

# RoboCupJunior SSL Team: A Joint Venture of Champion RoboCupJunior Teams for RoboCup Small Size League Division B

Fabian Brune<sup>1</sup>, Jurij Lenz<sup>1</sup>, Mark Krause<sup>1</sup>, Tomáš Kováč<sup>2</sup>, Matúš Mišiak<sup>2</sup>,  
Michal Imrišek<sup>2</sup>, Radko Bábíček<sup>2</sup>, Borut Patčev<sup>3</sup>, Ivan Matošević<sup>3</sup>,  
Ivan Perko<sup>3</sup>, Dino Furjan<sup>3</sup>,  
Christian Rieseberg<sup>4</sup>, William Plummer<sup>4</sup>, and Marek Šuppa<sup>4</sup>

<sup>1</sup>Team Faabs, Germany  
teamfaabs@technulgy.com  
<https://technulgy.com>

<sup>3</sup>ZG24Robotics, Croatia  
ivan.perko007@gmail.com,  
borut.patcev@gmail.com

<sup>2</sup>LNx Robots, Bratislava, Slovakia  
lnxrobots@gmail.com  
<https://lnxrobots.github.io>

<sup>4</sup>RoboCupJunior Execs & Liaisons,  
RoboCup Federation  
<https://junior.robocup.org>

**Abstract.** This paper presents the Team Description Paper of RoboCupJunior SSL Team, a joint venture of three champion RoboCupJunior Soccer teams—Team Faabs (Germany), LNx Robots (Slovakia), and ZG24Robotics (Croatia)—applying to compete in RoboCup Small Size League Division B at RoboCup 2026. Beyond a standard league transition, our participation represents an experiment in exploring whether RoboCupJunior teams can bring their existing robots, hardware expertise, and development approaches relatively directly into SSL competition. Our combined team brings together the top three teams from the RoboCupJunior Soccer Open World Championship 2025: ZG24Robotics (1st place), LNx Robots (2nd place), and Team Faabs (3rd place). We present our hardware designs including SSL-inspired dribblers, custom solenoid kickers, and omni-directional drive systems—technologies already developed within the RoboCupJunior ecosystem. A key contribution is our middleware approach using the standardized RoboCupJunior Communication Module to bridge SSL infrastructure with existing robot hardware. Our qualification video demonstrating gameplay is available at <https://youtu.be/x0EdRpS239E>. This paper examines what adaptations are truly necessary versus what can transfer directly, with implications for creating sustainable pathways from RoboCupJunior to Major RoboCup leagues.

**Keywords:** RoboCup SSL · Division B · Small Size League · RoboCupJunior · RoboCupJunior-to-SSL Transition · Robot Soccer

## 1 Introduction

RoboCupJunior SSL Team is a joint venture of three champion RoboCupJunior Soccer Open (now renamed to Vision) League teams, combining expertise

from Germany, Slovakia, and Croatia to compete in RoboCup Small Size League (SSL) Division B. More than simply a team transition, our participation serves as an experiment to answer fundamental questions: *Can RoboCupJunior teams bring their existing robots, accumulated expertise, and development ecosystems relatively directly into SSL competition? And can geographically distributed teams collaborate remotely to achieve this?*

Our joint team spans three countries across Central Europe, creating inherent challenges in coordination, hardware integration, and development synchronization. Rather than viewing this distribution as purely an obstacle, we approach it as an additional dimension of our experiment—exploring whether remote collaboration models can be viable for SSL team formation, particularly for teams transitioning from the RoboCupJunior ecosystem where members may be spread across different regions or nations.

The RoboCupJunior Soccer Open (Vision) League has evolved significantly, with top teams now developing robots featuring brushless motors, custom solenoid kickers, suspension-based dribblers, and advanced embedded systems—technologies traditionally associated with Major SSL competition. This convergence raises important questions about the pathway between RoboCupJunior and Major leagues, and whether the gap is as wide as historically assumed.

Our joint team approaches this transition not by starting from scratch with SSL-specific designs, but by deliberately attempting to adapt and extend our existing RoboCupJunior hardware and software. This approach allows us to identify which aspects of SSL competition genuinely require new development versus which can leverage years of RoboCupJunior-level innovation. The findings from our experience could inform future efforts to create more accessible pathways into SSL and potentially influence how both leagues evolve.

