

World Robot Summit
Harsh Environment F-REI Challenge
Standard Disaster Robotics Drone Challenge (STM)
Rules Ver.1

2025/01/08

These rules may be modified.
See <http://worldrobotsummit.org/> for the latest version.

1. Outline

1.1 Objectives

Standard Test Methods for performance (STM) for disaster response robots and drones developed by U.S. National Institute of Standards and Technology (NIST) supports social implementation of disaster response robots and drones using a repeatable, reproductive, low-cost, and quantitative evaluation process. In Japan, the standard performance evaluation methods for drones under restricted environmental conditions, such as confined spaces, GPS-less environment, or low visibility, has been developed as part of the Realization of Advanced Air Mobility (ReAMo) project of New Energy and Industrial Technology Development Organization (NEDO). The Standard Disaster Robotics Drone Challenge (hereinafter referred as STM Drone Challenge), aims to promote the social implementation of drones in harsh environments by adding harsh environment factors to the projects and methods developed by NIST and NEDO ReAMo.

Acknowledgement: We would like to thank the U.S. NIST STM development team (Team Leader: Adam Jacoff) and R&D of performance evaluation methods for drone under restricted environmental conditions of ReAMo project (Consortium Supervisor: Noritaka Satoh) for their technical advice.

1.2 The Number and Configuration of Robot

- ☐ The number of robots is unlimited.
- ☐ Any form of mobility will be allowed, as long as the tasks in the field can be carried out.
- ☐ Either remote controlled or autonomous robots are acceptable. Operators will not be able to see the robots and fields in their direct line of sight.
- ☐ The maximum gross weight must be under 10kg.
- ☐ Robots and all attachment devices must fit within a rectangular prism with the sum of its three orthogonal edge lengths amounting to 1.5 meters.
- ☐ Guards (e.g., propeller guards) are to be placed if robots have rotary wings.
- ☐ Robot operator: 1 person (switching operators during the competition is allowed).
Navigator (supporting operator): 1 person.
- ☐ During the robot inspection, in the inspection booth (photo booth), a sticker/seal will be attached to the robot, which will indicate that the robot is a competition robot. The competitors are not to remove the seal/sticker during the competition. Once the sticker is attached, no further robot configuration will be allowed.
- ☐ Extra points will be awarded for robots with environmental resistance.
 - 1) Water resistance: submitting a copy of the certificate verifying resistance to water, awards x2 points.
 - 2) Explosion resistance: submitting a copy of the certificate verifying resistance to explosion, awards x2 points.
- ☐ Only robots and control systems listed on the previously submitted Team Description Paper will

be allowed.

- ☐ Only robots and control systems that have passed the robot inspection in advance will be allowed.
- ☐ Changing the robot's configuration is prohibited, unless indicated during the robot inspection.
- ☐ Only safe batteries (batteries that have been certified as safe) can be used during the competition.
- ☐ View-sharing of control monitors including devices on autonomous operation should be outputted using an HDMI via first-person view (FPV) monitor with referees and audience during the competition. If view-sharing is not possible, competitors will only receive 80% of the total score (the score will be multiplied by 0.8).
- ☐ The teams are required to be prepared and respond in case of an abnormal situations, such as a robot catching fire.
- ☐ The teams are required to keep the law of the host country such as the Wireless Radio Act in Japan.

1.3 Contents of Evaluation

For the WRS2025, the following four performances will be evaluated. These evaluations are inspired by the performance test methods of NIST, NEDO ReAMo, and the Robocup competition.

Mobility (MOB): To evaluate the number of round trips in competition field.

Exploration (EXP): to evaluate the degree of task accomplishment.

Mapping (MAP): To evaluate the ability of map creation, position estimating and comprehension for search objects, and embedding information into the map.

Autonomy (AUT): To evaluate autonomy of **MOB** and **EXP**. Response for communication delay (**COM**) is also evaluated as **AUT**.

Competition Time

Preliminaries: 20 mins (prep 5 mins, **MOB** 5 mins, **EXP** 5 mins, clearing the field 5 mins)

Semifinal: 30 mins (prep 5 mins, **MOB** 10 mins, **EXP** 10 mins, clearing the field 5 mins)

Final: 30mins (prep and clearance 5 mins, **MOB** 10 mins, **EXP** 15 mins)

2. Competition field

The competition is carried out in four fields. Each field will have a dynamic change in environment. Mobility (**MOB**) is evaluated in the first half of competition, and Exploration (**EXP**) is evaluated in the second half. Autonomy (**AUT**), including Communication Delay (**COM**), is evaluated by autonomy of **MOB** and **EXP**. Mapping (**MAP**) is evaluated by map creation, position estimating and comprehension for search objects, and embedding information into the map. In addition, harsh environment factors are added to the fields according to competition stages (preliminary round, semifinal, and final).

