The 4th International Competition of the Military Technical College

Lt.General Ibrahim Selim Award
For Innovation in Unmanned Systems

Unmanned Systems Innovation Competition (UMSIC 2019)

Details, Rules and Format

Student teams are invited to compete and display their vehicles at the Unmanned Systems Innovation Challenge held at the Military Technical College in Kobry El-Kobba, Cairo, Egypt, on July 27th – August 1st, 2019

January 15, 2019

Unmanned Ground Vehicle Challenge (UGVC 2019)

Unmanned Aerial Vehicle Challenge (UAVC 2019)

Unmanned Maritime Vehicle Challenge (UMVC 2019)

The 4th International competition of the Military Technical College

Unmanned Ground Vehicle Challenge (UGVC 2019)

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Glossary and Abbreviations

CDR	Critical Design Review
PDR	Preliminary Design Review
TDP	Technical Design Presentation
UGV	Unmanned Ground Vehicle

1. Overview

The Unmanned Ground Vehicles Challenge (UGVC) provides an opportunity for engineering students from multi-disciplinary branches to realize a product and test its performance in an international competition. The competition awards, named in honor of the co-founder of the Military Technical College, Lt. General Ibrahim Selim, aim to encourage students at all levels of undergraduate and graduate education to participate in teams and gain hands-on experience. Students will experience how to work in organized team. There will be roles for team members from non-engineering disciplines such as business, management, media, …etc.

Students will have the opportunity to realize a challenging product through efficient integration between advanced control theory, machine vision, vehicular electronics and mobile platform fundamentals to design and build an unmanned ground vehicle. This will be helpful in real world applications of either civilian or military nature. The primary goal of competition is to advance engineering education in intelligent vehicles and related technologies. Through a series of technical events over the four-day competition, teams will be challenged to offer their very best in order to achieve the optimum unmanned vehicle according to the competition rules and guidelines.

2. Competition Contact Point

Kindly direct your comments and questions to the *competition@mtc.edu.eg*.
we encourage participants to communicate with us only through the email system.

3. Competition Venue Overview

The competition will be held at Military Technical College's stadium; located at MTC campus.

Figure 1: MTC stadium

During the competition, each team will be provided with a covered workspace. Teams are advised not to leave humidity-sensitive electronics, or other equipment uncovered or unattended.

Electricity (one outlet) is available in the workspace. The Arab Republic of Egypt uses a 220V 50Hz 15A electrical outlet plug. Usually 2 pins.

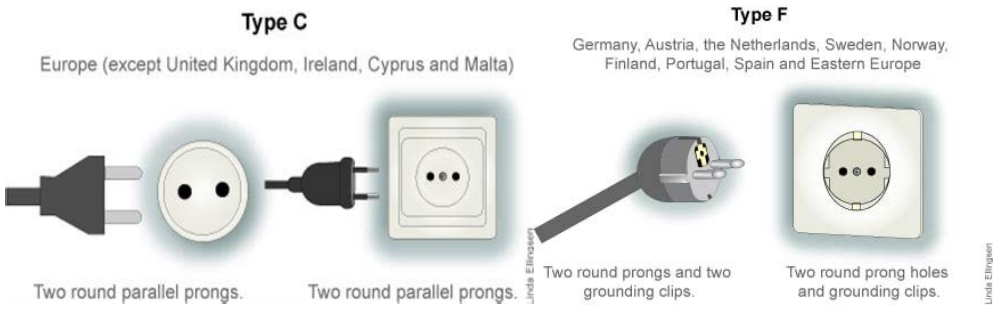

Figure 2: Electrical outlet plugs

4. Participation and Eligibility Requirements

Teams should be associated with a University/Institute/Organization/Research Centers. However, 75% of the participants must be full time students. The student members of a team are expected to make significant contributions to the engineering development cycle of their UGV. Please consider that a minimum of 3 team members are needed for UGVC operations, and the maximum allowed number of team members to attend the competition event is 7 plus 3 supervisors. Moreover, faculty, industrial and governmental sponsors are allowed to attend the events.

Each team must participate with only one vehicle in the competition. Each team must designate a student team member as their Team leader. The team leader is the only person allowed to speak for the team, request vehicle deployment, run start, run end, or vehicle retrieval.

5. Registration Information

- Teams' entry forms will be submitted by no later than February 28th 2019.
- An entry fee of 2000 EGP for residents (200 USD for internationals) per team (maximum10 members) is payable upon submission of an entry form (Registration).
- An extra fee of 500 EGP for residents (50 USD for internationals) per person for any extra team members and up to 5 members is payable on registration day (first day in the competition).
- **Any payments will be refunded ONLY in case of rejected teams.**
- Team proposal form must be submitted by no later than February 28th 2019. The main team's supervisor must sign the team proposal form, and certifies that all student team members are currently registered in academic year 2018/2019.
- Schools are encouraged to participate As a side event without evaluation but motivational gifts may be received for creativity performance; but are limited to a

maximum of three per school, and each vehicle must have a separate team of students and a distinct design report.

- The following team information must be provided:
  - Name of the team (and name of the vehicle, in case it's different).
  - Team members' full names.
  - Photocopy of the national ID (for Egyptian team members).
  - Photocopy of the passport (for non-Egyptian team members).
  - Personal cell phone no., email and address.
  - List of sponsors.
- All forms will be available on the competition website and are to be sent by Email to: competition@mtc.edu.eg

6. Team Sponsors Allowances

- 15 minute lectures during the competition opening ceremony.
- Exposure to the best of unmanned systems society.
- On-site booth (charged).

7. Team Deliverables

In addition to the field competition tasks, each team must document their efforts leading up to the competition by writing a Critical Design Review (CDR), authoring Introductory Video, and preparing a Technical Design Presentation (TDP). All elements of the competition will be conducted in English. Each registered team will receive an invitation to a cloud storage folder with Team Deliverables instructions, which will be provided at a later point.

7.1 Critical design review (CDR)

Each team is required to submit a CDR that describes the design of their vehicle, as well as strategies for their approach to the tasks. CDR should also include rationale for design choices. Teams must follow the TDR instructions, available in your Team Cloud storage (In case of any technical issues, please contact the competition board through email).

7.2 Team introductory video

Each team must submit an introductory video (max. 5 minutes/ 250MB). Please follow the official instructions available in your Team Cloud storage, which will be provided upon registration.

7.3 Technical design presentation (TDP)

The team will present to a committee of university staff and field judges the design, specifications, cost, in addition to a full function test of the system .

Static Judging is an opportunity for teams to introduce themselves, their vehicle, and special features and/or strategies for the competition. It is also an opportunity for judges to inspect the vehicle, and interview team members about the presentation and their contribution to the engineering development cycle.

Planned Presentation Breakdown:

- 20-minute oral presentation with visual aids (a PowerPoint file and a poster board).
- 5-minute question and answer session.
- 5-minute judges' inspection of the vehicle.

After the design presentation, teams should make themselves available for a team photo, and optional video interview for archival purposes. This video interview will not be judged.

7.4 How to submit team deliverables materials

Once your team has officially registered for the competition, the team leader will receive an invitation to an individual cloud storage folder, which will be used for the team's submissions. Only the team leader and UGVC staff will have access to this folder.

Detailed instructions on how to submit your items are included in your cloud storage folder, each team leader is responsible for meeting all deadlines listed on the competition website

8. Vehicle Configuration

The competition is designed for a small semi-rugged outdoor vehicle. Vehicle chassis can be fabricated from scratch or commercially bought. Entries must confirm to the following specifications:

- **General conditions**:
  - The vehicle shall be a stand-alone, off-the-grid, mobile platform. No tethers for connection to external power sources will be allowed during its operation.
  - A single connected platform must leave the designated start gate. In the open field, the primary platform may deploy any number of smaller sub-platforms, so long as the combined master/slave sub-platforms meet all additional requirements published.
- **Design**: Must be a ground vehicle (propelled by direct mechanical contact to the ground such as wheels, tracks, pods, etc.).
- **Weight**: The maximum allowable weight of the vehicle when deployed for any competition task is 50 kg. The total vehicle mass of all fielded vehicle parts should not exceed 70 kg. For example, the vehicle may have a robotic arm and/ or sensors that are never on the vehicle at the same time.
- **Propulsion:** Vehicle power must be generated onboard.
- **Mechanical Emergency Stop (E-stop) location**: The E-stop button must be a push to stop type, red in color and a minimum of 2.5 cm in diameter. It must be easy to identify and activate safely, specially, during the vehicle movement. It must be located in the center back

of vehicle at least 60 cm from ground, not to exceed 120 cm above ground. Vehicle E-stops must be hardware based and not controlled through software. Activating the E-Stop must bring the vehicle to a quick and complete stop.

- **Nature of Autonomy:** The vehicle is only required to be autonomous for the Autonomous Navigation Task. In the other tasks, autonomy is not required. Although some level of autonomy may be beneficial, such as the ability to backtrack to the last good communications location. The vehicle will adhere to the following main guidelines:
  - The vehicle may be operated remotely by team members (the operators) from a closed door control station so that they will not be able to view the vehicle on the site.
  - Line-of-sight communications are not guaranteed for all of the tasks. The vehicle may be commanded by the team using a wireless link (no wire communication is allowed), with information needed for guiding the vehicle acquired by the vehicle's own on-board systems and transmitted to the control station wirelessly. There shall be no time delay in communications, as the UGVC is based on the assumption that the vehicles in question are tele-robots/autonomous. Refer to section IV.3.h regarding the impacts of a loss of communications.
- **Communications**: Wireless communication methods used by teams shall adhere to all UGVC communications standards and regulations. The 2.4 GHz band is the only band allowed (other bands are not allowed). Teams must submit details regarding the communication standards they will be using, including frequency bands, channels, and any wireless communication devices being implemented, including control station and vehicle antennae, to the UGVC Director as part of the CDR package no later than ***May 16th 2019***. Teams must notify the UGVC Director immediately of any changes after this date.
  - Teams are required to power down communications equipment at the event sites while not competing, so as not to interfere with other teams.
  - Both omnidirectional and directional antennae are allowed, but communications equipment must not rely on the team's ability to watch and track the vehicle first hand. If a team wishes to steer a directional antenna they may:
    - Steer it manually from inside the control station/ tent, with no visual feedback on position.
    - Use a mechanized antenna mounted outside that is controlled via an electronic signal from the command station or operates autonomously.
    - Place someone outside to manually turn the antenna to point at the vehicle. Since they can see the vehicle they are not allowed to communicate with operators inside the control station. This option comes at a 20% penalty per event used.

      For any of the above options, signal strength, relayed GPS, or other strategies may be used to give feedback on antenna direction.

  - Antenna height is limited to **3** meters. Antenna bases must be located within **5** meters away from control station/tent, and shall adhere to all applicable regulations. Any ropes or wires used for stability purposes only may be anchored within **10** meters of the command and control station/tent. All teams should bring at least **10** m of antenna cable to deal with this scenario.
  - Lighter-than-air devices are not allowed for communications at UGVC.
  - The UGVC restrictions on the 2.4GHz band are as follows:

- 2.4 GHz frequency band (2.400-2.4835 GHz): Teams shall use center frequencies that correspond to channels 1-11 of the IEEE (Institute of Electrical and Electronics Engineers) 802.11 standard for 2.4 GHz. Teams shall not use frequency bandwidths greater than 22 MHz. The competition schedule will notify teams with which channels

  may be used for each task. Teams shall be limited to using no more than three channels in the 2.4 GHz band.

- Teams may use spread spectrum or narrowband (fixed channel allocation) within the sub-band limits, as they seem fit.
- There will be spectrum monitoring on-site to ensure that teams are not interfering with channels outside those allotted. Beyond this requirement, event scheduling will avoid communication interference to the greatest extent possible.

- **Safety and environment considerations: However,** fuel storage or running of internal combustion engines and fuel cells are not permitted in the team maintenance area (tent/building), but it's permitted in the field training, times which will be announced daily according to the competition schedule

Note: The UGVC is not providing internet service in the test field.

9. Competition Tasks

Prospective teams will undergo a review and a down-selection process in the Critical Design Review (CDR) package milestone. Only the top twenty teams will be selected and invited to present their vehicles in the competition field and continue the competition. The down- selection will be based on the evaluation of the CDR package that will be submitted by the teams on the specified deadline. The invited teams will continue to compete in four competition tasks; the presentation task, the terrain-traversing task, the equipment-servicing task, and the autonomous traversal task.

9.1 CDR package milestone

The teams should submit a technical report and a video before ***May 16th 2019***. The technical report and the video will be evaluated to select the best teams.

- Judges will be assessing each team's overall level of readiness to undertake the UGVC competition.
- The technical report and the video will be uploaded or submitted by mail through the contact person in each team.
- The technical report should not exceed 11 pages including graphs and appendices if applicable. Teams should show a description of the vehicle, the team management, time plan and how they will accomplish the required missions of the competition (A template technical report is posted on the competition website).

- The video should not exceed 5 minutes recorded time. The video format should be any of the common windows video formats such as (wmv). The video should show the vehicle design and manufacturing procedures and the team's level of readiness to undertake the UGVC competition. The video upload method will be posted on the UGVC website.
- While teams are not required to demonstrate any working systems/subsystems as part of the CDR package, such evidence will be considered by the judges in the down-selection process.

