

WRS Tunnel Disaster Response and Recovery Challenge

Rule Book (Ver.1.0)

WRS Task Development Team

Competition Overview

1. Competition

1.1. Symbol, Type and Duration of Mission and Task

1.1.1. Mission and the duration for the tunnel disaster response challenge are as follows.

1.1.1.1. Duration is subject to change.

Figure 1-1 : Task Symbol and Duration

Mission and Task Symbol		Duration (Min/Mission)	Detail
Mission	Task		
T1	T1-A	10	Traversing Obstacles
	T1-B		
	T1-C		
	T1-D		
T2	T2-1	15	Vehicle Inspection

	T2-2		
	T2-3		
T3	T3-1	20	Vehicle Inspection using Tools and Rescue
	T3-2		
	T3-3		
T4	T4-A	15	Secure the Route
	T4-B		
	T4-C		
	T4-D		
T5	T5-1	15	Fire Extinguish
	T5-2		
	T5-3		
	T5-4		
T6	T6-1	15	Shoring and Breaching
	T6-2		
	T6-3		

1.2. Number of Challenges

1.2.1. Each team is allowed to perform all the tasks twice during the competition.

1.3. Number of Participants

1.3.1. Out of the registered members, competition participants refers to the members who manipulate robots and engage in challenges.

1.3.2. The number of the participants is 2.

- 1.3.3. Exchange of participants during a mission (task) is not allowed.
 - 1.3.4. No other members are allowed to enter the robot control station (team booth) during a mission (task).
 - 1.3.4.1. No communication is allowed between the participants and other members during a mission (task).
 - 1.3.5. The participants and the member can prepare for start and restart. Only one member apart from participants can enter the control station to prepare for start and restart.
- 1.4. Referee and Organizer
- 1.4.1. Referee
 - 1.4.1.1. A referee is in charge of challenges, scoring and time measurement.
 - 1.4.1.1.1. During a challenge, a referee and an assistant referee are allocated to each team to give directions and judgements.
 - 1.4.1.2. A system referee makes judgement on the simulation system malfunctions such as network and computer problems.
 - 1.4.1.2.1. For a problem during a challenge which is supposed to be caused by simulation system fault, the participants report to the referee instead of the system referee. The referee then contacts the system referee if necessary.
 - 1.4.2. Organizers
 - 1.4.2.1. Manage competition and referees.
 - 1.4.2.2. The chairperson of the organizers is required as a person in charge of the competition.

2. Robot

2.1. Number of Robot

2.1.1. Up to 2 robots are allowed for all the missions.

2.2. Type of Robot

2.2.1. A platform robot or a self-built robot is used during the competition.

2.2.1.1. There are 2 types of platform robots.

※ Refer to a model for details (provided separately)

【Leg-type Robot】



【Dual Arm Robot】



2.2.1.2. Self-built Robot

• Robot custom made by participants without using the platform robots

※ TDP(Team Description Paper) with detailed specification is required for participation with the self-built robot.

※ Participants can develop their own robot using the basic robots provided by the organizer.

[Basic Robot]

Robots used to validate simulator and tasks.

Models and details of the basic robots are provided separately.

2.3. Robot Size and Challenges

2.3.1. The size of a robot can determine the challenge and the size of the field in which the team can participate.

2.3.2. Robots are classified into 3 categories by size.

[S size]

Robots that can go through an equilateral triangle hole with 60cm on a side.

[M size]

Robots that can go through a square hole with 80cm on a side.

[L size]

Robots larger than M size robots.

3. Field

3.1. Field Placement

- 3.1.1. Inside the tunnel of two-way and two-lane road, each 3.6m width, with 1m frontage roads on both sides.
- 3.1.2. The distance between the start and goal varies according to tasks, which are to be completed inside the tunnel.

3.2. Direction and Coordinate

- 3.2.1. The center of a start line is the coordinate origin.
- 3.2.2. Coordinate system is a right-handed system with (+)X coordinate toward a red pole and (+)Z coordinate upward from the origin.
- 3.2.3. (+) direction of Y coordinate is called forward and (-) backward.

4. Start and Goal

4.1. Mission and Start

4.1.1. Basically, a challenge starts at every mission or task.

4.2. Gate and Line

4.2.1. A gate with red and blue poles is placed at a start point, goal and checkpoints.

4.2.2. Each gate is equipped with numbered flags starting from "1", which is referred as a gate number.

4.2.3. The line to connect both sides of the gates is called a gate line (As with a gate number, referred to as a gate line No.1).

