engineering games 2024

MACHINE HANDBOOK

33rd ENGENEERING GAMES

THINK OUTSIDE THE BOX

January 3rd to 7th 2024

Université de Sherbrooke

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1 Introduction

1.1 Background

With the goal of innovating in field of space exploration, the OliRob-otics™ company is looking for the best team of engineers capable of developing their future Mars robots. To do so, they are holding an unprecedented competition directed towards Quebec engineers. The best team will be crowned the victor and have the chance to take over the department of Martian robotics at OliRob-otics™.

The goal of the competition is to create a high-performance robotic solution, capable of performing complex tasks in a very short turnaround time. The robotic solutions will be tested in a miniature environment where they will need to efficiently extract Martian minerals and place them in various deposit sites. OliRob-otics™ requires that the robotic solutions be capable of autonomous navigation, be able to be controlled remotely, move carefully in challenging environments, and be robust.

After 4 months of work, participants will put their solutions to the test with a trial to prove the abilities of the solution in predetermined and controlled conditions. Following this, the solutions with the best results will be invited to compete in a tournament of duels to prove their ability to adapt and the reliability of their strategy.

In the end, the best team will be crowned according to the rigour of their technical follow-ups, the quality of their presentation in front of the executives of the company, their individual trials, and their tournament ranking.

Good luck!

1.2 Challenge Summary

The challenge will take place in two distinct phases: the first is an individual trial and the second is a tournament of duels.

For the individual trials as well as the duels, the solutions must:

1. Retrieve minerals from the mining station (take a ball from the ball pit).
2. Store the minerals in the deposit sites (place a ball in one of the cylinders).
3. Climb onto the liftoff platform (the center table) at the end of the trial.

For the initial 30 seconds of each trial, the robotic solutions must function autonomously. The following 4 minutes 30 seconds permit the use of remote controls, for a total time of 5 minutes. Robotic solutions may only transport one mineral at a time, and the deposit sites have different values depending on their difficulty. At the end of the trial, solutions that are able to climb onto the liftoff platform will receive bonus points.

The 8 teams with the highest scores in their individual trials will advance to the tournament of duels, in which two robotic solutions will compete at the same time, on the same field. However, only the team with the highest score at the end of the duel will advance to the next round. The winner of the tournament does not automatically win the competition but obtains additional points.

Figure 1: Course

1.3 Elements and Nomenclature

1.3.1 Score

The term “score” refers to the team’s performance during a trial. Each team will thus have an individual trial score. In the duels, the winner will be the team with the higher score at the end of the duel.

1.3.2 Points

The term “points” refers to the points attributed to the “machine” section of the global point evaluation of the Engineering Games. The scores from the individual trial and deliverables are included in these points.

1.3.3 Robotic Solution

The term “robotic solution” refers to the robot(s) built by each team for the competition, excluding the control system.

1.3.4 Control System

The term “control system” refers to the element(s) used to wirelessly send commands to the robotic solution. The control system is not included in the robotic system.

1.3.5 Team

The term “team” will be referenced throughout the document to refer to the 6 members of the machine team from the participating university. Only the 6 members of the machine team are allowed in the machine rooms, and their names will need to be submitted before the competition.

1.3.6 Pilot

Only one team member is designated as the pilot. The pilot is the only person who is allowed to use the control system. The rest of the team is not allowed under any circumstance to interact with the control system but can help with the initial placement and re-placement of the solution. The pilot must be the same person throughout a single trial but may be different from one trial to another.

1.3.7 Organizers

The “organizers” refers to all the members of the Organizing Committee or machine volunteers who may be present throughout the competition.

1.3.8 OC Machine

The “OC Machine” refers to the 2 exceptional VP Machines on the Organizing Committee: Robin Mailhot and Olivier Fournier.

1.3.9 Minerals

The “minerals” are the 2.34-inch spheres that the robotic solutions must move to the deposit sites.

