Radar Tracking Challenge with IEEE MTT-S

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CZECH ROCKET SOCIETY

“RADAR” PROPOSED REQUIREMENTS FOR CANSAT ROCKET LAUNCHED IN 2026

AND

MEMORANDUM WITH IEEE MTT-S

Czech Rocket Society
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1. Mini CVs

Ota Michálek (Secretary, Czech Rocket Society)

Ota Michálek is a Secretary of the Czech Rocket Society since approved by the annual general meeting in the beginning of season 2023/24. Ota recently finished his Masters of Engineering Aerospace Engineering (Systems) at University of the West of England, Bristol. Ota took part in multiple ESA Academy projects (Ladybird Guide to Spacecraft Communications, Fly a Rocket, Symposium on Space Education Activities) and organizes the annual students conference Next stop: Space since 2022 together with the Prague Planetarium. Ota currently works part time in TRL Space Systems (Brno, Czechia) in a position of Space Systems Engineer Jr., where he works on proposals for ESA and systems engineering tasks.

Václav Valenta (ESA, IEEE MTT-S)

Václav Valenta has been with the European Space Agency since 2016. With over a decade of experience in RFIC design, he's running internal research and industrial R&D contracts in the area of RF equipment and technology, covering radar, navigation and satcom applications. His research interests include frequency generation & timing, high-power amplification and beamforming concepts in active antenna arrays and FMCW radars. Václav is the ESA lead engineer of a radio-scientific instrument LaRa embarked on the ExoMars surface platform Kozachok. He holds a dual doctoral degree in radio-engineering from the ESIEE Paris, France and the Brno University of Technology, Czech Republic. Václav is a member of the IEEE Microwave Theory and Techniques Society (IEEE MTT-S) and currently serves as the co-chair of the Technical Committee on Microwave Aerospace Systems (MTT-TC-29).

Markus Gardill (BTU, IEEE MTT-S)

Markus Gardill is a professor and head of the Chair of Electronic Systems and Sensors and the Brandenburg University of Technology Cottbus–Senftenberg, Germany. His main research interest includes radar and communication systems, antenna (array) design, and signal processing algorithms. Markus Gardill is a member of the IEEE Microwave Theory and Techniques Society (IEEE MTT-S). He currently serves as chair of the Technical Committee on Microwave Aerospace Systems (MTT-TC-29) and as a co-chair of the IEEE Low-Earth Orbit Satellites and Systems (LEO SatS) future directions initiative..

2. Project History and Background

The project started in January 2024 between Václav Valenta, Tomáš Gotthans, Ota Michálek and Jan Spratek to explore the options to utilize the existing RADAR system from ESA for the rocket velocity tracking (using Doppler shift). This was foreseen as potentially useful for supersonic rocket applications which was one of the discussed topics within CRS at the time (CRS internal channel “#radar”).

The intent was to use thin passive reflectors stuck on the fin of the rocket. This was later expanded to be tested on one of the Demo launches of Sherpa in the upcoming season. Tomáš Gotthans was to be responsible for the detection system adjustment to see if it would fit the needs of the project.

In March 2024 Václav Valenta also included Markus Gardill, who was his colleague from the Institute of Electrical and Electronics Engineers (IEEE) Microwave Theory and Technology Society (MTT-S). Together, they have conceived an idea of a student design challenge where participants would create the reflector part and the activity could get funding from IEEE MTT-S or similar body.

During the detailed definition between June-July 2024, it was realized that the reflectors would have to be active due to the focus of the committee supporting the activity and the background of the organizers. The passive reflectors located on the fins were therefore abandoned. The detailed specification and several discussions between January and July 2024 led to this document.

The document specifies the requirements imposed on the CRS rocket to be launched in April/May 2026 for a winning team selected by IEEE MTT-S. The full name of the competition is expected to be Radar Tracking Challenge: Amplifying Rocket RCS with Retro-Reflective Systems.

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3. Project Impact

The collaboration on international competition such as the Radar Tracking Challenge: Amplifying Rocket RCS with Retro-Reflective Systems (here "RTC") with the MTT-S which is part of the renowned IEEE could improve the public image of the Czech Rocket Society and further support the fulfillment of the goal of supporting education concerned with space exploration.

By demonstrating the capability of meeting user requirements and providing a service (such as with CanSat or Spacemanic CanSat in the past), the project members will gain an invaluable experience of completing a project with real life stakeholders which they can then use when applying for opportunities in the space or any other sector.

The international nature of the competition could potentially help grow cells of rocketry inclined enthusiasts in the Czech Republic who would build teams which could then engage with the CRS in the future projects. Radar tracking might be favorable to determine exact velocities and position when launching to up to 3 - 9 km altitudes as foreseen based on the ongoing negotiations.

