CZECH ROCKET SOCIETY

Czech Rocket Challenge - Competition handbook

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CZECH ROCKET SOCIETY

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1 Introduction

The Czech Rocket Challenge (CRC) is a rocket competition that brings together students, professionals and companies interested in the development of aerospace in the Czech Republic and gives students the opportunity to experience the real work of rocket engineers with all its responsibilities.

1.1 Aim

The aim of the Czech Rocket Challenge is to bring together those interested in rocketry and cosmonautics in the Czech Republic, especially students, and to give them the opportunity to build their own working rocket. The competition should teach individuals to work in a team on a new engineering project and provide them with a lot of new experience ranging from the initial design to the testing of the rocket.

1.2 Overview of the competition

The competition is divided into 3 categories:

- High school - beginners
- High school - advanced
- University - advanced

Apart from the main categories, teams can also win one of the following categories:

- Best report
- Special award of the jury
- Most accurately predicted altitude

The division between high school and university teams is fairly clear. If a team is mixed and there are 2 or more university students, the team automatically falls into the university category. Categories differ for example in: rules, scoring or challenge. More details can be found in the following chapters.

All university teams automatically participate in the *advanced* category. Any new high school team will be placed in the *beginners* category. Continuing teams from previous years will be placed in the *advanced* category. If a team is mixed and there are 2 or more students who have participated in at least one of the previous CRC competitions and have submitted the final report, the team automatically falls into the *advanced* category.

The engine will be provided by the CRC organizational team. Its thrust characteristics, impulse and other necessary data are included in **Appendix A**. Each rocket must use – and therefore have room for – a calibrated certified altimeter, which will also be provided by the CRC organizational team. Teams will be given rough instructions for building their rocket, however mostly independent work is expected. This will give individual members the opportunity to independently understand aspects of rocket design.

During the competition the teams will have support from members of the Czech Rocket Society (CRS) to whom they can turn in case of difficulties or seeking advice. There will also be a series of workshops for the teams which will take place throughout spring.

Each team's rockets will be judged on both design and flight performance. The evaluation of the rocket flight will take place on the final launch day, where the final score and the overall winner in each category will be announced.

2 Competition timeline

2.1 Registration

Registration is open until 23rd February 2025 on the website czeroc.cz.

The registration fee of 300 CZK is payable by 1st March to the account: 42637800/2010.

Variable symbol: 20250301. Message to the recipient: Czech Rocket Challenge [team name].

Please reach out to the CRC organizational team if you require help with the payment.

2.2 Design

From March to June, teams will have time to design, test and build a working rocket. Compared to last year's event, the contestants have an extra month to work on the rocket, so the success rate of rockets returned to earth is expected to be higher. For a smoother start, **several workshops during March and April and one workshop dedicated to your questions** are planned. The workshops will probably last 1-2 hours on one of the dates mentioned below and will be online for better accessibility for all registered teams from different parts of the Czech Republic. We will provide details later, but you can already count on the dates in advance. The workshops should allow participants to better understand the main components of the rocket, how to start designing it or how to divide roles within the team. The workshops will be recorded.

At the **first workshop (1-2 March)** we will introduce the competition, explain the rules, go through the handbook, the experience from last year and present the competition schedule. At the **second workshop (8-9 March)** you will try out the OpenRocket rocket simulator and learn how to use it. This software is key. At the **third workshop (15-16 March)**, we will explain how to safely design the avionics. At the **fourth workshop (22-23 March)** will be focused on the recovery system. During the **fifth workshop (29-30 March)**, competitors from previous years will describe their experiences, successes and obstacles. During the **sixth workshop (12-13 April)** we will explain the standardized tests that are mandatory in order to be invited to the final day.

The design of the rocket should roughly take the first two months and then the teams should move into the initial building and testing phase. Therefore, **6th April** is the deadline for submitting the progress and design of the rocket so far, called the *Concept Report*. All reports will be expected in a PDF format + attached files such as photos, videos, presentations, simulations or calculations. The *Concept Report* will not count towards the final evaluation, but is required to ensure that the rockets are safe and teams do not leave work until the last minute.

In **May**, teams should be building and testing individual components and systems. In **June**, they will build and test the entire rocket.

For ensured safety and detailed scoring in each category (see **Chapter 4**), a *Final Report* is required. It should be clear from the *Report* that the team has done some calculations and simulations of the individual components, the whole rocket and its flight. This should also be aided by the standardized tests that each team will need to document, further described in **Chapter 5**. The *Report* should also show that the rocket is airworthy, aerodynamically stable and has a working recovery system. Contestants will learn more practical details about the *Report* during the workshops. The *Report* should serve as the contestants' own critical review of the project, while better pointing out the rocket's shortcomings or limitations. Writing such a *Report* is challenging and may be a first experience for many, so a ***Final Report Draft* is required by 25th May** for which you will receive feedback. The *Draft* will also not count towards the final evaluation. By submitting a *Draft* you are showing that you are indeed going to participate in the final day, should you be selected.

The deadline for *Final Report* is 22nd June 2025 for high school teams and 28th June 2025 for university teams. If the *Report* is found satisfactory and the rocket is deemed airworthy, the team may be invited to the launch day based on the Rocket design points scored and competition ranking.

Finally, during June, we are also planning personal meetings with the competitors in Prague and Brno. During the meeting we can discuss together your ideas, questions or possible solutions, see your rocket or go through the *Report* and any comments on its *Draft*.

For the safety of competitors, organizers and spectators on the final day, the *Concept Report*, the *Final Report Draft* and the *Final Report* are **mandatory**. If teams do not prove their previous work, the organizer may disqualify them from the competition. In addition, the CRC organizational team may declare the rocket unairworthy on the day of the competition and not allow the team to the launch ramp.