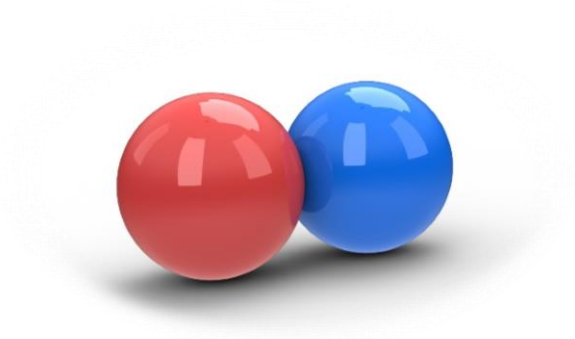

Figure 2: Minerals

1.3.10 Mining Station

The “mining station” refers to the entirety of the triangular structure that contains the minerals.

Figure 3: Mining station with minerals

1.3.11 Deposit site

The “deposit sites” are places to store minerals. The term includes every silo and the rocket.

Figure 4: Deposit Sites

1.3.12 Zones

The “zones” are groupings of deposit sites. There are 5 different zones on the course: The west and east analysis zones, the north and south transformation zones, and the shipping rocket.

Figure 5: Zone division

1.3.13 Liftoff Platform

The “liftoff platform” refers to the raised surface found in the center of the course. The middle of the platform holds the rocket.

Figure 6: Liftoff Platform

2 Score

For the individual trial and the duels, the score is calculated as such:

$$final\ score\ = \left(\sum S_{mineral} + \sum S_{control} + S_{liftoff}\right) \cdot \left(1 - \sum penalty\right)$$

There are three different ways to increase your score: by transporting minerals to deposit sites, by controlling a zone, and by successfully performing the liftoff maneuver. All penalties are summed and used as a factor to get the final score.

2.1 Timing of score calculation

The score is not calculated until the end of a trial. The minerals found in deposit sites are not counted if they are no longer there at the end of the trial, likewise for zone control scoring. For the liftoff, the solution may not be remotely controlled after the end of the trial.

2.2 Depositing of Minerals

The main way to earn points is by transporting minerals to deposit sites. The value of a deposit site varies according to its zone.

Zone	Score/mineral	Score for Zone control
Analysis East and West	10	N/A
Transformation North and South	20	50
Shipping Rocket	40	50

2.3 Acceptable deposit sites

The robotic solution may deposit minerals in any zone, except for the analysis zone on the same side as its mining station. If this rule is broken, a 20% penalty is applied for each mineral deposited in the zone, and they will not award any deposit nor control points.

2.4 Accepting of minerals

A mineral is considered deposited if and only if it is completely inserted into and held by the deposit site.

2.5 Zone Control

The different deposit sites are grouped into zones: the East and West analysis zones, the North and South transformation zones, and the shipping rocket. To control a zone, a team must have the last mineral in each of the deposit sites in the zone.

The last mineral of a deposit site is the highest one in a deposit site. If a mineral was pulled from a silo, it is no longer considered the last, as it is no longer in the silo.

2.6 Liftoff

To simulate a return to orbit of the solutions, at the end of each trial the robotic solutions may attempt to climb onto the liftoff platform. There are two possible difficulty levels for the liftoff:

Liftoff	Score
Partial	51
Total	101

2.6.1 Partial Liftoff

To perform a partial liftoff, the entirety of the robotic solution must be supported by the liftoff platform. The robotic solution must not be in contact with anything but the liftoff platform, not even the legs supporting the platform.

2.6.2 Total Liftoff

To perform a total liftoff, the robotic solution must be entirely above the plane formed by the top of the liftoff platform, and entirely supported by the platform.

2.6.3 Stability during Liftoff

The solution must be stable during liftoff. A stable position means the robot must not move, oscillate, or fall, and must stay autonomous without external assistance. If the solution fails to maintain a stable position at the end of the trial, the liftoff will be considered invalid.