2.1 Horizontal Slalom in Confined Space

Outline: A confined space simulating a disaster site, used to evaluate left and right maneuverability

going through vertical wall openings. The field is a closed space of 2-3m in width, 2-3m in height, and 10-15m in depth (5-7.5m in depth may be used in preliminary round) with vertical walls inside. Each wall has rectangular opening, 2-3m in height and 1-1.5m in width, which will be placed on the left or right alternatively. In this field, **MOB** performance will be evaluated through the horizontal slalom performance.

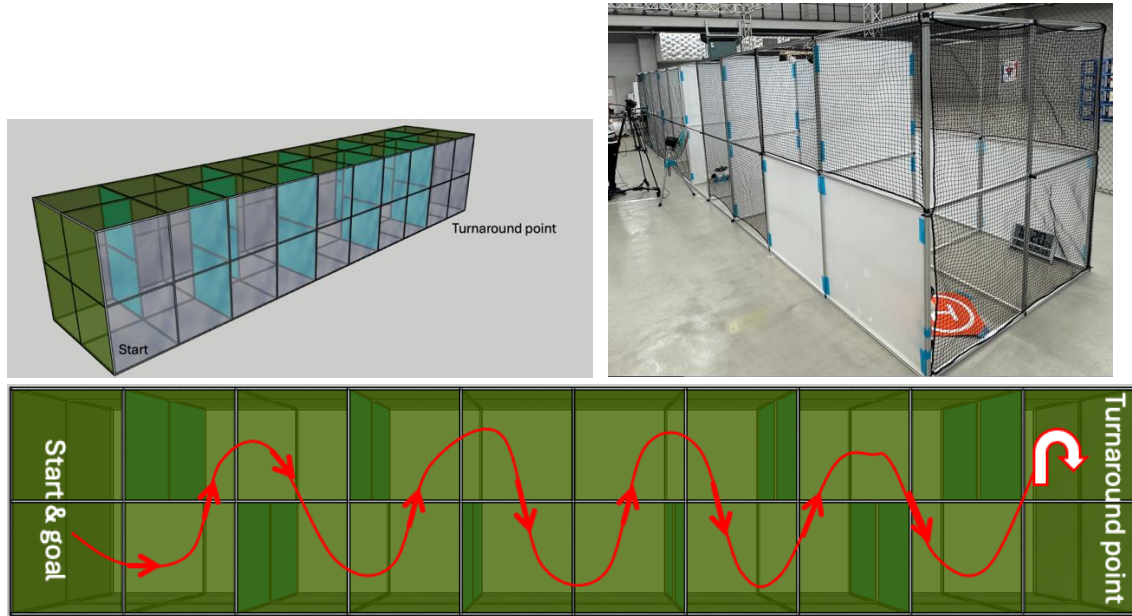
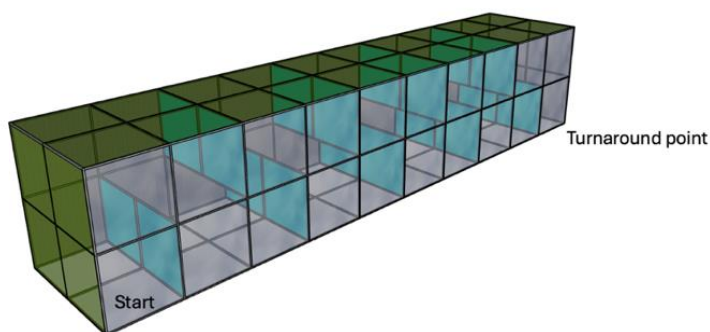


Fig 2: Horizontal Slalom in Confined Space (Overhead view and route. Photo taken from the 2024 Trial Competition, rough sketch)

2.2 Vertical Slalom in Confined Space

Outline: A confined space simulating a disaster site, used to evaluate up and down maneuverability going through vertical wall openings. The field is closed space of 2-3m in width, 2-3m in height, and 10-15m in depth (tentative plan) with 2-3m x 2-3m walls inside. Each wall has rectangular opening, 1-1.5m in height and 2-3m in width, which will be placed on the top or bottom alternatively. In this field, **MOB** performance will be evaluated through the vertical slalom performance.



