a landmine free world. The 8th year comes with new features at the minefield and the mission, take a look at our 2019 rules and get ready for the new mission in China.

2. Competition Categories

In this competition, each participating team constructs a teleoperated/autonomous unmanned ground/aerial vehicle that must be able to search for underground and aboveground anti-personnel landmines and UXOs and aggregate the surface mines. The position and the type of each detected object are visualized and overlaid on the minefield map. The robot must be able to navigate through rough terrain that mimics a real minefield.

The participants can take part in the competition through one of the following categories:

- Industrial Category: for professional companies and start-ups where metallic and non-metallic objects with different dimensions and profiles are available in the competition arena and landmine detection, landmine disposal, landmine imagining and minefield mapping are required.
- Academia Category: for undergraduate students where only, metallic objects are available in the competition arena and landmine detection, landmine disposal and minefield mapping are required.
- Juniors Category: for elementary and high school students where only metallic objects are available in the competition arena and only land-mine detection and landmine disposal, are required

3. Rules and guidelines

3.1 Time line

- 9 Sep.- 16 Sep. 2019: Teams registration.
- 25 Sep. 2019: Technical report and video submission deadline for repechage competition teams.
- 26 Sep. 2019: Technical report and video submission deadline for regional teams.
- 30 Sep. Repechage
- 01-02 Oct. 2019: Regional competition.

3.2 Registration

- Participation in ACADEMIA category is open to undergraduate and postgraduate university and technical college students.
- School students are eligible to compete in JUNIOR category only and NOT eligible to compete in the ACADEMIA category.
- Participation in the JUNIOR category is open to students in preparatory and high schools as well as students in home schools, after school programs, clubs, and community organizations of comparable grade levels.
- For ACADEMIA and JUNIOR: There are no limitations on the number of participating teams perorganization.
- Number of members in each participated team should not be less than 3 members and not exceed 10members.
- Fees:

  1- 250 $ registration fees for Academia teams.

  2- 200 $ registration fees for Junior teams.

  3- 500 $ registration fees for Industry teams.
- Once team registered, they must pay their registration fees within a week from their registration date (before the registration deadline).
- Payment method details will be sent to team leader after completing the registration form.
- Registration or regional fees are not including any accommodation or catering for teams from Minesweepers competition.

- Registration steps:
    1. Fill the team data form.
    2. Follow the payment instruction received to the team leader email.
    3. Waiting for a confirmation email from the organizing committee.
    4. Note: You may start working on your robot during the registration steps and do not wait to the registration deadline.

3.3. Competition Phases

The competition divided into two phases, the repechage and the regional phase.

3.3.1. Repechage Phase

All the registered teams must send by email Technical Report and a 3-minutes video showing the design and the operation of their robot. Deadline to submit the report and the video is 25 Sep 2019.

You can check more instructions and guidelines in Appendix A, the report template in Appendix C and check the score sheets in Appendix D.

3.3.2. Regional Phase

All the registered teams must send by email Technical Report and a 3-minutes video showing the design and the operation of their robot. Deadline to submit the report and the video is 26 Sep 2019.

At this stage all teams have to prepare their robot for the regional competition, your score will be out of 10 according to this evaluation and will be added to your mission score of the Classification Phase in round 1 only.

3.3.3. Classification Phase

Round1 (first day)

All the ready robots will participate in order established by gambling. The teams will be sorted based on the sum score obtained in this stage and the score of eligibility phase as well; the eight best teams in each category will be classified for the second round.

In case of equality in number of points, the robot that will finish the mission in minor time will win. If insufficient number teams have finished this round, the judge committee can select some of the unclassified teams to participate in round2.

You can check more instructions and guidelines of the mission in competition mission, and check the score sheets in Appendix F. **However, judges can introduce changes in consensus with team leaders.**

Round2 (second day)

The classified teams will have to accomplish a final mission according to the same guidelines of the previous round. Also required from top eight teams to give a 15 min technical presentation on a jury panel talking about their work and robot. The total score will be sum of mission score in round2 and presentation score.

You can find the presentation criteria in Appendix B also check its score sheet in Appendix E.

The winning teams that will be qualified to the international competition will have the highest score in round2.

Note: **However, judges can introduce changes in consensus with team leaders.**

3.4. Minefield Rules

1. Each robot starts the game from one of the corners of the competition arena. Team members will bring the teleoperated or the autonomous robot to this location. Then robot has to search the field to find buried mines or the mines scattered on surface. When the robot detects any kinds of mines, it should produce a light signal and siren. All the detected surface mines will be removed from the field before a new team enters the arena.
2. Robot has to able to navigate through rough environment of the minefield and avoid obstacles.
3. During the competition only one member will be the driver for each robot and two other members as co-drivers, only these three members will be around the arena and the remaining members will be outside the second fence,
4. The driver and co-drivers must wear safety vests and helmets during the team's game, which will be provided by the competition organizers.
5. If the team needs to add another member around the arena, the minefield judge must approve his/her presence.
6. During the reset time/ maintenance only one member can attend the arena. The minefield judge should approve allowing another team member if it is required.
7. The competition time allowed for each team is 20 minutes to finish the competition's mission including the rest time.
8. Any modification in the robots is not allowed unless reset time is requested.
9. Five minutes before the game beginning as a setup time for each team to make the last preparation of the robots, to fit their robots' sensors to the lighting and the material of the arena.
10. Jury committee will calculate the team's score and prepare the field for the next team during another 10 minutes.
11. The game will end with one of the following conditions:
    - The robot finishes the mission.
    - The dedicated time finishes.
    - Team dismiss the game.
    - Any cheating happens.

12. If the team uses any hydraulic or pneumatic systems, they must inform the competition organizers at least before the competition. Moreover, the team must pass the safety check on its system to be qualified to participate.
13. The organizers have the right to photograph and videotape the event and the right to reproduce, modify and use the photographs and video tapes for various media.

3.5. Robots Constraints

3.5.1. Weight Constraints

Anti-personnel landmines can be activated by small weights. For example, blast landmine is one of the most common used landmines whose triggers requires a minimum weight of about 5 kg. Bounding fragmentation landmines or bouncing betties are generally triggered by as little as 1.5kg of weight. The robot weight must not exceed 40Kg, if the robot exceeds this limit, it will be disqualified to participate. Assuming a uniform weight distribution in a 4-wheel robot for example, each wheel will provide 10 kg of weight over the landmine, which would be the weight of a mere child's foot.

3.5.2. Size Constraints

The robots will not have any limitations on size.

3.5.3. Technical Methods/Systems Constraints

The robots will not have any limitations on their sensors, power sources, control systems, and locomotion mechanisms. Each team can select their own set of sensors for landmine detection and localization. Although teams can install cameras on robot or install them on the sides of the field, no cameras or sensors are allowed to hangover the competition area.

4. Competition Mission

4.1. Industry Category

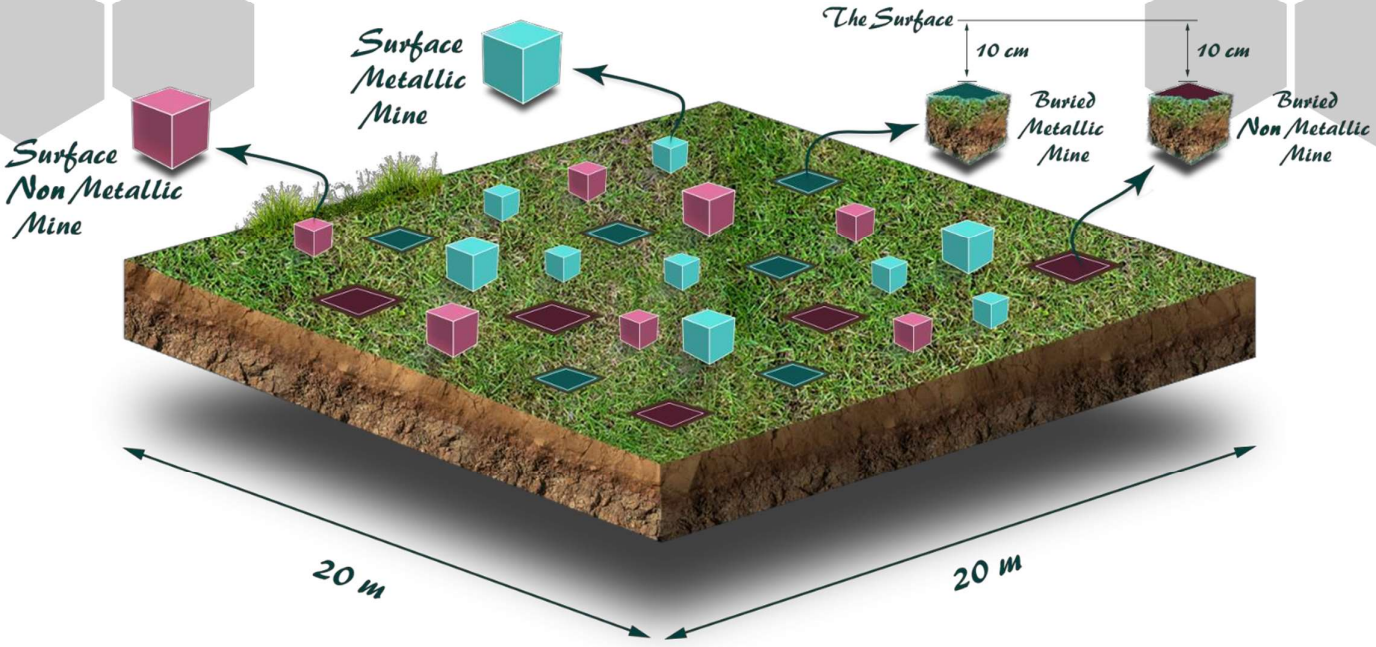
Companies are invited to participate in this category of Minesweepers competition and demonstrate their state-of-the-art solutions and technologies in the area of humanitarian demining. In this category, each participating team will have to perform the following actions:

- Search for surface-laid and buried metallic and minimum metal objects of different dimensions and shapes using teleoperated or an autonomous ground/aerial vehicle. These objects mimic the anti-personnel landmines and unexploded ordnances. The vehicle has to able to navigate through rough environment that mimics a real minefield.
- Automatically produce a high-precision map for the locations of the detected objects without human intervention.
- Identifying the types of the detected landmines.
- Collecting and moving the detected surface landmines to a built-in container or to a designated area outside the competition arena using a teleoperated or autonomous grasping mechanism.