2.3 Launch day

The launch day is scheduled for Friday 12 July 2024 for $\sim$ **20 teams**, which will be invited based on the *Final Report*. Depending on the number of entries, the competition may be extended to two launch days – Thursday 10 and Friday 11 July or Friday 11 and Saturday 12 July. All entrants will be notified of the launch day format after registration closes (23rd February 2025). The launch day date is subject to change depending on the weather.

Table 2.1: Timetable of the Czech Rocket Challenge 2025 competition

Competition timetable	
Registration	until 23rd February
Workshop 1	1-2 March
Workshop 2	8-9 March
Workshop 3	15-16 March
Workshop 4	22-23 April
Workshop 5	29-30 April
Concept Report	due 6 April
Workshop 6	12-13 April
Final Report Draft	due 25 May
Meeting with competitors	during June
Final Report (high school)	due 22nd June
Final Report (university)	due 28th June
Launch day	11 June

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3 Competition rules and requirements

This section describes the competition rules that apply to all rocket designs in all categories. These rules have been developed to ensure that the competition meets safety standards and that all teams have an equal opportunity to win.

Maximum Apogee

The maximum apogee is limited to 800 m. If a rocket climbs above this height, the team will receive 0 points for the flight performance. If the simulations predict a higher height, the team will not be allowed to launch their rocket.

Engine size

The engine will be the same for all teams and will be provided by the competition organizer for a deposit of 1 000 CZK on the day of the launch. The engine must be returned to the organizer. The deposit will be refunded upon the return of the engine in good condition on the day of the launch. Specifications can be found in **Appendix A**.

Rocket size

In the *beginners* category, the rocket must be at least 60 mm in outer diameter. For the *advanced* category this rule does not apply and the diameter can be of any size.

Other materials

The rocket must not use any toxic or reactive materials. If in doubt, always consult with the CRC organizational team.

Payload

Rocket payload, especially for the advanced category, must not contain living creatures, flammables or explosives.

Stability

The center of pressure C_p must be behind the rocket's center of gravity C_g. Minimum aerodynamic stability must be greater than 1 at the time when the rocket leaves the launch ramp (note: C_p should be at least one rocket's diameter behind C_g). The stability is determined through the OpenRocket software. The rocket's stability is determined by the following parameters: Degree of launch ramp angle = 1°; length of launch ramp = 250 cm; wind speed = 5 m/s.

Recovery system

For the *beginners* category, only a parachute or a streamer are allowed as the recovery system. The parachute or streamer must include either a red or an orange color for better rocket visibility. The *advanced* category is unrestricted, but other alternative methods will be carefully reviewed. The recovery system must ensure a controlled and non-ballistic descent of the rocket and all its parts and components after launch. If ejection charge is used for ejection, the **Appendix E** must be followed.

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Recovery system deployment

To ensure safety, all teams, regardless of category, must have a secondary system for the activation of the recovery system, e.g. a simple timer. The deployment of the recovery system, in particular a parachute or a streamer, shall be executed at speeds lower than 15 m/s. For alternative methods, the descent rate may vary.

Speed of descent

The rocket and all parts of the rocket must descend at a speed between 5 and 9 m/s (note that this excludes any parts separating immediately after the exit from the launch ramp). The satellite (payload) launched from the rocket must descend at 10–15 m/s for weights lower than 150g. For satellites heavier than 150g, the descent speed must be between 6 and 9 m/s.

Launch ramp

All rockets will be launched from the same launch ramp, which will be provided by the CRC organizational team. See **Appendix B** for more information about the dimensions of the launch ramp.

External Propulsion

The rocket must not use any other propulsion system that would help it reach a higher apogee.

Altitude recording

The rocket must contain an altimeter, provided by the CRC organizational team, in order to record altitude. See **Appendix C** for more details. The altimeter will be provided to the competitors for a deposit of 1 000 CZK on the day of the competition. The deposit will be refunded upon the return of the altimeter in good condition at the day of the competition. Additional measuring instruments and sensors are welcome.

Rocket launch procedures

Each team must write their own procedures for the correct launch of their rocket. Procedures should include all the information needed to assemble the rocket, ranging from screwing in the components, connecting the parts, turning on the system, to mounting the engine and placing the rocket on the launch ramp. The *Final Report* must include procedures comprising of at least 30 steps.

Systems minimum powered-on time

Each team must provide evidence that their flight system can last a minimum of 30 minutes in the powered-on state and then perform the required tasks. This requirement is mandatory due to the possibility that a ready/powered-on rocket will be on the ramp for a longer period of time while the surrounding area is being prepared for launch, whether due to other launch teams, launch device repairs, or waiting for launch clearance from the airport control tower.

Note: Failure to comply with any of the rules mentioned above may result in the immediate disqualification of the offending team from the competition.

The CRC organizational team reserves the right to change the rules.

4 Scoring

The *beginners* and *advanced* categories have a separate scoring system. In order to determine the winner of the competition, teams will be marked on several different criteria, the two main areas being **rocket design** and **flight performance**. The maximum score is 1000 points. The *Report* mainly covers the subcategories Design, innovation & payload; Analysis, simulation & report. **Table 4.1.** provides an overview of the scoring methodology.

Scoring will be preformed by a team of judges from CRS, academia, and industry who will impartially and independently score each team's category and their scores will then be averaged. Further details will be presented in advance of the final report.

