Czech Rocket Challenge - Competition handbook

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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

- High school - beginners
- High school - advanced
- University - advanced
- Best report
- Best rocket design
- 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 successfully launched their rocket, the team automatically falls into the *advanced* category.

All teams are required to design a rocket that will meet the mission below:

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 timetable

2.1 Registration

Registration is open until 29 February 2024 on the website czechrocketchallenge.cz/en. The registration fee of 300 CZK is payable by 10 March to the account: 42637800/2010.
Variable symbol: 20240229. 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 (9-10 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 (16-17 March)** you will try out the OpenRocket rocket simulator and learn how to use it. This software is key. At the **third workshop (23-24 March)**, competitors from previous years will describe their experiences, successes and obstacles. At the **fourth workshop (6-7 April)** we will explain how to design an avionics and recovery system correctly and safely. During the **fifth workshop (13-14 April)** we will demonstrate and explain the standardized tests that are mandatory in order to be invited to the final day. Afterwards you will be able to ask anything about your designs.

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, **30 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 more security and better scoring in each category (see **Chapter 5**), 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 6**. 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 June 11** 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 30 June 2024. If the *Report* is found satisfactory and the rocket is deemed airworthy, the team may be invited to the launch day.

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 **over 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 11 and Friday 12 July or Friday 12 and Saturday 13 July. All entrants will be notified of the launch day format after registration closes (2/29/2024). The launch day date is subject to change (± 1 week) depending on the weather.

Table 2.1: Timetable of the Czech Rocket Challenge 2024 competition

Competition timetable	
Registration	until 29 February
Workshop 1	9-10 March
Workshop 2	16-17 March
Workshop 3	23-24 March
Workshop 4	6-7 April
Workshop 5	13-14 April
Concept Report	due 30 April
Final Report Draft	due 11 June
Personal meeting with competitors	during June
Final Report	due 30 June
Launch day	12 June (2nd day on the 11 or 13 June)

3 Team organization

3.1 Team structure

To achieve a successful project, every team needs to be well organized. Teams should therefore have a project manager who will be responsible for communication within the team and outside the team with the CRC organizational team and will make sure that deadlines are met. There is no strictly given structure for the rest of the team, so roles can be divided in any way the team deems appropriate.

Nevertheless, it is advisable to divide the roles to correspond to the subsections of a typical rocket layout. The basic roles are listed below:

- Avionics
- Payload (Challenge)
- Structures
- Recovery

It is recommended that members take on other secondary roles that are necessary for the team to run and launch the rocket, such as:

- Aerodynamics
- Parts acquisition
- Report drafting

Of course it also depends on the total number of members. For example, given the size of the project, the project manager may take on additional primary or secondary roles. These roles are only recommendations and do not need to be followed.

3.2 Team activity

The Czech Rocket Challenge is a team competition, so commitment is expected from all team members. In the event that some team members stop participating in the project, the team should inform the CRC organizational team and appropriate action will be taken. In the case of several teams with insufficient active members, it is possible - by agreement of both parties - to merge the teams. This way at least one rocket will have the opportunity to take off.

4 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.

Engine size

The engine will be the same for all teams in all categories and will be supplied by the CRC organizational team on the launch day. 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 1.3 (note: C_p should be at least one rocket's diameter behind C_g).

Recovery system

For the *beginners* category, only a parachute or a streamer are allowed as the recovery system. 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.

Recovery system deployment

The deployment of the recovery system, in particular a parachute or a streamer, shall be executed at a speed of less 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. The satellite (payload) launched from the rocket must descend at 5–15 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 may 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. 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 motor and placing the rocket on the launch ramp.

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.

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5 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 **rocket flight performance on the launch day**. The maximum score is 1000 points. The report mainly covers the subcategories Design, innovation & payload; Analysis, simulation & report. **Table 5.1.** provides an overview of the evaluation 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 5.1: Scoring methodology

Criteria	Beginners	Advanced
Rocket design		
Design, innovation & payload	330	250
Analysis, simulation & report	170	150
Flight performance		
Accuracy of the predicted apogee	200	200
Highest apogee	100	150
Challenge	200	250
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 2 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. This year there is a devised challenge for the contestants, so they don't have to come up with their own payload. Even so, the challenge can be approached in a multitude of ways and contestants can be creative and innovative. Innovation, design & payload is the highest scoring category with a maximum of 330 / 250 points respectively *beginners* / *advanced*, which is roughly a third / quarter 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 behaviour of individual components. Teams must demonstrate the strength and safety of the rocket by passing standardized tests, see **Chapter 6**. They can also assist themselves with structural analysis, their 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 / 170 points is awarded for this section, equally distributed between analysis, simulation and report.