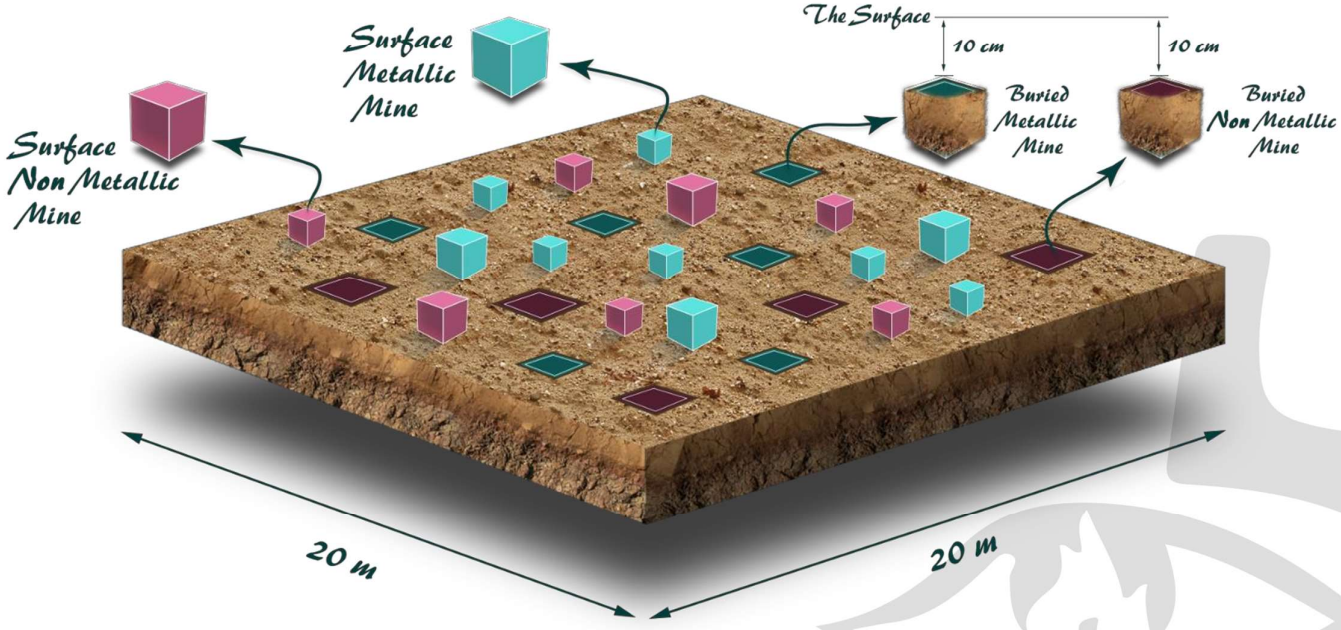
Minefields

The first competition arena will be an area with a size of 20m x 20m, delimited by four GPS coordinates. The competition area will be marked. Most of the arena may contain some of these; low grass with a few trees, some steep inclines, ditches, culverts and muddy water, or some sand, stones and as shown in the figures below. This competition arena is mainly dedicated to repechage.

The second competition arena will be an area with a size of 20m x 20m, delimited by four GPS coordinates. The competition area will be marked only by plastic tape (or another material) for visualization purposes to stop the robots from going outside the competition area, there will not be any flags or lines in the arena. There will be no mines in a stripe of 0.5 m of terrain along the borders of the competition area. Most of the arena may contain some of these; low grass with a few trees, some steep inclines, ditches, culverts and muddy water, or some sand, stones and as shown in the figures below.



"GRASS MINEFIELD"



"DESERT MINEFIELD"

The Mines

Two different kinds of artificial mines are used in this competition:

Buried Mines: These mines are metallic and non-metallic objects of different dimensions and shapes as illustrated in the following figures (see List of land mines, for more information about anti-personal landmine shapes and dimensions).

The metallic objects will be made of steel while the non-metallic objects will be made of different materials such as plastic and wood. The minimum metal objects will contain few small metallic parts that real landmine's spring, striker tip, or shear wire. These objects are completely buried underground with maximum depth 10 cm.

The arena will have the simulated surface and buried mines with different dimensions and shapes will up to 10*10*10 cm^3 (L*W*D)

Some landmines will be organized in a pattern for easier removal and accountability and others will be scattered randomly. The jury committee will know locations of each landmine.

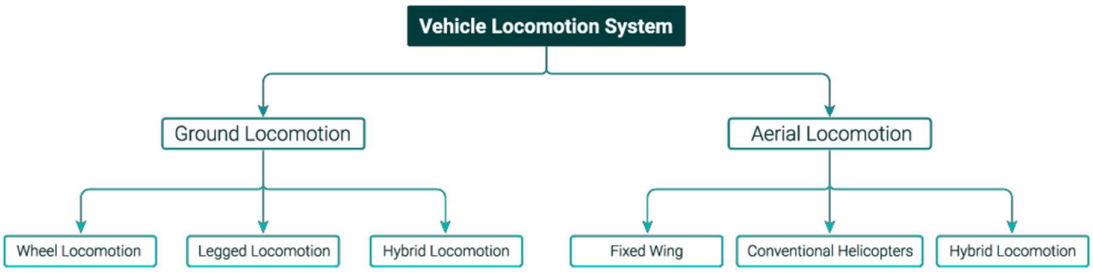
The mimic real anti-personnel (AP) blast mines. Real AP blast mines are deliberately designed to be small (typically 6-14 cm in diameter): this makes them cheaper and easier to store, carry and deploy. AP blast mines rely on the effect of explosive blast to damage the victim, and are designed to detonate when the victim steps on them. These mines are often buried in order to camouflage their presence.

Surface Mines: These objects are similar to the buried objects described and are labeled in black color to facilitate vision-based detection and localization. These objects are visible and are located on the surface of the competition area. These black objects are used to simulate above ground mines and unexploded ordnance (UXOs). Unexploded Ordnance is a piece of explosive ordnance or ammunition that has failed to function as intended. Although they have failed to function as intended, UXO can sometimes require only the slightest disturbance to detonate. UXOs vary greatly in size from hand grenades the size of an apple to large aircraft bombs.

The Robots

Each team must use a teleoperated or an autonomous robot per game. The robot has to be made by team members. Teleoperated robot must be operated remotely from a base station located outside the minefield.

The robot can be UGVs, UAVs with no limitations for size. Wireless controller based on ZigBee for example would be recommended to communicate the base station with the robot due to the large size of the field. In case of autonomous robots, all the actions of the robot must be completely autonomous without human intervention. Autonomous robot will be rewarded a 20% bonus over teleoperated robots. Careful attention must be paid to the robot locomotion systems, as the roughness of the terrain is very high. Both unmanned ground vehicles (UGVs) and unmanned aerial vehicles (UAVs) are allowed as illustrated in the figure below.



Unmanned ground vehicles can be wheeled, legged or hybrid. Wheeled robots include but are not limited to differential drive, tricycle drive, Ackerman steering, synchro drive, omnidirectional drive, Multi-Degree-of-Freedom (MDOF) vehicles, MDOF vehicle with compliant linkage or tracked vehicles. Legged robot can be uniped, biped, tripod, pentapod, quadruped or hexapod robot. Any types of hybrid locomotion can also be used. Examples of hybrid locomotion include a vehicle equipped with tracks for fast locomotion, and legs for more difficult terrain or flippers with self-cleaning tracks or legged vehicles with driving wheels attached to the end of each leg. UAV can be an alternative for the locomotion systems. As shown in above figure, UAVs can be classified into fixed wing, conventional helicopters and multi-rotor helicopters. Fix wind UAVs are naturally stable platforms capable of long flight times and extreme range. However, they are difficult to coordinate with slower ground systems. Conventional helicopters are common collective pitch model helicopters known for their excellent maneuverability and scalability. However they suffer from high level of complexity. Quad-rotors have the ability to hover and there are naturally stable and durable. However, they have limited pay-load. Ball-bots or UAVs that can land on a roving platform are also allowed. Robot can also be an unmanned aerial vehicle or a quad-rotor.

Robot can be actuated using electric, pneumatic or hydraulic actuation system, Diesel/Petrol engine or using solar energy.

