FIRST Slovenia

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FTC SEASON • DECODE • EINDHOVEN 2026

Portfolio

VegaMind

Team #22903

Vegova Ljubljana / Zavod 404 / FIRST Slovenia • Ljubljana, Slovenia

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1 Team Introduction

About Our Team

We, **#22903 VegaMind**, are a team from a small European country called **Slovenia**. We are the "senior" team of the two teams that we, as **FIRST Slovenia**, are split into. Our team consists of a couple of high school students who are dedicated to sharing and bringing **STEAM** to the youth.

The other team is our *sister* team, **#28080 VegaTech**, with whom we love to do FTC and other projects. We usually join forces for the FGC season, but split up again for the FTC season.

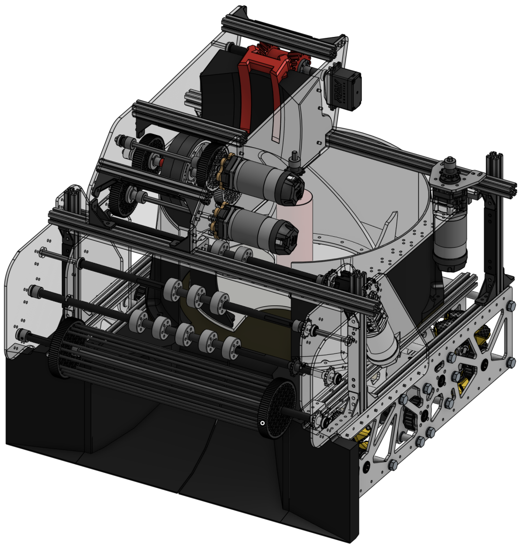
Team Members

Name	Role	Responsibilities
Nejc Furlan	Captain	Captain, CAD, Manufacturing, Testing
Domen Podgoršek	Hardware	Hardware & CAD Design, PR
Iztok Merljak	Mechanical	Hardware, Recruitment, Driver
Natan Jurca	Software	Lead Software, Autonomous, FTCTui
Maks Krese	Hardware	Manufacturing
Jonas K. Novak	Software & PR	General Software & Portfolio Writing

2 Robot Design

Design Goals

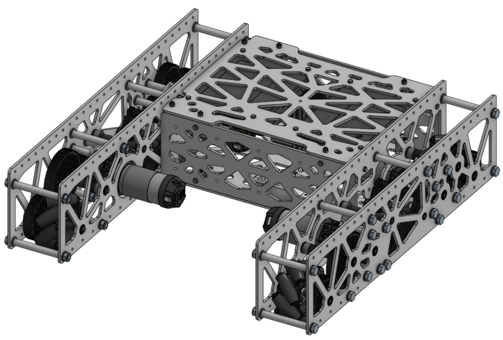
Our design goals for our robot, nicknamed *Luka*, were straightforward.
We wanted to incorporate as much functionality as possible (*within CM limits*), into a semi-compact form factor, while not sacrificing reliability, usability or making the robot structurally overly complex.



2.1 Drivetrain

As part of our **Project Strand**, the Drivetrain was **a big innovation** during this season. Designed by our now-alumni member, in cooperation with our sister team, the Drivetrain features a **fully-standardised** and **modular design**.

We opted for a fully laser-cut **aluminium chassis**, using the **goBILDA** system of **Mecanum Wheels, Motors and Odometry Pods** (*modifying it to use **any other system** is still **possible***). The Pinpoint Odometry System is used to **allow exact pinpointing** of the robot's position **at all times**.



Additionally, we implemented a **servo power module** into our Drivetrain, since we had noticed a lack of speed and power in the servos during our previous seasons. This change **boosted our servo power dramatically**.

For the Endgame, we implemented a **tilt function**, allowing the Robot to tilt and use less floorspace, allowing our alliance teammate's Robot to **slide into the bounds easier**.

The choice of chassis material mostly landed on cost, mass and strength, and aluminium seemed to be a good **middle ground**.