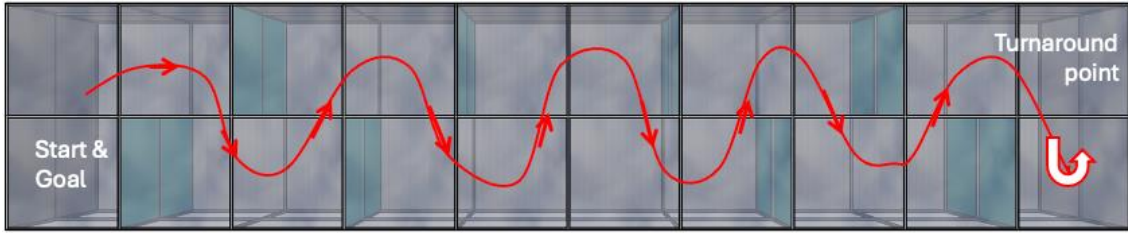
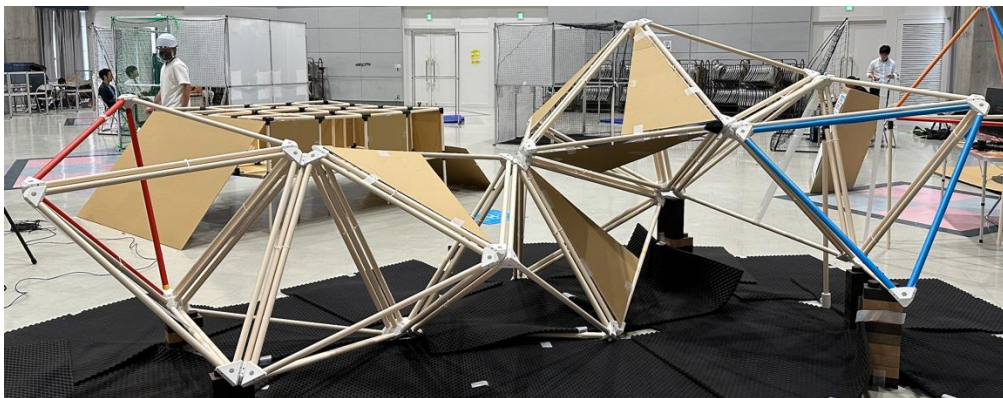
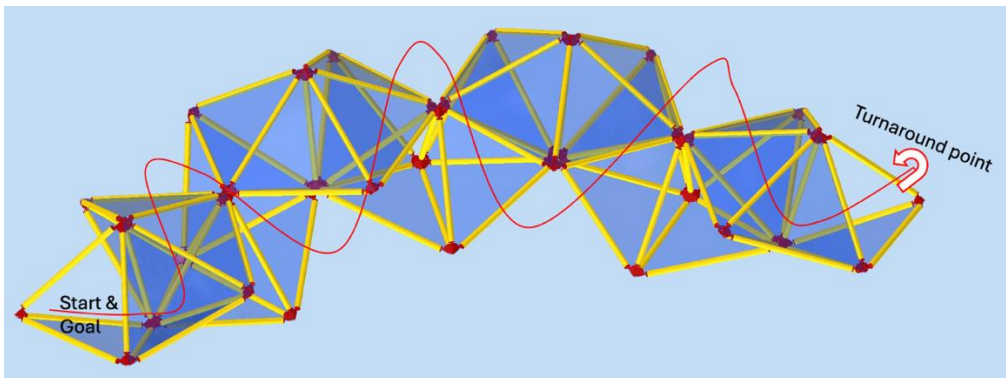


Fig 3: Vertical Slalom in Confined Space (Inner view and route, rough sketch)

2.3 Truss Field

Outline: While horizontal and vertical wall openings may appear in a disaster sight, collapsed buildings are sure to also have inclined/sloped wall openings. To simulate such inclined openings, this field has trusses with regular tetrahedrons and triangular prisms of pipes. A side length of a truss is 1.5m, which varies from 1m to 2m. Obstacles will be placed inside the truss field. In this field, **MOB** performance will be evaluated by going and returning through regular tetrahedrons. To satisfy the **MAP** or **AUT** performances, recognition of three-dimensional structure is required.