Mines Detection

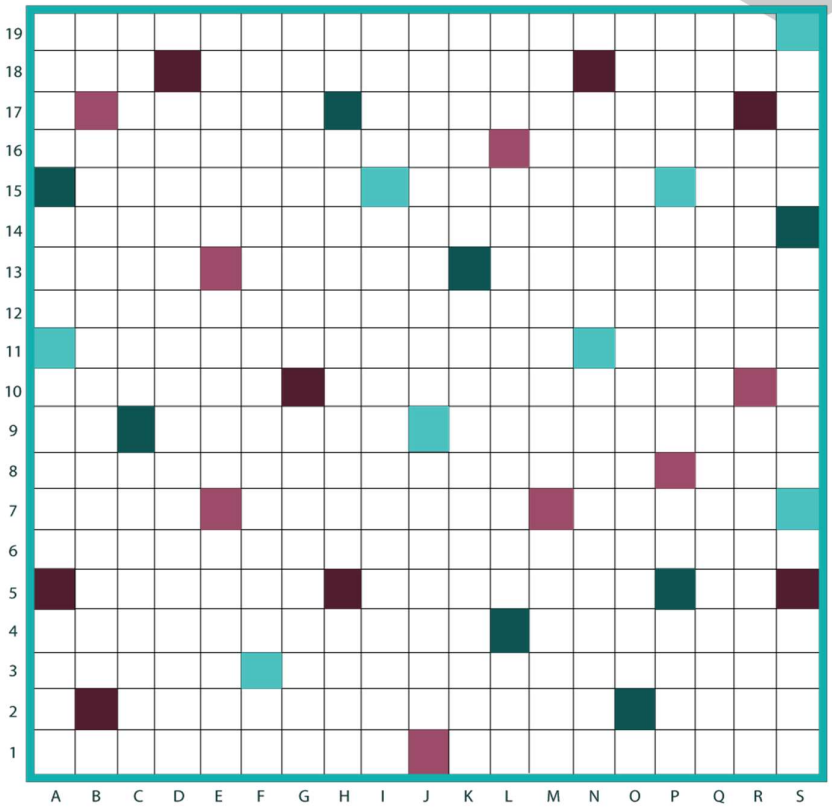
Each team can select their own set of sensors for detection of mines. When a robot detects a mine, it has to autonomously report this event using a light blinking signal or a warning siren.

Localization and Mine Map

Each robot has to provide automatically map of the detected mines when its competition time slot finishes. Depending on the mines location calculated and showing if, it is surface or buried mine and if it metallic or non-metallic. The map represents a 19×19 meter area. Letters A to S and the Y coordinate of the map consists of numbers 1 to 19 show the X coordinate of the map. This mine map can be represented graphically or using vector format as shown in the following figures.

The map may be shown using any display on the robot or on the laptop or other device outside the arena.

Each team can choose their own suitable sensors for localize the detected mines' position and the suitable software for mapping creation.



Buried metallic Mines

Surface metallic Mines

Buried Non-metallic Mines

Surface Non-metallic Mines

Graphical Representation

Surface Metallic mines found at:	
A	11
F	3
I	15
J	9
N	11
P	15
S	7
S	19

Buried Metallic mines found at:	
A	15
C	9
H	17
K	13
L	4
O	2
P	5
S	14

Surface Non- Metallic mines found at:	
B	17
E	7
E	13
J	1
L	16
M	7
P	8
R	10

Buried Non- Metallic mines found at:	
A	5
B	2
D	18
G	10
H	5
N	18
R	17
S	5

Vector Representation

Landmine Disposal

It is required to collect and move the detected surface landmines to a box/built-in container or to a designated area at one of the competition arena corners. Therefore, each team can build their own remotely operated or autonomous mechanism, with different scores, to collect the surface landmines without any limitation on any system as long as safety rules are considered.

Mission Score

- 10 points for detecting every buried metallic or non-metallic mine.
- 5 points for detecting every surface metallic or non-metallic mine.
- 10 points for each correct surface mine collected automatically.
- 5 points for each correct surface mine collected manually.
- 10 points for correct identification of every buried mine location.
- 5 points for correct identification of every surface mine location.
- 30 points for complete surf of field if 80% of mines are detected correctly.
- -5 points for wrong surface mine detection
- -10 points for passing over a buried mine without detecting it.
- -5 points for touching a surface mine by the robot randomly.
- -3 points failure in producing a light signal and/or a siren for a detected mine.
- -2 points for every minute reset time.

Extra bonus

- Note you can have only two bonus factors of the following:
  - The score will be multiplied by 1.2 for using autonomous robot.
  - The score will be multiplied by 1.2 for using multi robot system check it here
  - The score will be multiplied by 1.2 for using Drones check it here

*check the score sheet in Appendix F.

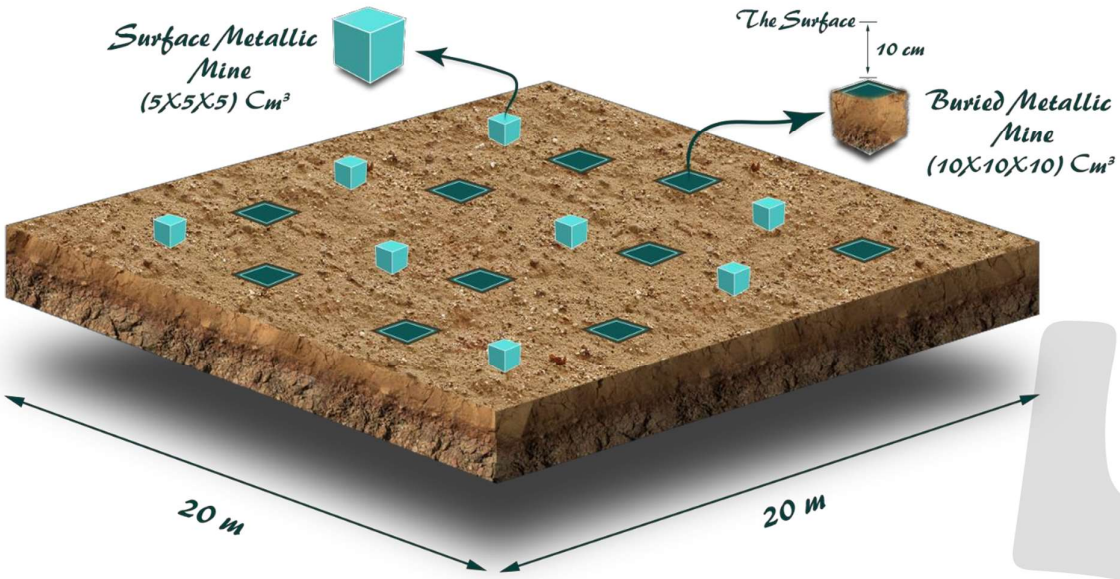
4.2. Academia Category

In this category, the following tasks are to be performed by the participating teams:

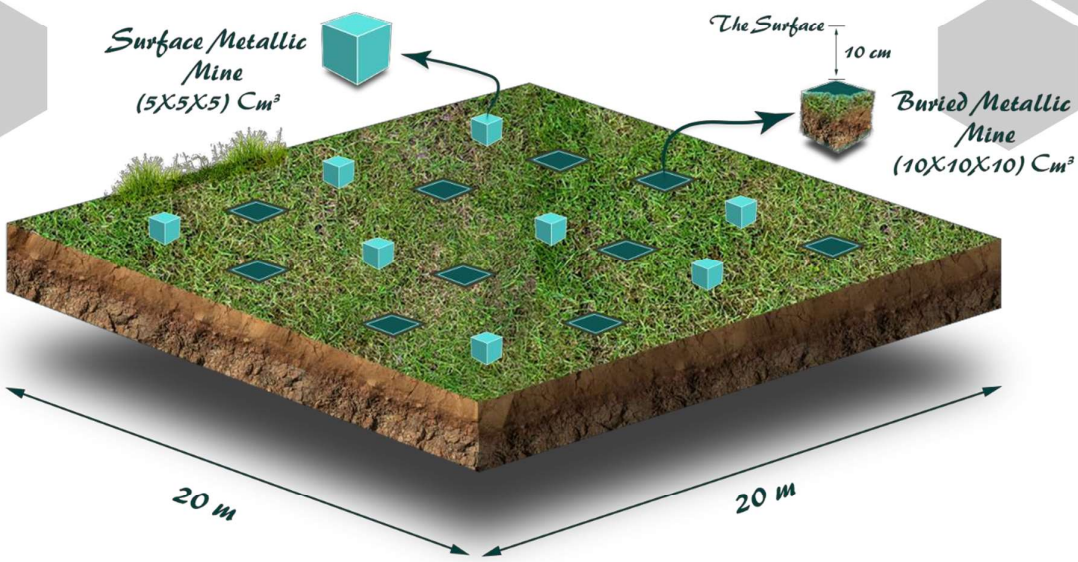
- Search for surface-laid and buried metallic objects of a cubical shapes using teleoperated or an autonomous ground/aerial vehicle. These objects mimic the anti-personnel landmines and unexploded ordnances. The vehicle has to able to navigate through rough environment that mimics a real minefield.
- Automatically produce a high-precision map for the locations of the detected objects without human intervention.
- Collecting and moving the detected surface landmines to a built-in container or to a designated area outside the competition arena using a teleoperated or autonomous grasping mechanism.