3 Individual Trials

3.1 Introduction

The individual trial is the first phase of the machine challenge. It is a 5-minute trial during which the team must show the effectiveness of their solution to enter the tournament and improve their score. In the first 30 seconds, the solution must act autonomously (autonomous phase) and will then be remote controlled for the remaining 4 minutes and 30 seconds. Only the top 8 teams with the highest individual scores will advance to the duel phase.

3.2 Preparation

To start a trial, the following conditions must be respected.

3.2.1 Minerals in the mining station

42 minerals are in the mining station.

3.2.2 Mineral at the start

The team may place an additional mineral in the starting zone before the start of the trial. This mineral may be placed inside the solution so that it can bring it directly to the deposit site during the autonomous phase.

3.2.3 No minerals may be in the deposit sites

The silos and the rocket must be empty and positioned according to the construction plans of the challenge.

3.2.4 Terrain is empty

No objects or other resources may be on the terrain.

3.2.5 The course mat is clean

The course mat must be clean before each trial. This includes but is not limited to having no sand/rocks on the mat, no dust nor debris.

3.2.6 Dimensions Restrictions

The robotic solution does not have any restrictions on height nor maximum weight but must fit entirely inside the starting area without external aid at the start of a trial. The starting area is a right triangle with 24” for the base sides.

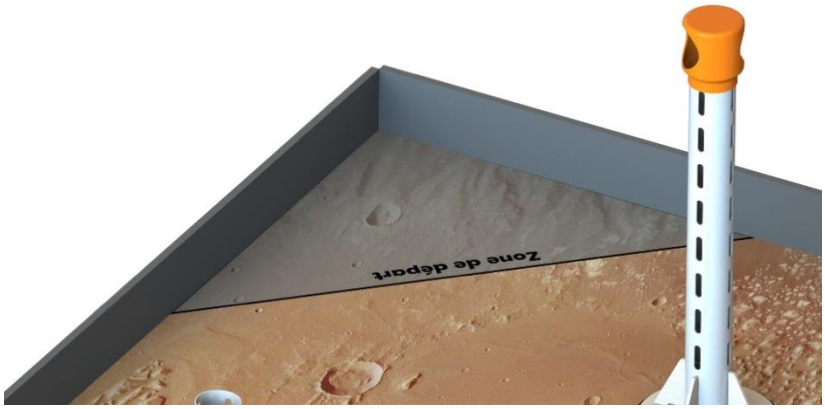

Figure 7: Starting area

3.2.7 Start

Once the solution is placed and its perimeter is within the starting area as specified by rule 3.2.6, the team must signal to the organizers that they are ready. Once the organizers are ready, one of the organizers will start a 5-second countdown. At the end of the countdown, the team may start the autonomous phase.

3.3 General Rules

3.3.1 Pauses during the Trial

The organizers reserve the right to pause trials for reasons including but limited to: damage to the course, external interference, or a technical problem. In the event of a pause, the team must stop sending commands to their solution, the time will be stopped, and measures will be taken to either resume the trial or restart it. If the trial is in the autonomous phase, it will be restarted.

3.3.2 Placement of the pilot

To allow the judges and audience to clearly see the trials, pilots are only permitted to be in certain places. Pilots must squat if they are in the restricted zone.