2.1.1 Project Strand

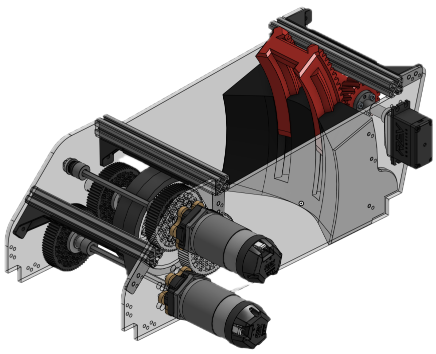
Project Strand is an effort made by our organisation to **standardise** as many **parts** of the robot as we can. It is fully **free and open-source**. Standardised parts are fully modular and may be reused by other designs in the future. This project is an ongoing effort by **both VegaMind and VegaTech** to enable any team to reuse existing and working designs that are compatible with their own designs, due to its modular nature.

Project Strand **reduces rebuild time** for existing robots and **reduces the *boilerplate period*** of every season (time spent building repetitive and non-changing modules).

The Drivetrain is, as such, part of this Project Strand.

2.2 Game Element Mechanisms

2.2.1 Shooter



The shooter has gone through several iterations since its initial scrimmage prototype, which lacked a hooded design and struggled with wheel selection, ultimately settling on **REV 90mm Grip Wheels** for their mass and higher inertia. The second iteration introduced a **hooded design** and **spindexer**, with a **1.5:1 gear ratio** selected to maximize power, theoretically reaching **4000 RPM** via a **REV HD Hex Motor**. Structural improvements were made to reduce vibration and stabilize **PID control**. Following the Germany Championship, a **flywheel** was added using repurposed e-waste electrical cables embedded between two traction wheels, increasing shot velocity, range, and consistency.

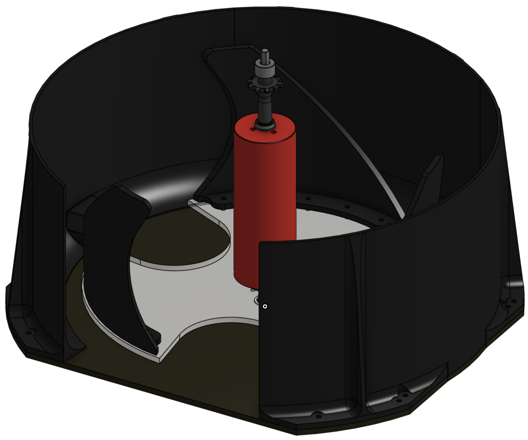
The new design features several improvements. The most notable improvement, is the addition of an **angle adjustor** (*see red object on figure*), allowing the robot to shoot ARTIFACTs at **variable angles**, saving time, as the robot **doesn't require to be physically moved** to target different distances.

The Flywheel features an **inertia disc**, which lengthens the spin-up/down time of the Flywheel, but provides extra energy to the ARTIFACT. The inertia of the flywheel can be calculated as such:

$$I = \frac{1}{2}MR^2 = \frac{0.11775\,kg \cdot 0.001225\,m^2}{2} = 721.2\,g \cdot cm^2$$

2.2.2 Spindexer

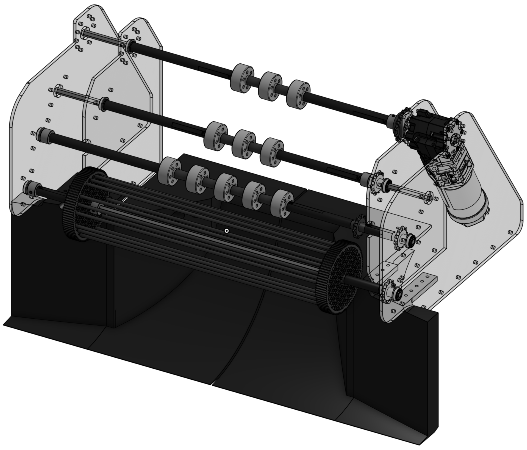
Our Spindexer is based off our original design, of a **horizontal, revolving compartment storing three ARTIFACTs**. The new design is similar in spirit, but **addresses some critical issues** of the original.



For one, the original Spindexer was slow. Due to the heavy, large separator columns of the original design, the mass caused the Spindexer to be slow, increased its inertia making it difficult to control, and generally contributed to a higher overall mass. It did however **work consistently**.

The new design addresses these problems, while still allowing the Spindexer to be consistent. The vertical columns were replaced with a **singular place with hole cutouts**, allowing the ARTIFACTs to sit in them. We replaced the previous active mechanism of pushing ARTIFACTs with a servo, with a **passive system**, which allows pushing of ARTIFACTs into one direction normally, allowing **sorting and positioning**, while rotating the Spindexer in the **other direction passively pushes the ARTIFACT into the Shooter**. This, in fact, **improves consistency**, due to the use of passive components, and **improves shooting speed** due to slashed wait times, that would be otherwise wasted waiting on active components.