4.2.3.1. A gate line at a start point for each mission (or task) is called a start line.

4.2.3.2. A gate line at a checkpoint for each mission (or task) is called a checkpoint line.

4.2.3.3. A gate line at a goal for each mission (or task) is called a goal line.

4.2.3.4. Robot has to start from a start point and aims at the gate of the goal by passing the gate lines as checkpoints in the numerical order.

4.2.3.5. Robot has to go through gates with a red pole on the right.

4.3. Duration

4.3.1. Preparation time is included in the time slot (including a preparation for a restart).

4.3.2. Time is that in the simulation world.

4.3.3. In case of difficulty in continuation of the competition, time may end even before the time in the simulation world did not reach the time limit.

4.4. Start

4.4.1. A start point is anywhere behind the start line.

4.4.1.1. A symbol of center of gravity is marked as a reference at 1m behind the center of a start line.

- 4.4.1.2. Robot is not allowed to take an active action before the start.
- 4.4.2. Any part of robot cannot be in front of a start line including the space above.
- 4.4.3. The procedure for a start is as follows.
 - 4.4.3.1. Participants set up necessary equipment for robot operation on the table in the control station
 - 4.4.3.2. With the referee's call for a start, the mission starts along with the preparation.
 - 4.4.3.2.1. Preparation includes a network connection between the robot operation computer and the competition system.
- 4.4.4. Time starts with the announcement of a start.
- 4.5. Goal
 - 4.5.1. When a referee ensures a robot marker passed a goal line, it ends a mission.
 - 4.5.1.1. Robot marker, which is placed at an easily recognizable point of the robot for a referee, is the position of a sphere attached to a robot.
 - 4.5.1.1.1. The sphere is defined in VRML in the JVRC technical guide.
 - 4.5.2. The task (subtask) ends when a robot reaches the goal and the time stops.
 - 4.5.3. A robot can reach the goal without completing all the tasks required in each task (subtask) such as target identification.
 - 4.5.3.1. In this case, there is no point elements added for unattempted tasks.
- 4.6. Checkpoint
 - 4.6.1. Checkpoints are placed between the start and the goal.
 - 4.6.2. A referee has to ensures a robot marker passed a checkpoint line.
- 4.7. Restart
 - 4.7.1. Participants can request restart.

4.7.1.1. Restart is to do the start again after the initial start.

4.7.1.2. Restart complies with the starting procedure.

4.7.1.2.1. In case of restart, the field condition returns to the initial state.

4.7.2. Preparation for restart begins when the referee accepted the request for restart.

4.7.2.1. No withdrawal from the restart once the referee accepts.

There is no need to restart if abstention is requested after a restart is accepted.

4.7.3. Participants can request restart for their own convenience.

4.7.3.1. In case of restart, the restart line is any line(start line, checkpoint line) behind the position where restart is requested.

4.7.3.2. Scoring elements and penalties occurred behind the restart line remain valid.

4.7.3.3. Scoring elements and penalties occurred in front the restart line are withdrawn.

4.7.4. When restart is accepted, time stops and the field returns to the initial state. Restart begins with the referee's announcement and time starts again.

4.7.5. The duration of the mission after restart is the remaining time by subtracting the time when the referee accept the restart from that of the official mission duration.

Ex) If restart is accepted at 4 minutes 30 seconds in 10 minute mission time, the remaining time after restart is 5 minutes 30 seconds.

4.7.6. There is no limit of the number of restart.

4.7.7. When a referee decides the participants need restart, the restart is mandatory. This restart is called forced restart.

4.8. Abstention

4.8.1. Participants may abstain from all or part of the tasks (subtasks).

4.8.1.1. Participants request to a referee for abstention.

4.8.2. In case of abstention during the challenge, points are given only when a robot passed through a checkpoint line.

Ex) When Task A and B are executed consecutively, points earned in task A is valid regardless of abstention during task B after the completion of task A.

- 4.8.3. Robots can proceed to the second task (subtask) even if they abstained from the first half of the consecutive tasks (subtask).

Ex) When Task A and B are executed consecutively, abstention from task A does not prohibit task B to be executed.

- 4.8.4. Abstention from the first half of the 2 (n) separate tasks (subtask) without time stop leads to $1/2(1/n)$ mission time.

Ex) When task A and B are executed consecutively for the total amount of 10 minute time slot, the mission time to proceed to task B after abstention from task A is $10\text{min}/2 = 5$ minutes.

5. Target

5.1. Definition of Target

5.1.1. Target consists of QR codes and pipes. The size of QR codes and the length of pipes as a “target” are to be one of the followings.