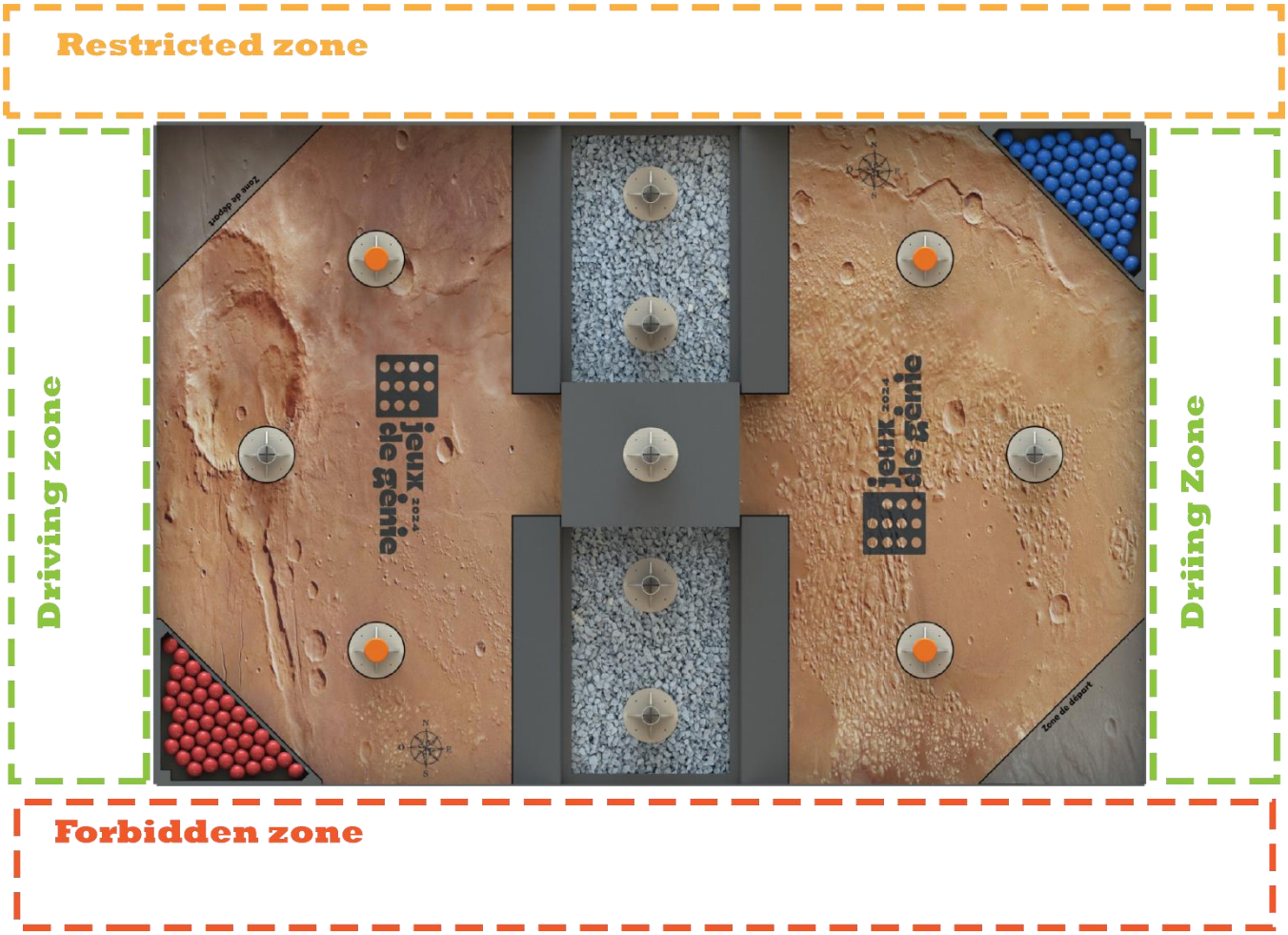

Figure 8: Pilot zones

3.3.3 Integrity of the robotic solution

The solution must never leave behind detached pieces or unfastened components during a trial. In the event of a part breaking during a trial, if the part is considered detrimental to a trial, the solution must be reset. During the reset, the part must either be repaired or thrown out of the terrain.

3.3.4 Security of the solution

The robotic solution must not pose a safety risk to the public, the participants, or competing robots. The use of explosives, fire, or all other dangerous materials is strictly prohibited. For the same reason, flying robotic solutions are not permitted. If in doubt, contact the Organizing Committee.

