ENGINEERING GAMES 2019

REACHING NEW HEIGHTS

ROBOTIC MACHINE

JEUX DE GÉNIE XXIX 2019

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SEPTEMBER 2, 2018

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1. Introduction

Technological progress allows engineers to conceive increasingly autonomous machines which are able of evermore complex human-machine interactions. In recent years, we have been able to witness the emergence of autonomous cars, ambulance drones, and even some breakthroughs in medical robotization. These technological innovations have been made thanks to brilliant altruistic engineers whose primary motivation is to serve public interest. To further these spectacular advances and improve everyone's quality of life, it is of the utmost importance that new engineers be stimulated by their passion and driven by challenges. This will allow the future engineers to overcome their limits and acquire new skills.

In order to develop new competencies among future engineers, the non-profit organization JDG19 is launching a competition open to all universities member of the QCESO (Quebec Confederation for Engineering Student Outreach). The purpose of this competition is to offer the engineering student community the chance to showcase its talents in design, construction, and operation of semi-autonomous emergency rescue vehicles. The vehicles designed by the students will allow alpine rescue crews to act in a timely manner when a need arises, regardless of the weather.

Throughout the competition, the students will have the opportunity to develop a robotic solution for alpine search and rescue missions. The solution must be able to operate in any and all atmospheric conditions.

The contest will take place under the form of a call for bids. At the end of the process, the team offering the most complete solution will be recognized as the team most able to execute the project to be used by the JDG19 organization.

1.1 The Competition

In order to select the most competent to fully execute the project, the selection process will take place in five stages, the last stage being the design and manufacturing of a scale prototype of the final product. This process' goal is to measure the technical abilities as well as the professionalism of each team throughout the execution of the project. The five stages are as follows:

1. Official Registration

This stage will allow the team to enter the selection process and will grant the team access to the official forum of the Engineering Games 2019 Machine Competition. In order to complete this stage, every delegation will have to submit their bidder application as per the registration policy.

2. Progress Report

This document will have to be sent to JDG19 before the prescribed date. This report will allow the committee to validate that the team will be able to provide a high-quality product for the demonstration.

3. Video Presentation

The purpose of the video is to demonstrate that the team has all the skills and abilities required to ensure the proper implementation of the solution.

4. Prototype Presentation

This presentation will be done as a sales pitch in front of a committee of engineers and leaders of the non-profit. It will be the first occasion for the teams to convince the committee that their prototype is the ideal solution for the challenge.

5. Product Demonstration

It is during this last stage that the teams will be able to demonstrate the functionalities of their machine and their on-track strategy. The machine will be a scale model of the proposed solution. It will allow the validation of the concepts and the team's strategy.

A detailed description of each of these steps is provided in section 4.1.

1.2 Your Mandate

As bidders for the JDG19 challenge, your mandate is to design and manufacture a prototype for a robotic search-and-rescue vehicle which is either autonomous or has the ability to be remotely controlled by a qualified operator.

In order to fulfill all criteria, your solution shall:

1. **Evacuate quickly and in a safe manner a maximum number of people from the mountain;**
2. **Clear the inaccessible zones in order to enable the work of specialized rescue teams;**
3. **Locate all people (on or inside the mountain) who cannot be rescued by your robot;**
4. **Identify all high-risk zones in order to ensure the safety of the rescue crew;**
5. **Protect all people that cannot be safely evacuated against the weather;**
6. **Create a mission report in order to provide the rescue crew with a maximum amount of information.**

This proof of concept should be operational by the 7th of January 2019, the official day of the live demonstration.

During the demonstration, the prototype presented by the team should rescue plastic dummies and safely bring them down them from the mountain to the start area. The prototype should also be able to measure images that represent restricted-access areas.

Finally, the prototype should identify the content of barrels which could contain high-risk materials as these barrels could pose a threat for the first responders. It should also clear the access routes that are blocked by natural deposits.

2. Challenge

In order to win the bid, the teams must design and manufacture a robot able to execute search and rescue missions on the model terrain pictured in figure 1. This terrain has been designed in order to validate the completeness of all specifications for all the bid entries.

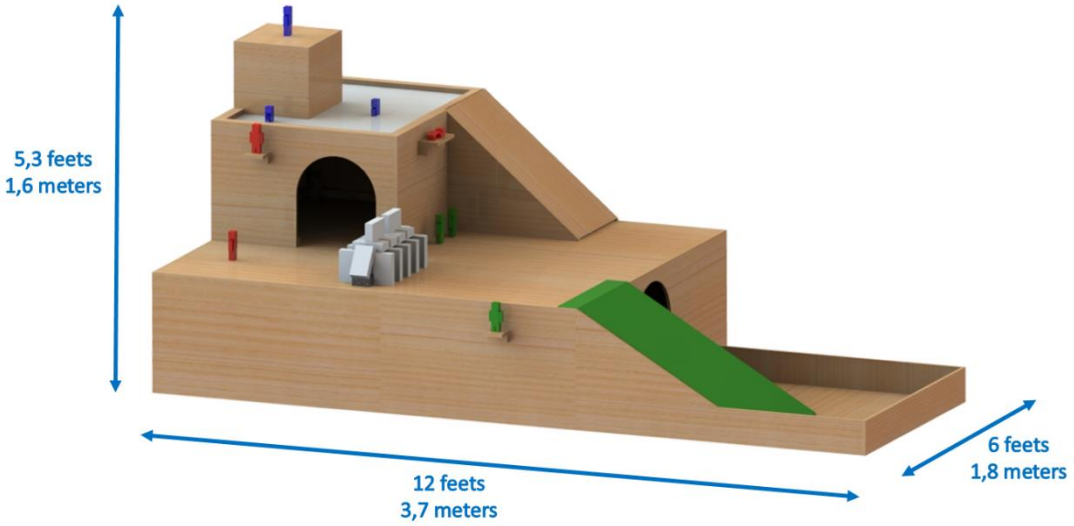

Figure 1 Terrain of the machine challenge 2019

This terrain represents a mountain on which several people in distress await to be rescued. This mountain is made of several inclined slopes that have to be climbed, obstacles to be crossed, and underground zones to be explored.

2.1 The mission

As mentioned before, your mission is to design and manufacture a robot that could intervene rapidly in an alpine disaster recovery mission. On demonstration day, the mission will be divided into two sections.

2.1.1 The first part of the mission

During the first part of the mission, the teams will have ten minutes to traverse the terrain and execute a maximum number of tasks. Before the start of the ten minute period, the entire robot (and all appendages) should be contained in a 12” x 12” x 20” zone representing respectively, the length, the width, and the height of the machine.

2.1.2 The second part of the mission

During the second part of the mission, the teams will have the option to spend an extra three minutes on the terrain in order to execute an additional number of tasks or spend eight minutes outside of the track in order to process the visual data acquired in the first part and make a more precise mission report. These eight minutes will take place outside of the stage, in an isolation

room. During this (longer) period, all members of the machine team will be allowed to handle the prototype as they see fit. The decision should be made and communicated to the committee at the start of the last Machine work period.