4. Rocket and RTC Requirements

The following table lists the requirements imposed on the *Czech Rocket Society* (CRS) and the Radar Tracking Challenge: Amplifying Rocket RCS with Retro-Reflective Systems (RTC) organizers/participants. Any non-conformance of requirements shall be resolved as soon as discovered.

The wording follows the definition:

- **Shall** - to indicate binding requirement.
- **Will** - to indicate a statement of a fact.
- **Should** - to indicate a goal.

Req. ID	Req. Owner	Req. Description	Rationale
RTC-001	CRS	The rocket **should** reach a maximum altitude of 1,000 m above ground.	The current rocket (Sherpa) reaches a maximum of 1,000 m altitude above ground.
RTC-002	CRS	The rocket **shall** reach a minimum altitude in range of 350 m to 400 m above ground.	The maximum altitude imposed by LKCM airport used for CanSat finale is expected at 400 m based on the latest safety discussions (May 9, 2024).
RTC-003	CRS	The rocket **will** have a subsonic velocity in the range of 100 to 180 m/s.	The maximum velocity of the current Sherpa Rocket is 142 m/s.
RTC-004	CRS	Necessary accommodations for a flexible reflector film (defined in req. RTC-012, RTC-013, RTC-014, RTC-015, RTC-016) stuck on the outside of the rocket fuselage (preferably not the payload bay) **shall** be made (surface finish, partner stickers, screws, etc.).	Agreed based on the preliminary rocket design brainstorms proposed for 2024/25. The payload bay should not be covered in case of potential interference.
RTC-005	CRS	A volume of 17.5 mm x 48.5 mm x 53 mm	Agreed based on the preliminary rocket design

		(2*26.5 or 2 x 9V batteries volume) **shall** be available in the rocket in the proximity of the reflector film.	brainstorms proposed for 2024/25 and the current rocket (Sherpa) specifications.
RTC-006	CRS	The fuselage diameter in place of the reflector film mounting bay **shall** be in the range of 80 to 155 mm.	The current rocket (Sherpa) diameter is 153 mm. The diameter of a CanSat to be carried is 66 mm.
RTC-007	CRS	The reflector film **shall** be stuck on the outside of the rocket fuselage by the CRS following the instructions from RTC.	Agreed based on the preliminary rocket design brainstorms proposed for 2024/25.
RTC-008	CRS	The reflector film and the volume inside of the rocket **shall** be available to be connected by a 2 mm wire (allowance for four 2 mm holes drilled in the fuselage).	Agreed based on the preliminary rocket design brainstorms proposed for 2024/25.
RTC-009	CRS	The internal volume allocated **shall** be expected to contain batteries.	Agreed in the meeting July 24, 2024.
RTC-010	RTC	The RTC planning **shall** account for postponement or cancellation of the rocket launch due to technical and weather reasons or force majeure.	One of the Sherpa 2024 incident investigation recommendations was a backup plan for launch postponement - we need to know the consequences to not bias the safety assessment.
RTC-011	RTC	The RTCD Challenge **shall** be rocket material and dimensions agnostic as only the reflectors' radar cross-sectional area will be considered for calculations.	The material of the current Sherpa rocket (aluminum) is expected to be replaced by composites based on the preliminary rocket design brainstorms proposed for 2024/25
RTC-012	RTC	The reflector film **shall** be flexible.	We are not completely sure about the rocket diameter yet, so given the diameter range, the film must be fit for any of the final decisions.

RTC-013	RTC	The reflector film **shall** have a maximum thickness of 5 mm.	On the current rocket the heads of screws go out about 5 mm, so as long as it is even along the circumference, it should not cause any major issue.
RTC-014	RTC	The height of the reflector film **shall** be maximum of 300 mm.	Height of one CanSat is 160 mm and at least 4 are expected to be carried.
RTC-015	RTC	The maximum mass of the reflector film **shall** be 150 g.	Estimated mass.
RTC-016	RTC	The reflector film mass **shall** be evenly distributed along the circumference and height of the allocated surface.	Best for the center of gravity.
RTC-017	RTC	The active reflector system **shall** have means to be safely disarmed in case of crash, launch abort or payload abort.	Safety precaution.
RTC-018	RTC	The active reflector system **shall** not contain any physical buttons or weak connectors.	Physical buttons and weak connectors could get disrupted during the launch due to vibrations.
RTC-019	RTC	The active reflector system **shall** not contain voltages above V_dc = 9 V.	Safety precaution.
RTC-020	RTC	The maximum mass of the payload to be inserted into the allocated internal volume **shall** be 80 g.	The mass of a single 9 V battery is 33.9 g.
RTC-021	RTC	The payload to be inserted into the allocated internal volume **shall** conform to the volumetric envelope specified in RTC-005.	See RTC-005 for rationale.
RTC-022	RTC	The battery for the active reflector system **shall** last a minimum of 3 hours from the power on.	Requirement imposed on CanSats during the competition finale launch. CanSats are the primary