If one or more batteries are used to power a system forming part of the robotic solution, a fuse must be used to protect this system against overloads. This fuse must be positioned as close as possible to the battery, and be adequately sized. The presence of this protection will be validated and will be necessary for participation in the tests. (Changed 2023/12/11)

3.3.5 Communications restrictions

The only authorized method of communication to the solution is the control system. The control system must be wireless and in direct communication with the solution. The control system does not have any size or weight restrictions; however, it must be battery powered and must respect the same security rules as the robotic solution.

3.3.6 Dirtying or damaging elements of the terrain

A solution that dirties or damages an element of the terrain will face a penalty up to and including disqualification of the team. This includes but is not limited to: the mat, the minerals and the deposit sites. In a duel, if a team damages the course in a way that the rest of the duel is altered, the team automatically loses the duel.

3.3.7 No contact with the terrain or the solution

During a trial, team members must not come in contact with the course or solution without asking the organizers. Should a team member touch any part of the course or solution without permission, the robotic solution must be reset without pausing for time. (Changed 2023/10/17)

3.3.8 Resetting the solution

The resetting of the solution must take place in the following order:

1. Ask and wait for approval from an organizer to reset
2. If present, give the mineral currently in control of the solution to an organizer (it is lost)
3. Take the solution and place according to rule 3.2.6
4. Wait for approval from an organizer
5. Restart the remote controlling of the solution

Each reset of the solution also imposes a 10% penalty to the final score. Time continues to run during the reset.

3.3.9 Repairing during a trial

If a team must repair its solution during a trial, they must perform a reset and may take the time they want to repair the solution. The repair must be done outside of the course or in the starting area. However, only repairs performed by hand without power tools are permitted. Additionally, no new code can be sent to the solution. Time continues to run during all these steps.

3.3.10 Minerals which leave the course

If a mineral touches the ground outside the course, it is considered lost and cannot be recovered in any way. The mineral will be taken by an organizer.

3.3.11 Robotic solution leaving the course

A solution that touches the ground outside the course must be reset according to rule 3.3.8. The solution may, however, go outside the perimeter of the course so long as it does not touch the ground.

3.3.12 Displacement of a deposit site

It is strictly forbidden to displace a deposit site from its base. Breaking this rule will result in a penalty up to and including disqualification should the action be judged to be intentional.

3.3.13 Control of a single mineral

The entirety of the robotic solution is only allowed to manipulate one mineral at a time. No other movement or control action on more than one mineral will be tolerated at any time during a trial. The phrase “control a mineral” includes all direct and indirect actions performed by a robotic solution to a mineral, including but limited to pushing, pulling, lifting, transporting, or otherwise moving a mineral.

3.3.14 Freeing a mineral

A robotic solution may not physically interact with a second mineral while they are still controlling another mineral. The “first mineral” must be completely freed, or no longer in control of the robotic solution, before it can interact with a “second mineral”.

3.3.15 Penalty for controlling minerals

In the event simultaneous control of multiple minerals, all the minerals controlled during the infraction are immediately removed from the course by the referees and will be considered out of play minerals until the end of the match. If the infraction is committed with one or multiple minerals of the opposing team, those will remain in play, but the penalty will be applied.

For each mineral control penalty, the team will receive a 10% penalty to their final score.

3.3.16 Obstruction by a mineral

A robotic solution may move a mineral that obstructs the course to continue its movement on the course. However, the robotic solution may not move minerals in an intentional and strategic manner to gain a competitive advantage. If the referees judge that a second mineral was displaced intentionally with the goal of gaining an advantage, it will be considered an infringement of the rules and the same penalties as those for controlling multiple minerals will apply.

3.4 Autonomous Phase

Once the starting the signal is given, the pilot activates the solution according to the following rules:

3.4.1 Starting the solution

The pilot must start the robotic solution with the help of a single manual action. This may include but is not limited to pressing a button on the control system, pressing the “reset” button on the microcontroller, or connecting the battery.

3.4.2 No contact during the autonomous phase

After sending the command, the team may not come in contact with the solution or the control system during the first 30 seconds of the trial. The control system must be given to an organizer during these 30 seconds.