Minefield

The competition arena will be an area with a size of 20m x 20m, delimited by four GPS coordinates. The competition area will be marked only by plastic tape for visualization purposes to stop the robots from going outside the competition area, there will not be any flags or lines in the arena. There will be no mines in a stripe of 0.5 m of terrain along the borders of the competition area. Most of the arena may contain some of these; low grass with a few trees, some steep inclines, ditches, culverts and muddy water, or some sand, stones and as shown in the figures below.



"DESERT MINEFIELD"



"GRASS MINEFIELD"

The Mines

Two different kinds of artificial mines are used in this competition:

Buried Mines: These mines are made from metallic cubes, with approximate dimensions of 10x10x10 cm^3 (L*W*D). These mines are completely buried underground with maximum depth 10 cm. These buried metallic cubes mimic real anti-personnel (AP) blast mines. Real AP blast mines are deliberately designed to be small (typically 6-14 cm in diameter): this makes them cheaper and easier to store, carry and deploy. AP blast mines rely on the effect of explosive blast to damage the victim, and are designed to detonate when the victim steps on them. These mines are often buried in order to camouflage their presence.

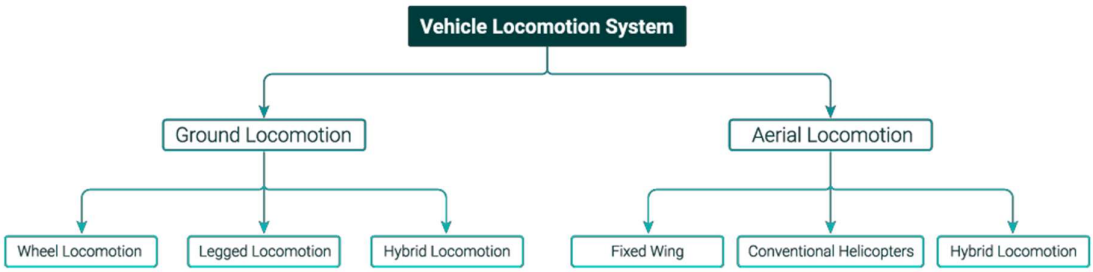
Surface Mines: These mines are made from metallic cubes, with approximate dimensions of 5*5*5 cm^3 (L*W*D) and labeled in black color. These mines are visible and are located on the surface of the competition area. These black metallic cubes are used to simulate above ground mines and unexploded ordnance (UXOs). *Unexploded Ordnance is a piece of explosive ordnance or ammunition that has failed to function as intended. Although they have failed to function as intended, UXO can sometimes require only the slightest disturbance to detonate. UXOs vary greatly in size from hand grenades the size of an apple to large aircraft bombs. The location of the surface mines will be changed every match.

Some landmines will be organized in a pattern for easier removal and accountability and others will be scattered randomly. The jury committee will know locations of each landmine.

The Robots

Each team must use a teleoperated or an autonomous robot per game. The robot has to be made by team members. Teleoperated robot must be operated remotely from a base station located outside the minefield.

The robot can be UGVs, UAVs with no limitations for size. Wireless controller based on ZigBee for example would be recommended to communicate the base station with the robot due to the large size of the field. In case of autonomous robots, all the actions of the robot must be completely autonomous without human intervention. Autonomous robot will be rewarded a 20% bonus over teleoperated robots. Careful attention must be paid to the robot locomotion systems, as the roughness of the terrain is very high. Both unmanned ground vehicles (UGVs) and unmanned aerial vehicles (UAVs) are allowed as illustrated in the figure below.



Unmanned ground vehicles can be wheeled, legged or hybrid. Wheeled robots include but are not limited to differential drive, tricycle drive, Ackerman steering, synchro drive, omnidirectional drive, Multi-Degree-of-Freedom (MDOF) vehicles, MDOF vehicle with compliant linkage or tracked vehicles. Legged robot can be uniped, biped, tripod, pentapod, quadruped or hexapod robot. Any types of hybrid locomotion can also be used. Examples of hybrid locomotion include a vehicle equipped with tracks for fast locomotion, and legs for more difficult terrain or flippers with self-cleaning tracks or legged vehicles with driving wheels attached to the end of each leg. UAV can be an alternative for the locomotion systems. As shown in above figure, UAVs can be classified into fixed wing, conventional helicopters and multi-rotor helicopters. Fix wind UAVs are naturally stable platforms capable of long flight times and extreme range. However, they are difficult to coordinate with slower ground systems. Conventional helicopters are common collective pitch model helicopters known for their excellent maneuverability and scalability. However they suffer from high level of complexity. Quad-rotors have the ability to hover and there are naturally stable and durable. However, they have limited pay-load. Ball-bots or UAVs that can land on a roving platform are also allowed. Robot can also be an unmanned aerial vehicle or a quad-rotor.

Robot can be actuated using electric, pneumatic or hydraulic actuation system, Diesel/Petrol engine or using solar energy.

Mines Detection

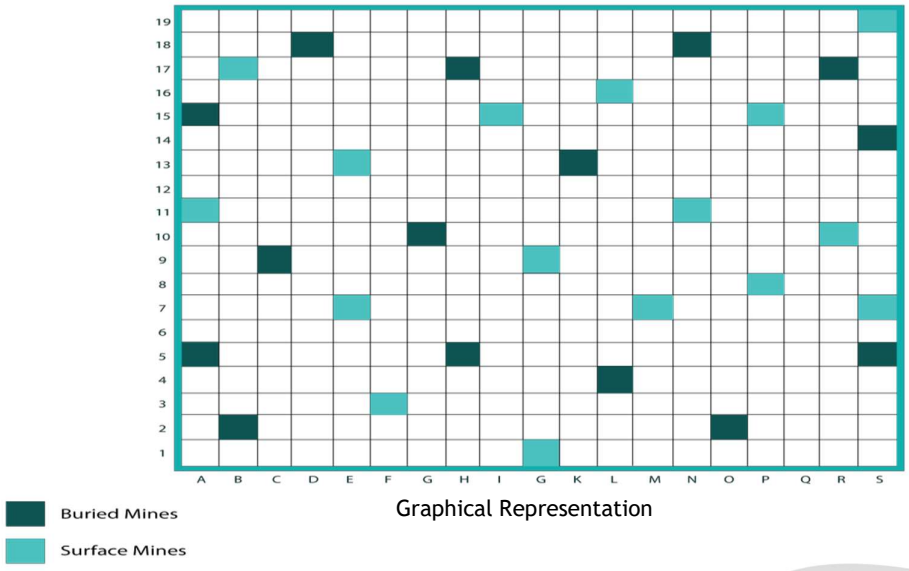
Each team can select their own set of sensors for detection of mines. When a robot detects a mine, it has to report autonomously this event using a light blinking signal or a warning siren.

Localization and Mine Map

Each robot has to provide automatically map of the detected mines when its competition time slot finishes. Depending on the mines location calculated and showing if, it is surface or buried mine. The map represents a 19m×19m area. Letters A to S and the Y coordinate of the map consists of numbers 1 to 19 show the X coordinate of the map. This mine map can be represented graphically or using vector format as shown in the following figures.

The map may be shown using any display on the robot, on the laptop or other device outside the arena.

Each team can choose their own suitable sensors for localize the detected mines' position and the suitable software for mapping creation.



Graphical Representation

Surface mines found at:	
A	11
B	17
E	7
E	13
F	3
I	15
J	1
J	9
L	16
M	7
M	11
P	15
R	2
R	10
S	7
S	19

Buried mines found at:	
A	5
A	15
B	2
C	9
D	18
G	10
H	5
H	17
K	13
L	4
N	18
O	2
P	8
R	17
S	5
S	14

Vector Representation

Landmine Disposal

It is required to collect and move the detected surface landmines to a box/built-in container or to a designated area at one of the competition arena corners. Therefore, each team can build their own remotely operated or autonomous mechanism, with different scores, to collect the surface landmines without any limitation on any system as long as safety rules are considered.

Mission score

- 10 points for detecting every buried metallic mine.
- 5 points for detecting every surface metallic mine.
- 10 points for each correct surface mine collected automatically.
- 5 points for each correct surface mine collected manually.
- 10 points for correct defining every buried metallic mine location.
- 5 points for correct defining every surface metallic mine location.
- 30 points for complete surf of field if 80% of mines are detected correctly.
- -5 points for wrong surface mine detection
- -10 points for passing over a buried mine without detecting it.
- -5 points for touching a surface mine by the robot randomly.
- -3 points failure in producing a light signal and/or a siren for a detected mine.

- -2 points for every minute reset time.

Extra bonus

- Note you can have only two bonus factors of the following:
  - The score will be multiplied by 1.2 for using Robot Operating System-ROS check it here
  - The score will be multiplied by 1.2 for using autonomous robot.
  - The score will be multiplied by 1.2 for using multi robot system check it here
  - The score will be multiplied by 1.2 for using Drones check it here

*check the score sheet in Appendix F.