The mission report shall be given to the judges, before the end of the allotted time. For every fifteen seconds delay for the submission of the report, 2% of the total demonstration points will be deducted, up to a total of 20% deduction. After the maximum delay, no points related to the mission report will be given to the team. The delay timer will start at the end of the total duration of the demonstration, as decided by the team.

2.2 Definitions

2.2.1 The terrain

The terrain is defined as anything within the volume of the assembly presented at figure 1. The only element excluded from this definition is the machine of the team executing the demonstration. Any element belonging to the terrain shall never be damaged by the team or their machine during their performance. Breaking this rule will imply a point penalty according to the importance and nature of the damage.

2.2.2 The machine

The robot, commonly called “the machine,” is defined as any and all elements belonging to the bidding team within the starting zone at the beginning of the demonstration. The combined weight of all components shall not exceed 20kg.

2.2.3 The victims

During the competition, the victims will be represented by 5.4 inch high dummies, with a mass of approximately 70 grams. This dummies will be 3D printed using any plastic available during the printing process. Two metal sheets will be inserted within the body of the dummy. These metal sheets will be made of 0.036-inch bodywork steel. The types of plastic most likely to be used are PLA and ABS. The teams will receive more details on the type of plastic used once the final choice will be made.

The 3D model and the STL printing files will be given to the bidding teams in order to allow the fabrication of the dummies for any use they see fit.

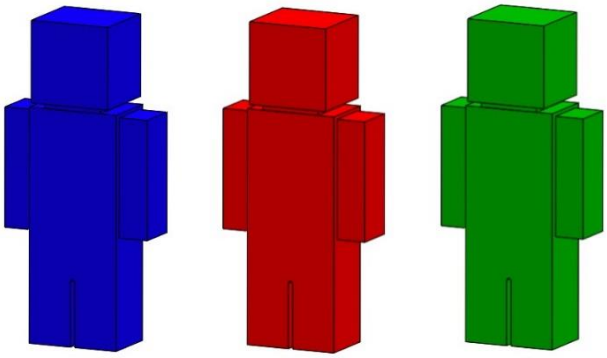

Figure 2 - Dummies to rescue

The dummies to be saved during the demonstration will be provided and put in place on the track by members of the organizing committee. On competition day, the teams will not, under any circumstance, be allowed to touch or handle the dummies without first having rescued them with the help of their robot. In addition, as these dummies represent human victims, they shall not, under any circumstance be damaged by the teams or their machines. Any points pertaining to a dummy that has been damaged by a team or their machine will not be counted. The values attributed to each color are, as per table 1.

Table 1 - Value of the dummies

Description	Value
Green dummy	2
Red dummy	6
Blue dummy	16

In order to safely rescue the dummies, the teams should, with the help of their machine, retrieve them and bring them safely into the work area. Once the dummies are in the work area (and nowhere else) the technician will be allowed to touch and handle the dummy. Each and any dummy in the work area will be counted as a rescued dummy and all points pertaining to the rescue will be allotted.

2.2.4 The team

During the demonstration, the machine team can be composed of a maximum of four members. Of these four members, there can be a maximum of 1 technician and three operators. Each role has specific attributes in terms of permissions and limitations.

The technician

The technician is defined as the only person that can handle the machine during the demonstration. The technician will not be allowed to handle the machine unless it is within the work area. During the competition, the feet and knees of this person should always be within the technician's zone presented in figure 3. Only one technician is allowed within the zone during the competition. In addition, the technician is not allowed to touch or handle any element which allows the control of the machine, nor are they allowed to communicate with the operators.

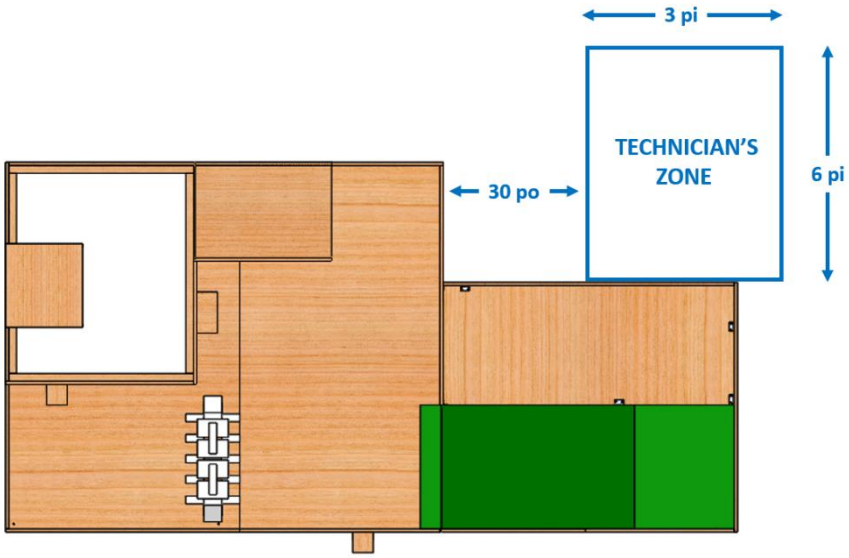

Figure 3 - Technician's working zone

The technician's zone will be marked by a rectangle made out of masking tape on the floor, placed as per figure 3.

The operators

The operators are defined as the only persons allowed to control the machine during the demonstration. During the demonstration, these members will always be within the pilot's area. There can only be a maximum of three people within this area. As soon as the demonstration starts, there can be no physical contact or material exchange between the technician and the operators. If a team considers that a contact or an exchange is necessary, they may choose to do so, however, 5 points will be deducted for every interaction.

2.2.5 The work area

In order for the technician to be allowed to handle the machine, the latter should be within the work area presented in figure 4. This area will be identified on the track by a yellow rectangle. In

addition, the technician will not be allowed to touch any dummy or any other element of the track if the element itself is not within the work area.

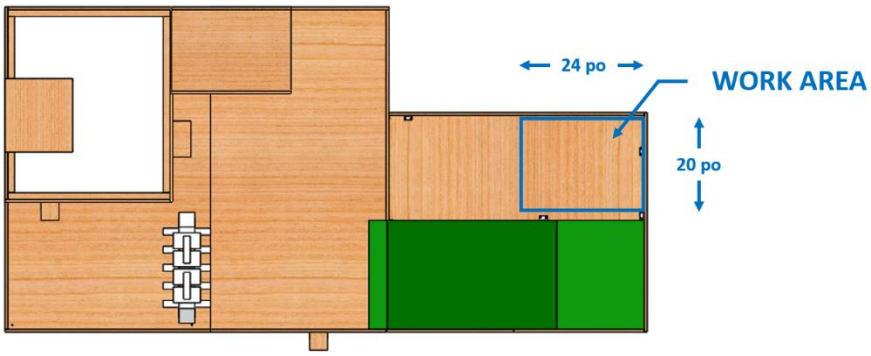

Figure 4 - Interaction zone between the technician and the machine

Any part of the machine that is outside of this zone is considered inaccessible, and cannot be handled by the technician.

If a team considers that an action on the machine is necessary whilst it is outside of the work area, the technician is allowed to exit the work area in order to handle the machine and replace it in the starting zone. This action will cause a deduction of ten points only applicable on the points already collected during the presentation. During this action, the stopwatch will not be paused nor restarted.