2.2.3 Intake



Our Intake is based off our original design, however, it was **adapted for a goBILDA-based** Drivetrain. We widened it allowing a wider area of ARTIFACT pickup, added more axles for a better grip and help the *REV Surgical Tubing*-based intake system to push ARTIFACTs into the feed of *Rev DUO Grip Wheels*.
It is connected to a **chain drive**, driven by a *REV Ultraplanetary HD Hex Motor*, and made out of **lasered acrylic and wood**.
This design integrated better with the existing Spindexer.

2.3 Materials & Manufacturing

Our choice of materials landed on a basis of cost vs. performance. On one hand, we could CNC each part or even use carbon fibre. That however, would've been out of our budget and reasonable capability.

We also really liked the fast-prototyping features of 3D printing. Therefore, we landed on a **hybrid combination** of **aluminium** for the drivetrain chassis, **acrylic *plexiglass*** for the upper section, with **3D printed** *PETG* custom parts.

Materials Used

- Laser-cut Aluminium
- 3D-printed parts (PETG)
- Laser-cut acrylic (*plexiglass*)

3 Software & Programming

The Software was developed by our programmer, Natan, using **Java**. The codebase consists of approximately **5400 lines of code** spread across **44 files**.

3.1 Drivetrain

The Drivetrain uses our own custom **PID Control System**, which maintains the robot at a **desired heading**. The desired **Translation** and **Rotation**, inputted by the driver, are both **Field-Centric** (*relative to the starting position*), which allows for simpler controls.

The PID System also functions for a **second purpose**, finding the **optimal angle for shooting ARTIFACTs**. The angle is derived via **Computer Vision**, that detects the **Goal AprilTag** on the field, and **geometrically calculates** the required shooting angle.

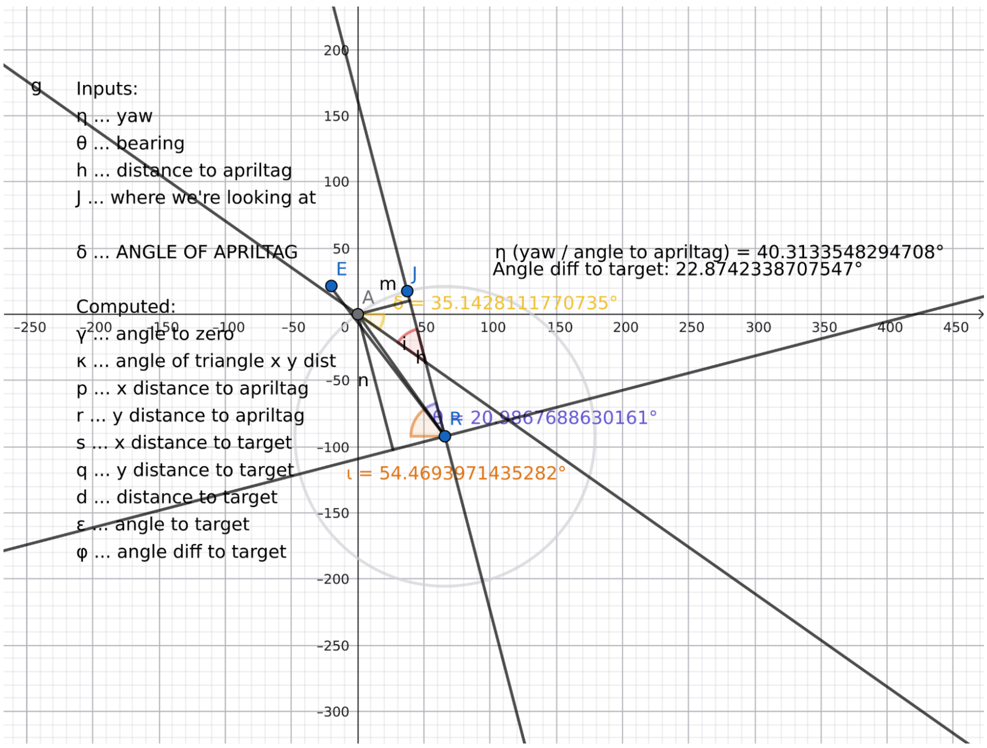


Figure 3.1. Visualizer of Geometric Calculations

Much of the Drivetrain code was **reused and repurposed** from last year's **FGC Panama** robot, although requiring a rewrite for FTC, to work with **Mecanum Wheels.**