Table : 5- 1 Type and symbol of target

Target Symbol		Width of QR code(mm)		
		140	35	7
Length of Pipe (mm)	0	140-0	35-0	7-0
	50	140-50	35-50	7-50
	100	140-100	35-100	7-100

5.1.2. QR code used as a target is version 1 (number of cells: 21x21). Q(25%) is used for the error correction level.



Figure : 3- 1 Target (140-50)

5.2. Target for Vehicle, Road Surface and Tunnel Structure

5.2.1. Use targets as in 5.1.1.

5.3. Target for Victim Identification

5.3.1. QR codes attached to the face, arms and legs of dummy victims are used.

5.3.2. The size and specification of QR codes are the same as targets for vehicles.

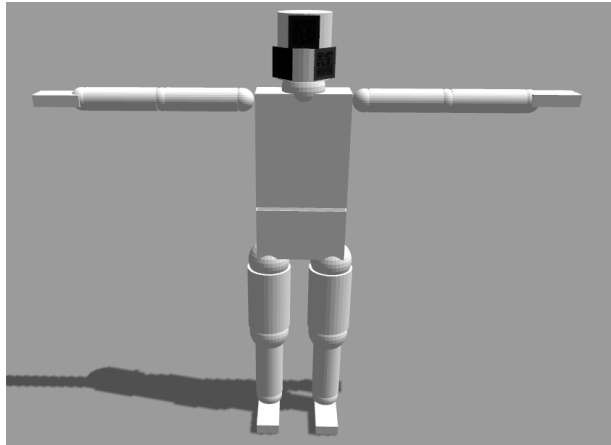


Figure : 5-1 Dummy Target
(QR code attached to the face)

5.4. Number of Targets

5.4.1. The number of targets in each task (sub task) varies according to each mission.

5.5. Identification of Targets

5.5.1. Target identification is to read QR codes on a target.

5.5.1.1. Participants are to report the findings of QR codes to referee.

5.6. Position and Location of Targets

5.6.1. Target's position is the coordinate center (x,y,z) of a target.

5.6.2. Target's location is the approximate location of a target in the field, which is represented as a symbol.

5.6.2.1. Symbol is defined separately.

5.7. Reporting Target

5.7.1. Participants are to report target's position for tasks which require the report.

5.7.2. Procedure and formats for reporting are defined separately.

6. Ranking, Scoring and Penalty

6.1. Ranking

6.1.1. Award placing is determined by the ranked cumulative scores.

6.2. Scoring

6.2.1. Perform scoring elements of each mission (task) to earn the points and meet the requirements for additional point elements to earn the additional points.

6.2.2. The official record is the point rounded off to the first decimal place.

6.3. Scoring Elements and Additional Point Elements

6.3.1. Scoring elements are the tasks to earn points allocated to each mission.

6.3.1.1. Perform scoring elements to earn points.

6.3.2. Additional points can be scored depending on the conditions specified in each mission such as obstacles.

6.3.2.1. Additional points are valid only when scoring points are earned.

6.3.3. Additional points can be scored for submission of environmental information maps in the field.

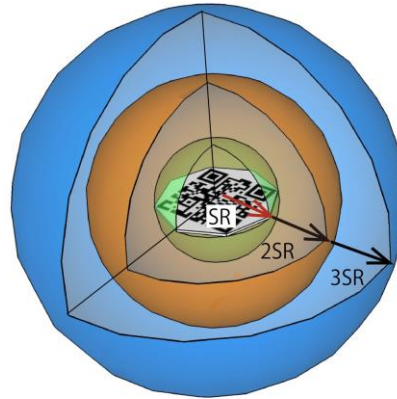
6.3.4. Additional points (position) are given for successful identification of an accurate target position in a mission (task).

6.3.4.1. If the coordinate of the position is within the radius SR (=radius of a target pipe), 100% of scoring element (position) is given. 50% for within $2SR$ and 25% for within $3SR$. (See the following figure).

Ex) For a 4 point task, 4 points in SR , 2 points in $2SR$ and 1 point in $3SR$ are given.

Ex) For a 3 point task, 3 points in SR, 1.5 points in 2SR and 0.75 point in 3SR are given.

※ The number of points are subject to change.



6.3.5. Details of scoring, additional points and penalties are noted separately.

Mission T : Tunnel Disaster Response and Recovery Challenge

7. Mission

7.1. Common Items in Mission

- 7.1.1. Tasks in each mission refer to basic technology of a robot required to complete a mission.
- 7.1.2. Information including field maps cannot be obtained prior to the start, because it simulates a disaster mission.
- 7.1.3. Field environments and conditions can be changed even in the same mission depending on the location of a robot and the mission time.
- 7.1.4. Field environments and conditions include followings as a parameter.
 - Lighting
 - Wind
 - Condition of wireless communication
 - Temperature
 - Visibility
 - Field configuration
 - Other limiting factors for robot mobility

7.2. Using Tools

- 7.2.1.1. Robot must execute tasks with functions already equipped to the robot. Robot can use tools in the field prepared in advance by the organizers.
- 7.2.1.2. Robot can use simple tools depending on a mission(task). Simple tools refers to tools without advanced mechanism, e.g., a platform table and a long stick with a camera mounted on the edge (known as a camera stick).