2.2.6 The pilot's area

The pilot's area is defined as the location where all the operators will be placed during the first part of the mission. Two tables, as well as a 110-volts outlet, will be available in this zone. Its minimal area will be of 4' x 8'.

This zone will be located on the stage, behind the track, at a maximum distance of 8 meters. There will be no obstacle intentionally placed between the operators and the track. The operators will thus have a partial view of the terrain. They will, however, not see the inner sections of the track.

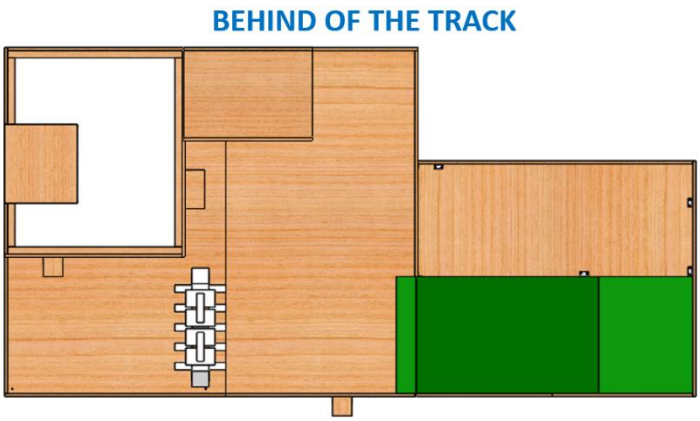

Figure 5 - Schematisation of behind the track

The final pieces of information pertaining to the track will be communicated to the bidding teams during the 2019 Engineering Games.

2.2.7 The start area

Before the start of the stopwatch, the entirety of the bidding team's robot will have to be placed within the start area.

Figure 6 - Starting zone of the machine

The start area, as well as the robot, will be measured at the beginning of every demonstration by using a rigid box of proper dimensions. The entirety of the machine should be contained within the box without any external help. As the start signal is given, the stopwatch will be started, and the technician will be allowed to remove the box in order to free the machine.

2.2.8 The mission report

The mission report will be given to the teams as pre-formatted 8 ½" by 11" paper sheets and will have to be filled in by hand. In the mission report, the teams will have to fill the data pertaining to

the geolocations and the unknown barrels that they will have gathered during the mission. This, in turn, will allow for the points pertaining to these sections to be counted.

Geolocation			
Description of the 2D person	Mapped area	Vertical position	Horizontal position

Unknown barrels	
Description	Mapped area

Figure 7 - Example of the mission report paper

In order to obtain all the points that can be granted for the report, the teams will have to note :

In the geolocation section

- **Description of the 2D person : the color of the person.**
- ***Mapped area* : the id of the zone of the geolocation.**
- **Vertical position : the vertical position, in inches, of the person marker in relation to the mapped area marker.**
- ***Horizontal position* : the horizontal position, in inches, of the person marker in relation to the mapped area marker.**

In the unknown barrels section

- ***Description* : description of the information within the QR code.**
- ***Mapped area* : the id of the area in which the barrel is found.**

The data to be filled in the report is exclusively the information pertaining to the inner sections of the track.

The information pertaining to the id of the zones can be found in Appendix B. These alphanumeric values are used within the *Mapped Area* columns in order to obtain the relative points. In addition, a complete example of a proper can be found in Appendix C.

3. Terrain

The terrain being used for the demonstration is an assembly of several areas containing independent tasks to be performed. This assembly is composed of the mountain, the summit, and the cave.

3.1 The mountain

The mountain is considered as being all the exterior elements of the terrain. This mountain is composed of three plateaus, as shown in figure 8. The starting zone is on the first plateau.

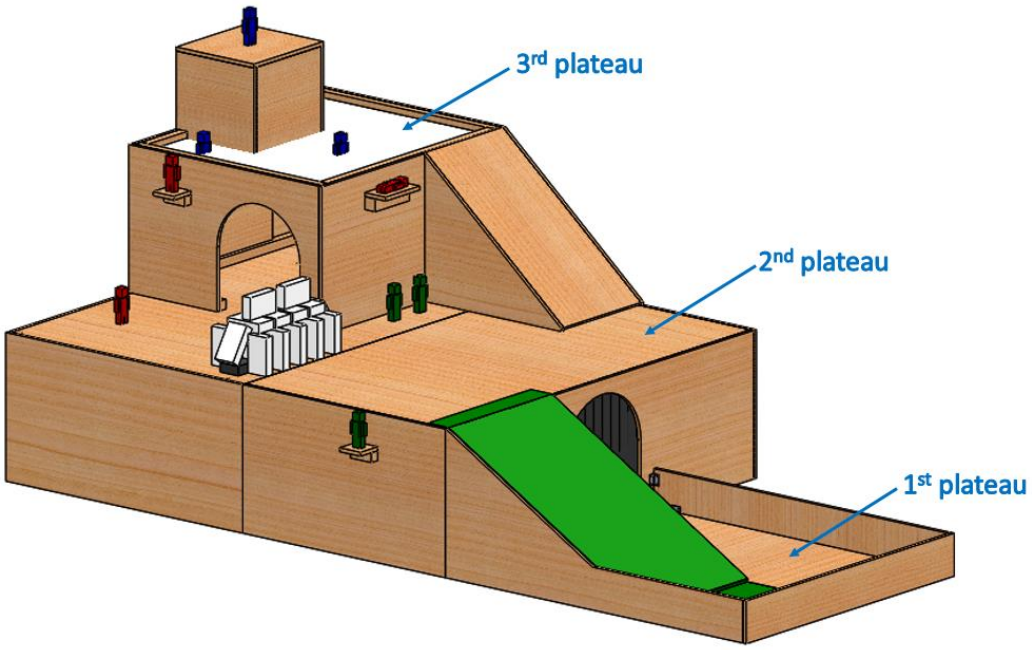

Figure 8 - Global view of the mountain

The first challenge of the exterior section is the first slope. This slope is a 30-degree climb covered by artificial turf.

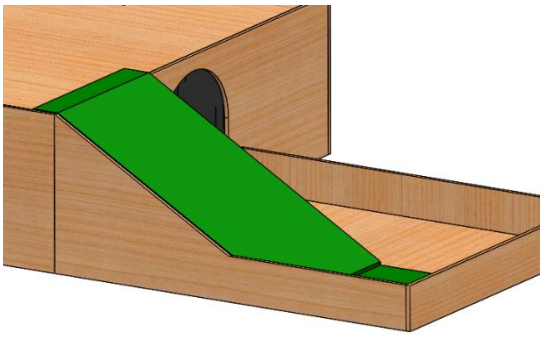

Figure 9 - 30° slope

Once the machine reaches the second plateau, several tasks are available to the teams: saving the accessible dummies, sweeping the snow accumulation which prevents the first responders from passing through, and climbing the second slope.

Figure 10 - 40° slope

The second slope is made out of white-painted plywood. There will be no points awarded for climbing the slopes. However, succeeding in doing so will allow the teams to gain additional points through other tasks.

After the climb onto the second plateau, another available task is to clear the access to the cave in order to enable the first responders to rapidly access this zone or to allow the machine to rescue the dummies in this obstructed zone.