Flight execution

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 points can be earned for this category. Points will be distributed according to the following equation:

$$\text{Points} = 200 \times \frac{\left(-(\text{Prediction})^2 + 2 \times \text{Prediction} \times \text{Reality}\right)^3}{\left(-(\text{Reality})^2 + 2 \times \text{Reality} \times \text{Reality}\right)^3} \tag{5.1}$$

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. Therefore, a maximum of 100 / 150 points can be earned for this category. But at the same time, we want to fairly reward the height achieved. Thus, all teams that surpass 750 meters above the launch ramp will earn full 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 5.2: Scoring methodology for the highest apogee

Points awarded		Highest apogee
100	150	Apogee 750m +
80	120	Second highest apogee under 750m
–	–	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 year a decision was made to introduce two different challenges. Contestants will choose which challenge they want to be scored for in the *Concept Report*. If they incorporate elements from both challenges, then, depending on their choice, one will be scored as a challenge while the other will be considered under the Rocket design category.

Ground station challenge consists of creating a functional groundstation. It will be judged based on functionality during the rocket's flight. It is therefore necessary to provide the CRC organizational team with a recording of the groundstation after launch (either in the form of a screencapture or a sufficiently high quality video). The more advanced the groundstation is (more data transmitted, visualization, etc.), the more points the team will receive. Teams will be scored relative to each other. Similar to the height achieved, the best team will receive the maximum number of points and the rest will be divided proportionally. The last team for the challenge will receive 0 points. Be sure to test the signal range of the rocket beforehand, as true functionality will be evaluated, not the maximum theoretical functionality. Remember that you will have to follow the rules in **Appendix F**.

The **Active roll challenge** consists of creating a system that will be able to control the rotation of the rocket along the longitudinal axis. The goal will be to rotate the rocket at a speed closest to 90°/s in any direction between 1s after engine burn and 1s before reaching apogee. After the flight, the team will submit measured data from the flight, which will include a recording of the rotation rate at a frequency of at least 10 Hz. The average deviation will be calculated from this data, with the goal of achieving the lowest possible value. Similar to the altitude achieved, the best team will receive the maximum number of points and the rest will be divided proportionally. Note that you will need to follow the rules in **Appendix D**.

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.

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 organisation can be found in **Chapter 8**.

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 8.**

In the case of a late final report, points may be deducted and the team may be disqualified from the competition.

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.

6 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.

6.1 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.

6.2 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.

6.3 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 be extended to include an RBFP functionality test.

6.4 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.

6.5 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.

6.6 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.

7 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 beginners. The rocket, however, may carry additional cargo, instruments or technology for which points may be awarded within the rocket design category.

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. 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.

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.