The teams that will pass the CDR package milestone will be invited to attend and compete in the competition events.

9.2 Technical Design Presentation task

All invited teams should give a presentation in front of the judges in no longer than 10 minutes introducing their team, vehicle design and functionality. Judges may ask follow on questions.

9.3 Terrain traversing task

1) The course may include soft sandy areas, stony areas, grass, vertical drops potentially in excess of 0.5 m and no deeper than 1 m, a step no higher than 0.5 m, and steep slopes in excess of 30 degrees and no more than 45 degrees.

2) This task may pose a significant hazard to some vehicles and teams may want to weight the risk vs. reward before attempting some of the obstacles. The teams may be allowed to walk through the course in the orientation held in the first day of the event.

3) Before the beginning of the task, each team will be given 15 minutes to setup their control station and antenna at the designated location outside the test field.

4) The course will contain two types of obstacles:
(1) Gates that must be passed through.
(2) Obstacles that must be avoided.

5) The exact number of gates to pass and their corresponding GPS coordinates will be given to the team directly prior to the beginning of the task. It is required from each team separately to cross all the gates in a 20 minutes time frame. At each gate, there are white arrows painted on the ground pointing to the correct direction of entering the gate.

6) The contesting vehicle must pass through the gates. The total distance covered will not exceed 800 m from the start gate where the control station is located. The gates consist of two white PVC pipes no less than 10 cm diameter, standing vertically from the ground to a height of 1-2 meters, spaced at least 2 m apart, and are marked so that they can be distinguished from each other. If the gate is a ramp (grade)

obstacle, a step obstacle or a drop obstacle, there will be a white solid filled arrow painted on the ground in the middle of the gate lane showing the correct direction of entering the gate. The vehicle should enter each of those gates from the designated direction to get the score of that gate. Also for those gates, there will be white ropes on the sides of the gate lane and are 2 m apart.

7) Obstacles to avoid in the course will be red painted cubes each with 1 m edge length. The placement of the obstacles may be randomly placed prior to every run.

8) A time schedule for the event tasks will be announced prior to the event. The order of teams' entrances will be based on a draw made by team leaders in the first day of the event.

9) Each team will be called 10 minutes ahead of time before start accessing the command station tent. Failing to be there at that time may cause the judges to abandon the team from the task and, hence, the team will not get a score for this task.

10) From the time, teams are given access to their command and control station/tent, they shall be able to set up all necessary systems, including all communications systems, and be ready to compete in no more than 15 minutes. Teams shall be able to fully disassemble all equipment in no more than 10 minutes after the task is finished, and may be asked to switch off radio equipment immediately. Judges have the authority to abandon any of the teams that fail to comply with the communications-turn-off command immediately.

11) Teams are expected to make best use of their maximum time (20 minutes) on course to traverse all gate obstacles while avoiding the red painted obstacles and do not have to return to the start gate. Teams will be scored for each gate and marked route they pass through. Points will be awarded for partial completion, and will be deducted for failure to stay within the gate lanes.

12) In the event of an intervention, the vehicle may be repaired in place or may be moved to a location as defined by the judge in the field. However, the judge may require the vehicle to be moved for the safety of team members or preservation of the course.

13) In the first day of the event, all teams will have a chance to calibrate their GPS devices by providing them with two sample GPS locations in the field. The GPS calibration is optional for all teams.

9.4 Equipment servicing task

Vehicles shall be required to perform several operations on a mock-up equipment system. The equipment servicing task will involve performing maintenance on a generator and will include the following sub-tasks:

- Flip open a cap on the fuel tank. It will be a press-to-fit cap with a large tab to grip,and hinged on one side.
- Start generator by pushing a button or flipping a switch.
- Verify operation by reading a message on an LCD display.

Teams will receive points for every sub-task completed successfully, but will be partially penalized for subtasks completed out of order. Sub-task point weights will be consistent with the level of difficulty. Teams will have between 20 and 45 min to complete the task.

9.5 Autonomous traversal task

The test field will be the same size as that of the terrain-traversing task. The control station and the antenna location will be the same as in the terrain-traversing task. The obstacle gates are replaced with waypoints to pass through and some obstacles to avoid. The obstacles to avoid (the red boxes described earlier) will be spread out randomly in the test field. The number of the waypoints as well as their corresponding GPS locations will be announced in the briefing given by the judges directly prior to the beginning of the task. There will be a ground mark on the exact GPS location of each of the waypoints in the test field. This ground mark will be a white solid filled circle of diameter 2 m. There will be also a white line circle of diameter 20 m around the waypoint location indicating the 10 m vicinity of the waypoint (see Figure 1 for more clarification). Once the operators finish the set-up of their waypoints entry in the control station and the *runners* (designated members for field intervention whenever needed) finish their vehicle set-up, none of the team members will be allowed to intervene neither in the control station nor in the field. The operators are only allowed to observe their screens inside the control station. It is required that the vehicle passes through all the waypoints in order while avoiding the $1m^3$ red boxes obstacles in time frame of **20** minutes. The waypoint is considered passed by the vehicle when it is at maximum 10m away from the ground mark measured from the closest point of the vehicle to the ground mark. Once the vehicle enters the 10m vicinity of the ground mark, the closer the vehicle from the ground mark, the more score earned. The participant teams are allowed to use any COTS mission controller but it is recommended and highly evaluated to use their custom-built mission controllers. The participant teams are allowed to use any number and any type of navigation sensors (GPS, Compass, IMU, odometer…etc.) to help the vehicle to complete the mission autonomously.

In the first day of the event, all teams will have a chance to calibrate their GPS devices by providing them with two sample GPS locations in the field. The GPS calibration is optional for all teams.

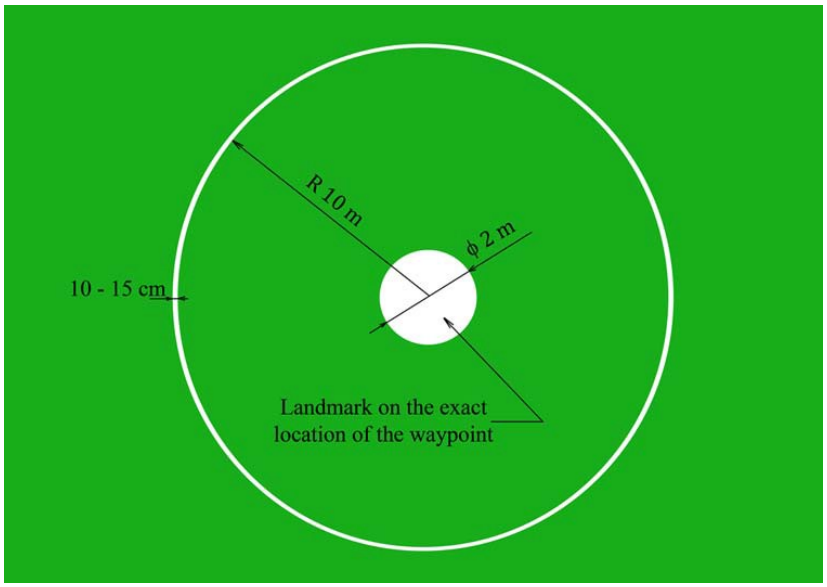

Figure 3: Top view of a sample waypoint in the test field showing the landmark on the exact location of the waypoint and the 10 m vicinity of the waypoint.

10 Evaluation Schemes and Penalties

As mentioned earlier, the CDR package is a milestone. This implies that it will be evaluated separately and its score will not be added to the scores earned in the event tasks.

The total score of all the event tasks will be out of 400 points weighted as follows:

− The terrain-traversing task will be evaluated out of 100 points.

− The technical design presentation task will be evaluated out of 100 points.

− The equipment-servicing task will be evaluated out of 100 points.

− The autonomous traversal task will be evaluated out of 100 points.

All the scores of the individual tasks for each team will be summed and compared against other teams' total scores to identify the winners as well as the order of all teams.

10.1 Evaluation scheme of CDR package milestone

The CDR package milestone aims to show the readiness of the teams to undertake the UGVC competition. Accordingly, the evaluation will be based on the completeness of the CDR package and the progress-to-date of the final system as well as the way the teams are representing their progress. Since the CDR is a competitive milestone, the CDR Packages will be judged against other teams' submissions by the judges.

10.2 Evaluation scheme of technical design presentation task

Scoring for this task will be assessed on the following equally weighted categories:

- Team structure, organization, and management
- Core vehicle design and presented functionality (vehicle need not function for presentation)
- Mission controller design
- Suitability and innovation of vehicle design to competition tasks
- Response to follow-on questions
- Overall quality of presentation

10.3 Evaluation scheme of terrain traversing and autonomous traversal tasks

1) The total score of the task will be the earned score minus deducted one. Score will be earned for passing through the gates (or the waypoints for the autonomous traversal task) within the designated period. Score will be deducted for vehicle overweight, failure to stay within the gate lanes (in the terrain traversing task only), touching the obstacles, not following the proposed orders of the gates or the waypoints and finally for the team members' interventions.

2) For the terrain-traversing task, the score of each gate will be announced in the field briefing given by the judges directly prior to the task. It is worth mentioning that the score of each gate will depend on its difficultness. Also, the GPS locations of the gates will be announced in the briefing.

3) For the autonomous vehicles task, waypoints' scores are weighted equally. Once the vehicle enters the 10m vicinity of the waypoint ground mark, 50% of the corresponding waypoint score is earned. Within this vicinity, the closer the vehicle to the ground mark, the higher the score earned, with increments 10% of the corresponding waypoint score, until the vehicle passes over the ground mark. The total score earned by a team is the weighted sum of the scores of all waypoints passed by the vehicle (weighted by the closest distance approached) within the designated time frame. The waypoints have to be passed in order. A penalty of 80% deduction of the waypoint score will apply if that waypoint was passed through not in order. If more than one team have finished all the waypoints in order within the time frame with equal score, those teams will be ordered according to how fast they finished the task.

4) The penalty for the overweight vehicle is 5% of the score earned in this task for each kilogram over 50kg.

5) The penalty of failure to stay within marked lines at the gates is 50% of the score of the corresponding gate.

6) The penalty of touching each of the obstacles to avoid (the red boxes) is 5% of the

earned score per each obstacle touched. If the same obstacle is touched in the return path, it will be considered a touch with another obstacle and the team will be penalized for it too.

7) If a vehicle suffers a critical problem during a task that requires direct team intervention (including a loss of communication that requires the team to move the vehicle to re-establish communications), that intervention shall be subject to the following guidelines:

- A request for an intervention can only come from the team members operating the vehicle, not any team members spectating in the field. They may designate any number of team members who may go to repair or retrieve the vehicle (runners).
- Runners may fix the vehicle in the field without moving it, returning it to the command station, or returning it to the start of that obstacle/task as defined by the judge in the field. However, the judge may require the vehicle to be moved for the safety of the team members or preservation of the course.
- If the vehicle is returned to the command station runners and spectators shall not communicate any details about the task site with the team members operating the vehicle (judges will monitor conversation), however all team members are permitted to take part in the diagnostic and repair process.
- Runners shall not be permitted to participate in the command and control of the vehicle, or analysis of any data, after this point for the current task. Runners will still be permitted to retrieve or repair the vehicle in future interventions. In other words, if a team member leaves the command station they are not permitted to return to operating the vehicle.
- Teams will be penalized 20% of the total points in that task for every intervention.

  The task clock will continue to run during an intervention. Multiple intervention penalties in a single task are additive: e.g. two interventions would result in a score of 60% of points earned, not 0.8×0.8 = 64%.

10.4 Evaluation scheme of equipment servicing task

Teams will receive points for every sub-task completed successfully, but will be partially penalized for subtasks completed out of order. Sub-task point weights will be consistent with the level of difficulty. Teams will have between 20 and 45 min to complete the task.

10.5 How competition will be judged

- The decision of the judging committee is final and non-negotiable.
- A team of judges will determine compliance with all rules.
- Designated competition judges will determine the official scores of all tasks. At the end of the competition, the total score for each team is calculated. Those teams earned the highest scores will be declared the winners.

11. Deadlines and Competition Program

11.1 Deadlines

No.	Item	Due date
1	Submission of team's proposals and entry forms	28th February 2019
2	Submission of CDR package	16th May 2019
3	Acceptance from the technical committee	22nd June 2019
4	Competition	27th July -1st August 2019

11.2 Copmpetition Program

No.	Activity	Date
1	Registration and orientation	27th July 2019
2	Presentation task	28thJuly 2019
3	Terrain-traversing task	29thJuly 2019
4	Equipment servicing task	30thJuly 2019
5	Autonomous traversal task	31stJuly 2019
6	Results announcement and awards	1stAugust 2019

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Lt. General Ibrahim Selim Award For Innovation in Unmanned Systems

Unmanned Systems Innovation Competition (UMSIC 2019)

Details, Rules and Format

Student teams are invited to compete and display their vehicles at the Unmanned Systems Innovation Challenge held at the Military Technical College in

Kobry El-Kobba, Cairo, Egypt, on July 27th – August 1st, 2019

January 15th, 2019

The 4th International Competition of the Military Technical College

Unmanned Aerial Vehicle Challenge

(UAVC 2019)

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Glossary and Abbreviations

AGL	Above Ground Level
BVLOS	Beyond Visual Line of Sight
CDR	Critical Design Review
COTS	Commercial off-the-shelf
EPAF	Egyptian Parachuting and Air-sports Federation
FMC	Flight Management Computer
FRR	Flight Readiness Review
FSO	Flight Safety Officer
FTS	Flight Termination System
GCS	Ground Control Station
GoE	Government of Egypt
GPS	Global Positioning System
MTOW	Maximum Take-off Weight
PDR	Preliminary Design Review
VLOS	Visual line of sight
FRR	Flight Readiness Review
RC	Radio Control
UAV	Unmanned Aerial Vehicle
WP	Waypoint

1. Structure of this document

Section 1 presents an introduction and overview.