Table 4.1: Scoring methodology

Criteria	Beginners	Advanced
Rocket design		
Design, innovation & payload	300	200
Analysis, simulation & report	150	150
PR Challenge	50	50
Flight performance		
Accuracy of the predicted apogee	200	100
Highest apogee	100	150
Challenge	200	350
Total	**1000**	**1000**

Rocket design

As mentioned in **Chapter 2**, teams will be required submit a report about their rocket in order to be marked in this section. The report should describe the operation and design of the various parts (structure, parachute, fins, etc.), show simulations and calculations of the rocket and the completion of the prescribed tests. For the rocket design described in the report, teams can get up to 500 points in the *beginners* category and up to 400 points in the *advanced* category. This scoring criterion is further divided into 3 smaller subgroups.

Design, innovation & payload

Innovation is what sets some engineering firms above the rest. For example, SpaceX or NASA are constantly pushing the boundaries of science and rocket capabilities. This is why teams are motivated to come up with innovative solutions to given problems and set themselves above the rest. Innovation can take any form – from an interesting design that solves a complex problem to the application of a new technology. Any section of the rocket can be innovated. Innovation, design & payload is the highest scoring category with a maximum of 300 / 200 points respectively *beginners / advanced*, which is roughly a third / fifth of the total score.

Analysis, simulation & report

Analysis, simulation and written reports are three key components in modern engineering. The use of technologies such as the finite element method or computer simulation allow engineers to model the forces or overall behavior of individual components. Teams must demonstrate the strength and safety of the rocket by passing standardized tests, see **Chapter 5**. They can also assist themselves with structural analysis, their

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own calculations or by using software (MATLAB, Python, etc.). The report should be clear and concise, but at the same time contain everything necessary as well as showcasing your work well. Contestants will be shown sample reports and given a list of items that must appear in the report. A maximum of 150 points is awarded for this section, equally distributed between analysis, simulation and report.

PR Challenge

The communication of science and innovation is an integral part of modern development. If we want to secure funding for a project, we need to present it effectively. This is especially true for space missions, as they are often sponsored by public funds, making it crucial for people to understand how their money is being used. That's why we decided to introduce a PR Challenge this year, which will take place during the competition. Teams are tasked to share their stories on Instagram throughout the competition and tagging @czechrocketchallenge. These stories will then be re-shared and evaluated by the organizers. There is up to 50 points awarded for this section.

Flight performance

The second area for which teams will receive a score is the flight execution on launch day. This section can subsequently earn up to 500 / 600 points and is divided into 3 smaller sub-groups.

Accuracy of the predicted apogee

In this competition, apogee prediction is a more important factor in rocket design than maximum altitude. An accurate prediction is a good indication of accurate modelling, simulations and calculations. As a parallel, consider the idea of fulfilling a space mission with delivery to a specific orbit – the launch provider must be able to achieve the goal the customer is asking for. Teams are therefore required to predict the apogee of their rocket before their launch on the day of the competition. Software (OpenRocket) or in-house calculations can be used for the prediction. Up to 200 / 100 points can be earned for this category. Points will be distributed according to the following equation:

$$\text{Points} = \frac{100}{1 + 0.0002 \times (Reality - Prediction)^2} \tag{4.1}$$

No points will be deducted Negative points will not be awarded for inaccurate apogee prediction.

Highest apogee

Reaching the highest apogee is one of the most enticing goals of all aspiring rocket engineers. Yet rockets don't always fly to go as high as possible. Our goal is to motivate competitors to pay more attention to the safety, flight-worthiness, and mission of the rocket than just mindlessly climbing X meters at the cost of a small, narrow, fast rocket. But at the same time, we want to fairly reward the height achieved. Thus, all teams that surpass 650 meters above the launch ramp will be awarded the full amount of points. The points for the third to penultimate place teams will be determined proportionally on the launch day according to the actual number of teams.

Table 4.2: Scoring methodology for the highest apogee

Points awarded		Highest apogee
100	150	Apogee 650 m +
80	120	First highest apogee under 650 m
–	–	Points are distributed proportionally from 0 to 80 (120) points
0	0	Lowest apogee
disqualification		Unsuccessful launch

Points for apogee and apogee prediction are only awarded if the rocket returns safely to the ground and has flown at least 50 m above the ground. Competitors will present the altimeter reading to the judges after landing.

Beginners challenge

The goal is to take a regular chicken egg and bring it back down to earth without breaking it. M-size eggs will be provided by the CRC organizational team at the competition site. If the egg is intact after landing, the team will receive the full 200 points. If the egg is broken (egg comes out of the shell), the team will receive 0 points. When the egg is cracked, the number of points awarded will be determined ad hoc by the team of judges on site.

Advanced challenge

This years challenge in the *advanced* category is to design a rocket which:

- **Carries the heaviest payload (water) weight** to an altitude of at least **500 meters**
- **Safely lands** including this payload

Why carry water? Carrying water as payload simulates real challenges in spaceflight. Water is a critical cargo in rockets: during missions, it is used for crew hydration, radiation shielding, or fuel production via decomposition into oxygen and hydrogen. Additionally, it can simulate liquid fuel, enabling testing of rocket systems under realistic payload conditions. Every additional gram tests the rocket's efficiency. Optimizing for the transport of the maximum amount of water mirrors real engineering challenges in delivering supplies and equipment to space. **Performance evaluation will depend on the weight of the water remaining in the rocket after landing.**

Scoring methodology

1. **Performance based on the weight of water successfully returned to Earth:**
   - **1st place:** 300 points (team that delivers the most water)
   - **2nd place:** 275 points
   - **3rd place:** 250 points
   - **Other placements:** Points will be awarded proportionally based on the amount of water delivered.
   - **Teams delivering less than 10 grams of water:** 0 points
2. **Height penalty:** For every meter the rocket falls short of the minimum required height, 1% of the total score for the challenge will be deducted.