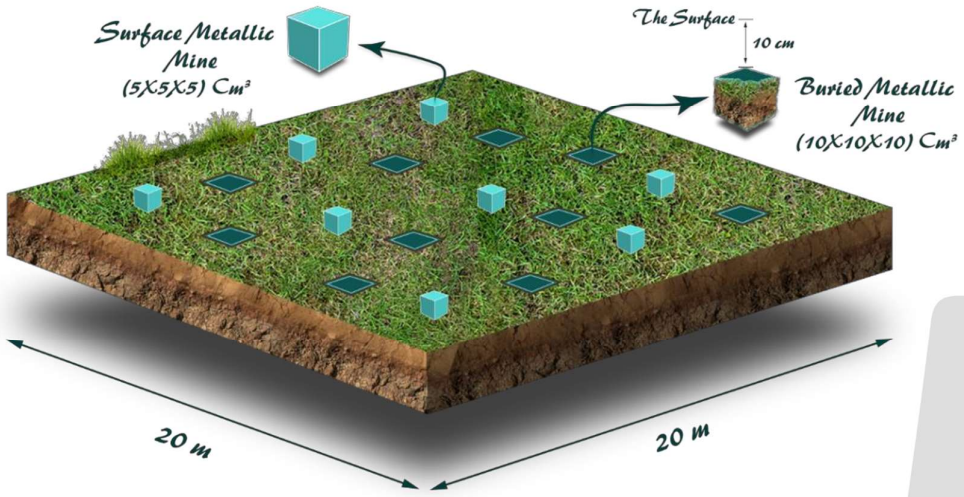
4.3. Junior Category

In this category, the following tasks are to be performed by the participating teams:

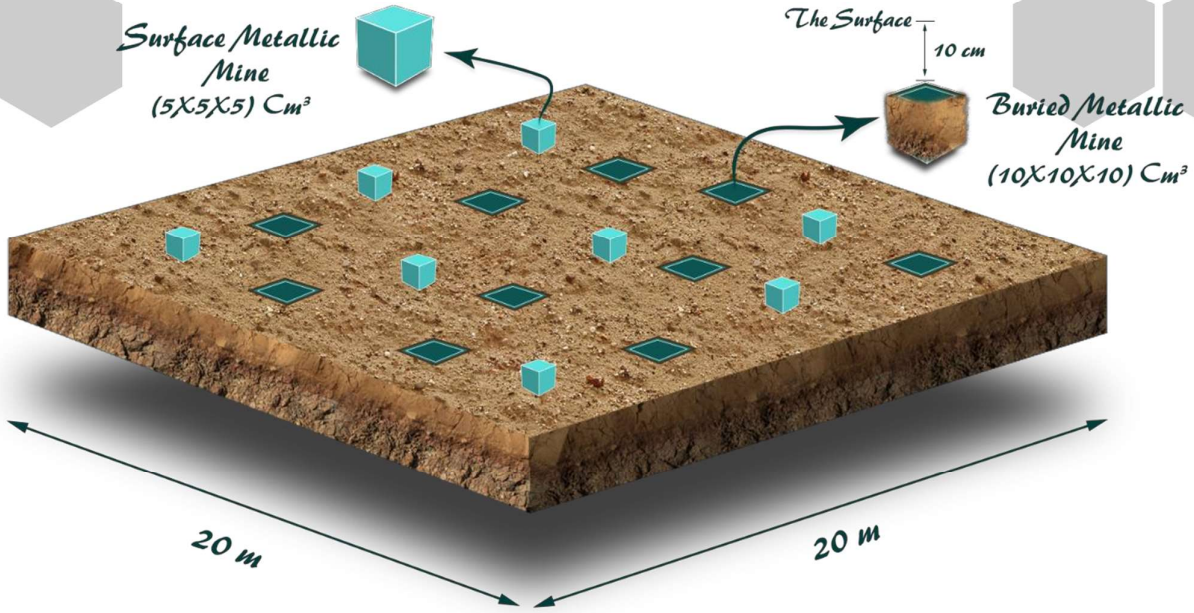
- Search for surface-laid and buried metallic objects of a cubical shapes using teleoperated or an autonomous ground/aerial vehicle. The vehicle has to able to navigate through rough environment that mimics a real minefield.
- Collecting and moving the detected surface landmines to a built-in container or to a designated area outside the competition arena using a teleoperated or autonomous grasping mechanism.

Minefield

The competition arema will be an area with a size of 20m x 20m, delimited by four GPS coordinates. The competition area will be marked only by plastic tape for visualization purposes to stop the robots from going outside the competition area, there will not be any flags or lines in the arena. There will be no mines in a stripe of 0.5 m of terrain along the borders of the competition area. Most of the arena may contain some of these; low grass with a few trees, some steep inclines, ditches, culverts and muddy water, or some sand, stones and as shown in the figures below.



"GRASS MINEFIELD"



"DESERT MINEFIELD"

The Mines

Two different kinds of artificial mines are used in this competition:

Buried Mines: These mines are made from metallic cubes, with approximate dimensions of 10x10x10 cm^3 (LxWxD). These mines are completely buried underground with maximum depth 10 cm. These buried metallic cubes mimic real anti-personnel (AP) blast mines. Real AP blast mines are deliberately designed to be small (typically 6-14 cm in diameter): this makes them cheaper and easier to store, carry and deploy. AP blast mines rely on the effect of explosive blast to damage the victim, and are designed to detonate when the victim steps on them. These mines are often buried in order to camouflage their presence.

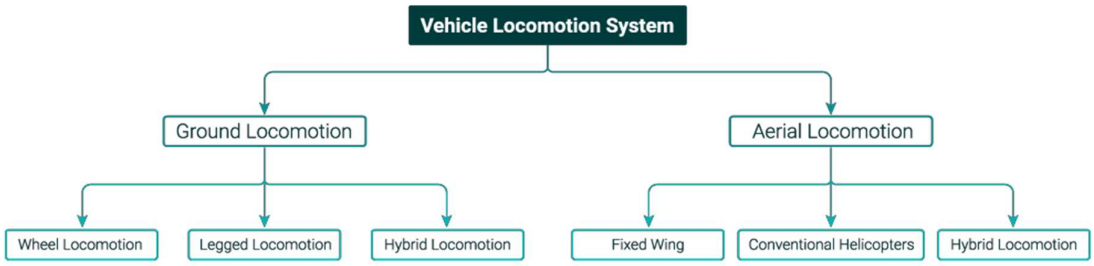
Surface Mines: These mines are made from metallic cubes, with approximate dimensions of 5*5*5 cm^3 (L*W*D) and labeled in black color. These mines are visible and are located on the surface of the competition area. These black metallic cubes are used to simulate above ground mines and unexploded ordnance (UXOs). *Unexploded Ordnance is a piece of explosive ordnance or ammunition that has failed to function as intended. Although they have failed to function as intended, UXO can sometimes require only the slightest disturbance to detonate. UXOs vary greatly in size from hand grenades the size of an apple to large aircraft bombs. The location of the surface mines will be changed every match.

Some landmines will be organized in a pattern for easier removal and accountability and others will be scattered randomly. The jury committee will know locations of each landmine.

The Robots

Each team must use a teleoperated or an autonomous robot per game. The robot has to be made by team members. Teleoperated robot must be operated remotely from a base station located outside the minefield.

The robot can be UGVs, UAVs with no limitations for size. Wireless controller based on ZigBee for example would be recommended to communicate the base station with the robot due to the large size of the field. In case of autonomous robots, all the actions of the robot must be completely autonomous without human intervention. Autonomous robot will be rewarded a 20% bonus over teleoperated robots. Careful attention must be paid to the robot locomotion systems, as the roughness of the terrain is very high. Both unmanned ground vehicles (UGVs) and unmanned aerial vehicles (UAVs) are allowed as illustrated in the figure below.



Unmanned ground vehicles can be wheeled, legged or hybrid. Wheeled robots include but are not limited to differential drive, tricycle drive, Ackerman steering, synchro drive, omnidirectional drive, Multi-Degree-of-Freedom (MDOF) vehicles, MDOF vehicle with compliant linkage or tracked vehicles. Legged robot can be uniped, biped, tripod, pentapod, quadruped or hexapod robot. Any types of hybrid locomotion can also be used. Examples of hybrid locomotion include a vehicle equipped with tracks for fast locomotion, and legs for more difficult terrain or flippers with self-cleaning tracks or legged vehicles with driving wheels attached to the end of each leg. UAV can be an alternative for the locomotion systems. As shown in above figure, UAVs can be classified into fixed wing, conventional helicopters and multi-rotor helicopters. Fix wind UAVs are naturally stable platforms capable of long flight times and extreme range. However, they are difficult to coordinate with slower ground systems. Conventional helicopters are common collective pitch model helicopters known for their excellent maneuverability and scalability. However they suffer from high level of complexity. Quad-rotors have the ability to hover and there are naturally stable and durable. However, they have limited pay-load. Ball-bots or UAVs that can land on a roving platform are also allowed. Robot can also be an unmanned aerial vehicle or a quad-rotor.

Robot can be actuated using electric, pneumatic or hydraulic actuation system, Diesel/Petrol engine or using solar energy.

Mines Detection

Each team can select their own set of sensors for detection of mines. When a robot detects a mine, it has to autonomously report this event using a light blinking signal or a warning siren.

Landmine Disposal

It is required to collecting and move the detected surface landmines to a box/built-in container or to a designated area outside the competition arena. Therefore, each team can build their own remotely-operated or autonomous mechanism to collect the surface landmines without any limitation on any system as long as safety rules are considered.