Section 2 presents the overview of the competition, what is involved for participating teams, the schedule of key activities, eligibility and funding.

Section 3 presents the requirement specification for the UAV, with sufficient information for teams to design and develop the system.

Section 4 provides the statement of work for the competition, outlining what is required in each of the stages, including the design review deliverables.

Section 5 presents the adjudication and scoring criteria. This should help the teams in selecting and designing their concept to maximize their score.

Annex A provides the representative missions to be flown, and around which the UAV is to be designed.

Annex B provides document templates and guidance for completion of the three design review deliverables, the PDR, CDR and FRR.

Annex C introduces in details the interoperability system.

2. Introduction

2.1 Overview

The competition will engage university undergraduate/graduate students in the design, construction, development and demonstration of an autonomous UAVs with a MTOW of 10kg and operating within VLOS. The competition awards, named in honor of co-founder of the MTC, Lt. General Ibrahim Selim, aim to encourage students at all levels of education to participate in teams and gain hands-on experience. Students will experience how to work in organized team and there will be roles for team members from non-engineering disciplines such as business, management, media, …etc. The system will be required to operate automatically, performing a series of tasks such as area search, navigating waypoints, accurately dropping payloads and returning to base via a defined route.

2.2 Objectives of the event

The event has a number of objectives, in particular to:

- Provide an opportunity for students to learn practical aerospace engineering skills for industry.

- Provide a challenge to students in systems engineering of a complex system requiring them to follow an industry-recognized engineering development lifecycle (design, development and demonstration) against the demanding mission requirements.
- Provide an opportunity for students to develop and demonstrate team work, leadership and commercial skills as well as technical competence.
- Enhance employment opportunities in the sector and foster inter-university collaboration in the UAV technology area, and to provide a forum for interdisciplinary research.

3. Competition Overview

3.1 Context

The competition is structured to replicate a real UAV design, development process, build, test and demonstration. Deliverables have been carefully specified to maintain reasonable technical accuracy, yet aiming to keep the workload manageable for student teams.

3.2 Generic mission tasks

The competition is to design, build and demonstrate an autonomous UAV to fly a number of missions. The competition seeks to test a number of characteristics, such as:

- Accuracy of payload delivery to pre-determined points on the ground.
- Maximum mass of payload that can be safely transported in an allocated time.
- Shortest time to complete the payload delivery mission.
- Navigation accuracy via waypoint co-ordinates provided on the day.
- Object recognition, detection and geo-location.
- Extent of automatic operations from take-off to landing.
- Safety, demonstrating safe design and flight operations throughout.
- Minimum environmental impact, notably noise levels and overall efficiency.
- Maximum payload / empty weight ratio.

3.3 Schedule

Key dates and activities are as follows:

Activity	Date
2019 Rules provided to entrants	15th January 2019
Entries submitted to MTC	28th February 2019
Complete Concept Stage & PDR Submission	14th March 2019
Complete Detail Design Stage and CDR Submission	18th April 2019
Complete Manufacture and Test and FRR Submission	16th May 2019
Acceptance from the Technical Committee	22th June 2019
Demonstration Event	27th July – 1st August 2019

* Tentative dates: noting that adherence to deadlines is a prerequisite for next stage entry, and the organizer retains the right to eliminate any team in the event who will not submit all required deliverables on time.

3.4 Engineering events

The competition has been designed to give students exposure to a number of disciplines that they will need in their engineering careers, and the requirement provides a number of engineering events. Factors which the judges will be looking for include:

- A methodical **systems engineering approach** to identify the requirements, selection of the concept with a design to meet those requirements, and then test to confirm that the actual system meets the requirements in practice.
- An elegant and efficient **design** solution, supported by an appropriate depth of analysis and modeling.
- **Innovation** in the approach to solving the engineering events.
- Due consideration of the **safety and airworthiness** requirements which must be addressed from the early concept stage right through into the flying demonstration.
- Appreciation of the **practical engineering** issues and sound design principles essential for a successful, robust and reliable UAV; e.g. adequate strength and stiffness of key structural components, alignment of control rods/mountings, servos specified appropriately for the control loads, consideration given to maintenance, ease of repair in the field.
- **Construction quality**, paying attention to good aerospace practice for such details as connection of control linkages, use of locknuts, security of wiring and connections, resilience of the airframe and undercarriage.
- Good **planning and team-work**; organizing the team to divide up roles and responsibilities. Good communication and planning will be essential to achieve a successful competitive entry, on time and properly tested prior to the Demonstration Event.
- **Autonomous operations**; the UAV should ideally be able to operate automatically, without pilot intervention from take-off to touchdown.
- A strong **business proposition** for your design, demonstrating good commercial understanding of how your design might be developed to generate revenue for an operator.
- Attention to **environmental impact**, including minimizing noise, developing an efficient aircraft design which minimizes energy consumption, and attention to minimizing use of hazardous materials.

3.5 Eligibility and team structure

The competition is open to **graduate / undergraduate students** from any Egyptian or overseas universities and research centers. Universities may form an alliance to enter a joint team. Industry specialists support may be allowed where specific skills and knowledge are required outside the scope of the undergraduate students. The extent of such support must be clearly declared in the CDR submission.

The numbers of members in each team will be entirely determined by the participating entity, whilst having a set of defined performance objectives to achieve, is as much about the development and demonstration of team-working skills.

The development team must consist of graduate and undergraduate students which attend universities full-time for at least one semester during the academic year. The team may have at most 1 graduate student participate during the academic year. While the team members which attends the competition, participates in the Flight Readiness Review (FRR), and participates in Mission Demonstration event is limited to no more than **7 members** per team, plus up to **3 support staff**, e.g. pilots or academic staff

One member of the competition team will fill the role of team leader. This student will be the primary point of contact for the judges. All questions, comments, statements, and deliverables must be submitted by the team leader. The judges must be immediately notified of any team leader change.

The assigned safety pilot for whom a safety pilot log is required, can be either a student, the advisor or non-student of the university. At competition, each team can have their own safety pilot or request a competition volunteer safety pilot. The safety pilot will count as **1 of the 10 team members,** regardless of whether he is an advisor or volunteer. For non-member safety pilot his role is only limited to safety related functions and communication, and may not advise or participate in other roles.

3.6 Sponsorship of teams

Participating entities are encouraged to approach potential sponsors, at any time prior to or during the competition, for both financial support and/or technical advice. Note that where technical advice is received from sponsors, the judges will need to be sure that by far the majority of the development work has been undertaken by the students themselves. Such sponsorship must be fully acknowledged in the design review submissions.

3.7 Costs and funding

An entry fee of **2000 EGP** for residents **(200 USD for internationals)** per team (maximum 10 members) is payable upon submission of an entry form (Registration). This fee contributes towards the cost of putting on the Demonstration Event. It is non- refundable in the event that a team cannot participate in the Demonstration Event. MTC will **not** fund the costs of the UAV design and development, nor the team attendance at the Demonstration event.

An extra fee of **500 EGP** for residents **(50 USD for internationals)** per person for any extra team members and up to 5 members is payable upon submission of an entry form (Registration).

Any payments will be refunded ONLY in case of rejected teams.

4. Design and Operational Requirements

The UAV must be designed to perform up to three missions whilst being compliant with the specification defined in this section The term ‘must’ denotes a mandatory requirement, the term ‘should’ denotes a highly desirable requirement.

Where a paragraph is in italics and preceded by “Note:” this indicates a point of guidance or clarification rather than a design requirement.

4.1 UAVC design requirements

4.1.1 Airframe configuration and mass

Fixed wing, rotary wing or other air vehicle configurations are permissible for mission (2) and (3). While fixed wing is only permissible for mission (1). The MTOW must not exceed 10 kg, including the payload(s).

4.1.2 Propulsion

Electric motors or internal combustion engines are permitted for propulsion.

4.1.3 Payload specification

The payload to be delivered by the UAV is flour bags of minimum weight 500 gm./bag and its integral multiplication,(For example: delivered payload is 2.2 kg will be counted as 4 bags, delivered payload is 3.9 kg will be counted as 6 bags). **These will be provided by teams themselves**. For more details, please refer to section ***5.2.3 Mission 3: Endurance in the presence of obstacles***

4.1.4 Payload carriage and delivery

The UAV should be designed to carry and deliver multiple payloads onto a target area. A greater mass of payloads delivered, scores more points. The payloads must be individually deployable from the UAV by either manual or automatic command. The payloads must be deployed whilst the UAV is in flight, from a minimum height of 50 m AGL. The UAV is **not** permitted to land to deploy the payload.

4.1.5 Autonomy

The UAV should operate in a fully automatic manner as far as practicable, including automatic take-off and landing. UAV which are manually operated are permitted, although manual operation will score considerably fewer points.

Notes:

- Stability augmentation systems do not classify as 'autonomous' or 'automatic' control, and must count as part of manual control.
- Automatic take-off implies that the system, after it has been started, can be positioned at the runway threshold manually, then when the control transferred to platform, it executes the take-off without human intervention.
- Auxiliary launch/landing equipment is permitted, so long as it all operates autonomously. Hand launch is also permitted.

4.1.6 Radio equipment

Radio equipment, including data links, must be capable of reliable operating ranges of 1-2 km. Radio equipment providing control of the UAV and the Flight Termination System must be 'Spread Spectrum' compliant on the 2.4 GHz band, to allow simultaneous testing of several UAV without interference. Evidence of compliance must be presented in the CDR submission and at the scrutineering. The radio equipment must include a RC transmitter. This is to allow the flight safety officer to activate the flight termination system via the RC should this be required.

If an imagery downlink is incorporated, and if it is central to the safety of flight, control or for flight termination decisions, then it must be suitably reliable and resilient to interference.

4.1.7 Camera / Imaging system

The UAV should carry a camera system and target recognition capability to undertake the target search, location and identification exercise set out in **A.3.2 Mission 2: Search, locate, identify and Rescue**.

4.1.8 Location finder

It is recommended that in the event of the UAV making an un-commanded departure and landing outside of the designated landing Area, the UAV makes an audible/visual warning to improve ease of UAV location.

4.1.9 Limits on use of COTS items

The UAV airframe and control systems must be designed from scratch, and not based upon commercially available kits or systems. This is a qualifying rule, meaning that an entrant based on a commercially available system will not be eligible for consideration. A bill of materials and costs will be required as part of the design submission. Low cost efficient solutions will score more points. Teams may use COTS components which already exist at the University, but for which no receipts are available. An estimate of the price can be obtained by looking up part numbers or by manufacturer, and a screen shot of the price will suffice.

Teams must also demonstrate that manufacture of the airframe and integration of the UAV involves a significant proportion of effort from the students themselves, rather than being substantially outsourced to a contractor.

Note: Permitted COTS stock component parts include motors, batteries, servos, sensors, autopilots and control boards such as the Pixhawk or Ardupilot platforms.

4.2 Operational requirements

4.2.1 Missions

Three separate missions can be flown, each testing different performance characteristics of the UAV. These are payload delivery in the presence of obstacles, reconnaissance (Search, locate, identify and rescue) and endurance in the presence of obstacles. Details of the three missions are set out at Annex A. The scoring criteria for these missions is presented at section 5.2 Flight Demonstration.

4.2.2 Take-off and landing

The UAV must be designed to take-off and land from within a 30 m diameter circle. The UAV should be capable of operating from short grass, sand or hard runway surfaces. Use of an auxiliary launcher, or hand launch is permitted providing the design and operation is deemed satisfactory by the Flight Safety Officer and scrutineers.

4.2.3 Design mission range and endurance

The UAV should be designed to operate not further than 500 m from the pilot. For resilience of operation, the radio equipment including data links, must be capable of reliable operating ranges of 1 km. For the purpose of sizing the fuel / battery load, the design team should consider Mission 3 in particular, which is designed to test the endurance of the UAV. For more details please refer to section ***5.2.3 Mission 3: Endurance in the presence of obstacles***

4.2.4 Weather limitations

The UAV should be designed to operate in winds of up to 10 m/s gusting to 15 m/s, and light rain. The UAV should typically be capable of take-off and landing in crosswind components to the runway of 5 m/s with gusts of 8 m/s.

4.2.5 Ground control station

In the Ground Control Station, it is desirable but not mandated that the following information should be displayed and be visible to the Operators, Flight Safety Officer and Judges:

- Current UAV position on a moving map.