3.2 Shooter

The Shooter code is responsible for **measuring RPM** and regulating it. We determine the **required shooter angle** based on our **distance from the target**, the **center of the Goal** (*using the aforementioned Computer Vision*), and a **polynomial** that converts distance into velocity based on **empirical measurements**.

The measurements were sourced from a few statically-measured distances in testing, which we then **interpolate** between on-the-fly. This ended up being **much simpler** than our previous plan of physically calculating based on elastic and potential energy, air resistance, etc., **without** any practical difference in the final result.

3.3 Spindexer

The Spindexer is **fully autonomous**, automatically **detecting the colour** of the loaded ARTIFACTs at the start of the match, and **continuously tracking them** throughout the rest of the match. It does so using a **colour sensor**. In practice, this allows us to essentially tell the shooter to simply *"shoot the green/purple ARTIFACT"*.

3.4 Autonomous

Autonomous is handled using the highly-deployed **Pedro Pathing** library. At OpMode Start, we **identify the colour sequence** presented on the game's OBELISK, navigate toward the Goal, and launch the stored ARTIFACTs in the **correct order**.

Engineering Note

As of writing this portfolio, the robot does not yet pick up new ARTIFACTs during autonomous, due to the turn-in deadline for portfolios being one week ahead-of-time. It is however planned.