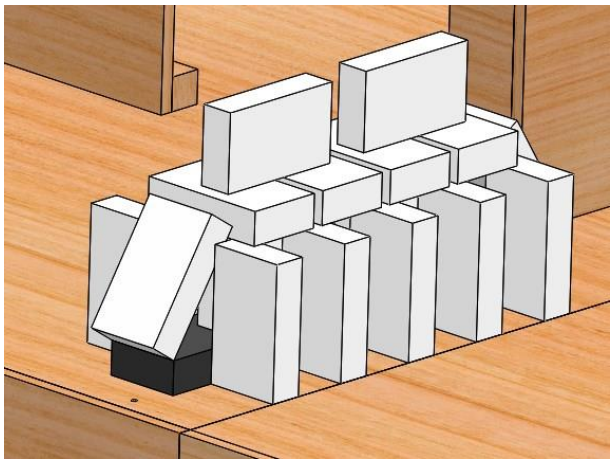

Figure 11 - Close view of the snow accumulation

In order to clear this area, the machine must expel outside of the track at least 50% of the snow blocks (10 blocks out of 20) that prevent access to the cave. The snow will be made out of white painted wooden blocks, of dimensions 3.5” wide x 1.5” thick x 6” high. The accumulation also contains three blocks painted grey. These blocks represent rocks. Their dimensions are identical to the ones representing snow. These three (3) blocks will be bolted to the terrain and the machine

will not be able to move them. During this intervention, it is paramount to not hurt any dummy that is at close proximity.

3.2 The summit

The summit represents the snowy area of the terrain found on the third plateau. This zone is the highest part of the mountain and also the hardest one to reach. It will be entirely painted in white, and its superior compartment will be filled with 2 inches of deicing salt. This salt will represent the snow of the snowy plateau.

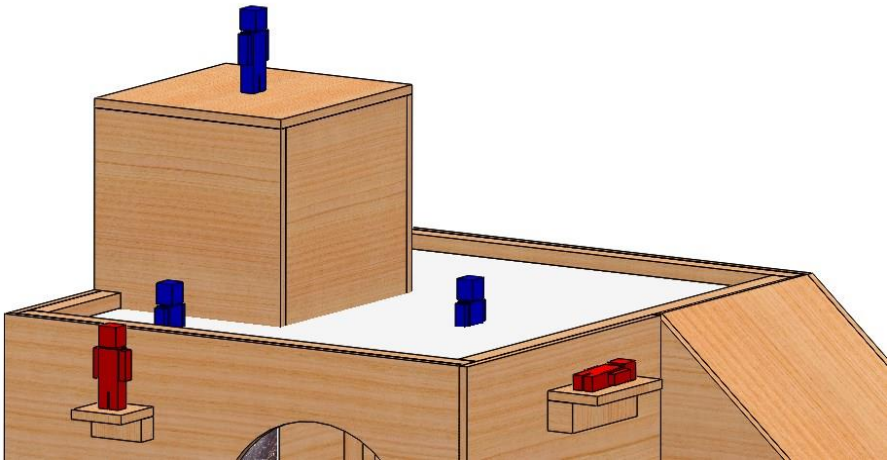

Figure 12 - Close view of the summit

On this summit, several dummies will be stuck and unable to climb down without external help. In order to rescue them, two options are possible. The first one is to rescue the dummies and bring them safely down with the help of the machine to the work area. The second option is to protect these dummies from the weather whilst they wait for the rescue helicopter to come.

In order to protect the dummies, they shall be covered with a closed container coming from the machine. In order for this element to be considered valid, all the visible parts of the dummy should be protected from exterior forces after the action. In order to obtain the points, the dummy should not be visible for the judges from any angle.

A maximum of three dummies can be evacuated by helicopter. They should all be on the snowy plateau or on a section of the white-painted summit so that the helicopter can proceed with the rescue. The teams will only have one opportunity to call the helicopter during their mission.

The air-evacuation helicopter is going to be fictive. Once the dummies are secured on the summit, the team should call the helicopter by emitting any sound audible at a distance of at least 10 meters. This audible signal should be emitted by an element of the machine which would also be on the summit.

3.3 The mine

The mine is the first interior zone of the terrain. This zone is located on the same plateau as the starting zone.

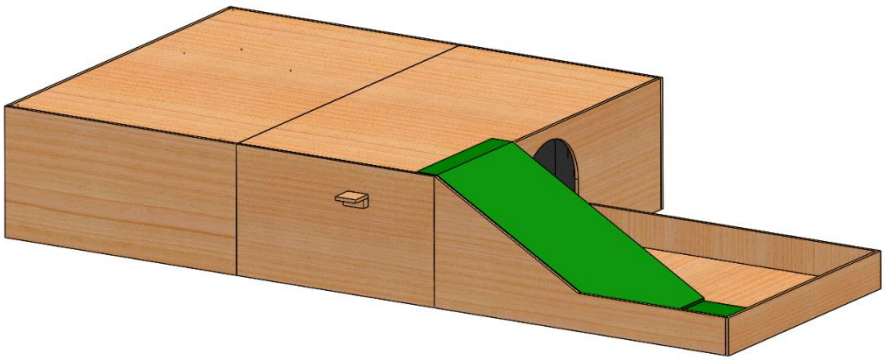

Figure 13 - Outside view of the mine

Inside the mine, several dummies are in a precarious condition. The inner section of the mine is composed of distinct elements placed as shown in figure 14.

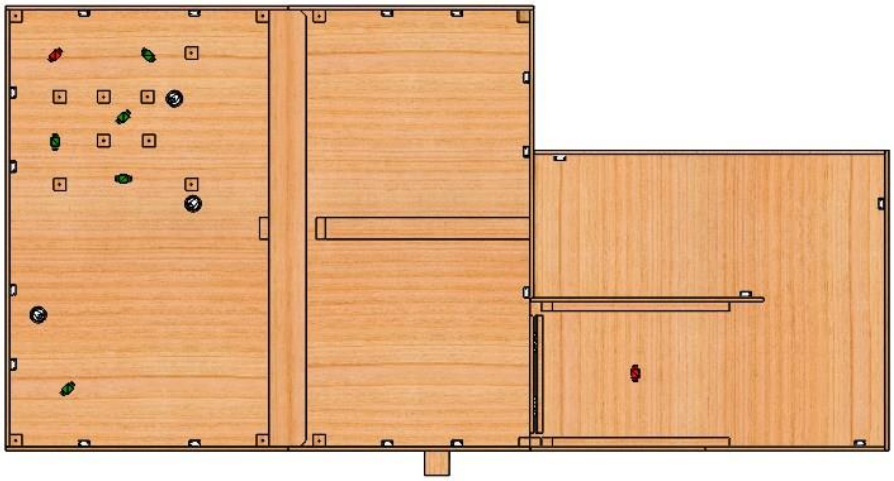

Figure 14 - Top view of the mine

3.3.1 The secure zone of the mine

The secure zone is where, during a catastrophe, all the employees of the mine should regroup whilst waiting to be rescued.