Refueling Rules

Competitors will have a time limit of 5 minutes to fill their rocket with water. Refueling will take place at the launch site just before preparing the rocket on the launchpad. Each team can choose its own refueling method, but during this time window, the rocket must be filled with the predetermined amount of water. After the refueling time has elapsed, no further manipulation of the tank will be allowed. For every additional started minute beyond the time limit, a penalty of 10 points will be applied. Refueling will test both the filling technique and the team's coordination. Buckets of water will be provided.

Technical Requirements for Water Storage

If the rocket carries liquid as payload, an appropriate technical solution must be implemented. The design is entirely up to the competitors; however, the teams must demonstrate in their report that their method of cargo storage meets the following conditions:

- **Prevention of water leakage** that could damage other parts of the rocket.

- **Resistance to sloshing,** i.e., movement of the liquid inside the tank, which could destabilize the rocket.
- **Ensure repeatable refueling,** which will be demonstrated during the pre-flight technical inspection (filling and emptying the tank).

The design of the water tank will be scored up to a maximum of 50 points, in addition to the points earned in the challenge. Overall, up to 350 points can be earned in this category.

Recovery system technology

In aerospace, the recovery system is often as important as the propulsion system. In the Czech Rocket Challenge, the recovery system is the most important. That's why we take great care in its quality and try to minimize its failure during the flight. The moment a rocket does not have a working recovery system, it can pose a serious safety risk to others and potentially cause the destruction of the entire rocket.

Points will be awarded for the recovery system in the Design, innovation & payload category. Only the use of a parachute or streamer as a recovery system is allowed in the *beginners* category. In the *advanced* category other types of recovery system are allowed. Make sure to discuss any other recovery systems with the CRC organizational team.

The recovery system must work. If it does, you can get points for the prediction of apogee, the apogee height or the challenge. If the recovery system does not work, the flight is likely to be unsuccessful and the team will face disqualification.

Penalization

In the event of a recovery system failure, the team is disqualified from the competition.

In the event of an unstable flight, the team will be penalized by up to 200 points at the judges' discretion.

If a team arrives at the launch day with a different rocket than specified in the *Final Report*, it will be automatically disqualified.

For *beginner* if the rocket diameter is smaller than 60 mm (excluding the back-end of the body, where fins are attached), the team will be penalized by up to 200 points. Or, if an large section of the rocket is below the 60 mm diameter, the team may be disqualified.

In case of late arrival at pre-flight check, a penalty of up to 200 points may be awarded depending on the length of the delay. Details of the launch day organization can be found in **Chapter 7**.

In case of excessive delay during the preparation for the start in the vicinity of the launch ramp (more than 10 minutes), the team may be deducted up to 100 points at the discretion of the launch ramp operators and judges. For more information about the format of the launch day, see **Chapter 7.**

In the case of a late *Final Report*, points may be deducted and the team may be disqualified from the competition.

In case of false parameters in the *Final Report*, the team will be deducted up to 50-100 points for each parameter. Should all parameters be false, the team will be disqualified.

In case of exceeded maximum apogee, the team will not receive any points for the flight performance.
Unsportsmanlike conduct during the design or construction of the rocket or on the launch day will result in disqualification of the team from the competition.

Rocket science is a dangerous activity, even at this level. Flammable substances and pyrotechnics are used and a flying rocket can very easily damage property or injure a person. The competition should therefore be taken very seriously. Any unacceptable behavior at any point during the competition that is deemed unsafe and/or poses a potential threat to others will result in individuals or teams being disqualified from the competition.

Note: Weather and wind conditions will be taken into account on the launch day and all teams will be judged relative to each other.

5 Standardized tests

As part of the *Final Report*, teams will be required to submit standardized test reports. These are intended to ensure a basic level of safety of the rocket, and therefore the safety of the competition as a whole. During the workshops, teams will be given specific and precise requirements for the content, parameters and format of the reports. The materials provided will include a template for writing a test report. However, teams can also use their own template as long as it clearly contains all the requirements. Below is a general overview of the tests. A separate *Standardized tests handbook* will be provided to teams accepted into the competition.

5.1 Strength test of the fins

The aim of this test is to verify that the fins have sufficient strength to prevent them from breaking off in flight due to aerodynamic forces.

5.2 Strength test of the launch ramp guides

In extreme cases, the rocket may jam in the launch track during launch. The purpose of the test is to verify that the guides will not break off and in turn deviate the rockets trajectory, which could endanger spectators, competitors and surrounding properties.

5.3 Functionality test of the recovery system release

In this test, the team's goal is to show that their chosen system is capable of successfully and fully opening the recovery device. For systems using an ejection charge, the test will include an RBFP functionality test.

5.4 Drop test of the recovery system

In this test, the team must demonstrate that their chosen solution achieves the required rate of descent. In the case of non-traditional systems, the aim is also to demonstrate the basic functionality of the principle.

5.5 Strength test of the mounts for the engine and the recovery system

The main objective of this test is to load the engine and recovery system mounts and to demonstrate that no deformation will occur that would compromise the safety of the flight.

5.6 Water tank refueling test

This test seeks to validate the water-proofing of the tank. Water must not reach areas of the rocket where the avionics of recovery systems are located.

5.7 Functionality test of active flight control termination

The main objective of this test is to ensure that active flight controls are terminated when the angle of attack exceeds 30° from the vertical.

6 Basic parts and functions of the rocket

Engine

The rocket engine will be supplied by the CRC organizational team and will be the same for all teams. The motor will have a total impulse of up to 140 Ns. Contestants must ensure that the motor does not move axially or radially relative to the rocket and does not loosen or fall out during ignition and flight. The motor must be installed without the use of brute force and must be returned to the CRC organizational team after the competition. Engine dimensions and other characteristics are provided in **Appendix A**.