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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8 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 in Brno - Medlánky. They have all their tools and rocket pre-assembled in several sections with them.
2. Upon arrival, the teams will register. In exchange for a deposit, they will receive an altimeter. They will only receive the charged motor at the launch ramp, but mock-up motors will be available on site for balancing the center of gravity, testing the threads, or a test build of the rocket.
3. Teams will be divided into several large groups for pre-flight checks. It is up to the teams to decide when to attend the flight checks during their window, but late arrival will be penalized with points.[1],
4. During the pre-flight check (about 20 minutes), the CRC organizational team and expert judges will assess the technical competence of the rocket and its systems, review the report and standardized tests and check the rocket's airworthiness. They will also assess whether the design and technical highlights written in the final report match the finished rocket on site. A jury of experts and organisers will then score the rocket.
5. Once the rocket is checked, scored and declared airworthy, the entire rocket is assembled on site together with the CRC organizational team and prepared for launch (the rocket is switched off). The team will stay with the rocket in the vicinity of the check and it will not be possible to manipulate the rocket in any special way, disassemble it, rebuild it, change parts, etc. The rocket should be easily accessible for switching the avionics on and off (preferably from the outside, but if not, very easy and quick to open), as well as for checking or switching the altimeter back on (it will only last for one hour in the switched state).
6. The team, with the rocket ready and powered off, waits for the instruction from the launch ramp.
7. As soon as the team is instructed, they move to the launch ramp.
8. At the launch ramp, the team gets the motor charged and prepares the rocket for the launch ramp (turn on the electronics, check the altimeter, etc.). The team has 10 minutes to prepare. If a team significantly exceeds this time limit, it can incur a point penalty. Ideally, the team shouldn't be significantly manipulating with the rocket as it will already be ready for launch from the previous check.
9. The team moves to a safe distance and waits for the remaining teams from the same wave of launches. However, they may be delayed, so the rocket should stay on for at least 30 minutes[2].
10. All rockets from one wave will be fired consecutively. ONLY THEN are teams asked to find and collect their rocket. The teams will present the altimeter with the measured height to the judge present.
11. Teams with completed launches can spend their time in the fun zone, at a local restaurant or watching their opponents.
12. All results will be announced after the launches of all eligible rockets are completed.

[1]The exact launch schedule will be announced to the qualified teams prior to the final day

[2]If a team does not meet the 10 minute limit nor any added time, the CRC organizational team may remove reschedule them to a later laucnh wave

9 Additional information

9.1 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.

9.2 Contact information

All public information needed is on the website: **www.czechrocketchallenge.cz/en**

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

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CZECH ROCKET SOCIETY

A Prometheus engine

Engine parameters

This year of CRC brings, as a novelty, a new version of the Prometheus engine, designed specifically for this competition. With this upgrade, our main goal was to eliminate the issues we received feedback on from past competitors, while changing the performance characteristics as little as possible. At the time of registration, the engine is currently undergoing final modifications and testing. Detailed characteristics and drawings will then be provided to registered teams as part of the non-public manual when the competition begins (March 1, 2024). Below are the parameters that the teams can expect.

Table A.1: Parameters of the Prometheus engine

Parameters of the Prometheus engine	
Outer engine diameter	40-44 mm
Engine length (without nozzle)	140-160 mm
Engine length (with nozzle)	153-173 mm
External engine temperature	230°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 from the 2023 competition.