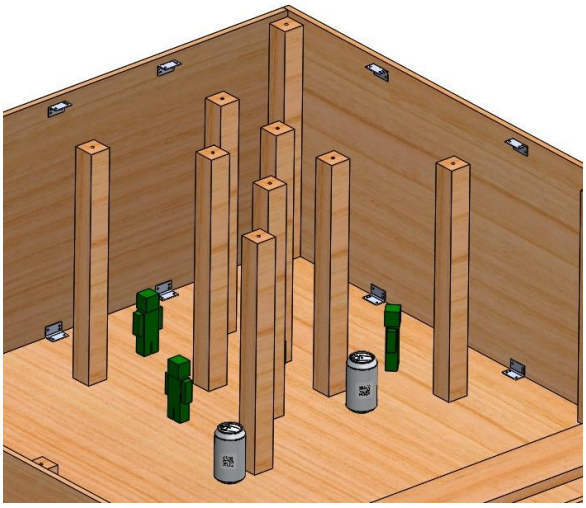

Figure 15 - View of the secure zone

1.3.2 The restricted-access zone of the mine

The restricted access zone is designed to represent a space with limited access. The proposed solution should be able to access this area and rescue the dummy placed within.

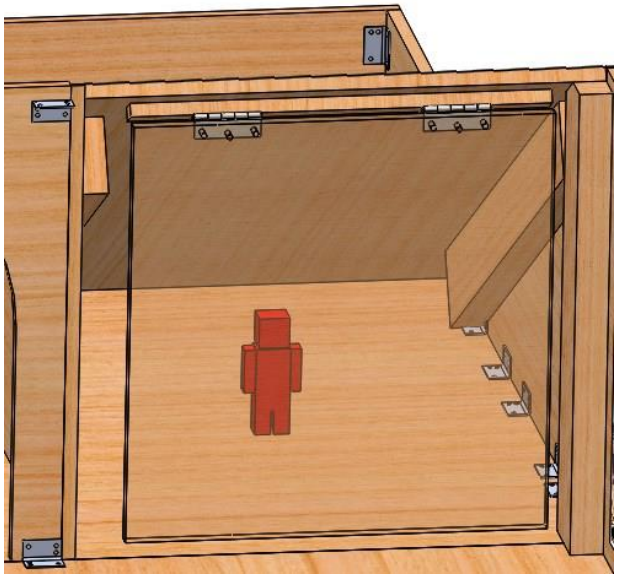

Figure 16 - View of the restricted-access zone, door in transparency

The dummy placed within will not be positioned within the opening arc of the door. The opening thereof will not displace the dummy, or topple it over.

3.3.3 The unknown content barrels

The barrels with unknown contents are cylindrical containers that will be positioned anywhere within the track. These barrels can contain a number of substances which could pose a threat to the rescue team. It is thus paramount for the machine to identify the content thereof in order to inform the rescue teams that will intervene.

Figure 17 - Unknown content barrels

In order to identify the unknown contents of the barrels, the machine teams should read the QR codes present on the exterior of the barrels. As the information is decoded, the teams should take note of the data in the unknown containers of the report, namely the mapped area in which the container was found as well as the contents thereof. All the QR codes will be placed at an angle which will enable their reading. However, the machine is allowed to handle the barrels without damaging them if the team considers it necessary. For ecological reasons, the containers should always remain within the boundaries of the track.

These barrels will be made out of 355ml aluminum cans, sanded down to the metal. The QR codes will be printed black on white on a square piece of paper. The size of the QR code will be 1” x 1”, with a 0.5” white border around it.

3.3.4 The geolocation

The geolocation is a mapping challenge whose main goal is to simulate areas with restricted access for the machine. Your robot will have to locate all the persons present on the image, identify their color, and to position them with respect to the reference marker of the image, as per the vertical and horizontal axis. These images will be printed on standard printing paper, pasted onto a wooden sheet with a thickness of 0.625”, and fixed onto interior walls of the track.

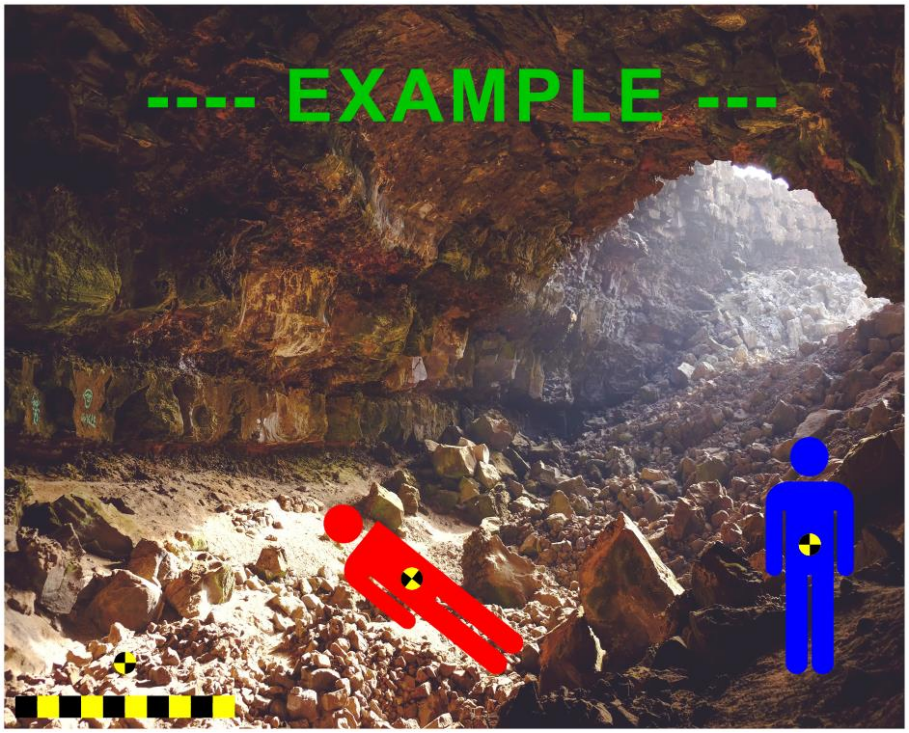

Figure 18 - Geolocation example

The 2D persons will have to be located in reference to their central marker and to the image's reference marker. The latter will always be visible in the lower left corner of the geolocation images. In their report, the teams will have to calculate the distance according to the scale, of which every square is 0.5" x 0.5". The exact result of the measures will be reported by a 2-decimal places number.

In order to obtain 100% of the available points, the team should provide the judges a vertical and horizontal position of which the maximum error is below 0.25" exclusively. In order to obtain 50% of the points, the maximum error should be smaller than, or equal to 0.5". A complete example is present in Appendix C.

All the geolocation images are made out of two papers of size 11" x 17". Once assembled, the final dimensions of the geolocation image will be 17" high x 21" wide.

3.4 The cave

The cave is the second interior part of the terrain. The entry of the cave is located on the second plateau of the track.