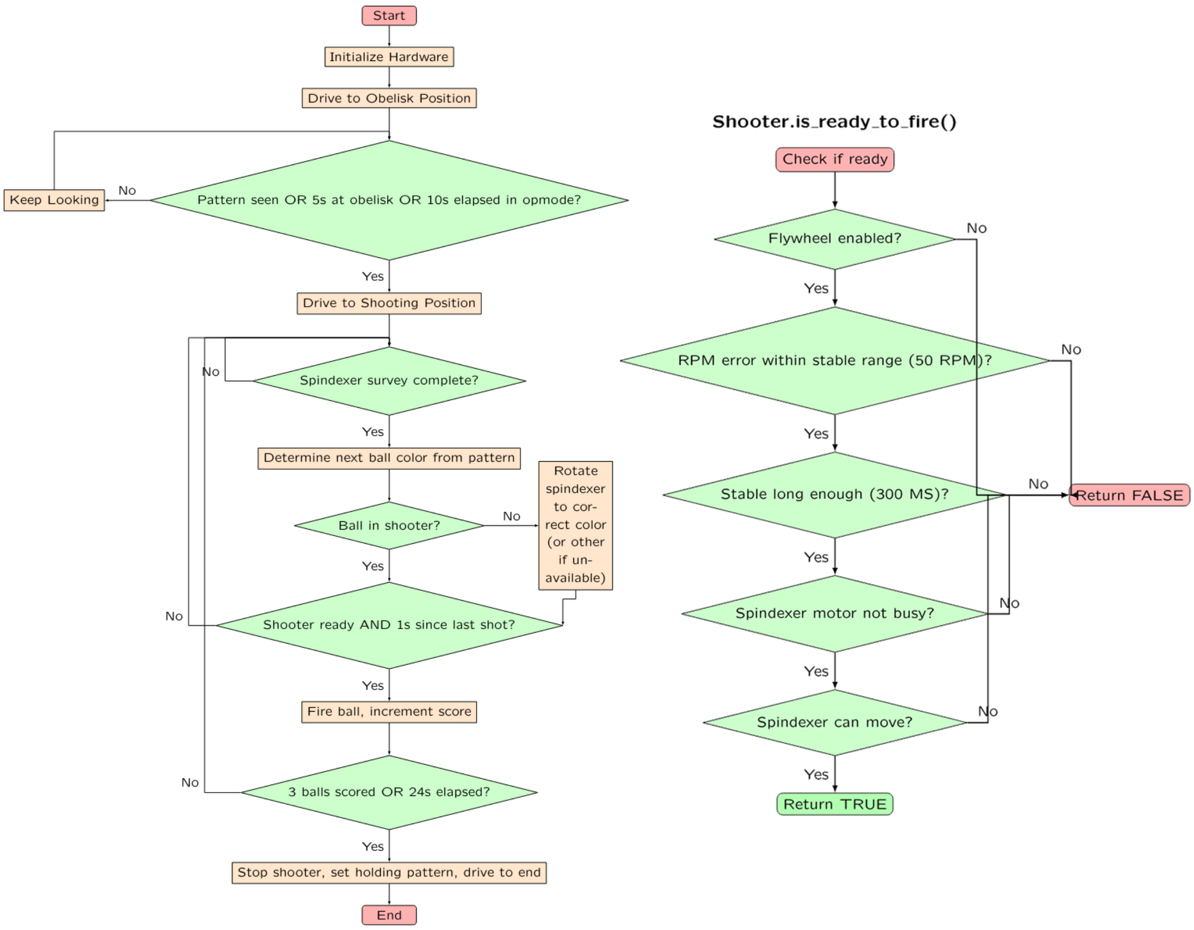


Figure 3.2. Robot Flow

We use **several OpModes**, depending on the Robot's starting position and Alliance Colour, and use a **Parent Class** to **avoid excessive code duplication**, from which the separate OpModes **inherit**.

3.5 FTCTui

The story of FTCTui begins back during the *Into The Deep* season, having grown vary of the Driver Hub's various issues. We conceived the idea of **controlling the Robot directly via a computer**.

Figure 3.3. FTCTui Application

Initially, the idea was running the Driver Hub in a Virtual Machine, but it presented significant difficulties. Our programmer, Natan, proposed **reverse-engineering the Driver Hub Protocol**, and **reimplementing it**.

The result of this was a **Rust implementation** of the protocol as a standalone application, of which we found the Driver Hub **no longer necessary for testing in our workshop**.

The FTCTui application requires **no additional modification** of the Control Hub, and **works natively**, and allows for **true computer-based control** of the Robot. It supports exporting of telemetry, allowing plotting of graphs, simplifying many aspects of Robot development (e.g. we used it for PID calibration).

Currently, the application is in the beta phase. Source code and release builds can be accessed via the adjacent QR code. We anticipate a full release in the coming months, which will include the implementation of the robot's hardware configuration. In the future, we also intend (permission permitting, of course) to publish the protocol documentation, thereby allowing other teams to benefit further from our newly acquired understanding of the protocol.

3.6 Miscellaneous

Testing is a **crucial part** of our software flow. To allow quick-identification of issues, we developed a **Diagnostic OpMode**, which allows us to test **individual components and subsystems**. More complex subsystems utilize **their own Testing OpModes**. To make debugging easier, we extensively **follow SOLID principles**.

This year's robot **heavily relies** on **sensors** for **intaking**, **shooting** and the **Spindexer**. This marks a departure from our earlier designs, which relied mostly on mechanical components and manual control. While sensors are very beneficial, we also acknowledge that they're not infallible. As such, the driver may, at any point **manually override** all autonomous systems.

The addition of a LED light allows for **easy status monitoring**, quickly alerting us to any issues that may arise during the Game, whether the shooter is at sufficient velocity, the AprilTag has been detected, etc.

3.7 Control Scheme

(a) Front **(b)** Back

Figure 3.4. Controller Mappings

Input	**Driver 1**	**Driver 2**
Left Stick	Field-Centric Translation	—
Right Stick	Field-Centric Target Heading	—
Left Trigger	—	Force Launch (Velocity Override)
Right Trigger	—	Auto-Launch At Target Velocity
Left Bumper	—	Select Green ARTIFACT
Right Bumper	—	Select Purple ARTIFACT
A / Cross	Align To Field	Check Spindexer ARTIFACT Colours
B / Circle	—	Spindexer To Position 0 (Backup)
X / Square	Toggle Intake Wheels	Activate Shooter
Y / Triangle	Scan AprilTag & Auto-Rotate	Reset Spindexer
D-pad	Precision Translation	Rotate Spindexer (Backup)
Guide / PS	Reset IMU / Set New Forward	—

4 Engineering Process & Iterations

4.1 Design Methodology

Our methodology of design this year was pretty simple. To create a **simple, controllable and reliable robot**, capable of **completing the Game Objective**.