Fins

Stabilizer fins are necessary for the correct orientation and stabilization of the model. Their size and material is up to the competitors. The fins must be secured to the model firmly and must not fall off. Be careful with the choice of material, paper or cardboard can become wet and lose strength. For steerable fins, rules in **Appendix D** apply to the team.

Fuselage

The fuselage can be made of any material. However, it must provide sufficient rigidity and safety to prevent the rocket from breaking. If paper tubes and other paper parts are used, remember that even if the rocket motor burns for only a short time, it radiates and can heat the outside of the chamber to tens of degrees. Therefore, sufficient insulation must be provided (also motor mounting, etc.) so that parts in the immediate vicinity of the motor are not damaged. Furthermore, as is the case for fins, the paper may become wet. The choice of size, fuselage thickness, diameter, weight and other parameters is up to the competitors according to the competition rules.

Nose cone

Shape, material and other characteristics are not limited in any way. The nose cone can be used as free space. For the best range it is essential to choose the ideal shape with the optimal coefficient of drag and aerodynamic properties. The nose cone must not free fall on descent.

Avionics

Electronic systems such as any recording devices, circuit boards, Arduino, parachute release system, or launch system should be firmly secured in the fuselage to prevent loosening and damaging the rest of the rocket during flight. It is also a requirement of every rocket to use either a sound, light, or other navigation indicator to locate the rocket after impact. It can happen (and has happened in past years) that during descend the wind will carry the rocket far from the launch site or into poorly accessible areas and it may never be found again. In addition, if your avionics include a groundstation, you must follow **Appendix F**.

Payload

This year, the payload is prescribed as part of the challenge for both categories. The rocket, however, may carry additional cargo, instruments or technology for which points may be awarded within the rocket design category.

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Recovery System

The rocket must have a working recovery system such as a parachute, streamer, function as a autogyro itself, or otherwise provide the safety of a slow return to earth. The parachute or streamer must include a red or an orang color for better rocket visibility. Free fall of the rocket and any part of it is not allowed! The recovery system may be installed in the head, fuselage or other parts of the rocket. The mechanism of parachute ejection is left to the creativity of the competitors. In case of failure of the recovery system, the team is disqualified. All parts of the rocket (excluding payload) must be connected together and descent as 1 unit.

Launch ramp

The launch ramp will be prepared by the CRC organizational team. Technical details are provided in the **Appendix B**.

Launch ramp guides

In order for the rocket to fly exactly along the ramp and for it to fulfill its purpose, launch ramp guides must be attached to the rocket. The guides must be strong enough to prevent them from breaking off during launch and spinning the rocket in the wrong direction. The guides should move freely in the ramp groove to avoid jamming during launch.

Procedures

Launch procedures will be required of all teams. The teams will provide a brief and clear description of all required pre-launch steps to the CRC organizational team. A minimum of 30 procedural steps will be included in the *Final report*.

Keep in mind:

- Power of rocket engines is never 100% same as the power given in the engine data sheets
- The drag coefficient used in the calculations is also variable depending on the ambient conditions. Each component such as head, stabilizers, etc. affects the coefficient of drag, but so do other momentary variable conditions.
- Wind speed is often more important than a better drag coefficient by one hundredth or a result better by one meter in OpenRocket.
- If the rocket is not flying straight up vertically its altitude range is reduced.

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7 Team's journey at the launch day

Further details of the launch day will be announced to the participants well in advance, but in any case the philosophy of the final day is as follows:

1. Invited teams will gather on the day of the launch at the airfield, bringing all their necessary tools and a disassembled rocket.
2. Upon arrival, the team will register and pay a deposit for the motor and altimeter. In exchange, the team will receive the altimeter. The loaded motor will be provided at the launchpad, but mock motors will be available at the pre-flight inspection for balancing the center of gravity, testing threading, or trial assembly of the rocket.
3. By 11:00, all teams must place a tag with their team name (provided during registration) on the board at the pre-flight inspection tent. Failure to do so will result in a penalty. Afterward, teams will be summoned to the pre-flight inspection by a coordinator from the organizing team. Teams do not need to wait in front of the inspection tent.
4. Teams will first be called for the technical pre-flight inspection, consisting of three parts. If a team is unable to appear for inspection when summoned, they will be penalized. First, the technical condition of the rocket will be evaluated, including measurements of the center of gravity, weight, and basic dimensions. Second, the OpenRocket flight simulation will be reviewed under current weather and wind conditions. Third, the safety officer will perform a safety review. If there are any concerns, judges may request a reconstruction of a test or demonstration of specific rocket systems. If a malfunctioning, non-operational, or unsafe system is found, judges have the authority to disqualify the team on the spot. If all is in order, the team will receive a certification of the rocket's flight readiness.
5. After the pre-flight check, the team proceeds to the scoring committee in an adjacent tent. Here, the team must defend their rocket design before a committee of experts and club members. The final report will be reviewed, and questions regarding the challenge, systems, and rocket functionality will be asked. Points will be awarded for the *Design, Innovation, and Payload* category during this review.
6. Once the rocket is inspected, scored, and declared flight-ready, it will be fully assembled on-site with the organizer's supervision and prepared for launch (the rocket must remain powered off). The team will remain near the inspection area, and no further modifications, disassembly, or part replacements will be allowed. The rocket should allow easy access for turning avionics on/off (ideally externally or via quick access). Similarly, the altimeter must be accessible for checks or reactivation (it remains operational for only one hour when turned on).
7. The team with a prepared, powered-off rocket will await instructions from the launch coordinator.
8. Once instructed by the team coordinator, the team will move to the launchpad.
9. At the launchpad, the team will receive the loaded motor and prepare the rocket for launch (turning on electronics, verifying the altimeter, etc.). The team will have 10 minutes for preparation. Significant delays beyond this time will result in penalties. Ideally, the team should perform minimal operations on the rocket, as it should already be prepared during the earlier inspection.
10. The team will then move to a safe distance and wait for the remaining teams in the same launch wave. Delays from other teams may occur, so the rocket's electronics must remain operational for at least 30 minutes.[1]
11. Rockets from the same wave will be launched sequentially. Only after all rockets in the wave have launched will teams be invited to locate and retrieve their rockets. The altimeter, with the recorded altitude, must be shown to a judge. Both the altimeter and motor must be returned to the organizer.
12. Teams that have already launched can spend their time in the fun zone, the local restaurant, or watching other teams.
13. All results will be announced collectively after all eligible rockets have launched.