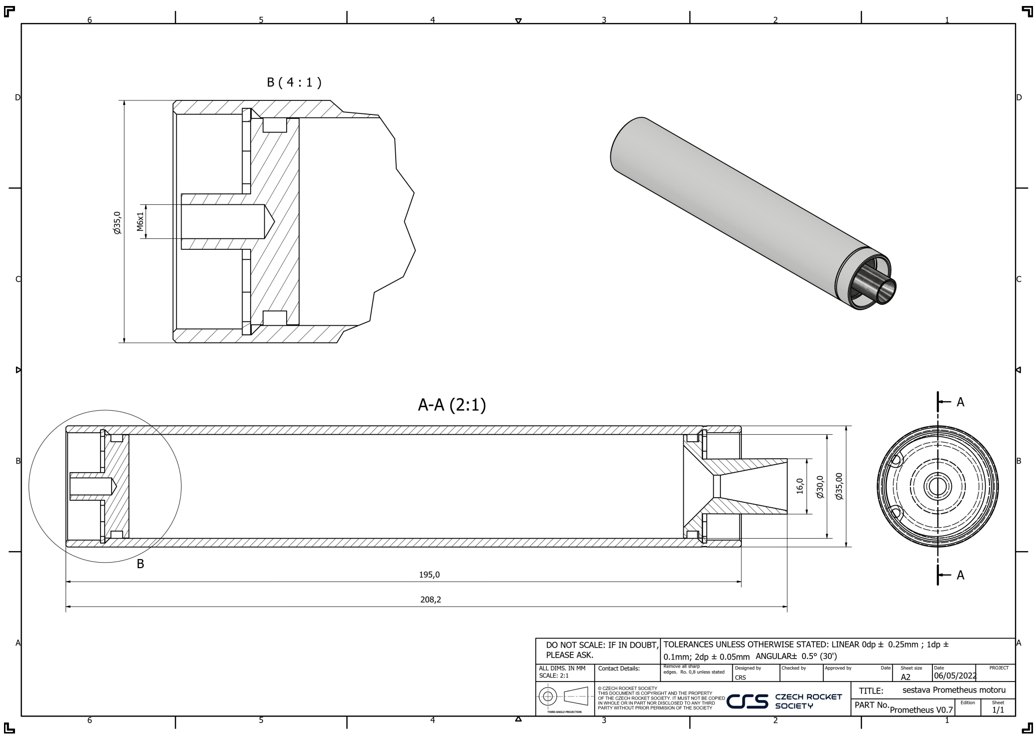

Figure A.1: Technical drawing of the 2023 Prometheus engine

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Below in **figure A.2** is the technical drawing of the plug, which will see a change of thread to M8 in the new design.