- 7.2.1.3. When use simple tools, robot must holds the simple tools at the start of a mission and carries them until the goal is reached.

7.3. Mission 【T1】 : Traversing Obstacle

7.3.1. Outline

- 7.3.1.1. Traverse and negotiate the following obstacles individually or in combination.

- 7.3.1.1.1. The size of a robot determines which tasks to be executed.

- (1) Task 【T1-A】 : Crossing Ramps

For S and M-sized robots

- (2) Task 【T1-B】 : Elevated ramps

For S and M-sized robots

- (3) Task 【T1-C】 : Narrow Space

For robots in all sizes

- (4) Task 【T1-D】 : Uneven Terrain (Chocolate&Waffle)

For L-sized robots

7.3.2. Obstacle Details (Type and shape)

- 7.3.2.1. 【T1-A】 : Crossing Ramps 【S and M-sized robot】

Alternating hill terrain with 15 degree slope.

- 7.3.2.2. 【T1-B】 : Elevated Ramps 【S and M-sized robot】

A diagonal hill terrain with 15-degree ramps of varied height.

- 7.3.2.3. 【T1-C】 : Confined Space(Jungle gym) 【Robots in all sizes】

- 7.3.2.3.1. Traverse in continuously linked rectangular frames. (see figure 7-3.1 and 7-3.2)

7.3.2.3.2. Obstacle type, shape and symbol

【Symbol】

Type (J) - Standard width (U) - Magnification Factor (S) -Height (h)

Type : J

Standard Width (U) : Width of a basic rectangular frame. The unit is meter.

Magnification Factor (S) : Magnification factor of frame. Ratio(%) to a frame of standard width.

Height (h) : Height of a frame. Ratio to the width of the frame width W ($=U \times S$).

Ex) J-1-100-1

A frame with $W=1\text{m}$ on one side and with $W=1\text{m}$ height.

Ex) J-1-70-1.5

A frame with $W=70\text{cm}$ on one side and with $W=1.05\text{m}$ height.

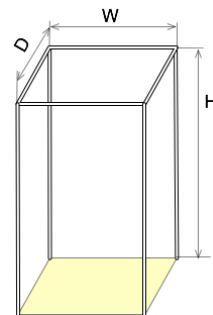


Figure 7-3.1 : Frame

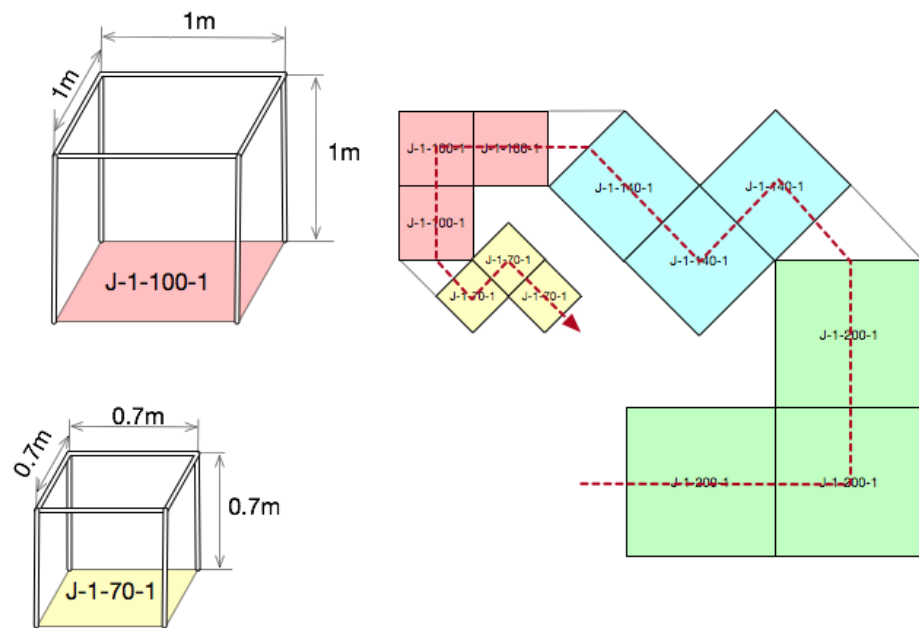


Figure 7-3-2 : Continuous Frames

7.3.2.4. [T1-D] : Uneven Terrain (Chocolate&Waffle) [L-sized robot]

7.3.2.4.1. A mountain or hole, made by cutting a square(standard length L) pyramid horizontally at $L \cdot S/100$ height from the base. See figure 7.3.1

7.3.2.4.2. Obstacle Type, Shape and Symbol

Obstacle type and symbol are as follows.