[1] If a team cannot meet the 10-minute preparation limit and additional delays occur, the organizer may exclude them from the current wave and move them to another.

8 Additional information

8.1 What will be provided

Several workshops will be held during the rocket design process to help teams divide up their roles in the team, start designing the different components and understanding different aspects of the rocket such as aerodynamics, flight simulation or structural analysis. In addition, "office hours" will be provided where competitors will be able to ask for information or problems with their particular rocket. Contestants will also be able to contact the CRC organizational team during the rocket design period on the CRC server on the discord platform.

On the day of the launch, the motor, altimeter and launch ramp will be provided on site, as well as all necessary pyrotechnics such as launch triggers, fuses and detonators.

8.2 Contact information

All public information needed is on the website: czeroc.cz

The person responsible is Iuliia Kostiuk: **crc@czechrockets.com**

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A Gragas engine

Engine parameters

Below are the main parameters of the Gragas engine.

Table A.1: Parameters of the Gragas engine

Parameters of the Gragas engine	
Outer engine diameter	43.4 mm
Engine length (without nozzle)	155.6 mm
Engine length (with nozzle)	167.7 mm
External engine temperature	$\sim 100°C$

The engine consists of 3 machined parts: nozzle, plug and chamber. For illustration, below in **figure A.1** is a drawing of the engine assembly.

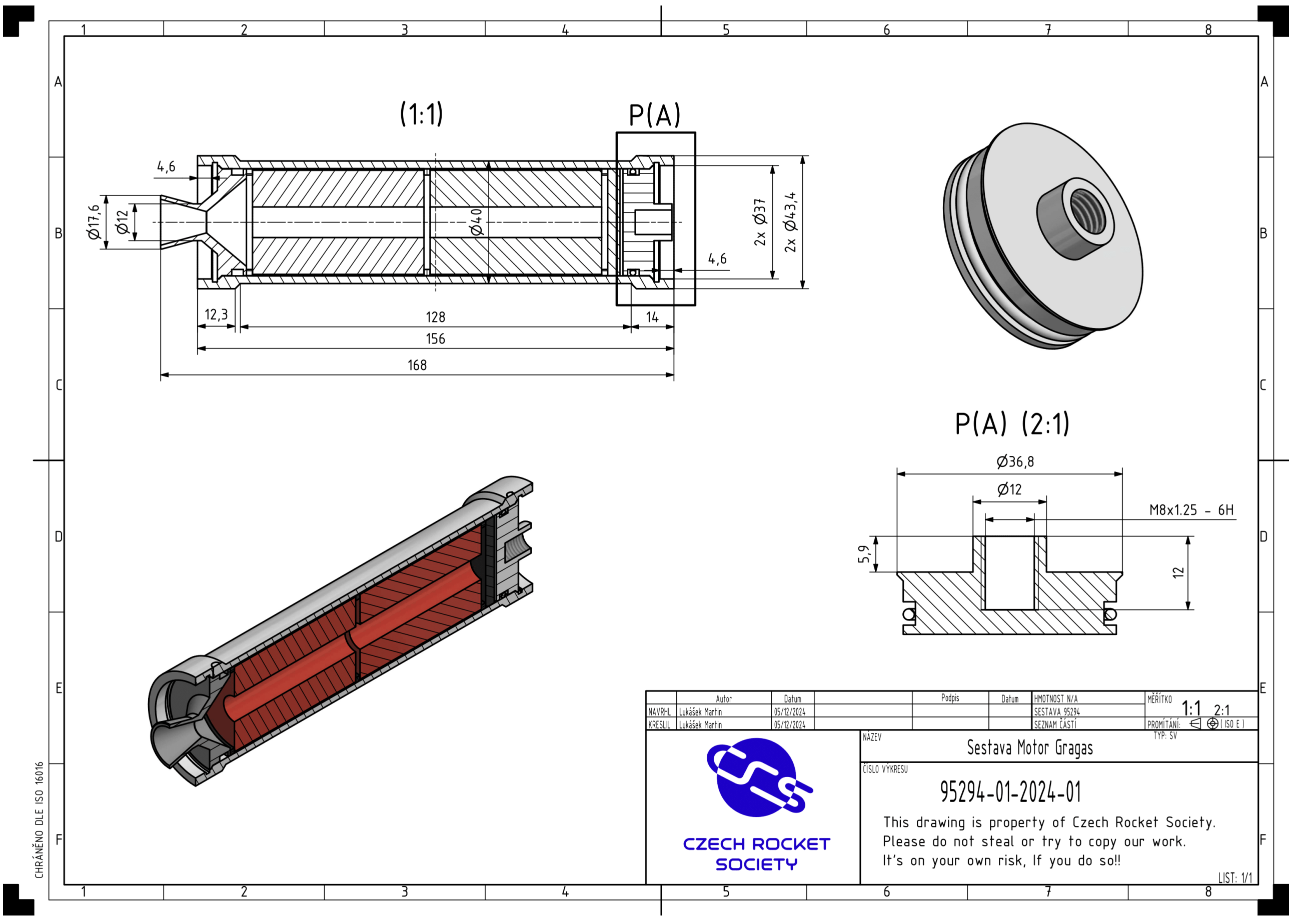

Figure A.1: Technical drawing of the 2024 Gragas engine

Technical drawings of the engine are a property of the Czech Rocket Society and may not be redistributed without permission of the Czech Rocket Society.