Mission Score

- 10 points for detecting every buried metallic mine.
- 5 points for detecting every surface metallic mine.
- 10 points for each correct surface mine collected automatically.
- 5 points for each correct surface mine collected manually.
- 30 points for complete surf of field if 80% of mines are detected correctly.
- -5 points for wrong surface mine detection
- -10 points for passing over a buried mine without detecting it.
- -5 points for touching a surface mine by the robot randomly.
- -3 points failure in producing a light signal and/or a siren for a detected mine.
- -2 points for every minute reset time.

Extra bonus

- Note you can have only two bonus factors of the following:
  - The score will be multiplied by 1.2 for using Robot Operating System-ROS check it here
  - The score will be multiplied by 1.2 for using autonomous robot.
  - The score will be multiplied by 1.2 for using multi robot system check it here
  - The score will be multiplied by 1.2 for using Drones check it here

*check the score sheet in Appendix F

4.4. ROS

To participate in the competition with ROS you must build the software of your robot system using Robot Operating System (ROS).

The competition mission with using ROS is the same as the mission in all classes shown previous with the score multiplied by 1.2 in the normal system

ROS is an open source platform that provides a set of software libraries and tools to help you build robot applications. It provides hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more. Building the robot based on ROS allows you to make use of interesting software module and the high fidelity simulator developed by the participants of the different editions of Humanitarian Robotics and Automation Technology Challenge (HRATC) organized by IEEE Robotics & Automation Society – Special Interest Group on Humanitarian Technology (RAS–SIGHT). Minesweepers is also organised under the auspices of IEEE RAS SIGHT

Hardware: You can build your own robot and make it ROS-enabled or you can use low-cost ROS-enabled robotic starter kits.

Software: You can write your own ROS code or you can download and use ROS Open Source Modules for Humanitarian Demining: SIGHT – Special Interest Group on Humanitarian Technology Open Repositories. You are encouraged to share the code in Minesweepers GitHub repo.

ROS Tutorials:

- What is ROS?

  ROS (Robot Operating System) is a flexible framework for writing robot software provides libraries and tools to help software developers create robot applications. It provides hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more. ROS is completely open source (BSD) and free for others to use, change and commercialize. It aims to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms and enable software developers to build more capable robot applications quickly and easily on a common platform.

- ROS Tutorials
- Video Tutorial
- ROS books

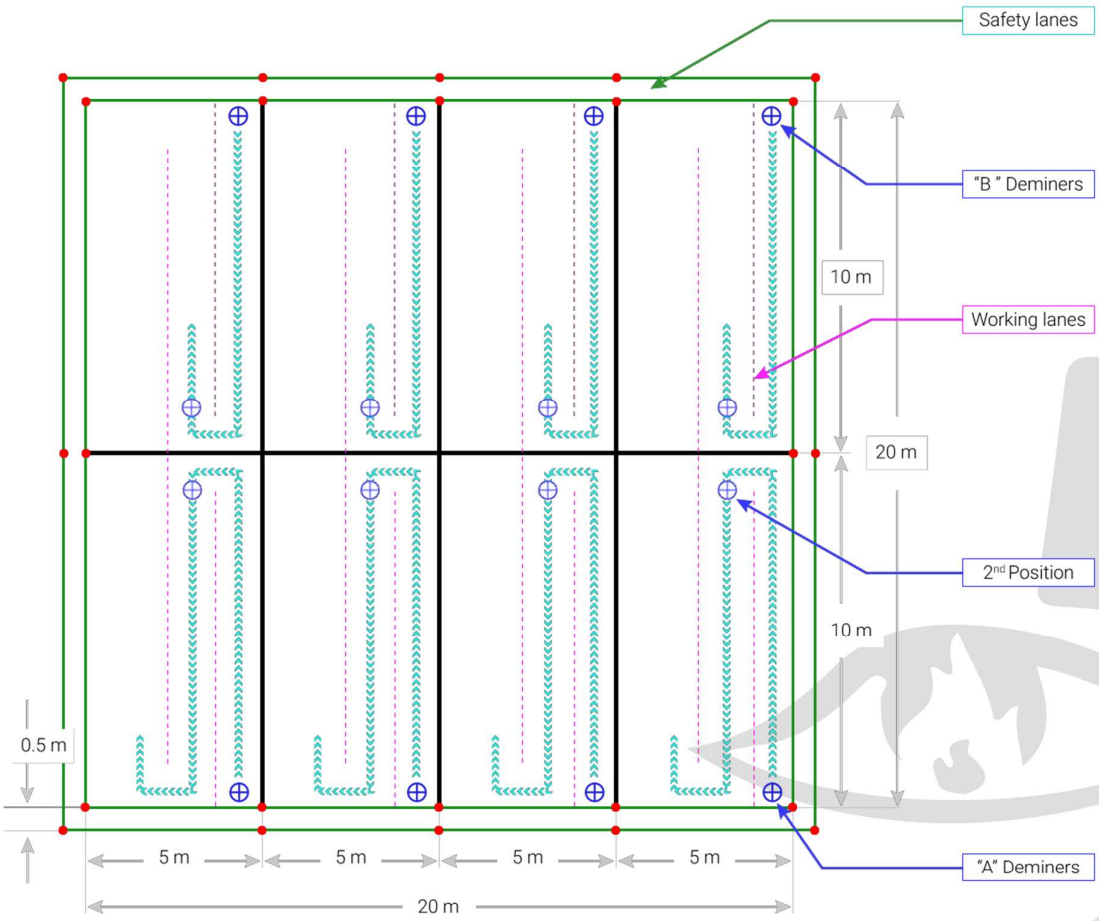
4.6. Multi-Robot Systems (MRS)

Multi-robot systems (MRS) are a group of robots that are designed aiming to perform some collective behavior. By this collective behavior, some goals that are impossible for a single robot to achieve become feasible and attainable. There are various foreseen benefits of MRS compared to single robot systems. These benefits include, but are not limited to the following [Khamis 2014]:

- Resolving task complexity: some tasks may be quite complex for a single robot to do or even it might be impossible. This complexity may be also due to the distributed nature of the tasks and/or the diversity of the tasks in terms of different requirements. Examples of these tasks include reconnaissance, surveillance, search and rescue.
- Increasing the performance: performance measures are application-dependent. However, and as an example, task completion time can be dramatically decreased if many robots cooperate to do the tasks in parallel. Spatial and/or temporal area/object coverage can be improved using multiple robots. Moreover, in some applications, these robots can cooperate to establish ad hoc communication relay network to improve radio coverage.
- Increasing reliability: increasing the system reliability through redundancy because having only one robot may work as a bottleneck for the whole system especially in critical times. However, when having multiple robots doing a task and one fails, others could still do the job.
- Simplicity in design: having small, simple robots will be easier and cheaper to implement than having only single powerful complex robot.

MRS can play a crucial role in humanitarian demining. According to the Standard Operating Procedures (SOPs) for humanitarian demining, human deminers use metal detectors to identify targets, which are then flagged for subsequent digging by a supervisor. The objective of this category is to mimic the conventional mag-and-flag approach or SOP using multiple unmanned teleoperated and autonomous vehicles. The arena of the competition is shown in the following figure. Teleoperated vehicles play the role of human deminers while an autonomous vehicle is used to mimic the supervisor/team leader's role. The team leader has to be equipped with a gripper or a marking mechanism to mark the location of the landmine detected by the deminers. More than one deminer can be integrated into the team but only one supervisor or team leader is allowed. If two deminers are used, these unmanned vehicles "A" and "B" are assigned to each lane as shown in the figure. Vehicle "B" starts to work after vehicle "A". If a deminer detected a surface-laid or a buried mine in its assigned lane, it has to produce a warning siren for at least 2 seconds and inform the team leader about the position of the detected mine. All the deminers have to stop and wait while the autonomous vehicle (the team leader) comes forward marks the detected mine with a red mark or flag and the scanning procedure continues until the entire arena is scanned.

If the team participate with using multi-robots system, the competition mission will be as mentioned before and not depending on the class it belongs to it.