[Symbol]

Type(A or V) - Standard Width (L) - Height and Depth (S)

Type : A : A-shaped mountain

V : V-shaped hole

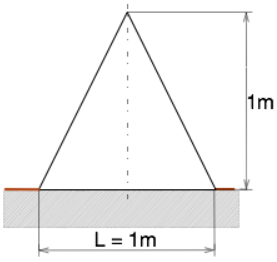
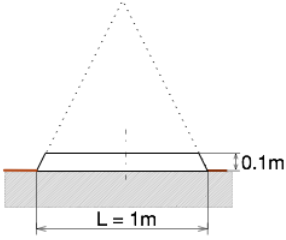
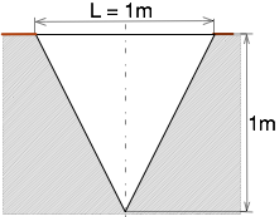
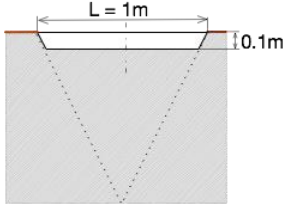
Height and depth(S) : Ratio(%) of the height of a mountain or the depth of a hole to the standard lengths

Ex) V-1-10

A hole with 1m on a side and 10cm depth

7.3.2.4.3. Uneven terrain is a combination of $S = 10$ mountains and holes (Table : see 7.3.1).

Table 7-3.1 : Uneven Terrain (Chocolate & Waffle)

L=1m	S = 100	S = 10
A	 <p>A-1-100</p>	 <p>A-1-10</p>
V		

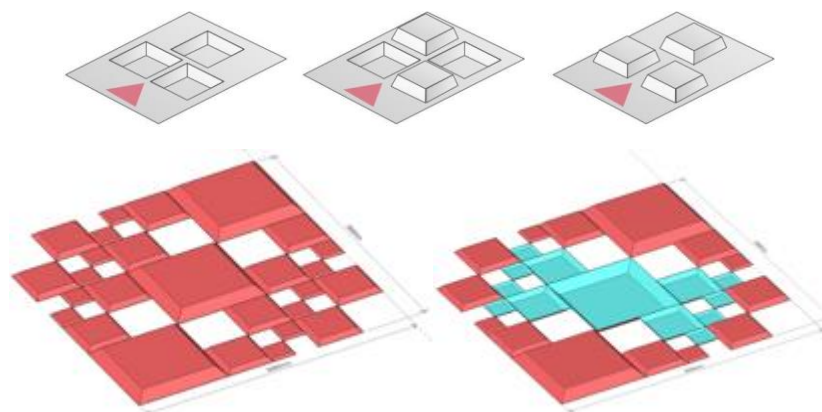


Table 7-3-3 : A combination of uneven terrain

7.4. Mission [T2] : Vehicle Inspection

7.4.1. Outline

Investigate inside and outside a vehicle and its surroundings.

Investigation is to identify a target on the specified spot and report its findings.

7.4.1.1. Execute the following 3 tasks.

7.4.1.1.1. [T2-1] Search victims and report their conditions.

Open the door, identify targets and dummy targets inside and report.

7.4.1.1.2. [T2-2] Investigate vehicle conditions.

Identify targets placed outside of a vehicle and report.

7.4.1.1.3. [T2-3] Investigate the surroundings of a vehicle (tunnel roof, wall and road surface).

Identify targets placed around a vehicle (road surface) and report.

7.5. Mission [T3] : Vehicle Inspection using Tools and Victim Extraction

7.5.1. Outline

Open or remove a door using specified tools to rescue victims left in a vehicle.

A 15kg spreader is to be used as a tool.

7.5.1.1. Execute tasks in the following procedures.

(1) [T3-1] Grasp a tool (spreader).

(2) [T3-2] Execute one of the followings to rescue victims in a vehicle.

(A) Cut the lock side of a door to open.

(B) Cut both the lock and hinged sides of a door to open and remove the door.

The following conditions are applied in executing the above task (A) and (B).

○ Cutting position is indicated as a yellow triangle.

○ A door weighs 18kg.