Engine properties

Table A.2: Expected performance properties of the 2024 Gragas engine

Performance property of the Gragas engine	Value
Total impulse	145 [N.s]
Burn time	3.5 [s]
Peak thrust	65 [N]
Fuel mass	166 [g]
Empty engine mass	209 [g]

Approximate expected 2024 Gragas thrust curve is shown below in **figure A.2**.

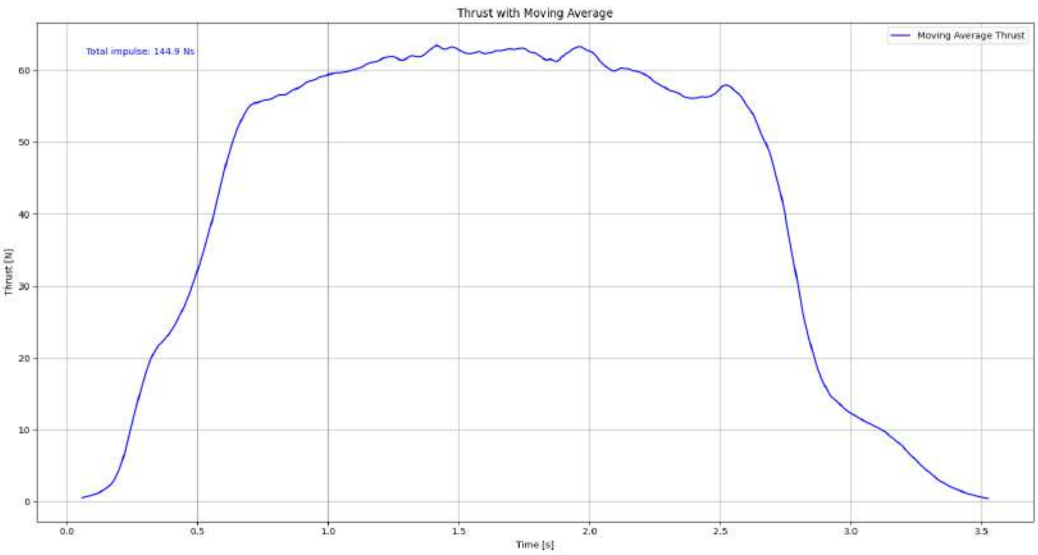

Figure A.2: Thrust curve of the 2024 Gragas engine

The CRC organizational team reserves the right to change the engine parameters.

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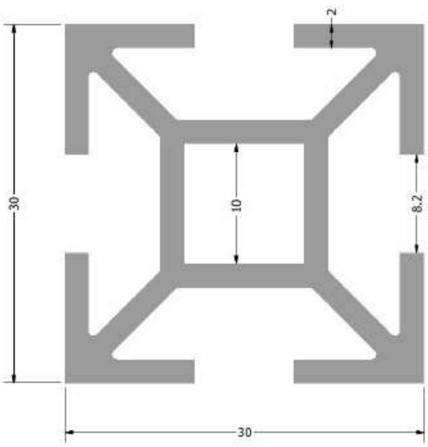
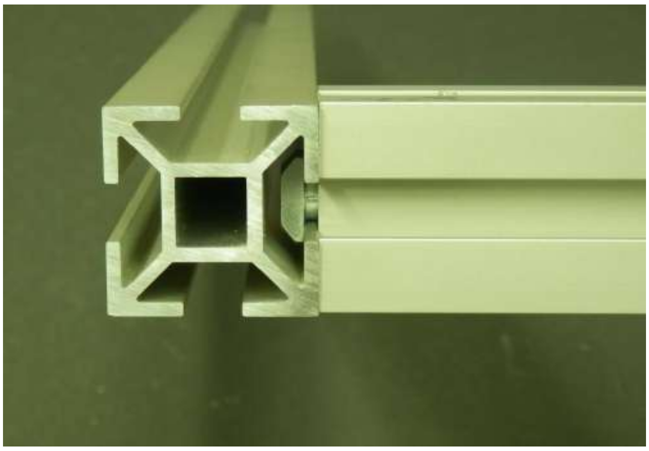
B Launch ramp

The launch ramp guide is 2.5 meters long.

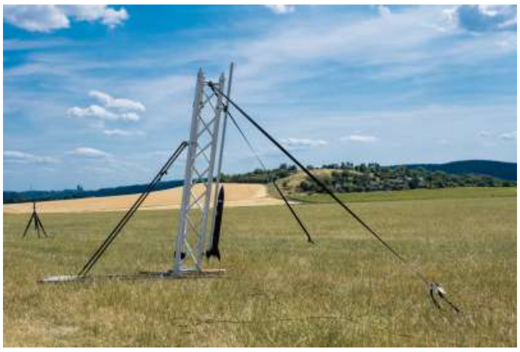
Profile of the launch ramp guide is "Alutec", specifically *system Kombi 30x30*, as seen in **figure B.1a** below. Photo of the profile is showns in **figure B.1b**. There is a 3D printed stopper at the end of the profile which holds the rocket in the profile. The mounting of the profiles is designed so that any possible contact with the rocket is eliminated. A photo of the launch ramp with an inserted rocket can be seen in **figure B.1c**.