- Local Airspace, including the Flying Zone.
- Height AGL.
- Indicated Airspeed.
- Information on UAV Health.

In the absence of such live telemetry, the Judges and / or Flight Safety Officer's decision on flight capability is final.

4.2.6 Interoperability system

The Interoperability System is a network and web server that teams should interact with during the flight demonstration. This system provides the required missions details and receives missions' deliverables. The system provides automatic evaluation for scoring, and is available to teams for testing. UAVC 2019 provides the following GitHub repository link for a similar system as a guide for teams to test their integrations. This repository contains all code and documentation for similar interoperability system developed by the ***Association for Unmanned Vehicle Systems International (AUVSI) Student Unmanned Aerial System (SUAS)***.

Interaction with System:

This section provides a high-level overview of the interaction with the Interoperability System. Teams should refer to Annex C for details.

Network Connection:

At setup time, teams will receive a single Ethernet cable with which to connect to the Interoperability System. This connection will provide a single static IP address. The IP addresses will be on the subnet 10.10.130.XXX with subnet mask 255.255.255.0. Teams will typically connect this to their Ground station network (router/switch). Teams will then connect to the Interoperability server given the server IP address/port number, username, and password that is provided at Check-In and Orientation. Teams may then use this connection until the end of the mission demonstration.

Mission Download:

Through this connection, teams must download certain mission details from the Interoperability System, e.g., Geo-fence, search grid coordinates… etc.

UAV Telemetry Upload:

In order to get maximum points for waypoint accuracy, teams will need to upload valid UAV telemetry while the UAV is airborne. Telemetry must not be duplicated, interpolated, or extrapolated beyond what is generated by the autopilot. Data dropouts will count against the team.

Object Upload:

Teams need to submit identified objects via the Interoperability System to earn more points. Teams should refer to Annex C for more details regards the identified object format.

4.3 Safety and environmental requirements

4.3.1 Flight termination system

A FTS must be incorporated as part of the design and is a mandatory requirement to achieve a permit to fly. The purpose of the FTS is to initiate automatically all relevant actions which transform the UAV into a low energy state should the data links between the GCS and UAV be lost or be subject to interference / degradation. The FTS must also be capable of manual selection via the RC, should the FSO deem the UAV's behavior a threat to the maintenance of air safety. The actions of the FTS must aim to safely land the UAV as soon as possible after initiation. The throttle must be set to idle / engine off. Other actions could include, but are not limited to: deployment of a recovery parachute; the movement of all control surfaces to a default position to achieve a glide; the initiation of a deep stall maneuver; movement of the relevant control surfaces to achieve a gentle turn. The FTS must be automatically initiated after 5 seconds lost uplink. The uplink is defined as the data link which provides control inputs to the UAV from the GCS (manually or autonomously), including manual initiation of the FTS. The FTS should be automatically initiated promptly and no longer than 10 seconds after lost downlink. The downlink is defined as the data link which relays the UAV's telemetry / positional info and video feed to the GCS. A 'Return to Home' function is **not** acceptable as an FTS.

4.3.2 Other design safety requirements

The design and construction of the UAV must employ good design practice, with appropriate use of materials and components; the design must be supported by appropriate analysis to demonstrate satisfactory structural integrity, stability and control, flight and navigation performance, and reliability of safety critical systems.

Batteries used in the UAV must contain bright colors to facilitate their location in the event of a crash; At least 25% of the upper, lower and each side surface must be a bright color to facilitate visibility in the air and in the event of a crash; Any fuel / battery combination deemed high risk in the opinion of the judges may be disqualified.

4.3.3 Operational safety requirements

The UAV must remain within VLOS and no greater than 500m horizontally from the Pilot, and remain below 100 m AGL. The UAV must not be flown within 50 m of any person, vessel, vehicle or structure not under the control of the Pilot. During take-off or landing however, the UAV must not be flown within 30 m of any person, unless that person is under the control of the pilot; The maximum airspeed of the UAV in level flight must not exceed 90 m/s; During the entire flight the UAV must remain in controlled flight and within the geophone

boundary of the flying zone; Failure of the pilot to recover promptly a UAV appearing uncontrolled or departing from the flying zone, must require activation of the FTS, either by the pilot or at the direction of the FSO.

4.3.4 Pilot qualifications

The team pilot must have a qualification or equivalent (such equivalence must be demonstrated to the satisfaction of MTC). Evidence of qualifications must be provided with the FRR submission. The team pilot must have flown the UAV and tested it before the competition.

4.3.5 Environmental impact

In the design process, consideration should be given to environmental impact, including the use of non-hazardous and recyclable materials; low pollution; low energy usage; low noise. Teams are encouraged to determine the overall efficiency of the UAV, by measuring the energy usage (chemical or electrical) during the testing prior to the Demonstration Event.

4.3.6 Flight course

The orientation (direction) of the flight course will be adjusted based on the prevailing winds as determined by the Flight Line Judge. The flight course will be positioned to maintain the greatest possible safety to personnel and facilities. (refer to Annex C for Airfield pam and flying zone boundaries figures)

4.3.7 Protest procedure

Submitting a protest is a serious matter and will be treated as such. Teams may submit a protest to the contest judicial board any time during the competition. Protests may not be submitted after the conclusion of the competition. Protests must be submitted in written format and signed by the team leader, designees are not allowed for protest submissions.

Protests and penalties (up to disqualification from the contest for deliberate attempts to misinform officials, violate the contest rules, or safety infractions) will be decided by the Contest judicial board. Protests submitted but not upheld by the judges may be given a penalty of the loss of one flight score to the team submitting the protest. The decision of the Contest judicial board is final.

5. Statement of Work

This section provides details of the activities and outputs in each stage.

5.1 Competition stages

Below, the stages of the competition, and the key deliverables:

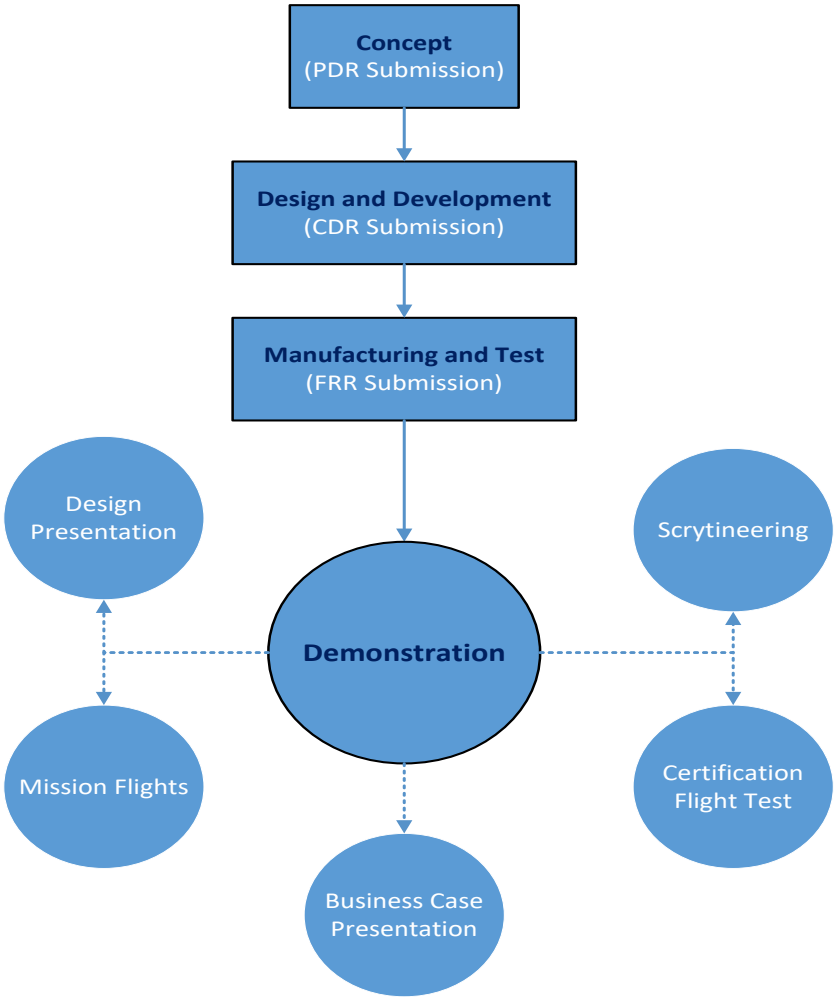


Figure 1 UAVC Stages and Deliverables

Concept: Requirements capture, trade studies, selection of system concept, initial sizing and performance studies, and generation of the outline design. As a guide, this stage concludes with the Preliminary Design Review (PDR) submission.

Design and Development: Detailed design for manufacture supported by structural, aerodynamic, system and performance analysis. This stage should include an assessment of how the requirements are to be verified through test, and importantly how the safety requirements are to be met. Some prototyping may also be undertaken. This stage concludes with the Critical Design Review (CDR) submission.

Manufacture and Test: Construction of the UAV. This may also involve the manufacture of prototypes during the earlier design stages to de-risk the design. Demonstration through analysis, modelling and physical test that the design will meet the requirements, and is sufficiently robust and reliable. Physical test should include subsystem test, as well as flight testing of the complete UAV. This stage concludes with the submission of the Flight Readiness Review (FRR) submission.

Demonstration: The flying demonstration event is held over two days and comprises a multi-stage process of qualification and demonstration, including:

- Design Presentation.
- Scrutineering.
- Certification Flight Test.
- Mission Flights.
- Business Case Presentation.

Further details of the Demonstration Event are provided at section 5.3 Demonstration Event.

5.2 Deliverable Items Description

5.2.1 Design Reports

Guidance on the PDR, CDR and FRR deliverable items is provided at Annex B Document Templates and Guidance.

5.2.2 Design Presentation

Early in the Demonstration Event, each team will give a 15 min presentation on key aspects of the design and development to the judging panel. As a guide, the presentation should include the FRR Video and 10 PowerPoint slides. There will be up to 10 minutes for questions. Timings will be strictly enforced.

The assessment panel will be looking to test each team's communication skills as well as technical knowledge; demonstrating good teamwork and organization; giving good responses to questions; demonstrating a clear and concise presentation of the concept selection process, key design features and supporting analysis, and the development and test program.

5.2.3 Environmental Impact Poster

Teams must produce an A3 size poster summarizing the environmental aspects of the design and operation. The assessors will be looking for evidence that the team has made efforts to minimize the environmental impact of the design.

5.2.4 Manufacturing Poster

Teams must produce an A1 size poster with pictures and summary showing the build, assembly and test. This must be submitted to the organizers on arrival at the demonstration event, and will be displayed at the event. The Judges will review the poster and the scrutineering panel will assess the manufacturing quality of the physical UAV.

5.3 Demonstration Event

5.3.1 Logistics

A detailed briefing will be given at the beginning of the Demonstration Event covering the logistics and timings for the event, rules and good conduct for safe operations, pre-flight briefings etc. Teams will also be given a running order and strict time schedule for the qualification process, including presentation, scrutineering, certification flight test, and flight missions. The schedule is necessarily tight and teams who are not ready to fly at their appointed slot time will have to re-apply for a later slot, at the discretion of the organizers. Note that the flying schedule is likely to be dynamic and updated during the event to take account of weather and UAV unserviceability.

It is expected that Teams will arrive with a fully serviceable UAV that is in good working condition. Efforts will be made to retain flexibility in the schedule to allow teams who fail to pass one of the qualification events time to repair, rectify, test and re-apply, but scoring penalties may apply.

5.3.2 Scrutineering

Following the presentation, a panel of expert aircraft engineers will inspect the UAV to ensure that it is safe and airworthy, that any Corrective Actions made following the CDR submission or at the Design presentation have been addressed, and that any late modifications introduced are reviewed and acceptable.

The scrutineering panel will have reviewed the FRR submission, which is a key input to the scrutineering process as it should contain evidence of satisfactory testing. The assessment will include:

- Regulatory Compliance - Pass/Fail criteria.
- Control checks – Communications; Function and Sense.
- Radio range check, motor off and motor on.
- Verify all controls operate in the correct sense.
- Airworthiness Inspection – Structural and Systems Integrity.
- Verify that all components are adequately secured, fasteners are tight and are correctly locked.
- Verify propeller structural and attachment integrity.
- Check general integrity of the payload and deployment system.

- Visual inspection of all electronic wiring to assure adequate wire gauges have been used, wires and connectors are properly supported.
- Verify correct operation of the fail-safe flight termination systems.

Should the UAV fail the scrutineering, the team will be given the chance, if practical and if time permits, to rectify the issues and re-apply for scrutineering.

5.3.3 Manufacturing assessment

The scrutineering panel will also conduct the manufacturing assessment (a marked prize) and look for:

- Design and Build quality, including use of appropriate materials, systems integration and configuration control.
- Attention to detail in assembly and aesthetics.
- Sound and safe workshop practices.