- Hold for 10 seconds with pushing the head of a spreader vertically of 150N force against the cutting position. Reaction force resulting from the door breakage will be transmitted to the robot through the spreader.
- When the spreader head is placed in the right position and direction, the yellow indicator will appear adjacent to the spreader and turn into red in 3 seconds.
- Errors in coordinate position and direction are allowed up to $\pm 30\text{mm}$ and $\pm 5^\circ$ respectively.

(3) 【T3-3】 Identify dummy targets in a vehicle, rescue victims inside and transfer to a designated area.

7.6. Mission 【T4】 : Secure Route

7.6.1. Outline

- Move or remove obstacles in the path and transfer to a designated area outside the path to secure the route (this is a task called removal).
- Transfer or stack obstacles onto a designated area.
- Shape, size and weight of obstacles differ according to tasks. Obstacles are either placed individually, in combination or in the stack.
- Basic shape of obstacles is L- or J- shaped and different in each task.

7.6.1.1. Obstacle Shape and Weight

Table: 7-6.1 shows the size and specific weight of L-shaped obstacles to transfer and reload, and Table: 7-6.2 shows the shape and mass of obstacles to extract.

Table 7-6.1 : Size and Weight Density of obstacles to transfer and reload

Shape	Size (cm)	Weight Density
-------	-----------	----------------

L	50	L-shaped obstacles, with the indicated length on a side, made of 4 rectangular frames linked together	1.5	Different in each rectangular frames
	25		1	
	12.5		0.5	

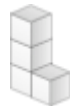


Table 7-6.2 : Shape and mass of obstacles (circular cross section) to extract

Shape	Diameter of circular cross section (mm)	Length (m)	Length of Short Side (m)	Angle (Degree °)	Mass(kg) per 100mm diameter · 1m length
I	100	2	-	-	4
L	50	1	Ratio of long side to short side 1 : 1 ~ 4 : 1	90	
J				15 ~ 60	

7.6.1.2. Execute the following tasks individually or in combination.

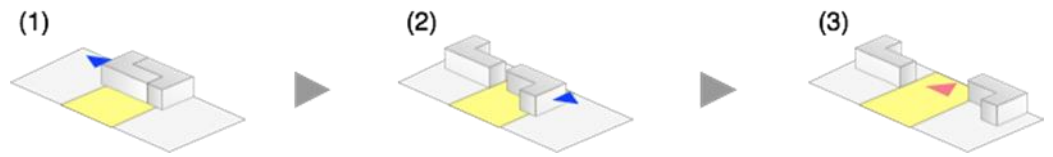
(1) [T4-A] Remove obstacles placed on a road surface.

Following the procedure, move two combined obstacles to ensure the route.

Ex. 1)

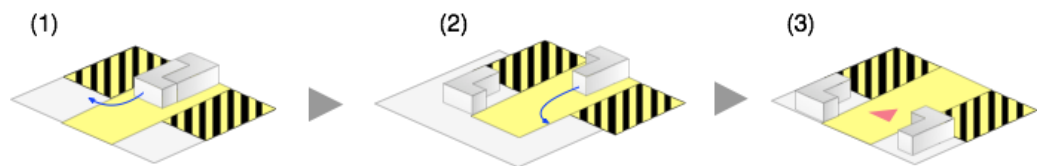
Move one of the combined L-shaped obstacles to the left and the other to the right.

Robot is required to remain in the passage (yellow area).



Ex. 2)

Pull forward one of the combined L-shaped obstacles and move to the left side designated area. Then pull the other one to the right. Robot is not allowed to enter no entry area (black and yellow area in the figure) including the space above. Robot is also required to remain in the passage (yellow area).

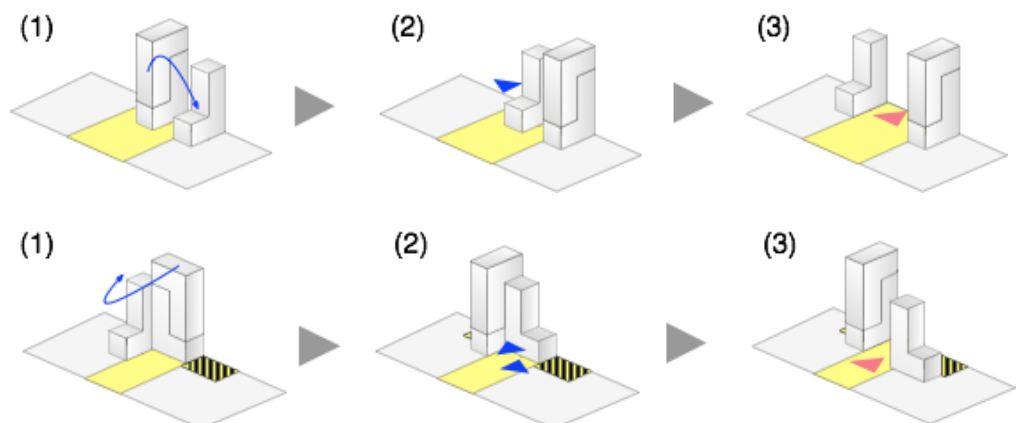


(2) 【T4-B】 Transfer or reload stacked obstacles

Move stacked obstacles or transfer onto another obstacle to ensure the route.