### 1.1 Team Background and Achievements

Our joint team brings together significant competitive experience:

**Team Faabs (Germany)** has achieved remarkable success including **World Championship 3rd place (2025)**, World Championship 1st place (2023), German Open 1st place (2024, 2025), SuperTeam 1st place at German Open (2023), and European Championship 2nd place in Lightweight (2022). The team has developed sophisticated hardware with precision-milled aluminum components manufactured by industry sponsors, advanced vision systems using NVIDIA Jetson Orin Nano with CUDA acceleration, and notably a dual-solenoid kicker system with both flat kick and chipper capabilities—directly relevant to SSL gameplay.

**LNx Robots (Slovakia)** has consistently competed at the highest levels, achieving **World Championship 2nd place (2025)**, participating in European Championships (2023, 2024, 2025) and World Championships (2023, 2024, 2025). They have pioneered innovations including a custom flat solenoid kicker explicitly designed by studying TIGERs Mannheim’s SSL publications, and a Raspberry Pi 5 with Hailo-8L AI accelerator providing 13 TOPS for real-time neural network inference.

**ZG24Robotics (Croatia)** achieved outstanding results at RoboCup 2025 with **World Championship 1st place** and **SuperTeam 1st place**, adding to their World Championship experience (2024) and European Championship participation (2025). Their focus on SSL-inspired designs including four-rod suspension dribblers and 360-degree camera vision systems directly contributed to this success.

## 1.2 SuperTeam Experience as SSL Stepping Stone

The RoboCupJunior Soccer SuperTeam competition [13] provides a natural intermediate step between standard RoboCupJunior and SSL. SuperTeam features:

- A larger “Big Field” of  $5.4\text{m} \times 3.4\text{m}$  (compared to  $1.82\text{m} \times 2.43\text{m}$  in standard play)
- Five robots playing simultaneously per team (compared to 2 in standard play)
- The RCJ Communication Module for robot-to-robot and referee communication
- Multi-team collaboration, requiring coordination between previously independent teams

Two of our member teams have SuperTeam championship victories: ZG24Robotics (RoboCup 2025) and Team Faabs (German Open 2023). These results demonstrate that our teams have already succeeded in scaled-up, multi-robot competition with centralized communication—key elements that mirror SSL’s structure. This experience with the RCJ Communication Module directly informs our SSL middleware approach described in Section 3.4.

## 1.3 Motivation and Research Questions

The transition from RoboCupJunior Soccer to SSL represents both a team progression and an opportunity to explore broader questions about league accessibility and knowledge transfer. Our teams have already incorporated SSL-inspired elements into our RoboCupJunior robots, including:

- Brushless motor drive systems with Maxon motors and ESCON controllers
- Solenoid-based kicking mechanisms
- Advanced dribbler designs with suspension systems
- Distributed microcontroller architectures

This technological overlap, combined with our distributed team structure, motivates our core research questions:

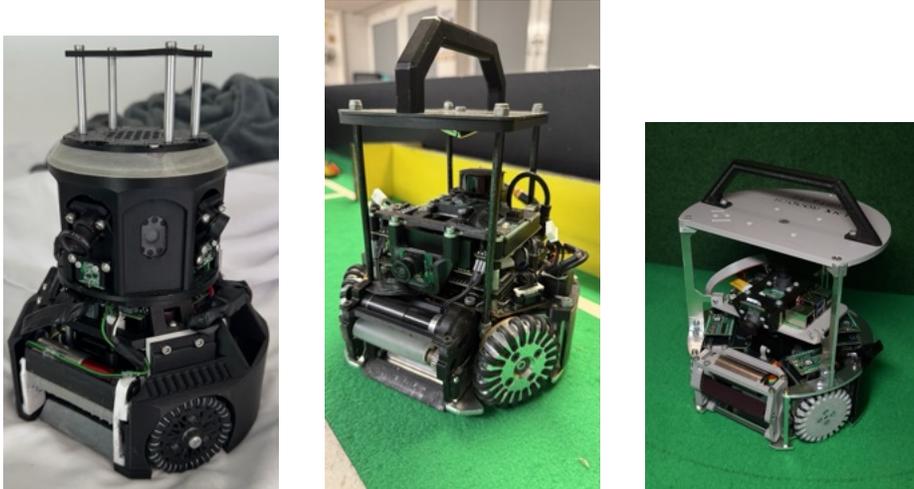
1. **Hardware Portability:** To what extent can RoboCupJunior robot hardware be adapted for SSL competition versus requiring complete redesign?