Truss Field Example: Details regarding the field will be unveiled on the day of competition

2.4 Complex Field (Secret Field)

Outline: A customized field combining basic elements from competition fields 1, 2, and 3. The field will be unveiled on the day of the competition.

3. Performance Evaluation

3.1 Mobility (**MOB**): The number of round trips of each field is evaluated (scored) in the first half of competition (preliminary round 5min, semifinal and final 10min). There is no limit to the round trips within the prescribed time.

□ Points: 1 point per one round-about (the starting point to the turnaround point, and back). x2 points will be granted for overcoming communication delay (**COM**), and demonstration of autonomy (**AUT**) will be awarded x10 the points.

➤ Land in port facing the Cold Zone timeclock so it is visible in the FPV monitor.

□ Point allocation for harsh environment factors

➤ Receive extra points by choosing to pass through routes that contain harsh environment elements.

✧ Ex) Wind (**WIN**), **NEG**

3.2 Exploration (**EXP**): Degree of task completion is evaluated (scored) in the second half of the competition (preliminary round 5min, semifinal 10min, and final 15min).

□ Sensing Mission: Object Sensing **PCP**

➤ Thermal Image Acuity (5pt)

➤ Hazmat Label Identification (4pt for Auto, 1pt for visual)

➤ Motion Detection *Auto Only (3pt)

➤ Visual Image Acuity QR Code *Auto Only (1pt)

➤ Proximity Sampling Magnetometer (2pt)

➤ Crack *Auto Only (3pt)

Recognize automatically a width, length, and position of a curving line set on 10cm x 10cm square shaped model (replicating a crack), and display a text indicating the width and length for a referee to confirm.

➤ Rust *Auto Only (3pt)

To recognize automatically painting area set on 10cm x 10cm square shaped model (replicating rust), and display a text indicating the degree of rust for a referee to confirm.

□ Dexterity **DEX** (tasks **INS**, **ACU**, **SMP**, **WIP**, **PRC**)

Dexterity tasks are each designated a basic point count; however, it is possible to score higher points by combining into the scenario harsh environment factors, perch, or utilizing autonomy function. The number of buckets to be placed in the field is not fixed.

➤ **INS**: Confirming the bottom of a pair of buckets (robot position control).

✧ Visually confirm and display on the FPV monitor the ring on the bottom of the buckets.

- ✧ The operator is to call out to the referees when a visual confirmation is obtained. Once the referees confirm the visual, the referee will call back to the operator the score received from the visual.
- ✧ Visual confirmation of the pair buckets, separately or simultaneously (basic score: 1 point)
- ✧ Bonus points will be awarded if visual confirmation was obtained simultaneously (x2 the basic score).
- ✧ The operator is to save the visual confirmation image of the bottom of the buckets, and submit the photos after the competition.
- **ACU:** Read the Landolt ring inside the buckets
 - ✧ Receive points for 5-positions Landolt rings (basic score: 1 point).
 - ✧ The operator is to save the visual confirmation image of the bottom of the buckets, and submit the photos after the competition.
- **SMP:** Contact and retrieve samples operation
 - ✧ Come into contact with samples placed in the field using the robot end effector (during the robot inspection, show the end effector, can be detachable and changeable) (basic score: 1 point).
 - ✧ Collect the sample into the robot (basic score: 10 points).
 - ✧ Collect the sample and retrieve it to the designated Cold Zone location (basic score: 10 points).
 - ✧ The samples will be glass marbles of different sizes and weights.
- **WIP:** Wipe clean
 - ✧ Wipe down 10cmx10cm tiles (20 points per surface).
A 10cmx10cm tile with a white board sheet placed over it, will be divided into four 5cmx5cm sections, drawn and filled in with a marker. The boards are to be completely wiped off. Pipes (etc.) will be placed around the **WIP** boards to be used as perching areas.
 - ✧ Collect the wiping area components (identify color of marker and location) (20 points).
- **Parch** **PRC** (10~20 degree incline (**INC**), 90 degrees vertical (**VRT**), 180 degrees ceiling (**CEL**)). Exemplify extended time period exploration performances by carrying out missions (**PCP**, **DEX**) in a perch position to reduce power consumption.
 - ✧ Carry out tasks by staying still on placed horizontal pipe barstools (with an estimated 20mm-40mm diameter) used as perching areas (every task type carried out in this manner will increase the basic score. **INC** score x5, **VRT** score x10, **CEL** score x10)
 - ✧ Hot Perch: In case a robot has rotary wings, its is possible to complete the tasks without halting the propulsion.
 - ✧ Cold Perch: The score will be doubled in case the propulsion system is deactivated.
- For non-autonomous exploration tasks, x2 points will be granted for overcoming communication delay (**COM**), and demonstration of autonomy (**AUT**) will be awarded x10 the points.