Ex)

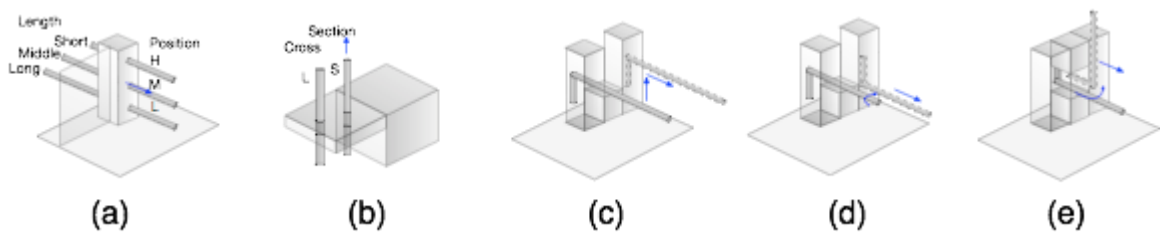
Move an obstacle placed on the obstacles to another obstacle outside the passage.



(3) 【T4-C】 Extract Obstacles

Remove obstacles buried in the wall, ground, vehicle and debris to clear a path.

- (a) Extract horizontally
- (b) Extract vertically
- (c) Pull up vertically and extract horizontally
- (d) Extract by rotating the axis
- (e) Extract with rotation



(4) 【T4-D】 Remove a vehicle out of a tunnel to clear the path. 【L-size robot】

Table 7-6.3 shows vehicle size and weight.

	Size (width × length × height)	Weight
(A)	1.5 × 3.5 × 1.6	750kg
(B)	1.7 × 4.5 × 1.5	1,500kg
(C)	1.9 × 5.0 × 1.8	2,000kg

Table 7-6.3 : Vehicle weight and mass

7.7. Mission 【T5】 : Fire Extinguishment

7.7.1. Outline

Extinguish fire in a tunnel with a firefighting equipment installed in a tunnel.

7.7.1.1. Figure 7-7.1 shows the exterior of a fire extinguisher cabinet.

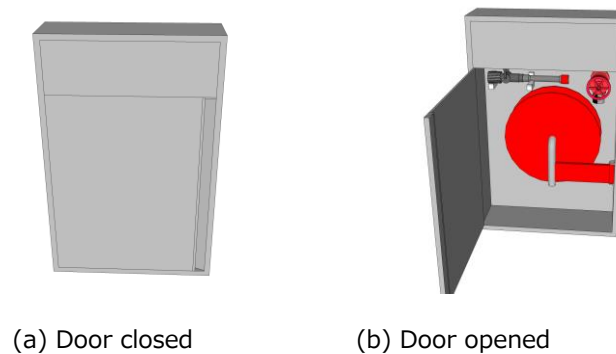


Figure 7-7.1 : Exterior of a fire extinguisher cabinet

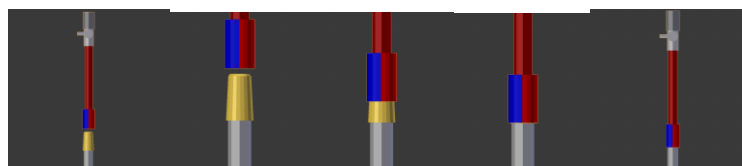
7.7.1.2. Task is executed in the following order.

(1) 【T5-1】 Open the door of a fire extinguisher cabinet and pull out the hose.

- The weight of a hose is 0.275kg/m.
- The weight of a hose coupling is 0.5kg.

(2) 【T5-2】 Pull out a nozzle and connect it to a hose.

- Pull out a nozzle installed in a firefighting equipment.
- Nozzle weighs 1kg.
- Insert the back end clamp of a hose into the rear edge of a nozzle until both fittings match (See the figure below).