3.4.3 Resetting during the autonomous phase

If the team must reset the solution during the autonomous phase, they may. However, the solution may not be remotely controlled so long as the 30 seconds of the autonomous phase are not elapsed.

4 Tournament of Duels

With the 8 best teams from the individual trials decided, they will now advance to the tournament of duels. The duels will follow the same rules as the individual trials, with a few small exceptions. The previous rules still apply, in addition to the rules found in this section.

4.1 Preparation of the course

4.1.1 Red team and blue team

The two teams must set up their robots in the same manner as the individual trials, with each team in their respective corner, beginning on the same starting signal. Once the starting signal is given, both solutions begin their autonomous period as in the individual trials.

4.2 General Rules

4.2.1 Modifying the solution

It is strictly forbidden to make any physical or software modifications between trials. This includes between the individual trials and the tournament, as well as between rounds of the tournament. The only acceptable modifications are those that do not require any power tools and fall into one of the following categories:

- Resetting sources of energy (changing batteries, resetting elastics, etc.)
- Replacement of a broken part with an exact copy

A team that infringes on this rule will be punished up to disqualification or more.

4.2.2 Opposing mineral interactions

It is forbidden to cause an opponent’s mineral to become unreachable. A penalty of 10% to the final score will be applied for each infraction.

4.2.3 Opposing mining station

It is forbidden to interact with the opponent's mine for any reason. A penalty of 10% to the final score will be applied for each infraction.

4.2.4 Removing opponent's minerals

Removing an opponent's mineral from a ~~starting area~~ deposit site is allowed. However, the mineral is counted when applying rule 3.3.13. (Changed 2023-13-09)

4.2.5 Restrictions on impeding other solutions

Teams are not allowed to use their robotic solution to intentionally block the path of another team. Any actions that seek to intentionally block another robotic solution's progress will be considered an infraction of the rules and will be punished as a result.

4.2.6 Contact between solutions

Contact between solutions is not prohibited and will be tolerated if the solutions are traversing the same limited space.

4.2.7 Attempts to damage

Any attempt to damage another robotic solution, either through direct or indirect contact, will be considered a serious infraction of the rules and will be punished as a result. It is therefore strictly prohibited for robotic solutions to have mechanisms whose function is to damage an opposing robotic solution or intentionally collide with an opponent with the goal of damaging their robotic solution. Infractions to this rule may lead to expulsion from the tournament.

4.2.8 Contact during liftoff

It is strictly forbidden to come in contact with a solution that is trying to climb onto the liftoff platform. The first solution to no longer be in contact with the ground therefore has priority for the chosen location to climb. Infractions to this rule will be punished according to the severity of the infraction, up to disqualification.

4.3 Tournament Bracket

The tournament will follow a single elimination format: the winners advance, and the losers are eliminated. The further a team advances in the tournament, the more points they earn. The initial seeding is determined by the score of each team in the individual trials. The best team in the individual trials will be given the seed #1.