In line with this methodology, we made several iterations this season, stemming from basic changes, all the way to complete overhauls.

4.2 Iteration Log

Version	Nickname	Description
v1.0	Oberkochen Robot	First functional prototype for the Oberkochen Scrimmage
v2.0	Stuttgart Robot	Completely overhauled version for the Stuttgart Championship
v3.0	*"Luka"* v1	First finalized design for the Italy Championship, similar in design to v2.0
v3.1	*"Luka"* v2	Updated robot with general improvements and additions for the Premier Event

5 Outreach, Sustainability & Sponsors

5.1 Competition Highlights

Our biggest competitive achievements this season were winning the **1st Place Control Award** at Stuttgart 2026 and the **1st Place Sustain Award** at Italy 2026, recognising our extensive use of **sensors and detection technology** to automate key operations on our robot and our budgeting plans for financial sustainability.

Event	Location	Award
Scrimmage	Stuttgart, Germany	1st Place Control Award
Championship	Cesenatico, Italy	1st Place Sustain Award

5.2 Outreach & Community Engagement

As *FIRST* Slovenia, our outreach mission is to grow the FTC/*FIRST* scene across Slovenia and inspire the next generation of STEAM enthusiasts. This year our social media presence continued to expand, with our primary Instagram account growing by ~**30%** and our shared *FIRST Slovenia* account by ~**25%**.

Activity	Description	Reach
FLL Tournaments (representative)	Promoted FTC/*FIRST* to middle- and high-schoolers; robot piloting demos	200+
Regional Events	Showcased robot, recruited new members	—
MOS Fair	Nationwide industry fair; advertised FTC & FGC to major companies	500+
School Technology Fair	Presented team, recruited new members	150+
Fair *Informativa*	Presented team	200+
Informational Days	Presented team, advertisement	1250+
Total estimated reach		**2300+**

Engineering Note

To sustain long-term growth, we run internal workshops in laser-cutting, 3D printing, and software development, ensuring every member acquires new, marketable skills each season—our team headcount has grown by ~**70%** as a result.

We **attended many meetings** with fellow teams, primarily discussing **strategy, robot design and code**. Some examples of teams we had meetings with include **#31570 Stark Robotics**, **#26075 Vampire Robotics** and **#14380 Blue BotBuilders**. Additionally, we discussed many cultural aspects of ***FIRST*** competition culture and differences between each other's approaches to it (e.g. discussing the process of competition in each other's nations). As such, we are **always open** to more meetings with other teams.

(a) MOS Fair

(b) FLL Competition

(c) Arena of Technology

Figure 5.1. Images from our physical outreach sessions

5.3 Future Outreach Goals

Our overarching goal is to make Slovenia a self-sustaining FTC nation. Key initiatives include:

- **Host a domestic FTC tournament** — open to foreign teams, raising both local and global awareness of *FIRST*.
- **New Team Starter-Kit** — subsidised hardware bundles for new teams, paired with our **mentoring programme** providing guides and resources to lower the entry barrier.

5.4 Financial Sustainability

Sound financial management is central to our long-term plan, particularly as we work towards a **government grant** to expand country-wide. Our strategy rests on three pillars:

1. **Aggressive sponsorship & in-kind support** — we actively seek sponsors who can contribute materials directly (e.g. Plastika Trček supplies free 3D-printing filament), reducing cash expenditure.
2. **Seasonal budgeting** — mentors oversee finances and seasonal budget plans keep unpredictable spending in check; components are reused across seasons wherever possible.
3. **Value-add projects** — we build custom solutions for sponsors (e.g. Project *Pajk*, a drawing robot for a local apparel shop) to strengthen relationships and generate word-of-mouth.

5.5 Sponsors

We are grateful to the following organisations for their generous support this season.

Sponsor	Contribution
Vegova Ljubljana	Institutional support & facilities
Zavod 404 / Institute 404	Financial, facilities & technical backing
Zavarovalnica Triglav d. d.	Financial sponsorship
MOL (Mestna občina Ljubljana)	Municipal grant / financial support
Delavska Hranilnica d. d.	Financial sponsorship
Plastika Trček d. o. o.	In-kind: 3D-printing filament
1Home Solutions GmbH	Financial sponsorship

We are committed to deepening these partnerships each season—through transparent reporting, custom technical projects, and active promotion of our sponsors at every public event we attend.