5.3.4 Certification flight test

The certification flight test will assess the basic operation, to include:

- Take-off from the designated Take-off and Landing area. After take-off the UAV must maintain steady controlled flight at altitudes above 50 m and less than 100 m AGL. Take- off under manual control with transition to automatic control is permitted.
- Demonstrate maneuverability by flying a figure of eight, in the same flight.
- Loiter in a ‘race-track’ pattern over the airfield at a defined point for a period of 2 minutes at a height of 100 m.
- Land, back at the take-off point.
- An element of ground-based assistance for take-off and landing is acceptable, but the aircraft should operate automatically during other phases of flight.
- Demonstrate switch between automatic and manual flight.

The assessors will be looking to confirm that the team operating the UAV is competent as well as confirming the airworthiness of the UAV itself.

5.3.5 Flight demonstration - missions

Upon successful issue of a Permit to Fly, the Team will have a short time to prepare their aircraft for each mission flight.

Three missions comprise payload delivery; reconnaissance and endurance will be detailed illustrated with example & waypoint data in Annex A. The exact mission waypoints, target co-ordinates and obstacles will be communicated through the interoperability system and briefed to each team at the start of the event.

5.3.6 Safety of operations

The Flight Safety Officer must have absolute discretion to refuse a team permission to fly, or to order the termination of a flight in progress. Only teams issued with a 'Permit to Test' through the scrutineering process, and a 'Permit to Fly' through the certification test flight, will be eligible to enter the flying demonstration stage. Teams must be responsible for removal of all batteries from the site that they bring to the event, including safe disposal of any damaged batteries.

6. Adjudication and Scoring Criteria

6.1 Overall scoring breakdown

The competition will be assessed across three main elements, themselves broken down into sub- elements:

Design (150 points), comprising:	
□□ PDR Submission	(25)
□□ CDR Submission	(85)
□□ Business Case Presentation	(25)
□□ Environmental Impact Poster	(15)
Flight Readiness (100 points), comprising:	
□ Design Presentation and FRR Submission	(50)
□ Scrutineering and Manufacturing Poster Flight	(50)
Demonstration (250 points), comprising:	
□ Mission 1 – Payload Delivery in the presence of obstacles.	(125)
□ Mission 2 – Search, locate, identify and rescue	(85)
□ Mission 3 – Endurance in the presence of obstacles.	(90)

A maximum of 550 points is therefore available. The detail of scoring the Flight Demonstration is given in the tables below.

6.2 Flight demonstration

6.2.1 Mission 1: Payload delivery in the presence of obstacles

Carrying the heaviest possible payload mass, after take-off navigate within the flying zone to WP 1,2, avoiding the given static and dynamic obstacles, then drop the payload on the target located on WP 3. Then fly to WP 4, 5, and return to the launch point to land. Repeat until 10 min are finished. Number of takeoffs, landings and weight of total payload dropped with them positions relative to the center of drop area are evaluated. Telemetry information should

be reported to the interoperability system for assessment during the mission demonstration time.

Through the Interoperability System, the teams will be given a set of stationary obstacles. Each stationary obstacle will be a cylinder, with height axis perpendicular to the ground, and bottom face on ground. The cylinders will have a radius between 3 to 5 meters, and height between 1 to 3 meters.

Test	Scoring	Max Score
Payload Delivery***	Score 7 points per 500g of payload mass dropped within 20 m of target.	42*
Payload Accuracy	Additional score 3 points per 500g of payload mass dropped within 5 meters of target center.	18*
	Additional score 1 point per 500g of payload mass between 5 m and 10 m from target center.	
	Additional score zero points per payload > 10 meters from target center.	
Navigation Accuracy	Score for the waypoint accuracy (submitted from the Interoperability system)	25
	Halve Navigation score for single extended breach of Geo-fence (> 5s).	
	Score zero Navigation points for persistent or repeated breach of Geo-fence	
Autonomous Operations	Score 25 points for fully autonomous operation including Take-Off, Navigation, Payload Drop, and Landing.	25
	Deduct 5 points for manual take-off.	
	Deduct 5 points for manual landing.	
	Score zero Autonomous Operations points if flight fully manual.	
Obstacles Avoidance	Score 3 points per obstacle successfully navigated and avoided up to maximum 15 points.	15
Maximum Preparation Time**	Deduct 10 points if team is not ready for take-off within 10 minutes of arriving at the flight line and mission will be terminated after 20 minutes.	
Maximum Mission Time**	Deduct 5 points for every minute over the 10- m i n u t e maximum mission time, measured from take-off to touchdown and the aircraft coming to a halt.	
Maximum Flight line Time	For each attempted mission, whether successful or not, the maximum time limit is 20 minutes from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Deduct 2 points for every minute over this 20-minute limit.	
Maximum Score:		125*

* Maximum score assumes 3kg payload mass deployed. Note that 3kg is not a maximum payload mass limit within the rules (though it may be challenging technically). Thus, the maximum score achieved could be greater than 125 if more than 3kg payload mass were successfully deployed.

** Total permitted time is 30 minutes. If the permitted time passed without performing the mission the mission will be cancelled and can't be repeated however, only the judge board can give this permission in specific condition.

*** Payload safely delivered.

6.2.2 Mission 2: Search, locate, identify and rescue

Search, locate and identify four human body targets within a given search area. Search area boundaries will be submitted to teams in the field. Report back the GPS co-ordinates of each identified human body via the interoperability system for evaluation. Also, identify and report back whether the identified target is on one of the ally's victims or enemy based on uniform cam color. Teams must submit identified target via the Interoperability System (see annex C for Object file format example). Teams may additionally provide identified target via the Object File Format over USB drive, which will be used only in the event of an unplanned failure of the judging system.

Friend

Foe

Mission Leg 1: Body Identification

In the first part of the mission, it is essential that for specific geographic areas, the UAV platforms should cooperatively scan large regions in an attempt to identify injured persons. Generating a map pinpointing potential victim, their geographical coordinates and sensory output such as high-resolution photos and/ or thermal images of potential victims.

The resulting saliency map would be generated as the output of such a cooperative UAV mission and could be used directly by emergency services or passed on to other UAVs as a basis for additional tasks.

Mission Leg 2: Supplies Delivery

In the second part of the mission, the saliency map generated in Leg I would be used as a basis for generating a logistics plan for the UAV with the appropriate capabilities to deliver food, water and medical supplies to the injured identified in Leg I.

Test	Scoring	Max Score
Locate Target	Score 8 points for correctly identifying the GPS co-ordinates of each of 4 victims Targets, to within 5 meters' accuracy from measured target position.	32
Accuracy	Deduct 1 point per meter error for each reported location greater than 5 meters in error from the measured position. Maximum deduction 9 points per target. (A target position reported with 14 meters or greater error would thus score zero).	
Reporting Time	Score as a percentage of the fastest competitor's time. Maximum of 12 points for achieving the shortest time, defined as the mission time from take-off to landing and including reporting the WP positions, divided by the number of successfully identified targets (i.e. those targets reported within 5 m accuracy). Reporting Time score for Team B = 12 x S / B, where 'S' is shortest time, and 'B' is time for Team B.	12
Identified Allies victims	Score additional 3 points per Allies Human body target identifying correctly through uniform color. (2 of them are enemies and 2 allies)	12
Identified alphanumeric	Score additional 3 points per correctly recognized alphanumeric in identified target through the reported object files. (2 of them are enemies and 2 allies)	12
Allies victims Supply Delivery	Score additional 3 points per Allies supply delivery dropped within 20 m of the identified victim location.	6
Autonomous Operation	Score additional 21 points for completing the mission fully automatically from take-off to landing, and including automatic reporting of target position and alphanumeric.	21
	Deduct 5 points for manual take-off.	
	Deduct 5 points for manual landing.	
	Deduct 2 points per target for manual reporting of position and / or alphanumeric. An example of manual reporting would be the Pilot confirming the alphanumeric by watching the video stream from the UAV, either in real time or from post flight analysis and reporting the Object files using USB.	
	Score zero Autonomous Operations points if flight fully manual.	
Maximum Preparation Time*	Deduct 10 points if team is not ready for take-off within 10 minutes of arriving at the flight line. Mission will be terminated after 20 minutes.	

Test	Scoring	Max Score
Maximum Mission Time*	Deduct 5 points for every minute over the 10-minute maximum mission time, measured from take-off to touchdown and the aircraft coming to a halt.	
Maximum Flight line Time*	For each attempted mission, whether successful or not, the maximum time limit is 20 minutes from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Deduct 2 points for every minute over this 20-minute limit.	
Maximum Score		85

*Total permitted time is 30 minutes. If the permitted time passed without performing the mission the mission will be cancelled and can't be repeated however, only the judge board can give this permission in specific condition.

6.2.3 Mission 3: Endurance in the presence of obstacles

Team declares the mission payload mass, which is validated by the judges before the mission flight, also ensuring maximum all up mass limit not exceeded. Take-off, fly a prescribed 1 km course around the airfield for as many laps as possible up to a maximum of 6 laps and land at the designated landing point.

Through the Interoperability System, the teams will be given a set of stationary obstacles. Each stationary obstacle will be a cylinder, with height axis perpendicular to the ground, and bottom face on ground. The cylinders will have a radius between 3 to 5 meters, and height between 1 to 3 meters.

Test	Scoring	Max Score
Payload Mass	Score 4 points per 500g of payload mass carried. UAV must complete at least one full lap to score points.	24*
Endurance	Score 3 points per lap completed.	18**
Lap Time	Score as a percentage of the fastest competitor's time, with a maximum of 12 points for achieving the fastest average time, defined as mission time from take-off to landing divided by the number of successfully completed laps.	12
Obstacles Avoidance	Score 3 points per obstacle successfully navigated and avoided up to maximum 15 points.	15
Navigation Accuracy	Score 1 point per WP successfully navigated up to maximum 5 points.	5
	Halve Navigation score for single extended breach of Geo-fence (> 5s).	

	Score zero Navigation points for persistent or repeated breach of Geo-fence	
Autonomous Operation	Score additional 16 points for completing the mission fully automatically from take-off to landing.	16
	Deduct 3 points for manual take-off.	
	Deduct 3 points for manual landing.	
	Score zero Autonomous Operations points if flight fully manual.	
Landing out	Penalty of 5 points for failing to land back at the designated take-off and landing point.	
Maximum Preparation Time***	Deduct 10 points if team is not ready for take-off within 10 minutes of arriving at the flight line. Mission will be terminated after 20 minutes.	
Maximum Mission Time***	Deduct 5 points for every minute over the 10-minute maximum mission time, measured from take-off to touchdown and the aircraft coming to a halt.	
Maximum Flight line Time***	For each attempted mission, whether successful or not, the maximum time limit is 20min. from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Deduct 2 points for every minute over this 20 min. limit.	
Maximum Score		90 *

* Maximum Payload Mass score assumes 3kg payload mass carried. Note that 3kg is not a maximum payload mass limit within the rules (though it may be challenging technically). Thus, the Maximum Score could be greater than 90 if more than 3kg of payload mass were carried.

** Maximum endurance score shown above assumes six laps, though this is not a limit within the rules. The practical limit may be dictated by the Maximum Mission Time. The maximum number of laps could thus be greater than six, with an Endurance score greater than 18.

***Total permitted time is 30 minutes. If the permitted time passed without performing the mission the mission will be cancelled and can't be repeated however, only the judge board can give this permission in specific condition.

Annex A Missions

A.1 Objective

Three separate missions must be flown, each testing different performance characteristics of the UAVC.

a. Payload Delivery in the presence of obstacles - testing the UAV load capacity; ability to carry and accurately deploy a number of payloads; navigation around a preset course; autonomous operations in ten minutes (no limitation for how many takeoff and landing).
b. Search, Locate, Identify & rescue - testing ability to search one or more areas and locate Allies and enemy targets in the shortest time; autonomous operations.
c. Endurance in the presence of obstacles – testing the UAV endurance around several laps of a preset course; UAV load capacity; teams' knowledge of their UAV's performance.

The scoring criteria for these Missions is presented at section 5.2 Flight Demonstration.

A.2 General points

A.2.1 Take-off

Take-off must be conducted within the designated take-off and landing box, into wind as far as practicable. After take-off the system must maintain steady controlled flight at any suitable height, typically between 50 - 100 m. Take-off under manual control with transition to automatic flight is permitted, though a higher score will be given to automatic take-off. The mission time starts when the team signal they are ready and the Flight Safety Officer gives clearance for take-off.

A.2.2 Landing

The UAV must return to and land at the designated take-off and landing zone. Transition to manual control is permitted for landing, though a fully automatic landing will score more points. The mission is complete when the UAV comes to a halt and the engine is stopped.

A.2.3 Navigation

Each team will be provided with a map of the airfield, showing the Geophone boundary within which the UAV must remain at all times, together with any other no- fly zones. The map will provide GPS co-ordinates for the Geophone vertices, the Waypoints (WPs) and the Target(s).

A mission route will define the WP order. The UAV should aim to fly directly overhead each WP, and the accuracy of the navigation will be evaluated by analysis of the GPS data logger after the flight. Points will be deducted for breach of the Geophone. At the Flight Safety Officer's discretion, the Flight Termination System may be initiated upon such breach, or the team may be directed to land the UAV as soon as it is safe.

A.2.4 Operating height

All operating heights between 50:100 m are valid within the allowable flying zone. The UAV must drop the payload from a minimum of 50 m height above ground, and cannot land to place the payload. During transit phases between the landing area to the target area, the UAV must maintain a safe height above ground.