2. **Infrastructure Bridging:** Can middleware solutions (such as our RCJ Communication Module approach described in Section 3.4) effectively bridge the gap between RoboCupJunior and Major league infrastructure?
3. **Gameplay Impact:** How will robots developed in the RoboCupJunior ecosystem perform in SSL Division B, and what unique characteristics might they bring to competition?
4. **Remote Collaboration:** Can geographically distributed teams effectively collaborate on SSL robot development, and what tools and practices enable this?
5. **Development Pathway:** What lessons can be drawn for creating sustainable RoboCupJunior-to-SSL pathways in RoboCup?

Division B provides an ideal entry point for this experiment, with its 6-robot format (compared to Division A's 11) and  $9\text{m} \times 6\text{m}$  field allowing us to test our adaptation approach while learning SSL-specific requirements.

## 2 Hardware & Mechanical Systems

This section presents the mechanical designs developed by our three teams. Each subsystem showcases different approaches, demonstrating the breadth of expertise our joint team brings to SSL competition.



**Fig. 1.** Current robot designs from ZG24Robotics (left), Team Faabs (center), and LNX Robots (right). All robots feature omni-directional drive, solenoid kickers, and active dribblers.

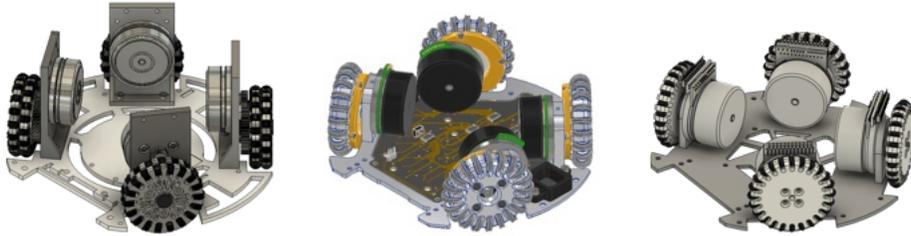
## 2.1 Chassis & Wheelbase Design

All three teams employ four-wheel omni-directional drive systems with brushless DC motors, though with different configurations:

**ZG24Robotics** uses an SSL-inspired motor layout with rear motors at  $90^\circ$  and front motors at  $120^\circ$ , providing space for the dribbler and kicker while maintaining maneuverability. They use Maxon EC 45 flat motors (30W) with ESCON Module 24/2 drivers. Custom omni-wheels feature two 3D-printed layers with embedded rubber rollers ( $8 \times 3 \times 3$  mm).

**Team Faabs** employs a standard four-wheel configuration with 50W Maxon EC-series brushless motors, each with a 3:1 gear reduction for optimal torque. Their wheels are precision-milled from aluminum with five elements: base, gear unit, cross wheels with pins, retaining lid, and internal bearing. X-rings are used instead of O-rings to minimize friction.

**LNX Robots** uses four Maxon EC 45 flat 70W motors with encoders for precise speed control at low velocities. They developed custom 6cm diameter omni-wheels consisting of two 3D-printed halves, a circular iron wire axle, and 24 small idler rollers with O-rings for traction.



**Fig. 2.** Chassis designs from ZG24Robotics (left), Team Faabs (center), and LNX Robots (right), showing different motor configurations and omni-wheel designs.

## 2.2 Dribbler System

The dribbler is critical for ball control, and our teams have developed various custom designs designs:

**ZG24Robotics** developed an SSL-inspired dribbler over six months, featuring:

- PETG body with 1:1 gear transmission using three custom PAHT-CF gears
- Four-rod suspension system with linear bearings for vertical movement
- Silicone roller (A45 hardness) with spiral groove for ball centering
- Maxon EC-max 16 motor (8W brushless with Hall sensors)

Material testing revealed PAHT-CF as optimal for gears running at 12,000 RPM, outperforming resin, PLA, and PETG in durability.

**Team Faabs** uses a spring-loaded adaptive mechanism with:

- High-friction rubber roller for maximum ball grip
- Independent high-torque brushless dribbling motor
- Dynamic speed adjustment based on ball position and movement
- Adaptive pressure control to reduce impact forces

**LNX Robots** implemented a bottom-mounted rotating dribbler system powered by a Maxon EC-max 22 (25W) motor, chosen for its superior ball holding compared to stationary designs. The bottom-mounted point of rotation prevents the ball from being pushed out before reaching the dribbling position.



**Fig. 3.** Dribbler mechanisms: ZG24Robotics’ four-rod suspension design (left), Team Faabs’ spring-loaded system (center), and LNX Robots’ bottom-mounted rotating dribbler (right).