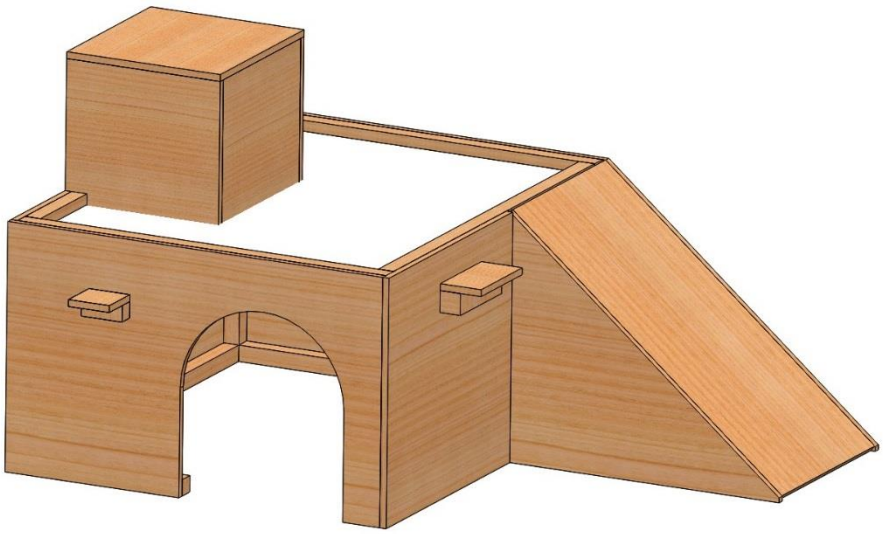

Figure 19 - Isometric view of the cave

The challenges within the cave are similar to the ones inside the mine, however, succeeding in their execution will allow teams to quickly score a larger amount of points.

4. Competition and Evaluation

Table 2 contains all the important dates pertaining to the machine competition of the 2019 Engineering Games.

Table 2 - Important dates pertaining the machine competition 2019

Dates	Event
2nd of September, 2018	Publishing of the Machine [cahier]
14th of October, 2018	Last day for the official bid registration
4th of November, 2018	Due date for preliminary report draft
11th of November, 2018	Commentary on the preliminary report draft
25th of November, 2018	Due date for progress report
4th of January, 2019	Due date for the machine video
7th of January, 2019	Demonstration

During the 2019 Engineering Games, the machine teams will be allowed to partake in three work periods of four hours. The official track of competition will be at the disposal of all teams during the last two work periods according to a schedule which will be pre-determined in the first work period.
The location and times of the work periods will be communicated several weeks prior to the beginning of the 2019 Engineering Games.

4.1 Selection process

As mentioned in the beginning of this document, the selection process will be done in five stages. This section presents these stages as well as the points awarded for the completion of each stage.

4.1.1 Official Registration

In order to complete this stage of the selection process, the bidding teams have to register their representative, the machine chief, to the 2019 machine forum. This registration must take place before the 14th of October, 2018.

Then, before the 29th of December, 2018 at 11:59PM, the teams will have to send the names of the four delegates that will take part in the first work period. The four names will have to be sent to machine@jeuxdegenie.qc.ca .

Table 3 - Official Registration scorecard

Criteria	Points
Respecting the format and requirements of the registration	50
Respecting the deadlines	50
Total	100

4.1.2 Progress Report

The progress report is a report that will inform the client as to the potential design and strategies of the bidding teams. This report should be at most 14 pages from first to last page, including the cover page and any additional appendixes.

Table 4 - Progress Report scorecard

Criteria	Points
Expressing a thorough understanding of the challenge and the odds at stake	25
Initial solution approach to the challenge and the possible strategies	20
Presentation of the preliminary design, dimensions, mass, and expected performance	20
Risk mitigation	15
Expected results	5
Structure and readability	15
Total	100

This report will be read by technical and non-technical people alike, therefore it should be adequately vulgarized, made for light reading, and be complete.

4.1.3 Video Presentation

The machine video is a video presentation of the machine that has as main goals to present your team, your work methodology, your resources, as well as your university. This video will be shown to the public at large right before your demonstration. The duration of the video shall be between three and four minutes.

Table 5 – Presentation Video scorecard

Criteria	Points
Team and university presentation	15
Presentation of the machine and its functional state	20
Originality of the video	30
Quality of the video	10
Vulgarization of the content and correctness of the information presented therein	15
Respecting the university's theme	10
Total	100

This video can be made in either french or english, as every team sees fit. For english-language videos, french subtitles must be added. Moreover, any video containing scenes deemed violent, offensive, or otherwise containing sexist comments will not be presented. The right to judge a video as inappropriate is an exclusive and irrevocable right of the organizing committee.

Videos should be handed in, on a USB key, as MP4 formatted files, on the 4th of January 2019, before the end of the first machine work period. A video that will be handed in late will automatically incur a 50% penalty.

4.1.4 Prototype Presentation

The presentation of your solution should have the format of a sales pitch presented to the selection committee. This sales pitch will have to convince the committee that the bidding team's solution is the best solution at the committees' disposal. Your presentation shall last a maximum of eight minutes and must answer all points on the scoresheet.

Table 6 – Prototype Presentation scorecard

Criteria	Points
Presenting the team and the university	5
Understanding the challenge and the stakes	10
General presentation of the machine's components	15
Presentation of the strategy used to maximize the points count	15
Structure of the presentation and team's appearance	10
Demonstration that the solution is the best option for the committee	35
Question period	10
Total	100

The presentations will take place on the day of the competition, right before the demonstration. At the end of the presentation, a question period of five minutes will take place. The bidding teams will present in front of the committee one by one and will also have the opportunity to execute one last trial run on the track and location in which the competition will take place, before the final demonstration.

4.1.5 Product Demonstration

During the demonstration, the points awarded to the teams will be granted in accordance to the tasks that their machine will have accomplished. As mentioned in the specifications, during the demonstration, the teams can gain points by saving the dummies, by sweeping the obstructed areas, by identifying potentially harmful containers, and by geolocating the dummies that cannot be saved by the machine. Table 7 presents the total amount of points available on the track.

Table 7 – Product Demonstration scorecard

Tasks	Points
Identifying the containers	20
Saving the dummies	106
Locating the 2D persons	48
Sweeping the area	6
Total	180

A complete score sheet is available in Appendix D. On the track, the bidding teams will have the ability to collect up to 180 points.

4.2 Contest scorecard

The scorecard used for the competition in its entirety is presented in table 8. The final points count of each section will be summed up according to the following values and will provide the final points count for each team.

Table 8 – Contest scorecard

Criteria	Points
Official Registration	5
Progress Report	10
Video Presentation	15
Prototype Presentation	20
Product Demonstration	50
Total	100

4.3 Bonus points

In addition to the contest's points. The teams will have the ability to collect up to eight bonus points during the presentation. These points will be added to the contest's total, allowing the teams to collect up to 108 points.

In order to collect these points, the teams must invite a 5th person on stage. This person's role will be to inform the public on the actions that the machine is executing in real time. This person will not be allowed to help the machine teams collect further points in the challenge in any way, shape, or form. The 5th person's presence is only required for the entertainment aspect of the competition. If the judges decided that the extra member provided a form of aid to the other four members, the points that are deemed as gained through this help will not be granted. This decision will be final.

This person can come from any and all universities, as long as they are registered as a participant in the 2019 Engineering Games. They could be a delegate, a chief, or a godmother or godfather. The points will be granted according to their ability to communicate useful information to the public, as well as their ability to excite the crowd.