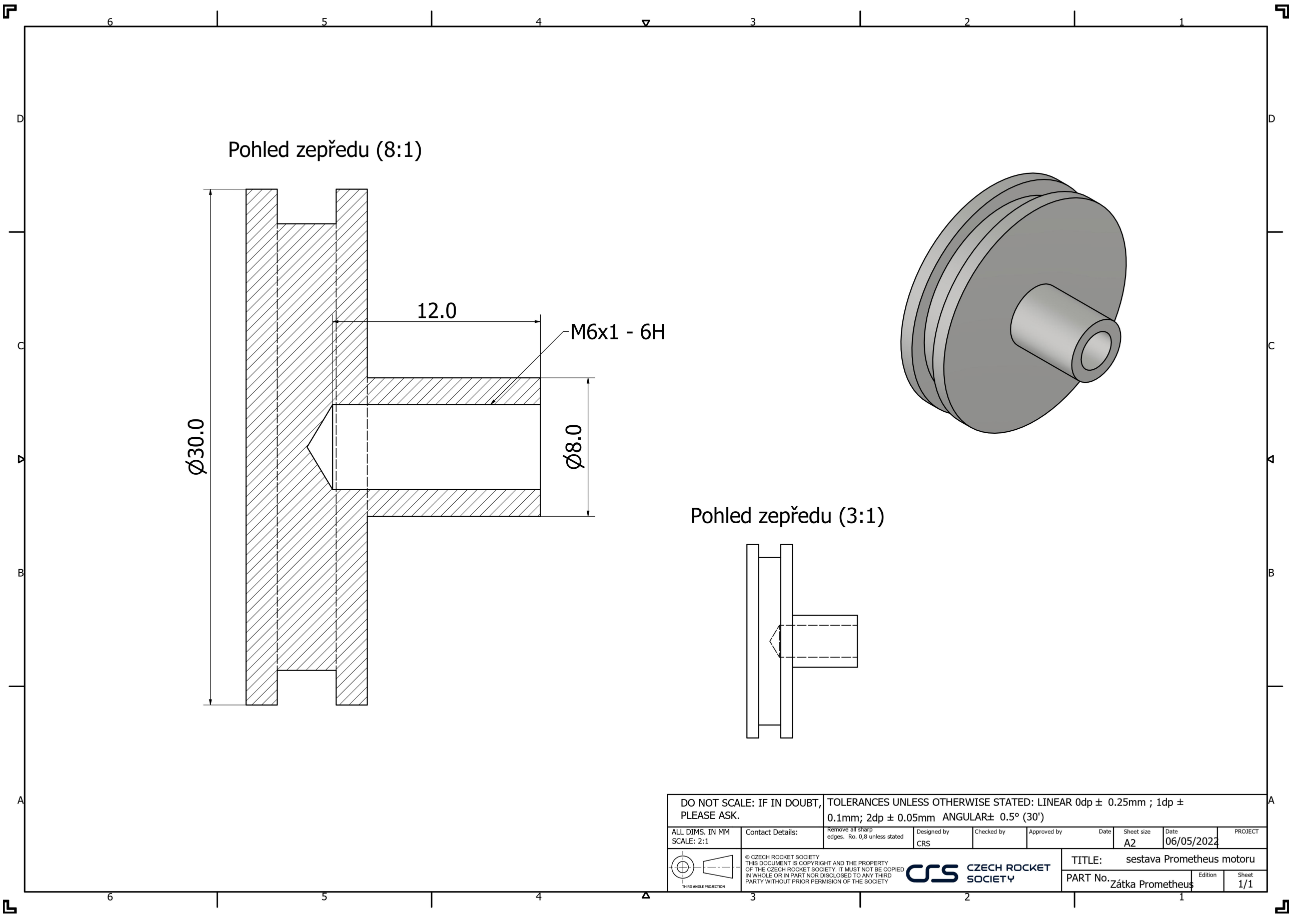

Figure A.2: Technical drawing of the 2023 engine plug

Technical drawings of the Prometheus 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: Preliminary performance properties of the 2024 Prometheus engine

Performance property of the Prometheus engine	Value
Total impulse	140 [N.s]
Burn time	1.7 [s]
Peak thrust	102 [N]
Fuel mass	135 [g]
Empty engine mass	130 [g]

Approximate expected 2024 Prometheus thrust curve is shown below in **figure A.3**.

