

MBZIRC

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Mohamed Bin Zayed International Robotic Challenge
INSPIRING FUTURE ROBOTICS

ORGANIZED BY



جامعة خليفة
Khalifa University

MBZIRC 2020



SCORING SCHEME

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GENERAL

01 TRIALS

- Each team will have two trials for Challenges 1-3. There will be only 1 trial for the Grand Challenge.
- The best score from the two trials will be retained.
- Trial schedules will be during daylight hours, from 7.30AM – 5.30PM.
- We will make every effort to complete the trails during daylight hours (7.30AM-5.30PM). However, we may use floodlights if needed (e.g. due to adverse weather conditions, overrunning of schedules etc).
- If we cannot complete two trials for each team during the allotted schedule (e.g. due to adverse weather conditions etc), then only the score from the first trial will be retained for all teams (irrespective of the number of trials completed by the teams).

02 MODES

- The competition can be attempted in either full autonomous (A) or manual (M) mode.
- Any human intervention during any of the 4 challenges will result in the team being assigned to manual mode. The team will remain in Manual mode for the rest of the Challenge. The team will retain any A mode score attained before the switch, and will have a mixed mode score.

03 RESETS

- Teams can request resets at any time during their allotted time period.
- For a reset to be requested, all the robots must be stationary on the ground.
- The teams can either let the robots stay where they have landed or place the robots in the start zone, and recommence the challenge.
- If the team needs to perform any interventions on a particular robot (i.e. changing batteries, refilling water canisters etc), then that robot must be moved to the start area, prior to implementing interventions.
- No changes to the hardware will be permitted during resets, except teams may change batteries or refill/reattach fire extinguishers or fire blankets (Challenge 3 only) during resets.
- No additional time will be provided for resets.
- There will be no scoring penalties for resets.

04 SCORING OVERVIEW

OVERVIEW -1

- Each Challenge has a number of separate Tasks:
T1, T2, ..., Tn
- Each of these tasks will be scored separately. The score for Task i will be:
S-Ti = 100% if task is fully completed or
S-Ti < 100% if task is only partially completed.

OVERVIEW - 2

- The final score will be a weighted average of the individual task scores:

$$S\text{-Final} = \frac{\sum(w_i * S\text{-}T_i)}{\sum(w_i)}$$

$$= \frac{(w_1 * S\text{-}T_1 + w_2 * S\text{-}T_2 + \dots + w_n * S\text{-}T_n)}{\sum(w_i)}$$
 where **w1, w2, ..., wn** are the scoring weights.

OVERVIEW - 3

- Non-zero Mode A scores will be ranked above Mode M scores.
- In the case of a tie in A mode scores, and one or more of the teams have an M mode score, the team with the higher M mode score will be ranked higher.
 In the case of a tie in A mode scores, and the teams do not have an M mode score, or the M mode scores are also tied, the team with the faster completion time (T) will be ranked higher.
- Teams will need at least an A mode score to qualify for prize money.

05 DRONE SIZE

- Current upper limit: 1.2m x 1.2m x 0.5m. Drone with all attachments, in take-off configuration, should fit into a box of dimensions **1.2m x 1.2m x 0.5m**.
- Arms etc can be extended after takeoff, during flight.
- Teams may use bigger drones (up to 1.7m x 1.7m x 1m) but with a penalty.
- The penalty will vary from 0 to 25%, in proportion to the maximum increase in any one of the three dimensions, for marks scored with that drone: e.g. A drone of dimensions 1.5m x 1.6m x 0.5m will incur a penalty of **25% x (1.6-1.2)/(1.7-1.2) = 20%**

06 RTK GPS

- The arenas will have GPS access, except within the indoor structure (for Challenges 3).
- Teams may use RTK/DGPS in any of the arenas.
- However, a penalty of 25% will be applied to teams using RTK/DGPS.

CHALLENGE 1 - OVERVIEW

- The Challenge 1 duration is 15 minutes.
 - The moving target will have a speed of 8 m/s for the first 8 minutes and 5 m/s for the next 7 minutes.
 - TASKS
 - 0 T1 = Catch and deliver target ball to receiving box (a square with 3m sides close to one corner of arena).
 - 0 T2 = Pierce balloons scattered around arena.
 - A penalty of X1 % will be applied if the team drone makes contact with target ball carrying drone.
 - A penalty of X2 % will be applied if the team drone disables or damages the target ball carrying drone.
- All Challenge 1 scoring variables are defined in PAGE NO 07.