5. Restrictions and precisions

Regarding the prototype

1. The maximum voltage on the machine should not exceed 26 volts.
2. No explosives are allowed during the duration of the 2019 Engineering Games.
3. No flying machinery is allowed.

Regarding the terrain

1. It is strictly forbidden to damage or soil the playing track. In accordance, a machine should not leave any material, residue, liquid, or any other element that could compromise the quality and integrity of any element of the terrain. Breaking this rule could bring forward disciplinary actions in the form of points deducted in accordance to the severity and nature of the damage. In extreme cases, these measures could involve disqualification.
2. In order to allow the public to view the machines in the underground zones, infrared cameras will be installed in certain corners of the track. These cameras will generate a small infrared light, impossible to see with the naked eye, that could potentially interfere with your systems. You should design accordingly. Their use will be limited to a strict minimum and their positioning will be communicated during the first practice period on the official track. The following link contains the specification of one of the models considered. http://org-info.mobi/shop/sq11-mini-dv-guide-fr.htm
3. The exact position of the figures to be evacuated will be revealed during the first work period of the machine. However, the position of the figures on the 3D model gives an excellent idea of how they will be positioned.

Regarding the competition

1. During the 2019 Engineering Games, the teams are absolutely encouraged to bring their own track either in part or in its entirety. Know, however, that all tracks and parts thereof should be at the disposition of all the teams.
2. During the competition, the teams will be allowed to place their promotional posters in the operator's zones and nowhere else.
3. All components belonging to the teams should be safe for the participants, the volunteers, and the public. At any point, the organizing committee reserves the right to forbid the usage of a machine during practice periods or during the competition in order to ensure everyone's safety.

4. The machine vice-president reserves the right to adjust and change the rules at any point in time. These adjustments will only take place in order to guarantee the proper running of the 2019 Engineering Games Machine Competition.

Appendix A
Organizing committee

The Organizing Committee of the 2019 Engineering Games thanks you for the time and effort spent during the four months before the event in order to demonstrate a machine that rises up to the challenge. We would also like to make good use of this space by wishing you the greatest luck in fulfilling this challenge. We are extremely eager to see the fruit of your labor.

If you have any questions or remarks that do not concern the machine competition, do not hesitate to send them to the corresponding responsible at the following e-mail addresses.

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Appendix B
Inner zones’ mapping

In this section you will find the maps of the interior areas of the mountain. These maps will enable you to locate the position from where the measurements will have to be taken. The maps will also allow you to locate the containers to be identified by the use of QR-code readers.

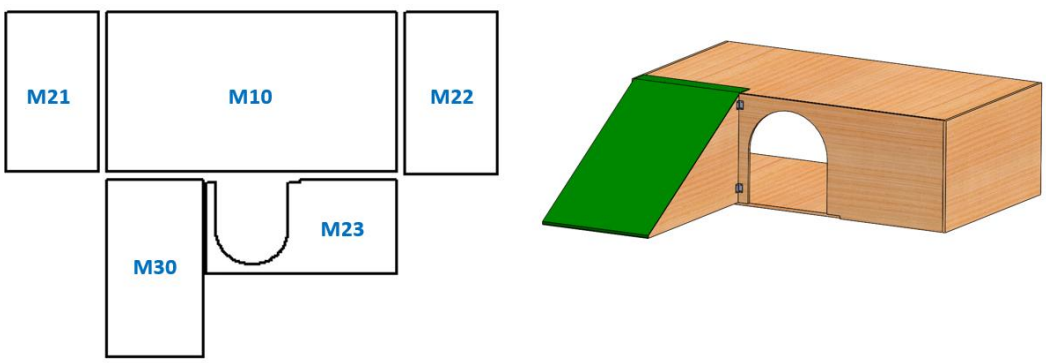

Figure 20 – Front section of the mine, flat view

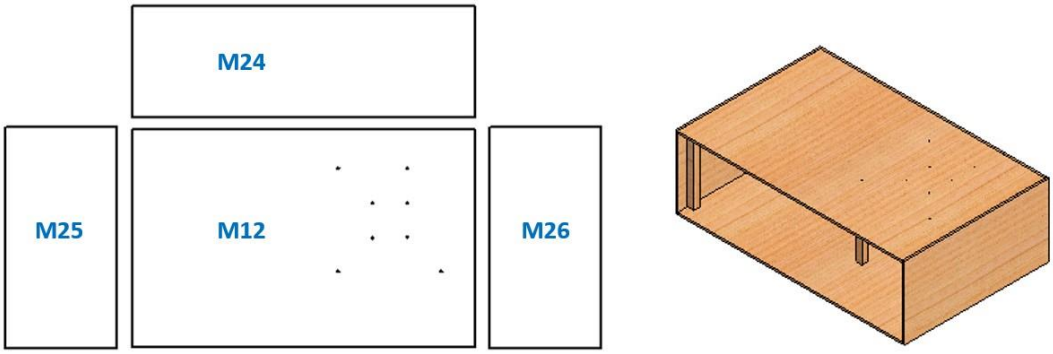

Figure 21 - Rear section of the mine, flat view

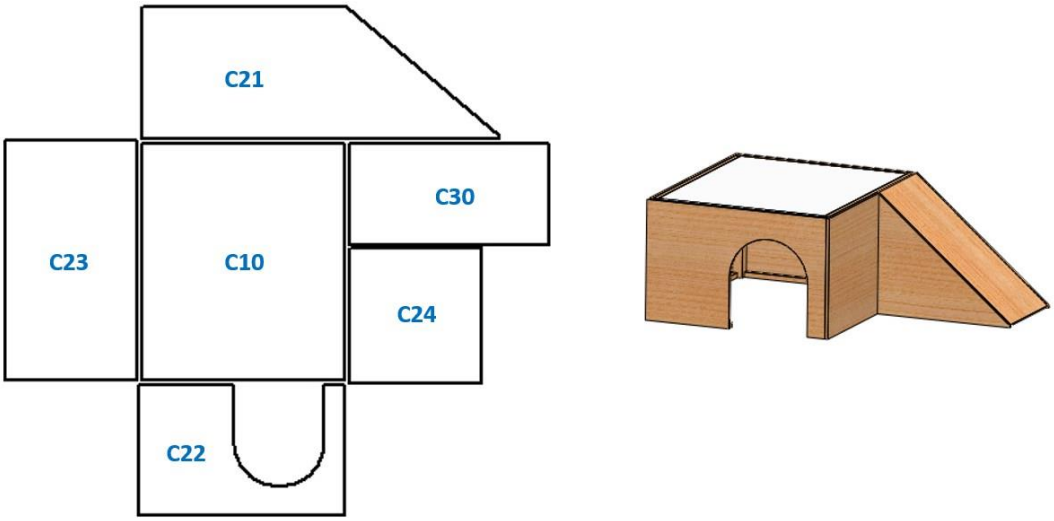

Figure 22 - Cave, flat view

On these images, the alphanumeric codes are the area’s IDs that you must write in your mission report. The geolocation images will all be fixed on the walls of the track and the barrels will all be positioned on the plateaus.