3.3 Mapping (**MAP**): The ability of map creation, position estimating and comprehension for search object, and embedding information into the map are evaluated. Explanation of mapping may be required for referees' evaluation.

□ Mapping **MAP**

50 points will be awarded for field mapping.

□ Embedding **EMB**

Embed the position and comprehension of buckets, collected samples, visual confirmation test objects, and wiping area test components, into the map. 10 points will be granted for each target/component/object. The report must be converted to the coordinate system for the original field and global coordinates, which will be provided.

3.4 Autonomy (**AUT**): Autonomy on **MOB** and **EXP** is evaluated according to levels of autonomy. The levels of evaluation are communication disruptions (**COM**) and complete autonomy (**AUT**), where x2 points will be granted for overcoming communication delay (**COM**), and demonstration of autonomy (**AUT**) will be awarded x10 the points. As the **COM** will be implemented via TCP/IP vSTING model [1] (article: GitHub: [Team-Dynamics/vsting-sa](https://github.com/Team-Dynamics/vsting-sa)), Only control systems that compatible/can intervene with this system will be allowed.

[1] Manuel Patchou, Janis Tieman, Christian Arendt, Stefan Böcker, and Christian Wietfeld, [Realtime Wireless Network Emulation for Evaluation of Teleoperated Mobile Robots](#), In *IEEE Symposium on Safety, Security, and Rescue Robotics (SSRR)*, 2022.

3.5 Harsh Environment Factors

Each field is initially equipped with harsh environment factors such as space restriction, confined and closed space, and GPS-less environment. In addition, Autonomy (**AUT**) as a response to communication delay or shutdown (**COM**) is required. Moreover, extended period of flight durability is required as robots are required to fly to the designated points (starting/turnaround) for battery change purposes.

The following factors are expected to be introduced in the competition.

- **Confined Openings (TRA)**: Regular triangle of side length 90cm openings and/or 1m x 1m square openings on vertical or horizontal wall in between the field, start point, and halfway point. 3 points will be awarded for passing through triangles. Triangular openings are based on fire-fighting breaching opening shapes.
- **Wind (WND)**: Creating wind in certain segments of competition field. The purpose of the wind is to disturb robot functions, especially UAV (**MOB**: 5 pt for each passing, **DEX**: with wind, basic score x 5). In **MOB**, a route to avoid the strong wind may be constructed.

- ❑ **Closed Space:** Carry out **EXP** in certain segments surrounded by walls with only one regular triangle of side length 90cm opening or 60cm x 60cm square opening. Rotary wings generate the turbulence in closed space (basic score x5 for each task of **EXP**).
- ❑ **Dust (Powder of Piece of Paper):** Pieces of paper will be placed in different segments, and will be scattered and lifted by the downwash from the propellers in the closed space (basic score x7 for each task of **EXP**).
- ❑ **Smoke:** Filling certain segment of closed space with smoke. Smoke will be generated by fog machine or dry ice.
- ❑ **Strong Light:** A strong light source or natural light will be set up in certain segments of the competition field (basic score x2 for each task of **EXP**).
- ❑ **Darkness:** Dark areas will be arranged in certain segments of the field. If there is dark point in field, all robots is required to pass it in **MOB**.
- ❑ **Negotiate (NEG):** Requiring to make space by touching movable wall or rope-shaped obstacles set up on the route the robot is taking (**MOB**: 5pnt for each successful pass). A route to avoid these opening may be constructed.
- ❑ **Rain (Waterproof/drip-proof):** There is possible that a Rainfall Test will take place during the RTF indoor test field. However, this requires water-resistance not only for robots, but also for competition field. Therefore, if robots have any water-resistance qualities, all scores may be doubled by presenting proof, i.e. a copy of a certification verifying water resistance.
- ❑ **Combustible Material (Explosion-proof):** Simulating combustible material or explosive substance. However, this is hard to implement from a safety perspective. Therefore, if robots have any explosion resistance, all scores may be doubled by presenting proof of resistance, i.e. a copy of a certification verifying explosion resistance.