CHALLENGE 1 - TASKS AND SUB TASKS

- S-T1 = 1 (i.e.100%) if task is fully completed (delivery of target ball inside a square box of 3m sides) OR
- S-T1 = a1 for successful grasping of the target and delivery to vicinity of collecting zone (inside a square with 6m sides)
- S-T1 = a2 for successful detachment of the target
- S-T1 = a3 for physical contact with the target
- S-T1 = 0 for no physical interaction with the target
- S-T2i = 1 if balloon i is pierced (i=1, 2, ---, n1)
- S-T2i = b1 if balloon i is touched without piercing
- S-T2 = [Sum (S-T2i)] / n1

CHALLENGE 1 - SCORING

- **S-Final = (w1 * S-T1 + w2 * S-T2) / (w1+ w2)**
- Marks will be normalized at the end of the trials, with the Team(s) scoring highest mark awarded 100%.
- Teams need to achieve an A Mode Score in Task 1 (catch and deliver target ball) to be eligible for prize money).

CHALLENGE 1 - SCORING PARAMETERS

CHALLENGE PARAMETERS

n1 number of balloons 5

PARTIAL COMPLETION SCORES

a1 (grasp and deliver)	0.8
a2 (grasp and remove)	0.6
a3 (physical contact)	0.3
b1 (touch balloon)	0.7

PENALTIES

x1% (contact with drone)	25%
x2% (damages drone)	50% for damage to first drone OR
x2%	100% and disqualification from that trail for damage to second drone

(we will review these penalties during the event, and reserve the right to increase them and apply them retrospectively, if needed).

WEIGHTS

w1 (ball)	0.7
w2 (balloon)	0.3

CHALLENGE 2

- Task T1 Assemble Wall 1 and Wall 2 using 4 types of bricks:
Br (red),
Bg (green),
Bb (blue) and
Bo (orange)
- Each team will be given a randomly generated blueprint for the wall to be assembled.
- Wall 1, to be assembled by UGV, will have 5 layers consisting of 45 bricks in total: 20 Red, 10 Green, 5 Blue and 10 Orange
- Wall 2, to be assembled by UAV, will consist of 4 layers and 46 bricks in total: 24 Red, 12 Green, 6 Blue and 4 Orange.
- Collaboration between UAVs and UGV is permitted.
- Wall 1 bricks will be placed by UGVs. | Wall 2 bricks will be placed by UAVs.
- Prior to placing bricks the UAV and UGV can collaborate.
- A brick is considered as built if all the needed sub-tasks are performed by the robot: locating and picking bricks, transporting bricks, and laying bricks so it is positioned stable (that is without falling) on the wall structure.
- If a brick is correctly positioned, and gets blown away subsequently, the score will remain.
- Teams will be allowed a reset without scoring penalty, to reassemble the wall. However, no extra time will be permitted.

CHALLENGE 2 - SCORING

- Assembled bricks will be scored as follows:

Br = d1 for UAV or d2 for UGV

Bg = d3 for UAV or d4 for UGV

Bb = d5 for UAV or d6 for UGV

Bo = d7 for 2 UAVs or d8 for UGV

- $S\text{-Final} = (\text{Total score of bricks assembled}/N) * 100$

Where N is the maximum attainable score:

$N = c1*d1 + c2*d3 + c3*d5 + c4*d7$

- Only 4 red, 2 blue and 1 green brick will be counted per layer (e.g. a fifth red brick in a given layer will not get a score).
- No penalty will be applied for gaps between bricks.
- Out of sequence bricks will be penalized as outlined in next slide.

Out of sequence bricks will be penalized as outlined below:

- Brick Interfaces

The interfaces between two adjacent bricks as well as between the outer bricks and the two Ends are defined as follows:

For the sequence of 7 bricks given by

RED-GREEN-RED-BLUE-RED-RED-GREEN

The two sets of interfaces are

ER, RG, GR, RB, BR, RR, RG, GE (measured left to right) or

EG, GR, RR, RB, BR, RG, GR, RE (measured right to left).

CHALLENGE 2 - SCORING

- These two sets of interfaces will be compared with the actual interfaces made by a team, for each layer of Wall 1 and Wall 2, to give a % similarity score.
- The maximum similarity score of the two scores will be used.
- If the similarity score is below 60%, then the team will be penalized by 30%. If the similarity score is between 60% and 100%, then the penalty will linearly decrease from 30% to 0%.
- Marks will be normalized at the end of the trials, with the Team(s) scoring highest mark awarded 100%.
- Teams need to achieve an A mode score in Wall 1 and Wall 2, to be eligible for prize money.