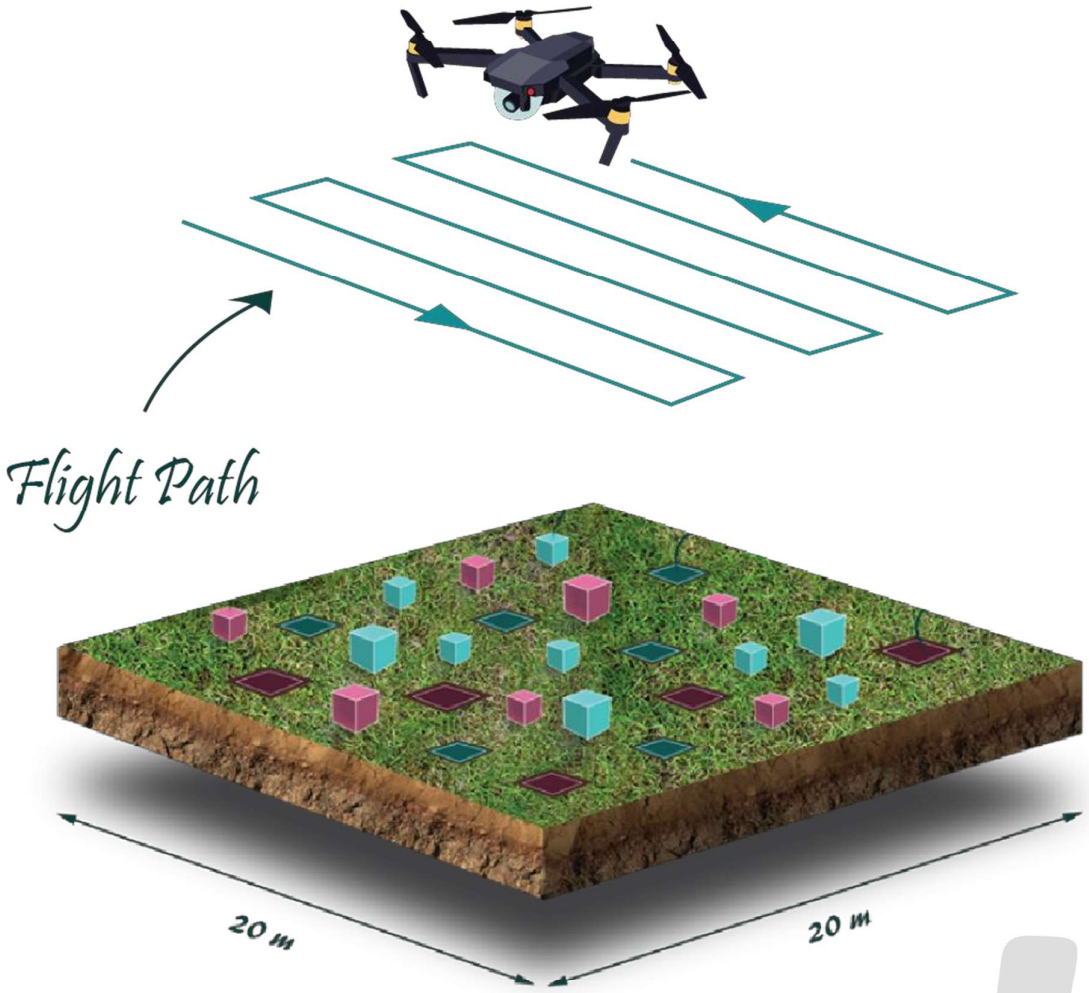
Mission Score:

- 10 points for detecting every buried metallic or non-metallic mine by the deminers.
- 5 points for detecting every surface metallic or non-metallic mine by the deminers.
- 10 points for each correct buried mine marking by the supervisor.
- 5 points for each correct surface mine marking by the supervisor.
- 30 points for complete surf of field if 80% of mines are detected correctly by the robot team.
- -5 points for wrong surface mine detection by the deminers.
- -10 points for passing over a buried mine without detecting it by the deminers
- -10 points for failure of correct buried mine marking by the supervisor.
- -5 points for failure of correct buried mine marking by the supervisor.
- -5 points for touching a surface mine by the deminer.
- -5 points for failure of collecting the mine.
- -5 points per deminer for failure of pausing the movement of the deminer after detecting the landmine and failure in waiting the supervisor.
- -3 points failure in producing a light signal and/or a siren for a detected mine by deminer.
- -2 points for every minute reset time.

*1.2 will multiply the whole score

4.5. UAVs/ Drones

UAVs/ Drones are allowed to be used in the competition to do the same tasks like the teleoperated or autonomous robots in all categories but if the team uses UAV, it will have 20% bonus score additional to the main missions score.



5. Appendices

5.1 Appendix A

MINESWEEPERS COMPETITION 2019

REPORT & VIDEO CONTENT AND INSTRUCTIONS

- Report

1- The team leader must send report with attached video before 1Jul 2019 for local teams, (1 Sep 2019 for international teams) at 11: 59 PM and no accepted reports a1fter this date and you will not compete in the finals without sending it.

2- Download the template from the competition website www.landminefree.org

3- Fill this template with font Arial and size 11 black and max six pages.

4- Add the video link at the end of the report and resend it in PDF Format to tech@landminefree.org with your team name, competition category and co. unity on the mail subject.

- Video

- Basics & notes to accept video

1- Period: 3 minutes (not less nor more)

2- Your video Title may contain team name, university, name of your device then followed by – The Minesweeper competition.

3- All videos should be uploaded to YouTube website then you should send the link (URL) attached with the report.

4- NO uploaded videos will be accepted [attached files or link (URL) from any other website]

5- You can use any kind of software that helps to improve video output like [Movie Maker – After Effects -...]

6- You can use music or sound effects but using it should not be covering any speaker voice in the video.

7- Putting your own team logo and university logo is also preferred.

8- Any Speaker in the video should represent himself and his role in the team.

9-Not necessary to make all team speakers in the video.

a. Language used is ENGLISH to talk or to write notes of captions on the video.

- Director view

1- Light, voice, camera used also any kind of tools should be tested before the first shots.

2- For voice improvements you can use these soft wares [Mixcraft – Audacity]

3- Using wired microphone is preferred for best voice output in the video.

4- Try to record voice separately to help you to improve the voice output.

5- Prepare a silent room to record the video and sound and do not forget to test everything before start to take first shots.

6- Training before the first shots is also preferred to get excellent video.

7- Don't forget that you have 3 minutes maximum so prepare a small scenario, using stopwatch could help you

8- Zooming in and out too much destroy your video.

9- Try to make many versions of video and select one of them to be your video.

- Technical view

The target of this video not just to be an expert of making movies but we as Minesweepers committee want to make sure that you show the specs of your robot and how it will compete the other robots in our competition.

1- Show your final works on your robot [new design – new idea – power & control circuits]

2- Build a small arena and show your robot detects mines.

3- Competition has many challenges, talk about your technical solutions for it.

4- If you did not finish your robot, just show us your power & control circuits, design of body using software and your final draft plan to finish this robot.

5- What problem has your team face to finish this robot?

- Spirit

Here you are some ideas to make your video better

1- Smile all the time in the video.

2- If you have slogan just say it.

3- Say that you will win the first place.

4- Say any word that inspired you to start this project.

5- Finish your video with a gathering photo for your time.

5.2 Appendix B

MINESWEEPERS COMPETITION 2019

PRESENTATION CRITERIA

For the top 8 teams qualified to finals stage, your team is required to give a 15 minutes oral presentation to a panel of professors from different universities. Your presentation should describe the engineering behind your vehicle's design and operation. It should also highlight any design innovations or creative solutions to solving the mission tasks. After the presentation, the judges will take 5 minutes to ask the members of your team questions about your Robot. The judges will evaluate both your presentation and responses to their questions.

Who presents?

All members of your team must participate in this presentation and question and answer period. You are required to have your robot with you. Your mentor is allowed to attend the presentation but not allowed to participate in presenting or answering questions.

You should talk about:

- Over all system / robot.
- Your mechanical design and locomotion system.
- Sensors and landmine detection mechanism.
- Aggregation and marking mechanisms.
- Electronics / control system and used platform.
- Mapping and localization systems.
- Arena navigation plan.
- Rough environment and high heat facing.
- Your team, budget and working plan.
- Your vision or plan after the competition.

Preparing for your engineering presentation and evaluation

- You are free to make your presentation oral only or with printed flyers or with PowerPoint or Prezi or any other software tools but you must get your laptop or notebook with you as we will provide only the data show facilities.
- Make sure that every member of your team has a good, general working knowledge of your vehicle, even though they may have specialized in one specific aspect of its design and construction.
- Research the specifications of the components that you use in your vehicle.
- Freely share information among the members of your team

- Produce clear, simplified diagrams that you may choose to use in your presentation.
- Make sure that your vehicle is complete and in working condition for the presentation.
- Make sure that all the members of your team are familiar with your technical report. Ask every member to read it over to catch any errors or omissions. This exercise will help to familiarize everyone with all aspects of the project.
- Practice your presentation so that you become comfortable speaking in front of other people in a coherent and organized way. Generally, you will have more to say about your Robot than can be presented in 15 minutes. That is why it is critical to organize your material and practice communicating it. Ask instructors or mentors to give you feedback. However, avoid coming across as having memorized your presentation verbatim. Judges want to see that you are prepared and understand the information, not that you can simply regurgitate a rehearsed speech from memory.
- When your team is prepared and knows the material well, you will all be more comfortable and confident. This will come across favorably to the judges.
-

5.3 Appendix c

MINESWEEPERS COMPETITION TECHNICAL REPORT

[Team Name]

Team Logo or members' photo or robot photo (5 Points)

[University/School]

[Supervisor/Mentor]

[Competition Category]

[Country]

Abstract [Overview about robot/system] [250 words] (5 Points)

Describe your mechanical design and locomotion system [250 words + image] (10 Points)

Describe the landmine disposal and marking mechanisms [250 words] (10 points)

Describe sensors and how can it detect landmines? [250 words] (10 Points)

Describe your electronic circuit/control system/platform used [Teleoperated/Autonomous] [250 words + image] (10 Points)

Put your plan to navigate the whole arena [250 words] (10 Points)

Describe how to provide the map of detected mines? [250 words] (10 Points)

How to face the rough environment and the high heat? [250 words] (5 Points)

Put your Video YouTube link here:

5.4 Appendix D

MINESWEEPERS COMPETITION 2019

REPORT & VIDEO SCORE SHEET

TEAM NAME:	UNIVERSITY/SCHOOL:
(Academia / juniors / Industry)	JUDGE:

Total: 75 points Report + 25 points video = 100 points

1- Team Logo or members' photo or robot photo (max 5 Points)

		1	2	3	4	5
Team photo or Logo or robot photo	[REPRESENTED OR NOT]					
Team name & University	[REPRESENTED OR NOT]					

2- Abstract [Overview about robot/system] [250 words] (max 5 Points)

		1	2	3	4	5
Excellent	[[BRIILIANT IDEA & CONCEPT]					
Very good	[JUST NEW CONCEPT & GOOD DESIGN]					
Good	[WILL DO THE JOB]					
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]					

3- Mechanical design and locomotion system [250 words + image] (max 10 Points)

		1	2	3	4	5	6	7	8	9	10
Excellent	[[BRIILIANT IDEA & CONCEPT]										
Very good	[JUST NEW CONCEPT & GOOD DESIGN]										
Good	[WILL DO THE JOB]										
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]										

4- Landmine disposal and marking mechanisms [250 words + image] (max 10 Points)

		1	2	3	4	5	6	7	8	9	10
Excellent	[[BRIILIANT IDEA & CONCEPT]										
Very good	[JUST NEW CONCEPT & GOOD DESIGN]										
Good	[WILL DO THE JOB]										
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]										

5- Sensors and how can it detect landmines? [250 words] (Max 10 Points)

		1	2	3	4	5	6	7	8	9	10
Excellent	[[BRIILIANT IDEA & CONCEPT]										
Very good	[JUST NEW CONCEPT & GOOD DESIGN]										
Good	[WILL DO THE JOB]										
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]										

6- Electronic circuit/control system/platform used [Tele-operated/Autonomous]

[250 words + image] (Max10 Points)

		1	2	3	4	5	6	7	8	9	10
Excellent	[[BRIILIANT IDEA & CONCEPT]										
Very good	[JUST NEW CONCEPT & GOOD DESIGN]										
Good	[WILL DO THE JOB]										
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]										

7- Put your plan to navigate the whole arena [250 words] (max 10 Points)

		1	2	3	4	5	6	7	8	9	10
Excellent	[[BRIILIANT IDEA & CONCEPT]										
Very good	[JUST NEW CONCEPT & GOOD DESIGN]										
Good	[WILL DO THE JOB]										
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]										

8- Describe how to provide the map of detected mines? [250 words] (Max 10 Points)

		1	2	3	4	5	6	7	8	9	10
Excellent	[[BRIILIANT IDEA & CONCEPT]										
Very good	[JUST NEW CONCEPT & GOOD DESIGN]										
Good	[WILL DO THE JOB]										
Poor – Missing	[NOT REPRESENTED OR POOR OF DATA]										

9- How to face the rough environment (sandy soils or rocky) and the high heat? [250 words] (Max 5 Points)

		1	2	3	4	5
Excellent	[[BRIILIANT IDEA & CONCEPT]					
Very good	[JUST NEW CONCEPT & GOOD DESIGN]					
Good	[WILL DO THE JOB]					
Poor –Missing	[NOT REPRESENTED OR POOR OF DATA]					

10- VIDEO score sheet total (Max 25 points)

Director view (Max 7 points)

	1	2	3	4	5	6	7
Using intro and after effects							
Video resolution							
Scenario and video sequence							

Technical view (Max 16 points)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Robot works on simulated arena – just body or design																
Power & control circuit is showed on video																
Overall technical content & concept																
spirit of team																

	1	2	3	4	5
10- Extra Points					
11- Deduction Points					
Total Points =					

5.5 Appendix E

MINESWEEPERS COMPETITION 2019

PRESENTATION SCORE SHEET

Team Name:..... Judge Name:.....

Evaluation parts	score
Teamwork and presentation(5)	
Overall Mechanical Design and Locomotion System (5)	
Landmine disposal/ marking mechanisms (5)	
Sensors and landmine detection mechanism (5)	
Systems Design and Operation (5)	
Control and Electrical System (5)	
Mapping and Localization System (7)	
Arena Navigation Plan (5)	
Rough Environment and High Heat Facing (5)	
Budget / Working Plan (5)	
Design Evaluation (5)	
Bonus (3)	
Total (50) not including bonus points	
10% ofthe score	

Comments: ----------

5.6 Appendix F -

MISSION SCORING SHEETS MINESWEEPERS COMPETITION 2019

JUNIOR SCORING SHEET

Team name: judge name:

Action	Count	Unit/Subtotal	Score
Weight check the robot weight must not exceed 40Kg			
Above 40kg	Yes No	Disqualified	
Arena Score: The following score will be based on the performance of the robot in the competition arena and will be observed and calculated by the in-field judge.			
Detected Surface Mines		5	
Detected Underground Mines		10	
Completely Scan the field and 80% of Mines Detected (Systematic Motion)	Yes No	30	
Collected surface mine automatically	Yes No	10	
Collected surface mine manually	Yes No	5	
Wrong Detection of a Mine		-5	
Passover Buried Mine without Detection		-10	
Touching Surface Mine randomly		-5	
No light signal and/or a siren		-3	
Reset Time (-2/1min)		-2	
Mine field score:			
Autonomous robot	Yes	Multiply*1.2	
Running with ROS	Yes	Multiply*1.2	
Multi-robots system	Yes	Multiply*1.2	
Using UAV	Yes	Multiply*1.2	
Final score:			

MINESWEEPERS
TOWARDS A LANDMINE-FREE WORLD

MINESWEEPERS COMPETITION 2019

ACADEMIA SCORING SHEET

Team name: judge name:

Action	Count	Unit/Subtotal	Score
Weight check: The robot weight must not exceed 40Kg			
Above 40kg	Yes No	Disqualified	
Arena Score: The following score will be based on the performance of the robot in the competition arena and will be observed and calculated by the in-field judge.			
Detected Surface Mines		5	
Detected Underground Mines		10	
Completely Scan the field and 80% of Mines Detected (Systematic Motion)	Yes No	30	
Collected surface mine automatically	Yes No	10	
Collected surface mine manually	Yes No	5	
Wrong Detection of a Mine		-5	
Passover Buried Mine without Detection		-10	
Touching Surface Mine randomly		-5	
No light signal and/or a siren		-3	
Reset Time (-2/1min)		-2	
Mine field score:			

Mine Map Score: A mine map (in vector or graphical format) must be created automatically by the robot system and presented to the out-field jury committee by the team representative to calculate the following scores:			
Mine Map True Positive for Surface Mines (a minefield cell contaminated by surface mine is labeled in the map as a cell with surface mine or the position of the mine X,Y and mentioning it is surface)		5	
Mine Map True Positive for buried Mines (a minefield cell contaminated by buried mine is labeled in the map as a cell with buried mine or the position of the mine X,Y and mentioning it is buried)		10	
Mine Map False Negative for Surface or Buried Mines (a minefield cell contaminated by surface or buried mine is labeled in the map as a clean cell)		-5	
Mine Map False Positive for Surface or Buried Mines (a clean cell in the minefield is labeled as contaminated by surface or buried mine is the mine map)		-5	
Mine map score:			
Total score:			
Autonomous robot	Yes	Multiply*1.2	
Running with ROS	Yes	Multiply*1.2	
Multi-robots system	Yes	Multiply*1.2	
Using UAV	Yes	Multiply*1.2	
Final score:			

MINESWEEPERS
TOWARDS A LANDMINE-FREE WORLD

MINESWEEPERS COMPETITION 2019

INDUSTRIAL SCORING SHEET

Team name: judge name:

Action	Count	Unit/Subtotal	Score
Weight check: the robot weight must not exceed 40Kg			
Above 40kg	Yes No	Disqualified	
Arena Score: The following score will be based on the performance of the robot in the competition arena and will be observed and calculated by the in-field judge.			
Detected Surface Mines		5	
Detected Underground Mines		10	
Completely Scan the field and 80% of Mines Detected (Systematic Motion)	Yes No	30	
Collected surface mine automatically	Yes No	10	
Collected surface mine manually	Yes No	5	
Wrong Detection of a Mine		-5	
Passover Buried Mine without Detection		-10	
Touching Surface Mine randomly		-5	
Failure for collecting mine		-5	
No light signal and/or a siren		-3	
Reset Time (-2/1min)		-2	
Mine field score:			

Mine Map Score: A mine map (in vector or graphical format) must be created automatically by the robot system and presented to the out-field jury committee by the team representative to calculate the following scores:			
Mine Map True Positive for Surface Mines (a minefield cell contaminated by surface mine is labeled in the map as a cell with surface mine or the position of the mine X,Y and mentioning it is surface)		5	
Mine Map True Positive for buried Mines (a minefield cell contaminated by buried mine is labeled in the map as a cell with buried mine or the position of the mine X,Y and mentioning it is buried)		10	
Mine Map False Negative for Surface or Buried Mines (a minefield cell contaminated by surface or buried mine is labeled in the map as a clean cell)		-5	
Mine Map False Positive for Surface or Buried Mines (a clean cell in the minefield is labeled as contaminated by surface or buried mine is the mine map)		-5	
Mine map score:			
Total score:			
Autonomous robot	Yes	Multiply*1.2	
Multi-robots system	Yes	Multiply*1.2	
Using UAV	Yes	Multiply*1.2	
Final score:			