4. Competition Schedule

- ❑ Outline (Scheduled)
 - October 9th-10th Preliminary Round
 - October 11th Semifinal
 - October 12th Final
- ❑ Competition Time (Approximate Time)
 - Preliminary round: 20min (prep 5min, **MOB** 5min, **EXP** 5min, clearing the field 5min)
 - Semifinal: 30min (prep 5min, **MOB** 10min, **EXP** 10min, clearing the field 5min)
 - Final: 30min (prep/clearance 5min, **MOB** 10min, **EXP** 15min)
 - Teams participating semifinal are selected by the result of preliminary round. Competition of semifinal is different from preliminary round.
 - Teams participating final are selected by the result of semifinal. Competition of final is different from preliminary round and semifinal.

5. Score

From the points acquired from every task (raw points), the team with the highest raw point count will be used as a measure to normalized to a 100-point common scale (normalized points), which will then be used to calculate the points acquired by each team.

6. Team Member

A team may have a maximum of 6 members, which are required to register in advance. Only team members may enter the paddock area (waiting area).

The roles of team members are as follows:

- ☐ Team Leader (1): Representative of the team. Objections or complaints regarding the competition result is to be carried out by team leader.
- ☐ Robot Operator: The team member to operate the robot. Operators can change under the following rules during competition.
 - All operators should be registered to the competition in advance.
 - Only 1 operator can operate the robot during the competition.
 - During competition, all other operators should wait around control desk.
 - Communication with other members except navigator is prohibited.
 - Operator switch is allowed only when UAV is not flying.
- ☐ Navigator: The team member that discusses and advices regarding the operating plan with the operator. Navigators and operators can switch with each other. However, it is prohibited for both of them to see the field directly. Navigators are prohibited from communicating with other members of the team except the operator.
- ☐ Network Manager: The team member in charge of controlling and managing the network.
- ☐ Safety Manager: The team member in charge of managing the safety of members and robots, while also responsible for carrying robots to the start point or from the re-start point on resetting.
- ☐ Tetherer: The team member in charge of tethering communication cable and cable communication.

The operator cannot assume the role of a safety manager or tetherer at the same time. It is possible to switch the roles of every member in every competition, except the team leader.

7. Further Details on the Competition

- ☐ Cold Zone: An area that is safe in a disaster location. It is the starting point, as well as a return point, an area where landing is possible.
 - It is permitted to repair the drone, change the battery, and swap operators while the drone is landed on the Cold Zone.
 - The operator is to call out to the referees when commencing repairs, switching the battery, or swapping operators.
 - When in the Cold Zone, the competition time-clock will not pause.
 - During a restart, the operator is to call out to the referee when intending to restart.
- ☐ Hot Zone: The area of disaster. It is permitted to land for the purpose of investigation and carrying out work tasks, however, the operator may not repair, switch the battery, or swap operators during that timeframe. The area outside the Cold Zone in the competition field.

- ☐ Reset: the operator is to call out “reset” if the operator wishes for help to return.
 - The robot will be returned to the location where the robot landed last, whether the starting or returning point.
 - As a penalty, an operator that calls for a reset is prohibited from restarting for 1 minute after calling for a reset during the Preliminaries, and 2 minutes after calling a reset during the Semi-finals/Finals.
- ☐ Forfeiture: When all measures have been exhausted, and the mission cannot be carried out.
- ☐ Deduction and disqualification: If any dangerous behavior defined as a major issue by the safety officers or judging panel has taken place during the competition, the issue will be discussed among the competition administration, and a point deduction/disqualification may be issued. Furthermore, if there is a risk that the issue may possibly repeat, the competition will cease from continuing.
- ☐ As for the competition final decision results, the team leader may submit a complaint to the judging panel. The submission must be done before the upcoming competition round.

8. Safety Management

Safety officers are responsible for managing the team’s safety. While in the competition field, the team members are obligated to wear helmets and goggles. When handling the drones, the competitors must wear gloves. In addition, please avoid clothes that expose the skin. Sandals, etc., are strictly prohibited.

9. Communication Network

The competitors may choose whichever communication structure they prefer between the operator computer and robot (wired or wireless). However, the competition administration will not be in-charge/manage the wireless network environment. As for the communication network terms and conditions, the competitors are to comply with the WRS’s general regulations on communication provisions provided separately.

10. Winners

The ranking will be decided based on the score calculation explain in Chapter 5.

11. Miscellaneous

The participants must adhere to instructions by the Executive Committee.