A.2.5 Timing

With many teams flying multiple missions, it is essential for the smooth running of the event that teams are punctual with their timing, and do not over-run the allocated slot time. To keep up the flying sequence, there will be at least two teams at the flight line at any one time, so that if one team has to withdraw because of technical problems, another team is immediately ready to fly. From arriving at the flight line and being nominated first in line to fly a mission, a maximum of 10 minutes is allowed for pre-flight preparation. Each mission is a maximum of 10 min duration, from take-off to landing with the UAV stopped. Additionally, an overall maximum time limit of 20 minutes must be strictly enforced from a team being notified it is first in line for a mission flight to departing the flight line area after the mission. Points will be deducted if the team breaches these time limits. If a team cannot get the UAV ready within the 10 min allowance, it must retire and request another mission slot time, which may be granted at the discretion of the organizers.

Annex B Document Templates and Guidance

This Annex provides guidance on the structure and content of the PDR, CDR and FRR deliverables. Teams are also encouraged to reflect on the engineering events summarized in section 2.4 Engineering Events, which indicates what the Judges are looking for throughout the competition.

B.1 Preliminary design review submission

The Concept stage culminates with the Preliminary Design Review Submission, a written report of no more than **15 pages** in the body of the report supported by a maximum of 3 pages of schematics or tables. The suggested structure and content should be:

Introduction

Team Details

- Chart showing the team organization and roles;

Project Management

- Project plan with the main activities, lead times and dependencies.
- Table summarizing the project risks and their mitigation.

Requirement Capture

- Summary of UAV Requirements, including regulatory requirements.

Concept Selection

- The Systems Engineering approach adopted to develop compliant solutions;
- Discussion of the design drivers, the concept generation process, concept options considered, the trade studies undertaken, and the factors influencing the down select to the chosen concept;
- UAV overall layout & description with a three-view scale drawing.

Performance Calculations

- Preliminary aerodynamic, structural and performance calculations supporting the initial sizing, basic stability and control calculations, together with a weight and balance estimate.

Weight Budget

Cost Budget Safety

- An overview of the safety risks, presented in a table of hazards and mitigating design features.
- A short description of the approach to RF compliance;
- A short description of the safety features incorporated to mitigate the risks such as the flight termination system.

Design Description

- Diagram showing the preliminary system architecture and data flow for the navigation and mission control, flight control, vision sensor and the design for automatic operation;
- Brief functional description, and the rationale for selection of each of the proposed systems, including airframe, propulsion, flight controls, navigation & mission control, sensors, image processing, autonomy / automatic operation, payload carriage and delivery system, FTS.

Test Plan

- A short summary of the approach to 'Certification and Qualification', which could include design and analysis evidence to be generated in the next stage, and the outline elements of the test program to demonstrate the integrity of the system.

Guidance on how the PDR Submission will be assessed

The assessment panel will be looking for a number of factors including:

- Demonstration of a sound systems engineering approach to meeting the design requirements.
- A structured design process adopted by the team, and how the derived performance requirements are developed for each of the sub-systems such as wing, airframe, propulsion, control, navigation, payload handling etc.
- Extent of innovation in the outline design;
- Adherence to the rules;
- Depth and extent of underpinning engineering analysis.
- Design and planning to meet safety and airworthiness requirements.
- Evidence of sound project management, planning, budgeting.
- Overall Quality of PDR submission.

B.2 Critical design review submission

A key output towards the end of the Detail Design stage is the Critical Design Review Submission, a written report of no more than **25 pages** supported by a maximum of 5 pages of diagrams and appendices. The suggested structure and content should be:

Introduction

Changes from PDR

Note any ***update*** to the information presented in the PDR.

- Team organization and roles;
- Project plan including main activities, lead times and dependencies;
- Project risks and their mitigation;
- System concept
- Performance, weight and cost

Detailed Design and Manufacturing Description

UAV overall layout & description with a three-view drawing showing dimensions and center of gravity. summary of the rationale for the layout and key design features;

Description of the Aero-mechanical Design, including where appropriate the materials and construction techniques for each of the elements. This should include:

- Arrangement of flying surfaces and major components.
- Airframe structural design including consideration of flight, ground, handling and transport requirements.
- Aerodynamic design and performance, including stability and control.
- Control actuation system providing roll, pitch and yaw control.
- Propulsion system.
- Fuel system / propulsion battery.
- Undercarriage.
- Payload carriage and release system.
- Payload protection system.
- Flight termination system.
- Description of the avionics, mission system and electrical power.
- Mission planning and performance analysis.
- Autopilot design and automatic operation.
- Avionics, navigation and mission control system.
- Sensors and image processing system.
- Radio control system, including data link and telemetry.
- Ground control station.
- Brief description of any consideration given to support equipment, such as test equipment, handling or storage fixtures.
- Analysis and modelling. Provide a summary of the analysis and test undertaken to support the design and development, e.g.
- Structural performance.
- Aerodynamic performance.
- Payload release dynamics.
- Navigation and mission performance.

Qualification Test Plan

Summary of the proposed test plan for the UAV, which may include physical testing supported by modelling, and including:

- Structural testing.
- Subsystem testing.
- Flight testing.

Safety Case

The safety case should show an understanding of the main regulations relevant to this UAV. It should present the argument demonstrating the airworthiness of the UAV, summarizing the main safety risks and their mitigation, with arguments supported by evidence from design, analysis or test.

One of the mitigations to a number of safety risks is the incorporation of the FTS. The safety case should describe how the FTS mitigates each of the identified risks that it is designed to address. The approach to compliance of the RF requirements should be described. The safe operation of the UAV should be discussed, in addition to the technical design.

Verification & Validation Register

A short description of the approach to Verification & Validation supported by a detail table of results.

Conclusions

Guidance on how the CDR Submission will be assessed

The assessment panel will be looking for:

- Factors as for PDR plus:
- Technical assessment of UAV Detail Design;
- Integrity and depth of design data and supporting analyses;
- Design and demonstration of key safety features such as FTS.
- Extent of scratch design vs. COTS procurement.
- Overall quality of CDR submission.

B.3 Flight readiness review submission

The Manufacture and Test stage culminates with the FRR Submission, comprising:

- A video no longer than 4 minutes in duration showing evidence of the test flying undertaken;
- A statement of any changes introduced since the CDR;
- A confirmation that any Corrective Actions required by the judges from the CDR have been fully addressed;
- Confirmation of the team pilot and the compliance of pilot qualifications with the requirements of section 3.3.4 Pilot Licensing and Insurance;
- A signed declaration by supervisor, that in their opinion:

- The UAV appears compliant with the requirements noted in section 3 Design and Operational Requirements; the design and build quality is satisfactory;
- Safety and airworthiness aspects have been addressed satisfactorily, with appropriate fail safe mechanisms and a risk register completed;
- The system has been tested, both by modelling and demonstration to evaluate the performance and reliability;
- The team members preparing and operating the UAVs are suitably competent to ensure safe operations.

A 'Permit to Test' will be issued by the Flight Safety Officer for teams that submit a satisfactory Flight Readiness Review, and also satisfactorily complete the scrutineering on the first day of the Demonstration Event.

Guidance on how the FRR Submission will be assessed

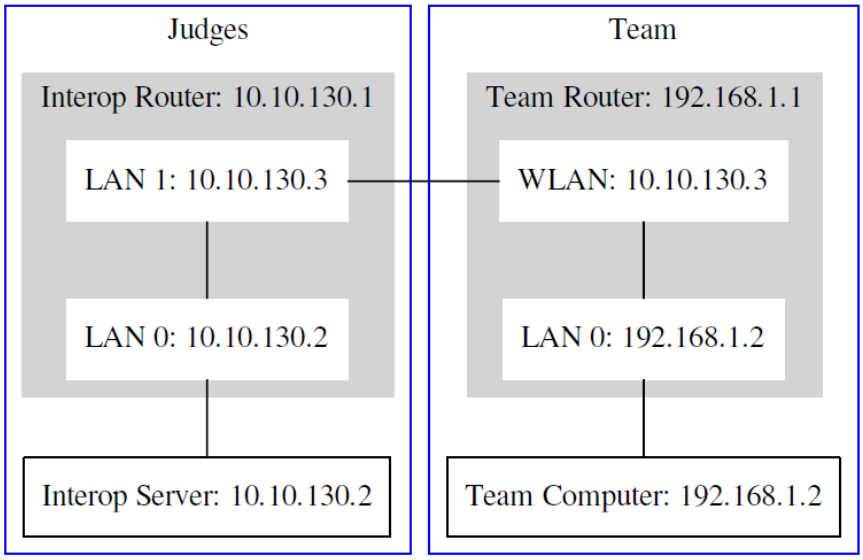
The assessment panel will be looking for evidence in the FRR Video about the extent and rigor of testing to demonstrate the performance and safety features of the UAV.

Annex C Interoperability System

This Annex describes the computer and networking setup at competition. The teams should replicate this setup to test their integration. In addition, this annex illustrates examples of the teams' deliverables during mission demonstration.

C.1 Computers and networking

At Check-In and Orientation, teams will be given a static IP address, a DHCP IP address range, the server IP address and port, a username, and a password. During Mission Setup, the teams will be provided a single Ethernet cord. This cord will connect the team's system to the interop router, which will be connected to the interop server. The following figure shows how the Interoperability System will be connected, and the recommended means of connecting the team's system. Note the IP addresses are examples.



It is recommended that teams use a router to have a separate subnet. The competition board provided Ethernet cord will then connect a LAN port on the interop router to the WAN port on the team's router. This will allow multiple team computers to communicate with the interop server at the same time. This will also allow a single computer to simultaneously communicate with the interop server and other team computers.

The teams will need at least one computer to communicate with the interop server. Competition Board will provide client library and tools with documentation for communication. Teams may also integrate directly via the HTTP + JSON protocol.

Sample Mission Map

At Check-In and Orientation, teams will be given the GPS locations of the Geo-fence boundaries and the Waypoints.

Figure 2 Mission Flight Boundary

Figure 3 Waypoints, Air Drop Location & Boundary

Deliverables submission

According to the competition rules, all deliverables will be submitted to the judges via the Interoperability System during the flight demonstration. Teams should declare their readiness for connecting and submitting deliverables via the Interoperability system before the flight demonstration. Teams failed to declare their readiness are allowed to submit their deliverables manual or in USB with deduction in their score points.

The required deliverables are the UAV telemetry information during flight, the identified targets colors and alphanumeric identification in the following object file format. On the other side, the Interoperability server sends the obstacles GPS coordinates to the teams' ground stations.

Object File Format

The Object File Format is a folder containing object detection files. Each object submitted by the team gets 2 files in the folder, both of which start with a number unique to the object, where one has the extension “json”, and the other has either the extension “jpg” or “png”. The “json” extension file must contain a JSON formatted object data. A “jpg” extension file must be a JPEG image, and a “png” extension file must be a PNG image. The team will copy this folder to a USB drive provided by the judges. If the team is attempting actionable objects, the team will be provided 2 USB drives.

Example folder structure for 2 objects:

- myteam/
  - 1.json
  - 1.jpg
  - 2.json
  - 2.png

Example JSON file:

```
{
"type" : "Enemy" ,
"latitude" : 38.1478 ,
"longitude" : -76.4275 ,
"orientation" : "n" ,
"background_color" : "Blue" ,
"alphanumeric" : "C" ,
}
```

The judges will ignore object detection files which are not proper JSON or do not conform to the specification. The judges will ignore object images which are not in either JPEG or PNG format.

It is worth mentioning that the competition board will issue the set of commands specification that the teams can use to test their client library. Through these HTTP commands, teams will be able to acquire the Waypoints GPS coordinates, check the availability of the server, receive obstacles GPS coordinates, and submit their deliverables automatically.

C.2 Target description

The following figure demonstrates an **example** of identified target in a red 1 m x 1 m central square, incorporating an alphanumeric code in white. Background and alphanumeric colors are subjected to change.

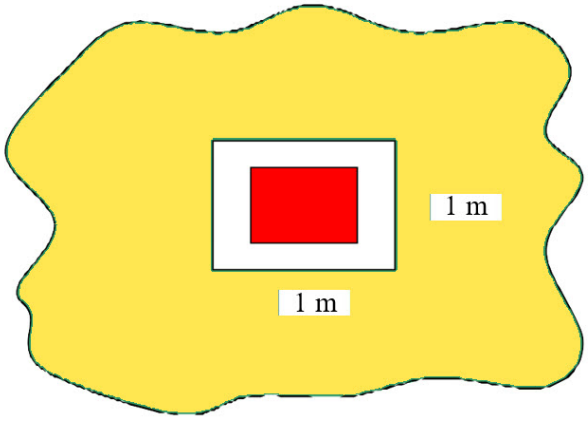


Figure 4 Target Dimensions.