			payload of the expected launch.
RTC-023	RTC	The RTC planning **shall** allow for the launch date to be specified by February 27, 2026.	The launch date is specified in collaboration with ESERO Czech Republic who is the customer of the rocket launch service. The launch usually takes place in the first week of May and would probably take place between April 13 to May 17, 2026 (TBC).
RTC-024	RTC	The RTC planning **should** aim to procure financial contributions to the launch which will be in the range of 1,000 to 1,500 EUR to cover the rocket manufacturing, necessary adjustments and launch operations costs.	Since we will possibly need to make some minor adjustments to the design, it would be nice to also get some costs covered partially from the RTC. This would obviously be reciprocated in the promotional campaign and sticker on the rocket.
RTC-025	RTC	Instructions on mounting of the internal volume payload and film **shall** be provided to CRS at least 45 days prior to the expected launch date window specified.	The launch date window will be specified in September 2025, it would be good to know how it would be mounted as soon as possible.
RTC-026	RTC	Instruction on operation of the active reflectors system **shall** be provided to CRS at least 45 days prior to the expected launch date window specified.	The launch date window will be specified in September 2025, it would be good to know how it would be turned on etc. as soon as possible.
RTC-027	RTC	The active reflector system **shall not** pose a high risk of leaks or charging.	Safety precaution. Nominally expected, but better to be stated.
RTC-028	RTC	A risk assessment for the active reflector system **shall** be filled out at least 60 days prior	Safety precaution. Especially important in case of LiPo batteries and hazardous material disposal.

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		to the launch date window specified in the format specified by CRS.	
RTC-029	RTC	The active reflector system RF frequency **shall** be in range of 76 - 81 GHz.	Based on automotive radar frequency range.
RTC-030	RTC	The active reflector system **shall** allow conventional RF communication frequencies pass through for CanSats placed inside the payload bay and rocket communication.	The CanSats usually use LoRa which uses 433/868 MHz. The rocket usually also uses 2.4 GHz. Both need to be connected to the ground station during the flight. The reflector will be placed somewhere on the outside of the rocket body, preferably not the payload bay.

5. Memorandum of Understanding

The implementation of the requirements has been put to a vote in the Czech Rocket Society (CRS) "Per Rollam" vote running between August 1 July to August 15 2024. A total of 48 members out of 68 members eligible to vote participated in the vote which resulted in 45 supporting the signing of the memorandum.

The Czech Rocket Society and the members of the IEEE Microwave Theory and Techniques Society would therefore like to show their interest in proceeding with the project to the next phase and show they are willing to make every possible effort to fulfill the requirements listed in this document.

Based on this memorandum (signatures below), the IEEE MTT-S representatives Václav Valenta and Markus Gardill plan to submit the Radar Tracking Challenge: Amplifying Rocket RCS with Retro-Reflective Systems (RTC) as part of the IMS 2025 student design competition proposal with a deadline of September 8, 2024.

The CRS also agrees that Václav Valenta and Markuss Gardill take any necessary steps to ensure fulfillment of the requirements in terms of the RTC organization and further funding proposals.

This memorandum does not serve as a contract and is only a confirmation of understanding and intent between the parties. The contract for the launch shall be signed no earlier than September 1, 2025 and no later than March 31, 2026 before the launch based on the current CRS rocket capabilities.

The contacts for this project are:

- Ota Michálek (tajemnik@czechrockets.com), cc to info@czechrockets.com *(email likely to update to ota.michalek@czechrockets.com in 2025)*
- Markus Gardill (markus.gardill@b-tu.de)
- Václav Valenta (vaclav.valenta@esa.int)

Signatures confirming the memorandum

Ostrava, Czechia
Date: 17. 8. 2024

Ota Michálek
CRS Secretary

Brandenburg, Germany
Date: 21.08.24

Markus Gardill
IEEE MTT-TC-29, RTC

Hague, Netherlands
Date:

Václav Valenta
Digitally signed by Václav Valent
Date: 2024.08.27 11:29:23 +02'00'

Václav Valenta
IEEE MTT-TC-29, RTC

6. Appendix - Preliminary Sketch for RTC Participants

Notes in the sketch to be adjusted based on the final version of this document.