(a) Launch ram groove profile



(b) Photo of the "Alutec" profile



(c) Photo of the launch ramp with a rocket

Images are taken from the supplier's website Alupa s.r.o., **here** and **here**.

https://www.ehlinik.cz/al-profil-kombi-stojka-30x30/pro-CBU0000101.html
https://www.alupa.cz/hlinik/system-kombi-30x30/kat-JX74000101.html

The rocket must be guided through the groove. It is not recommended to produce a shape that exactly replicates the groove's profile as the ramp guide is at a high risk of getting stuck in the profile during launch or it may not fit into the groove at all.

The CRC organizational team reserves the right to change the launch ramp parameters.

C Altimeter

The altimeter has maximum dimensions of 62x33x25 mm and is equipped with an eyelet on one side. It features a positional toggle switch that activates the measurement mode when engaged. The altimeter operates based on barometric pressure sensing, requiring unobstructed airflow around it for accurate readings. The altimeter remains operational for one hour when turned on. It is recommended that the altimeter be easily accessible after the rocket's landing without requiring complex disassembly. Additionally, the altimeter should be securely tethered to a fixed part of the rocket to prevent its loss in the event of rocket damage upon impact.

The CRC organizational team reserves the right to change the altimeter within the outlined parameters.

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D Active flight controls

Definition

Active flight control systems are defined as controlled systems, which have the primary aim of influencing the direction and stability of the rocket prior to reaching apogee. This consists mainly of steerable fins, reaction wheels and others.

Requirements

This section lists all requirements related to active flight controls:

1. Active flight control systems are only allowed in the *advanced* category.
2. Active flight control systems may only be used to guide the rocket as close to vertical as possible. Targeting a ballistic trajectory is prohibited. This is for the safety of competitors and spectators.
3. Stabilizer fins, ensuring the stability of the rocket, must not be actuated.
4. A rocket with the system disabled in neutral must still meet the stability conditions. This applies especially to steerable fins.
5. Active elements can only be activated after engine burn-out. This can be achieved either by burnout detection or by a timer from the moment of launch.
6. Active elements shall be mechanically lockable in neutral position in the event of not being cleared for active flight. A possible alternative is to dismantle the system.
7. Active control systems shall be described in detail in the final report, including the operating principle, planned control authority and flight path. The CRC organizational team has the right to request additional information and impose additional restrictions.
8. The maximum allowed deviation from vertical is 30°. The maximum permitted speed of rotation about the longitudinal axis is 360°/s. If one of these values is reached, the active flight control system shall be automatically put into neutral and powered off until the end of the flight. This is to prevent the control system from oscillating around the shutdown value.
9. Active flight control systems must have mechanical stops to limit the maximum movement of the mechanism
10. As part of the *Final Report*, the team must include a simulation of the landing area should the recovery system fail and the rocket was at the maximum deviation angle. The landing area must not exceed a diameter of 500 m. The organizational team reserves the right to further specify the simulation requirements and issue further restrictions.

Standardized tests

Rockets using active flight controls will be under scrutiny of an additional standardized test. Further details will be provided in the Standardized tests handbook.

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E Ejection charge

Definition

Ejection charge, is a small charge of gunpowder used to eject a recovery device.

Requirements

This section lists all requirements related to the ejection charge:

1. The total charge must not exceed 0.5 g of gunpowder.
2. The recommended method for determining the amount of powder is given at https://rocketrycalculator.com/rocketry-calculator/bp-estimator/. It is possiblee to use an alternative calculation method, but this must be thoroughly documented in the final report.
3. Ejection charge must be transported shorted.
4. When working with the ejection charge, everyone present must wear goggles or shields. Please ensure personal safety.
5. The use of homemade gunpowder is prohibited.
6. RBFP (remove before flight pin) must be incorporated into the circuit. This will physically separate the fuze from the battery when inserted. This will ensure that premature firing does not occur in the event of a faulty signal from the avionics.
7. The RBFP must be inserted at all times when the burner is connected until the moment of departure from the launch ramp.
8. A unique audible signal of at least 2 seconds shall sound when the RBFP is withdrawn. The status *Armed* should then be continuously indicated by a light signal.
9. Parachutes and other susceptible systems shall be protected against hot exhaust fumes from echarge activation.
10. Ejection charge shall be detailed in the final report. The amount of powder, the structure of the entire ejection charge, the method of engagement with the RBFP and the protection of the recovery equipment from combustion gases shall be documented.

Standardized tests

Rockets using ejection charge will undergo an additional step in the standardized test within the Functionality test of the recovery system release. Further details will be provided in the Standardized tests handbook.

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F Groundstation

The fundamental problem of groundstation in the context of a competition like the CRC is the risk of teams interfering with each other. The standard modules have only a limited number of frequencies in use and can interfere with each other. At the same time, up to 3 teams can start at the same time, and, provided there is a lot of interest in this challenge, it can happen that up to 3 different groundstations run at the same time.

We have therefore decided to introduce a basic communication module, namely **IOT 433MHz LoRa LPWAN SX1278**, available for example **here**. A program for mapping this module will be presented to the teams during the workshops and support will be provided to CRS members in its implementation. Should teams use their own communcation modules, they must fullfill the following:

1. The use of the 2.4 GHz frequency and the frequency range 136-174 MHz, which are reserved for use by the organizers, **is prohibited**.
2. All custom modules must be compatible with the data addressing system specified by us. This applies not only to the 433 MHz frequency but also to others. This requirement is in place to minimize the chance of interference on any of the frequencies.

Figure F.1: IOT 433MHz LoRa LPWAN SX1278

Standardized tests

Since the groundstation function is not critical to the safe flight of the rocket, we do not require any standardized tests. However, we strongly encourage teams to test the maximum transmission length in advance. Remember that the team zone is approximately 400 meters from the launch ramp.