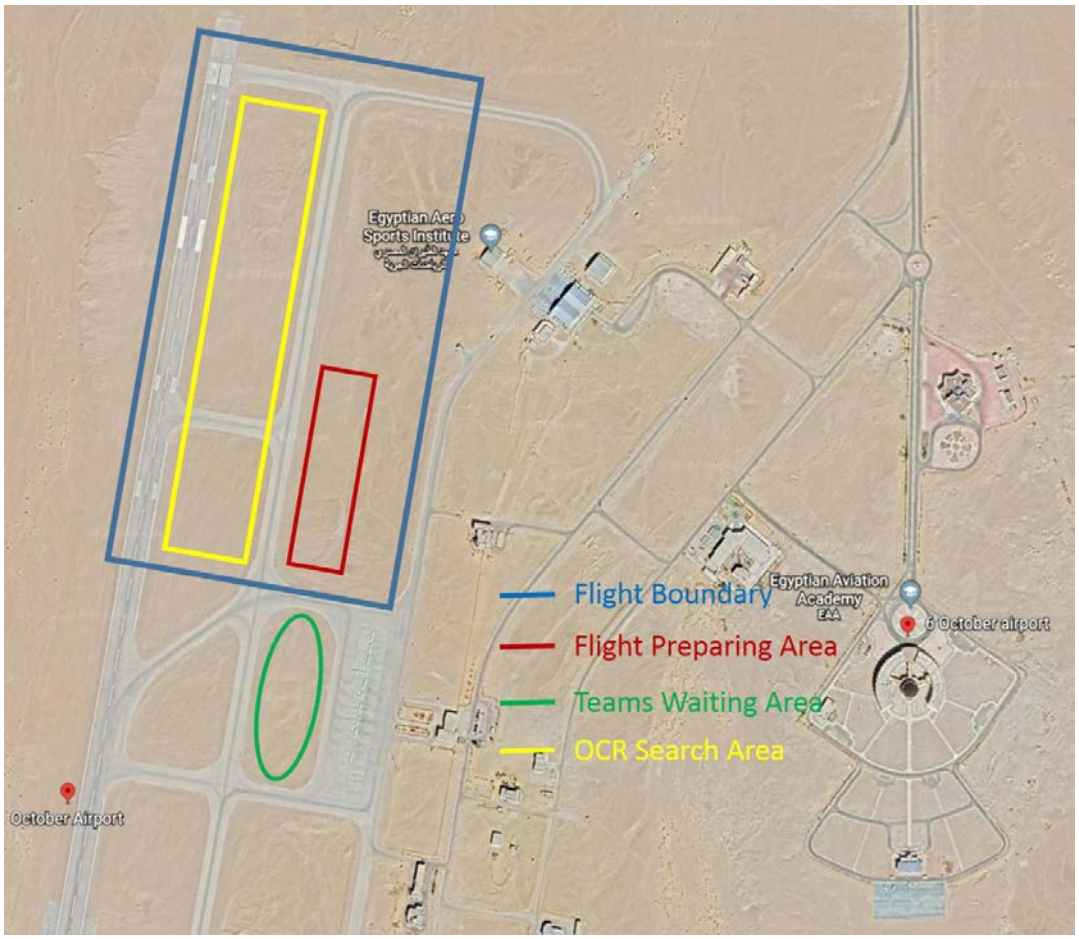


Figure 5 Airfield Plan.

The 4th International Competition of the Military Technical College

Lt. General Ibrahim Selim Award
For Innovation in Unmanned Systems

Unmanned Systems Innovation Competition (UMSIC 2019)

Details, Rules and Format

Student teams are invited to compete and display their vehicles at the Unmanned Systems Innovation Challenge held at the Military Technical College in

Kobry El-Kobba, Cairo, Egypt, on July 27th – August 1st, 2019

January 15th, 2019

The 4th International Competition of the Military Technical College

Unmanned Maritime Vehicle Challenge (UMVC 2019)

Contents

List of Figures

Glossary

AI	Artificial Intelligence
Amp	Ampere
cm	Centimeter
CP	Cathodic Protection
DC	Direct Current
e-Kill	Electronic Kill
ID	Identification
Kg	Kilogram
MB	Mega Bytes
ML	Machine Learning
MTC	Military Technical College
ROV	Remotely Operated Vehicle
RSSI	Received Signal Strength Indicator
S	Seconds
TDP	Technical Design Presentation
TDR	Technical Design Review
UMVC	Unmanned Maritime Vehicle Competition
V	Volt
VR	Virtual Reality

1. Objective

UMVC is an international competition that aims to build and enhance a community of innovators capable of making substantive contributions to the Remotely Operated Vehicle (ROV) domain.

Such vision is achieved by providing a venue and mechanism, whereby practitioners of this technology come together at the event to share knowledge, innovate, and collaboratively push the envelope of ROV systems.

2. Competition Contact Point

Kindly direct your comments and questions to:

competition@mtc.edu.eg

We encourage participants to communicate with us only through the email system.

3. Competition Venue Overview

The competition will be held at the swimming pool of the Military Technical College; located at MTC campus. The swimming pool measures roughly 50m by 25m and water depth ranges from 1.5m to 6m. The pool is generally free from obstacles with crystal clear water.

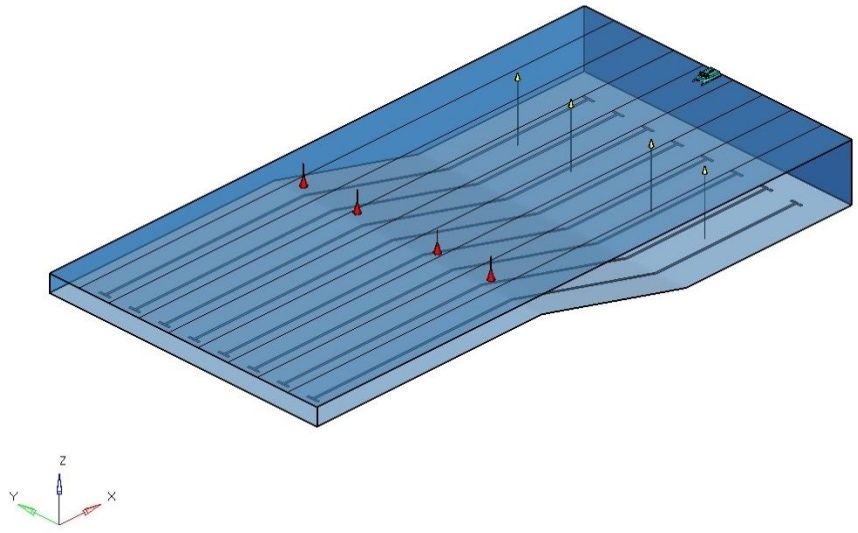


Figure 1: MTC swimming pool

During the competition, each team will be provided with a covered workspace. Teams are advised not to leave humidity-sensitive electronics, or other equipment uncovered or unattended.

Electricity (one outlet) is available in the workspace. The Arab Republic of Egypt uses a 220V 50Hz 15A electrical outlet plug. Usually 2 pins.

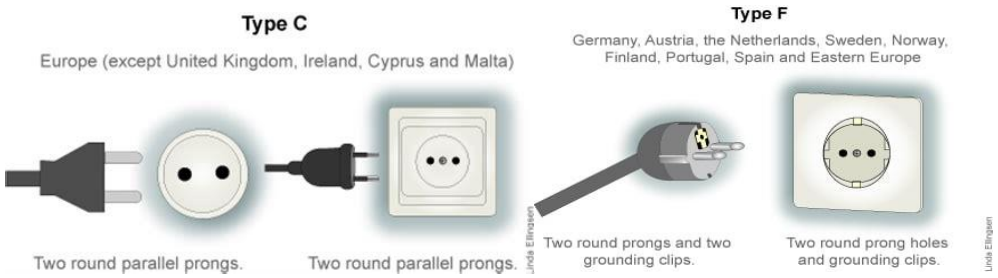


Figure 2: Electrical outlet plugs

4. Participation and Eligibility Requirements

Teams should be associated with a University/Institute/Organization/Research Center. However, 75% of the participants must be full time students. The student members of a team are expected to make significant contributions to the engineering development cycle of their ROV. Please consider that a minimum of 3 team members are needed for UMVC operations, and the maximum allowed number of team members to attend the competition event is 7 plus 3 supervisors. Moreover, faculty, industrial and governmental sponsors are allowed to attend the events.

Each team must participate with only one vehicle in the competition. Each team must designate a student team member as their Team leader. The team leader is the only person allowed to speak for the team, request vehicle deployment, run start, run end, or vehicle retrieval.

5. Registration Information

- Teams' entry forms will be submitted by no later than February 28th 2019.
- An entry fee of 2000 EGP for residents (200 USD for internationals) per team (maximum 10 members) is payable upon submission of an entry form (Registration).
- An extra fee of 500 EGP for residents (50 USD for internationals) per person for any extra team members and up to 5 members is payable on registration day (first day in the competition).
- **Any payments will be refunded ONLY in case of rejected teams.**
- Team proposal form must be submitted by no later than February 28th 2019. The main team supervisor must sign the team proposal form, and certifies that all student team members are currently registered in academic year 2018/2019.
- The following team information must be provided:
  - Name of the team (and name of the vehicle, in case it's different).
  - Team members' full names.
  - Photocopy of the national ID (for Egyptian team members).
  - Photocopy of the passport (for non-Egyptian team members).
  - Personal cell phone no., email and address.

  - List of sponsors.
- All forms will be available on the competition website and are to be sent by Email to: competition@mtc.edu.eg

6. Team Sponsors Allowances

- 15 minute lectures during the competition opening ceremony.
- Exposure to the best of unmanned systems society.
- On-site booth (charged).

7. Team Deliverables

In addition to the in-water competition tasks, each team must document their efforts leading up to the competition by writing a Technical Design Report (TDR), authoring Introductory Video, and preparing a Technical Design Presentation (TDP). All elements of the competition will be conducted in English. Each registered team will receive an invitation to a cloud storage folder with team deliverables instructions, which will be provided at a later point.

7.1 Technical design report (TDR)

Each team is required to submit a TDR that describes the design of their vehicle, as well as strategies for their approach to the tasks. TDR should also include rationale for design choices. Teams must follow the TDR instructions, available in your Team cloud storage folder (In case of any technical issues, please contact the competition board through email).

- Judges will be assessing each team's overall level of readiness to undertake the UMVC competition.
- The technical design report will be uploaded or submitted by mail through the contact person in each team.
- The technical design report should not exceed 10 pages including graphs and appendices if applicable. Teams should show a description of the vehicle, the team management, time plan and how they will accomplish the required missions of the competition (A template technical design report is posted on the competition website).
- While teams are not required to demonstrate any working systems/subsystems as part of the TDR package, such evidence will be considered by the judges in the down-selection process.

The best teams, that will pass the TDR package assessment stage, will be invited to attend and compete in the competition events.

7.2 Team introductory video

Each team must submit an introductory video (max. 5 minutes/ 250MB). Please follow the official instructions available in your team cloud storage folder, which will be provided upon registration.

7.3 Technical design presentation (TDP)

The team will present to a committee of university staff and field judges the design, specifications, cost, in addition to a full function test of the system (dry test).

Static Judging is an opportunity for teams to introduce themselves, their vehicle, and special features and/or strategies for the competition. It is also an opportunity for judges to inspect the vehicle, and interview team members about the presentation and their contribution to the engineering development cycle.

Planned Presentation Breakdown:

- 20-minute oral presentation with visual aids (a PowerPoint file and a poster board).
- 5-minute question and answer session.
- 5-minute judges' inspection of the vehicle.

After the design presentation, teams should make themselves available for a team photo, and optional video interview for archival purposes. This video interview will not be judged.

7.4 Innovation

We highly encourage all teams to innovate in all possible areas, and their efforts will be evaluated by UMVC judicial board according to the following:

- Introducing new capabilities in one or more of the following categories, or any other field of choice, will be rewarded with 25 points during the team TDP:

    1. Sealing
    2. Propulsion
    3. Dynamic positioning
    4. Underwater communication
    5. Control
    6. Image processing
    7. Autonomous systems
    8. Energy Efficiency
    9. Artificial Intelligence(AI), Machine Learning(ML)
    10. Virtual Reality(VR)
    11. Underwater guidance using acoustic waves RSSI

12. Stealth materials
13. Biomimicking
14. …Etc.

- Publishing a paper for the presented innovation compliant with the scientific research papers guidelines and referencing, will be rewarded with 25 extra points.
- In addition to the gained points, special recognition in the form of certificates will be awarded to exceptional performers.

Further details will be announced later.

7.5 How to submit competition deliverables

Once your team has officially registered for the competition, the team leader will receive an invitation to an individual cloud storage folder, which will be used for the team's submissions. Only the team leader and UMVC staff will have access to this folder.

Detailed instructions on how to submit your items are included in your cloud storage folder, each team leader is responsible for meeting all deadlines listed on the competition website

8. Competition Rules

The official source for all information concerning rules, interpretations, and information updates for UMVC is the World Wide Web home page at: *www.mtc.edu.eg*

Rule 1 **Judges' decisions are final.**

Rule 2 One student member of the team must be designated as the "team leader". The team leader, and only the team leader will speak for the team during the competition run.

Rule 3 No team member is allowed to enter the arena at any time (this includes wading, swimming and diving as well as floats, boats, etc.). Competition officials will be responsible for recovering lost vehicles. All teams recognize that by entering the competition, they risk damage to or the loss of their vehicle. The judges, officials, hosts, and sponsors can take no responsibility for such damage or loss.