CHALLENGE 2 - SCORING PARAMETERS

CHALLENGE PARAMETERS

Total Bricks

c1 (red)	44
c2 (green)	22
c3 (blue)	11
c4 (orange)	14

SCORES

d1 (Br for UAV)	3
d2 (Br for UGV)	1
d3 (Bg for UAV)	4
d4 (Bg for UGV)	2
d5 (Bb for UAV)	6
d6 (Bb for UGV)	3
d7 (Bo for 2 UAVs)	16
d8 (Bo for UGV)	4
d9 (Bo for UAV)	10

Wall 1 Maximum Score

$$20 \times 1 + 10 \times 2 + 5 \times 3 + 10 \times 4 =$$

$$20 + 20 + 15 + 40 = 95$$

Wall 2 Maximum Score for 1 Layer

$$12 \times 3 + 6 \times 4 + 3 \times 6 + 2 \times 16 =$$

$$36 + 24 + 18 + 32 = 110$$

CHALLENGE 3

- The Challenge 3 duration is 15 minutes.
- Task 1, T1 = UAVs and UGV to eject water at a total of 6 fire sources.

The maximum amount of water to be delivered to a target listed above is 1 liter, in order to obtain the full marks for that sub task.

- Task 2, T2 = UAVs and UGV to cover 2 fire sources using with fire blankets:

CHALLENGE 3 - TASK 1

T₁ FIRE SOURCES:

F₁ Ground floor indoor to be extinguished by UGV or UAV

F₂ First floor indoor to be extinguished by UAV

F₃ Second floor indoor (smoke filled room) to be extinguished by UAV

F₄ Ground floor façade (wind gusts up to 8m/s) to be extinguished by UAV

F₅ First floor façade to be extinguished by UAV

F₆ Second floor façade to be extinguished by UAV

The locations of the target fires will be random.

Task 2, T2 = UAVs and UGV to cover 2 fire sources listed below, using with fire blankets:

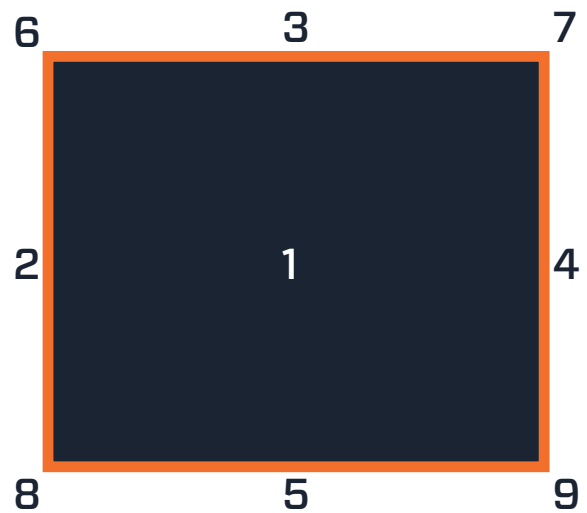
- F7 Ground level outdoor fire to be extinguished by UAV or UGV
- F8 Ground level outdoor fire to be extinguished by UAV or UGV

Task 1 Score

- **S-T1i** = (Water in liters delivered to target i) (i=1 to 6)

CHALLENGE 3 – TASK 2 SCORE

- If the blanket covers any area inside the target (area 1) a score of 20% will be awarded.
- For each of the lines (2,3,4 and 5) and corners (6, 7,8 and 9) covered by the blanket a score of 10% will be awarded.
- So if the blanket covered part of the inner area and lines 2, 5 and corner 8 the score will be : $20+10+10+10= 50\%$



SCORING

- The final score will be a weighted average of the individual Task scores:

$$\mathbf{S-Final} = \frac{\sum(w_i * \mathbf{S-T}_i)}{\sum(w_i)} = \frac{(w_1 * \mathbf{S-T}_1 + w_2 * \mathbf{S-T}_2 + \dots + w_n * \mathbf{S-T}_n)}{\sum(w_i)}$$

where **w1**, **w2**, ..., **wn** are the scoring weights

- Marks will be normalized at the end of the trials, with the Team(s) scoring highest mark awarded 100%.

CHALLENGE 3 - SCORING PARAMETERS

CHALLENGE PARAMETERS

V (Maximum water in liters to target) 1 liter 1

SCORING WEIGHTS

w1 (Ground floor indoor)	10UAV, 10UGV
w2 (First floor indoor)	16
w3 (Second floor indoor, smoke)	24
w4 (Ground floor façade, wind)	14
w5 (First floor facade)	8
w6 (Second floor facade)	8
w7 (Blanket 1)	10UAV, 5UGV
w8 (Blanket 2)	10UAV, 5UGV

GRAND CHALLENGE

SCORING

- The Grand Challenge duration is 25 minutes.
- During the Grand Challenge the three individual challenges will run simultaneously.
- Teams will be ranked for each of the 3 constituent challenges as outlined in the previous slides.
- Teams failing to complete at least one of the three constituent challenges will be placed equal last in the final ranked list.
- A mean score (MS) will be calculated for each of the remaining teams and teams ranked accordingly.

MS = Arithmetic mean of the ranked positions in each of the three constituent challenges

e.g. A team ranked 2, 4 and 9 in Challenges 1, 2 and 3 respectively will have a mean score of $MS=5$



THANK YOU