Appendix C
Mission report example

As an example, figure 23 presents a real situation that could be inscribed in the mission report.

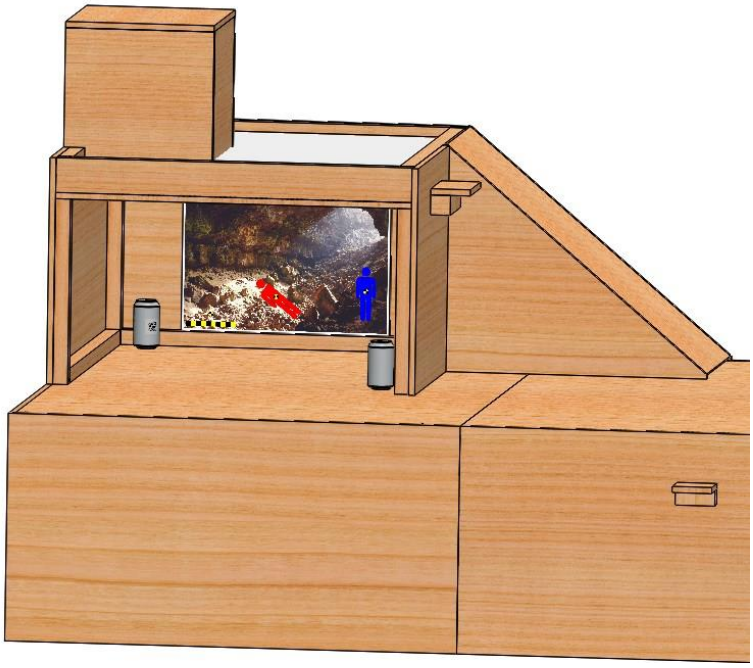

Figure 23 - Example of the geolocation images and the unknown barrels

C.1 Unknown barrels

For the unknown barrels section of the mission report, the two containers are on the C10 floor, and following the QR code reading, the data shows that the two containers are on fire. The report should be filled thus.

Unknown barrels	
Description	Mapped area
Barrel on fire	C10
Barrel on fire	C10

Figure 24 - Example of a completed report for the unknown barrels section

C.2 Geolocation

On the geolocation example, the blue 2D person is located at 2.69” vertically and 15.59” horizontally from the reference marker. The red person is located at 1.92” vertically and 6.53” horizontally from the reference marker. In addition, the geolocation image is fixed on the C21 wall.

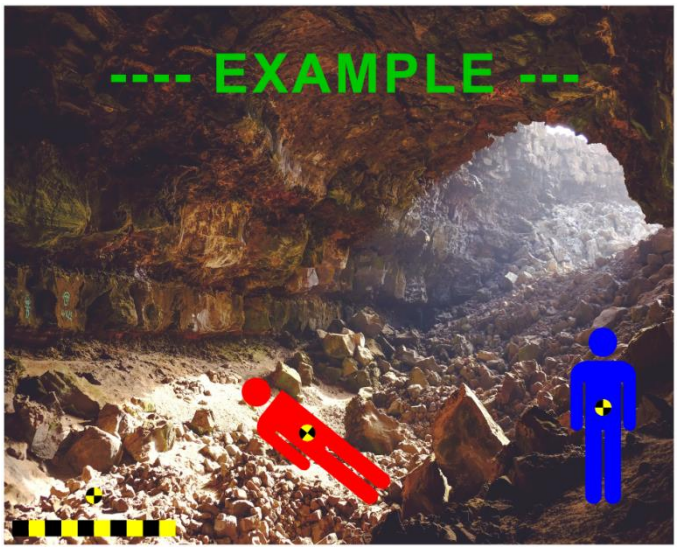

Figure 25 - Example of a completed report for the geolocation section

The geolocation section of the mission report should be filled thus.:

Geolocation			
Description of the 2D person	Mapped area	Vertical position	Horizontal position
Red person	C21	1,82	6,77
Blue person	C21	2,99	15,37

Figure 26 - Example of a completed report for the geolocation section

In this report, the maximum positioning error of the red person is 0.24 inches, abs(6.53-6.77). The team will thus receive 100% of the available points for the red person.

Moreover, the maximum positioning error of the blue person is 0.3 inches, abs(2.69-2.99). The team will thus receive 50% of the points available for the 2D person.

Appendix D
Demonstration scorecard

Table 9 presents the points available for each element present on the track. In this table, the dummies are the 3D-printed objects described in section 2.2.3 and the 2D persons are the victims on the geolocation images presented in section 3.3.4.

Table 9 - Product Demonstration detailed scorecard

	Related points	1st plateau	2nd plateau	3rd plateau	Total of points
Unknown barrels	2	5	5	0	20
Green dummies	2	5	3	0	16
Red dummies	6	2	5	0	42
Blue dummies	16	0	0	3	48
Green 2D person	2	2	0	0	4
Red 2D person	6	2	2	0	24
Blue 2D person	10	0	2	0	20
Snow accumulation	6	0	1	0	6
Total					180

The first column on this table represents the quantity of points granted for the successful completion of the challenge's element. The following three columns allow one to calculate the distribution of points on the track as per figure 27. Together, these columns and the figure present the number of element occurrences per terrain section. The last column represents the total number of points that can be collected for each element. A machine that only rescues the blue dummies can collect a maximum of 48 points out of 180.

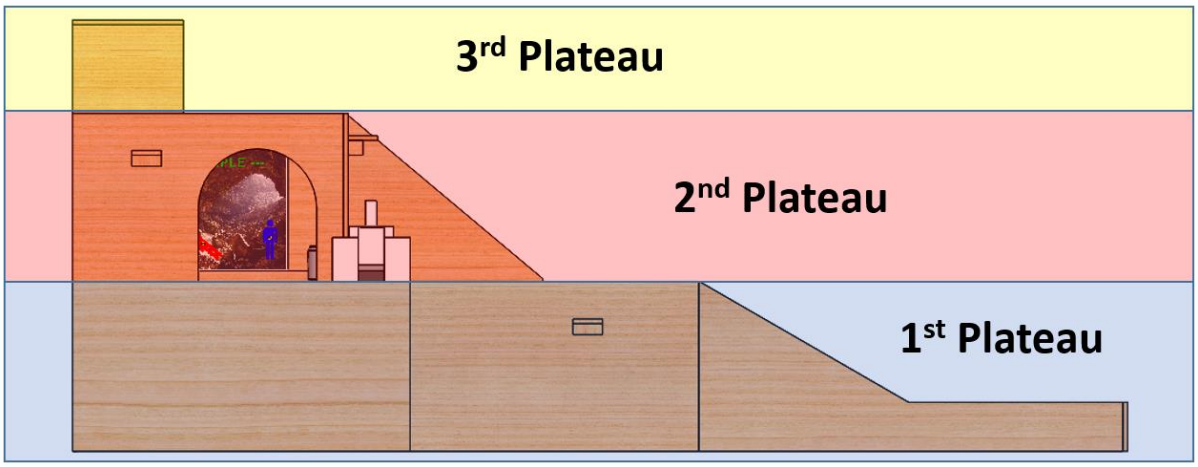

Figure 27 - Distribution of points on the track