Rule 4 The officials will suspend the competition / competitors at any time they deem that it is required by safety or security considerations. (Please refer to safety instructions provided on-site)

Rule 5 Preparation period: The vehicle may remain, or be placed on the dock, but not in or touching the water. A team may waive any portion of the 5-minute-long

preparation period and start the performance period. Once the performance period starts, the team forfeits any remaining time in the preparation period.

Rule 6 Performance period: When the officials signal the start of the performance period, the team may ask to have their vehicle deployed into the water and released to perform the mission. Only tournament officials may recover any faulty vehicle. This is to prevent unsafe actions in an attempt to speed the deployment and recovery processes.

Rule 7 The mission ends when any of the following occurs:

- The performance period time limit ends.
- The judges' order the end of the mission.
- The team leader requests the end of the mission.
- The vehicle breaches the surface outside the surface marked area.

Rule 8 Any bonus will be rewarded only in case of attempting all performances (at least 50% of performance period under water)

8.1 Vehicle requirements

- **Buoyancy:** The vehicle shall be neutrally buoyant and remain submerged underwater for at least 30 minutes.
- **Communication**: The vehicle can send or receive any control information while in submerged underwater mode (to and from Operators Control Station).
- **Deployable**: The vehicle must be deployable from the deployment point (dock).
- **Energy source**: The vehicle must be surface powered by the DC 48 V 30 Amp fused power supply provided on-site by UMVC.
- **Kill Switch**: The system must have a red button located at the operator control station that, when actuated, must instantaneously disconnect power from the ROV.
- **e-Kill Switch**: In addition to the physical kill-switch, the vehicle may have at least one remote kill switch that, when actuated, must instantaneously disconnect power from all motors and actuators. If the remote kill switch system is turned off, vehicle must instantaneously disconnect power from all motors and actuators.
- **Propulsion**: Any propulsion system may be used. However, all moving parts must have a shroud.
- **Remote-controllable**: The vehicle must be remote-controllable (tele-operated) to be brought back to the dock. If the remote controller is turned off, vehicle power must be instantaneously disconnected.
- **Safety**: All sharp, pointy, moving or sensitive parts must be covered and marked.
- **Towable**: The vehicle must have a tow harness point installed at all times.

- **Weight**: The ROV weight must be 40 Kg or less **(excluding the tether)**, and it will be assessed according to Table 1 in section 11.3.
- **Size**: The vehicle size will be assessed according to Table 2 in section 11.3.

8.2 Interference

- Interference with course elements will result in a penalty.
- Any vehicle entangled in, dragging, pushing or damaging competition elements or the landscape is interfering.
- Any vehicle leaving its assigned course is interfering.

9. Water-Based Tasks

9.1 Airplane wreck recovery challenge [100 points]

As the ROV crew, you have a mission to locate the wreckage of an airplane, and recover its parts to the surface. The task will require using the installed cameras, sensors and underwater markers to find and report the location, in addition to recovering the parts to the dock using a crane basket.

Figure 3: Airplane wreck recovery challenge

9.2 Underwater structure challenge [100 points]

Carry out precise inspection for various members of the platform underwater structure, detect the percentage of marine growth on these members, Measure the cathodic protection (C.P) for this platform, Replace the old expired anode with a new one and returning it to the surface and Secure a clamp which is holding one leg of the structure to the riser.

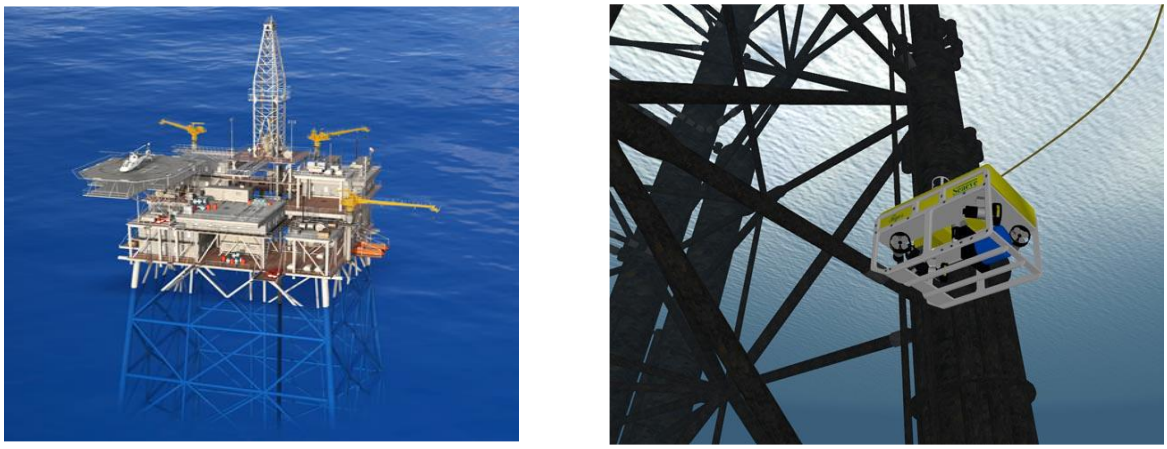


Figure 4: Underwater structure challenge

9.3 Maritime archeology expedition challenge [100 points]

As the ROV crew, you have a mission to explore a newly discovered underwater archaeological site. The task will require taking measurements and salvaging some artefacts that need to be recovered to the dock without being damaged.

Figure 5: Maritime archeology expedition challenge

10. Network

10.1 Software security

Our intent is for students to develop skills in systems engineering by accomplishing realistic missions. We have a zero-tolerance policy for any deliberate attempts at sabotaging other teams, or the competition network. Any attempts (successful or not) to hack any of the software systems or other teams' vehicles will result in disqualification of the team.

10.2 Team deployed network

Each team is responsible for deploying their own 'network' solution for communication with their vehicle. There is no restriction on the actual communication mechanism
(e.g., underwater modems, cellphone, 802.11xx wireless, etc.). Each team must provide a base station that can bridge the communication between their vehicle and the wired RJ-45/cat5 Ethernet network of the competition.

11. Evaluation Schemes and Penalties

As mentioned earlier, the TDR package is a milestone. This implies that it will be evaluated separately and its score will not be added to the scores earned in the event tasks. The score is weighted as follows:

- The presentation task will be evaluated out of 100 points.
- The ROV field performances will be evaluated out of 300.

All the scores of the individual tasks for each team will be summed (as well as bonus points and penalties) and compared against other teams' total scores to identify the winners as well as the order of all teams.

11.1 Evaluation scheme of TDR milestone

The TDR package milestone aims to show the readiness of the teams to undertake the UMVC- ROV competition. Accordingly, the evaluation will be based on the completeness of the TDR package and the progress-to-date of the final system as well as the way the teams are representing their progress. Since the TDR is a competitive milestone, the TDR Packages will be judged against other teams' submissions by the judges.

11.2 Evaluation scheme of TPR

Scoring for this task will be assessed on the following equally weighted categories:

- Team structure, organization, and management.
- Core ROV design and to explain its functionality (it is required to bring your ROV).
- Mission controller design.
- Suitability of ROV design to competition tasks.

- Response to follow-on questions.
- Overall quality of presentation.

11.3 Evaluation scheme of ROV field tasks

In addition to every task performance time, there will be have 5 minutes to set up the ROV system and 5 minutes to dissemble the ROV and exit from the competition area. The performance period will begin after the full 5 minutes of set up time expires. During the preparation period the vehicle may remain on the swimming pool dock, but not in or touching the water.

The total score of the task will be the earned score minus deducted one. Score will be earned for completing all tasks within the designated period. Score will be deducted for ROVs overweight or size, touching the obstacles and team members' interventions.

The penalty of touching each of the obstacles is 5% of the earned score per each obstacle touched. If the same obstacle is touched in the return path, it will be considered a touch with another obstacle and the team will be penalized for it too.

Teams will be penalized 10% of the total points in that task for every team members' intervention. The task clock will continue to run during an intervention. Multiple intervention penalties in a single task will incur multiple penalties.

The max penalized points could reach up-to 50% of the total earned score per mission.

Weight constraints: The bonuses and penalties of ROVs overweight are shown in the Table 1.

Table 1 weight constraints of ROVs

ROV Weight	Bonus	Penalty
ROV > 40 kg	-	Disqualified
ROV < 40 kg	Bonus of (1 point) for every 1 kg less than 40 kg up to 15 points. Example: - ROV weighs 30 kg: 10 bonus points. - ROV weighs 25 kg:15 bonus points. - ROV weighs 24 kg: 15 bonus points. All measured weights will be rounded to the nearest whole number (kilogram).	

Size constraints: If the largest dimension of the ROV and all its equipment is less than50 cm, the team will receive +25 bonus points. If the largest dimension of the ROV and all its equipment is larger than 50 cm and less than 60 cm, the team will receive +15 bonus points. If the largest dimension of the ROV and all its equipment is larger than 60 cm and less than 70 cm, the team will receive +10 bonus points. If the largest dimension of the ROV and all its equipment is larger than 70 cm and less than 80 cm, the team will receive +5 bonus points. If the largest dimension of the ROV and all its equipment is larger than 80 cm and less than 100 cm the team will receive no bonus points, but can still compete in the product demonstration. If the largest dimension of the ROV and all its equipment is larger than 100 cm the team will not be permitted to join the competition. Table 2shows the bonuses and penalties regarding the ROV size constraints assuming "x" represents the largest dimension of the ROV and all its equipment.

Table 2 size constraints of ROVs

ROV Size	Bonus	Penalty
x>100 cm	-	Disqualified
80cm<x<100cm	No bonus points but the team can compete	-
70 cm < x < 80 cm	+5 bonus points	
60 cm < x < 70 cm	+10 bonus points	-
50 cm < x < 60 cm	+15 bonus points	-
x < 50 cm	+25 bonus points	-

If more than one team have finished all the tasks within the time frame with equal score, those teams will be ordered according to how fast they finished the task. There will be a time bonus which will be calculated from the remaining time period of the task.

For example, with a remaining time of 5 minutes and 30 seconds, a team will receive (5+(30/60)) ×10=55 points. Calculating the remaining time depends on achieving the following conditions:

- Completing the entire task.
- The ROV return to the surface under its own power and is grabbed by one of the team members before the performance time ends.

The mission ends when any of the following occur:

- The performance period time limit ends.
- End of the mission by the judges.
- The team leader requests the end of the mission.

12. General Notes

12.1 Time allocation during field performance

The allocated time varies between different missions.

Pre-Start Time: To maximize in-water time for each team, teams should be physically present with their vehicle, in a ready state, at least five minutes before the start time. Organizers will utilize this time to conduct a safety check of your system.

Dock Time: The first five minutes of the allocated time is for docking. Dock time begins when receiving a signal from the main judge. If the vehicle is still at the dock when the dock time runs out, in-water time will automatically start.

In-Water Time: For every mission, a certain limit will be announced for the in-water performance time following the designated dock time. During in-water time (performance time), teams may attempt as many 'runs' as desired. The in-water time keeps running, even when vehicles are being bought back to the dock (towed or under their own power, intervention will be penalized as mentioned).

The mission time will automatically end as soon as one of the following occurs:

- The in-water time runs out.
- The team leader requests termination of the run.
- The technical director or a judge orders termination of the run.

Note: TDs and Judges rarely order termination of a run but they can do so at their discretion for safety or competition rule violations.

At the end of the mission time, vehicles must be brought back to the dock, under their own power. In case of catastrophic system failure, UMVC staff may manually tow the vehicle back.

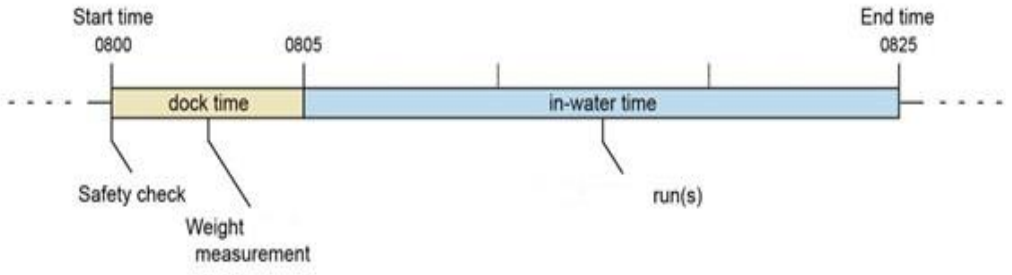


Figure 6: Example breakdown of mission time

12.2 Deadlines and competition program

12.2.1. Deadlines

No.	Item	Due date
1	Competition Rules	15th January 2019
2	Missions Details	31st January 2019
3	Submission of Team's Proposal and Entry Forms	28th February 2019
4	Submission of TDR and Introductory Video	16th May 2019
5	Acceptance from the Technical Committee	22nd June 2019
6	Orientation Day	20th July 2019
7	Competition	27th July – 1st August 2019

12.2.2. Competition schedule

No.	Activity	Date
1	On-site Registration and Opening Ceremony	27th July 2019
2	Presentation and ROV competition tasks	28th– 31st July 2019
3	Results announcement and awards	1st August 2019