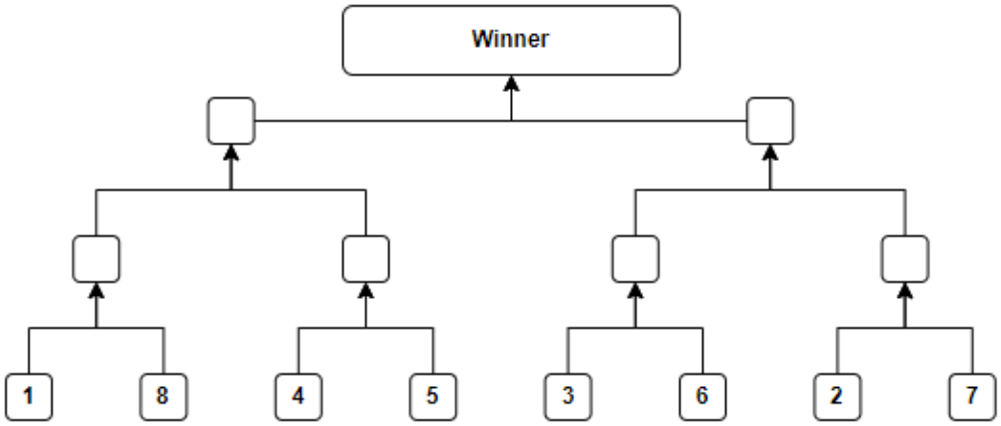

Figure 9: Tournament bracket

4.3.1 Inability to continue

Should a team be unable to advance to the next round of the tournament, the eliminated team with the highest score in the individual trials will take its place. The replacement team may continue in the tournament at the same level as the others, however this bye will not count as a win when calculating points.

4.3.2 Ties

If two teams have the same score at the end of their individual trials or a duel, the time it took for each team to place their first mineral will be used as the deciding criterion. For tournament seeding, the time from the individual trial will be used. For a duel, the time during the duel will be used.

5 Scoring and Deliverables

Though the individual trials and the tournament are central to the competition, multiple other deliverables account for the other aspects of the engineering work involved in a large-scale project. The various deliverables are presented in this section. Every deliverable submitted late with receive a 10% penalty per day of delay.

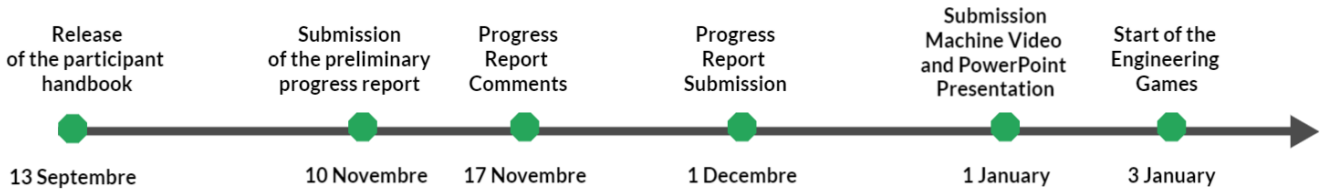

Figure 10: Timeline

Deliverables	Weight (%)
Progress Report	10
Judge Presentation	25
Video Presentation	5
Individual Trial	42
Tournament	18
Total	**100**

5.1 Individual Trial

The individual trial accounts for 42% of the final score. The final points for each time will be determined using the following equation:

$$Individual\ trial\ points\ = \frac{Time\ score}{Best\ team's\ score}\ *\ 42$$

5.2 Tournament Results

Each victory in the tournament will give 6 additional points to the team. A team who wins all the matches of the tournament will receive 18 points, and a team losing in the quarter final will receive no tournament points.

5.3 Progress Report

The goal of the progress report is to inform the Organizing Committee of your robotic solution's progress. The report must be concise and clearly present your engineering process. The report should not document each individual iteration leading to your robotic solution, but rather the most recent and updated version. It must be a snapshot of the state of your project.

The report must be no longer than 12 pages, including the title page and table of contents. Supplemental figures may be included in the appendix, however they must not be essential to comprehension of the report. The following criteria will be used for evaluation. The structure of the report may not necessarily follow the listed criteria, however all subjects should be addressed.

A preliminary version of the report may be submitted before November 10th, 2023. The Organizing Committee will provide constructive commentary to help the teams.