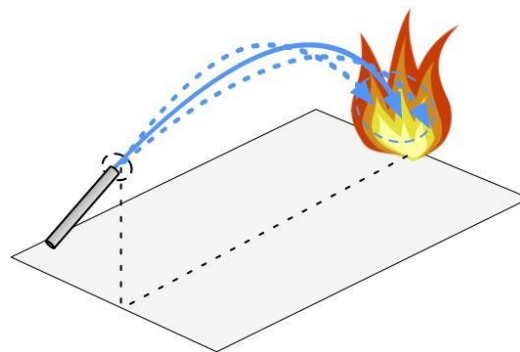


(3) 【T5-3】 Open the valve of a fire extinguisher.

- Rotate the valve 90° anticlockwise.
- Torque required to rotate a valve is 5Nm (a valve rotates with a minimum torque 5Nm).

(4) 【T5-4】 Move to the fire origin with holding a nozzle connected with a hose. Turn the nozzle toward the fire and extinguish fire.

- Spray water from a designated area (Move to the designated area).
- Rotate the lever attached to a nozzle to spray water.
- Torque required to rotate a lever is 2Nm (a lever rotates with a minimum torque 2Nm).
- Spraying a specified amount of water on the fire to extinguish.
- The flame will gradually spread once the task starts.

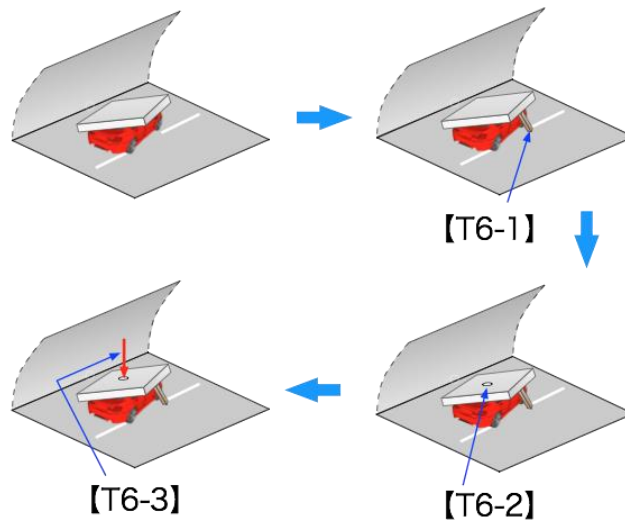


7.8. Mission 【T6】 : Shoring and Breaching

7.8.1. Outline

Shoring and breaching of rubble on a vehicle to investigate inside of a vehicle.

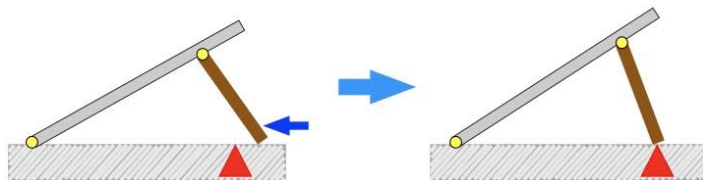
7.8.1.1. Task is executed in the following order.



(1) 【T6-1】 Shoring

【M-size robot】

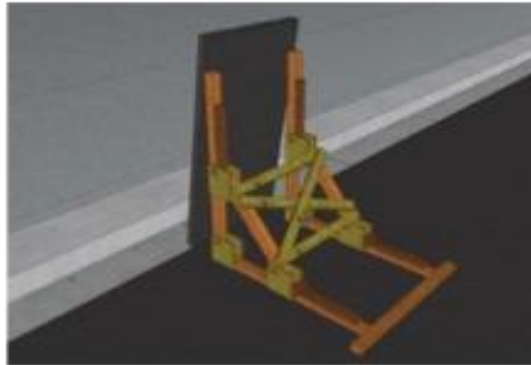
- Move a shoring equipment to a designated area.
- Push the equipment into a specified point.
 - Moment required to push the equipment is 25Nm with an obstacle as a pivot (The part moves with a minimum torque 25Nm)



【L-size robot】

- Push the already assembled shoring equipment into a specified point.
 - The weight of the assembled equipment for shoring is to be 50 to 200kg.

- Push-in distance is to be 1 to 5m.



(2) 【T6-2】 Breaching

- Grasp a tool.
 - Use a 30kg concrete boring drill.
- Drill a 10cm hole in diameter into rubble and the ceiling of a vehicle.
 - Hold for a specified amount of time, pushing the head of the drill vertically with 300N force against the cutting position. Reaction force resulting from breakage will be transmitted to the robot through the tool.
 - Errors in coordinate position and direction are allowed up to $\pm 30\text{mm}$ and $\pm 5^\circ$ respectively.
 - When the drill head is placed in the right position and direction, the yellow indicator will appear adjacent to the drill and turn into red in 3 seconds, which indicates the completion of drilling.

(3) 【T6-3】 Victim Identification

- Identify a dummy target in a vehicle through a drilled hole as in 【T6-2】