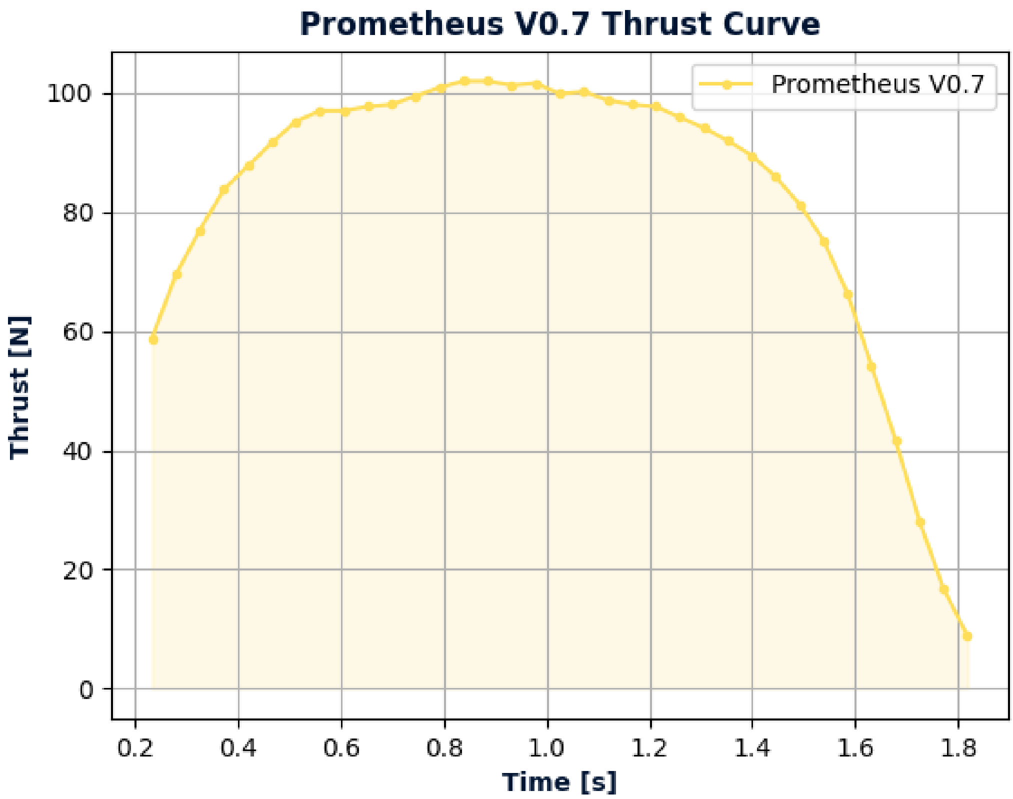

Figure A.3: Thrust curve of the 2024 Prometheus engiene

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

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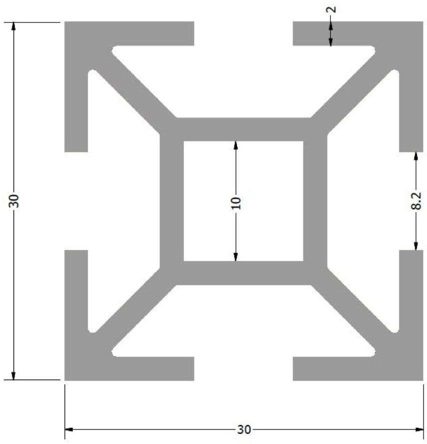
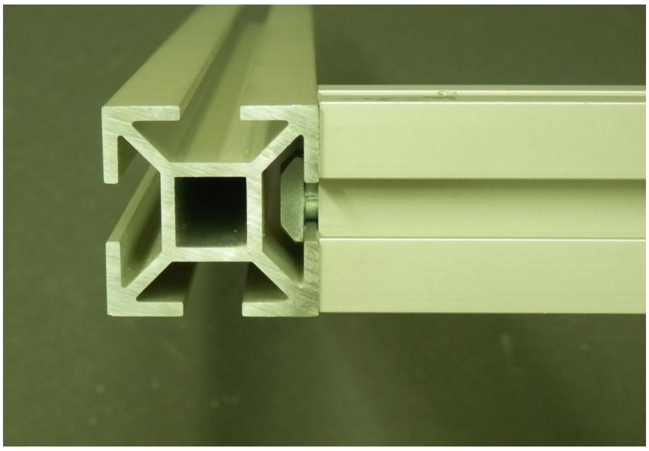
B Launch ramp

The launch ramp guide is 2 meters long.

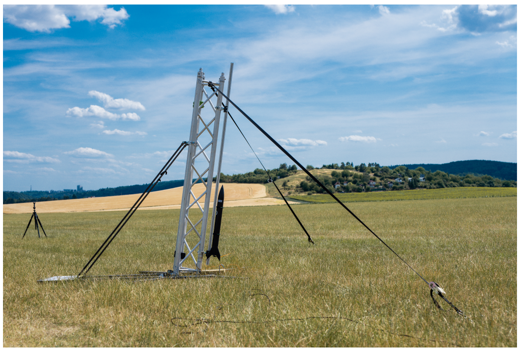
Profile of the launch ramp guide is "Alutec", specifically *system Kombi 30x30*, as seen in **figure B.1a** below. Photo of the profile is showns in **figure B.1b**. There is a 3D printed stopper at the end of the profile which holds the rocket in the profile. The mounting of the profiles is designed 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

Illustrative photo of the altimeter is shown in **figure C.1** below.

Figure C.1: Altimeter

Specific technical parameters are available at the **supplier's website** ESTES Industries.

https://estesrockets.com/wp-content/uploads/Instructions/002246.pdf https://estesrockets.com/products/altimeter?_pos=1_sid=006fbc24a_ss=r

The altimeter is 55x18x16 mm. On one side it is equipped with a loop. There is a position switch on it which turns on the altimeter measurement. The small button is used to switch the height from feet to meters. The altimeter works by sensing barometric pressure, so it needs air to flow freely around it. The altimeter lasts for an hour in the powered-on state and then automatically turns off. It is also useful if the altimeter can be easily accessed after the rocket has landed, without having to intricately disassemble the rocket. It is also convenient to tie the altimeter to a fixed part of the rocket so that if the rocket is broken by impact, the altimeter is not lost. Please read the attached instructions carefully at the link provided.

The CRC organizational team reserves the right to change the type of altimeter.

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. A rocket with the system disabled in neutral must still meet the stability conditions. This applies especially to steerable fins.
4. 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.
5. 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.
6. 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.
7. 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.

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.

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. RBFP must be inserted at all times when the throttle is connected until the moment of departure from the launch ramp.
7. 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.
8. Parachutes and other susceptible systems shall be protected against hot exhaust fumes from echarge activation.
9. 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 **mandatory** 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 this module not be sufficient for all your functions, please feel free to contact the CRC organizational team to request an exception. This rule is not intended to restrict teams, but rather to allow fair competition. We will do our best to accommodate your requests.

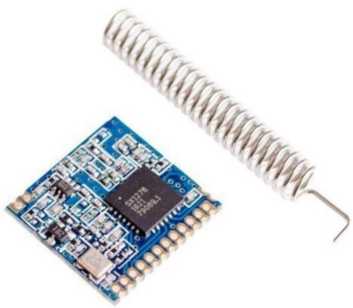

Figure F.1: IOT 433MHz LoRa LPWAN SX1278

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.