Evaluation Criteria	Points
Clarity and structure	1
Overall solution presentation	1
Subsystem presentation	3
Considered strategies and expected results	2
Risk management process	3
BONUS: CAD of the solution	1
Total	**10**

5.3.1 Overall solution presentation

Before going into the design details, the solution should be presented at a higher level. The following elements shall be addressed to ensure a good understanding:

- Sketch or photo of the solution
- Presentation of the movement system
- Presentation of the grabbing/dropping system
- Presentation of the control system

5.3.2 Subsystem presentation

Now that the reviewers have an overall idea of the solution, it is time to present the subsystems in detail. For each of the subsystems, the following points will be considered:

- What criteria guided your decisions
- The strengths of your choice
- Potential performance validation of your choices
- If necessary, a diagram of the system

5.3.3 Considered Strategies and Expected Results

A key factor in an engineering project is optimizing a solution for efficiency using a strategy. You must present your strategy considering the strengths and weaknesses of your solution. You will not be judged on the goals of your expectations, but rather on your ability to maximize your time and accurately evaluate your performance. The following points will be considered:

- Strategy for the individual trial
- Strategy for the duels

5.3.4 Risk Management Process

The challenge's complexity presents some risks. Whether these risks are related to design or to strategy, they must be considered in a mitigation and contingency plan. You must therefore present your risk management approach while addressing the following points:

- Identifying risks
- Identifying the probability and impact of these risks
- Mitigation plan: how to reduce the probability of encountering these risks
- Contingency plan: how to reduce the impact should these risks arise

5.3.5 CAD of the solution

A bonus of up to 1 point will be given to teams that include a CAD of their robotic solution. They may be complete or partial. They must not be essential to the comprehension of the report and may not increase the total score of the progress report above 10 points.

5.4 Video Presentation

The goal of the machine video is to present your team and your robotic solution to the public. This video will be shown to the public before the on-stage demonstration of each team and should be 3 to 4 minutes long. Its goal is to entertain viewers while also informing the audience about the university, the team members, and your design and building approach. This video may be in French or in English. Any video deemed inappropriate by the Organizing Committee will not be shown and will receive a score of 0/5. The video must be submitted via email to machine@jeuxdegenie.qc.ca as a .MP4 file. We recommend using WeTransfer for the file Share. (Modified 2023/12/11)

Evaluation Criteria	Points
Introduction of the team and university	1
Presentation of the solution	2
Presentation of the strategy	1
Originality	1
Total	**5**

5.5 Judges Presentation

Before the trials in front of the public, you must present your solution to a panel of judges. The goal of this presentation is to show the results of your design process and the expectations of your solution. The panel of judges will consist mostly of engineers, with some not familiar with robotic design. The presentation will be complemented by a slide (ex. PowerPoint) presentation. The presentation will be 10 minutes long followed by 5 minutes of questions. (Modified 2023/12/11)

The presentation's structure is flexible; however, you must at least present the following points:

- How the subsystems work
- How the solution works overall
- Possible improvements and a critical analysis of your design decisions
- Strategies for the individual trial and duels
- Your realistic expectations

Evaluation Criteria	Points
Introduction of the team and university	1
Solution presentation	8
Design analysis	4
Strategy presentation	6
Presentation structure	2
Question period	4
Total	**2**

6 Logistics

6.1 During the Engineering Games

A specific handbook regarding the machine working time and specific details of the week of Engineering Games will be published later in the year. For now, you may consider that the procedures will be similar to previous years.

6.2 Changes to the Rules

The Organizing Committee reserves the right to change these documents at any time and will inform the delegations of a modification, in the event of a change. In the event of a discrepancy between the French and English versions of these documents, the French version prevails.

7 Questions

Any questions about the machine competition can be asked via a *Google Form* on the official EngGames Website. The answers will be shared via a *Google Doc* on the same page.

8 Organizing Committee

For any questions or comments regarding the challenge, you may contact the machine team at the following address:

Olivier Fournier – Vice-President, Machine

Robin Mailhot – Vice-President, Machine

machine@jeuxdegenie.qc.ca

For any or all questions and comments nonrelated to the challenge, do not hesitate to contact these members of the organizing committee at the following addresses:

Rima Al-Hayek, President

presidence@jeuxdegenie.qc.ca

Rose-Line Tougas - Vice-President, Partnerships

partenariats@jeuxdegenie.qc.ca

Good luck in the challenge everyone!