### 2.3 Kicker System

All teams have implemented solenoid-based kicking systems with capacitor energy storage. Notably, Team Faabs has developed chipper (lofted kick) capability, which is essential for SSL gameplay where chip passes over defenders are a key tactic:

**Team Faabs** uses a dual-core solenoid system:

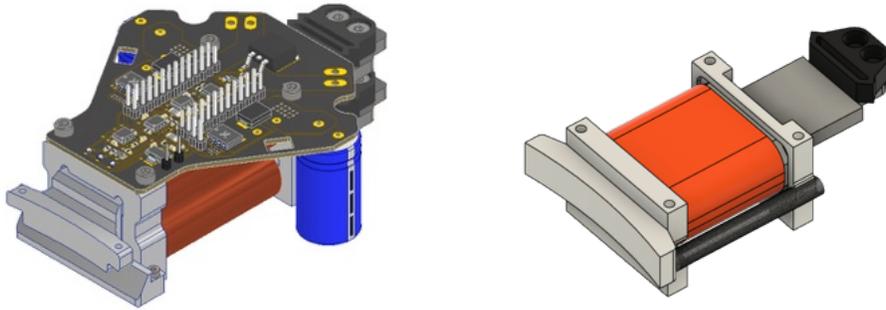
- Separate plungers for horizontal (flat) and vertical (chip) kicks
- 42V capacitor storage via boost converter from 3S LiPo batteries
- Adjustable chipper blade angle for trajectory control
- Spring return mechanism for high shooting frequency

**LNX Robots** designed a custom flat solenoid inspired by SSL teams, particularly TIGERs Mannheim:

- Calculated to achieve approximately 1/3 of TIGERs Mannheim’s kick power
- Custom plunger with aluminum non-magnetic and iron magnetic sections
- 47.5V boost converter charging 4.4mF capacitors
- 15V LDO powering MOSFET gate driver for efficient switching

**ZG24Robotics** uses a modular 48V pre-made solenoid with custom mounting:

- 15mm stroke solenoid powered via voltage booster
- Two-part kicker plate: CNC-machined metal base and 3D-printed adjustable front
- IRF3415 N-MOSFET switching with protection diode
- $2 \times 2200 \mu\text{F}$  capacitors for energy storage



**Fig. 4.** Kicker mechanisms: Team Faabs' dual-solenoid system with flat kick and chipper (left), and LNX Robots' custom flat solenoid design (right).

### 3 Embedded & Electrical Systems

Our teams have developed diverse embedded architectures, each with unique strengths that contribute to our joint capability.

#### 3.1 Control Architecture

**Team Faabs** uses a dual-processor architecture:

- **Teensy 4.1** (600 MHz ARM Cortex-M7): Low-level control including motor actuation, sensor processing, and real-time decision-making
- **NVIDIA Jetson Orin Nano**: High-level compute for object detection, camera input, and LiDAR processing with GPU acceleration and CUDA support

**LNX Robots** employs a three-processor distributed architecture:

- **Raspberry Pi 5**: Central processing unit for computation and neural network inference

- **Hailo-8L AI accelerator:** Dedicated acceleration for real-time computer vision
- **STM32F767:** Time-critical control tasks (motors, kicker, IMU, user interface)
- **STM32G474:** Lower-level sensing (line sensors, LiDAR preprocessing)

**ZG24Robotics** uses a distributed Teensy architecture:

- **Teensy 4.0 (Line Sensor PCB):** Line sensor data processing
- **Teensy 4.0 (Slave):** Input from sensors and cameras, ball/robot position calculation
- **Teensy 4.1 (Main):** Motor control, dribbler, communication, high-level strategy

### 3.2 Power System

All teams use similar power architectures based on LiPo batteries:

**Common Elements:**

- Dual 3S LiPo batteries in series providing 22-24V nominal
- Buck converters for regulated voltage rails (12V, 5V, 3.3V)
- Boost converters for kicker capacitor charging (42-48V range)

**Team-Specific Improvements:**

- **Team Faabs:** Custom Li-ion battery pack (14.4-16.8V), modular PCB system (Powerboard, Kickerboard, Lineboard, Teensyboard)
- **LNx Robots:** Board-to-board connectors reducing cable count from 150 to 20, improving reliability during competition
- **ZG24Robotics:** Pololu regulators for 5V/3.3V, custom kicker PCB with dedicated voltage boosting and MOSFET switching

### 3.3 Motor Drivers

All teams use Maxon ESCON Module 24/2 servo controllers for brushless motor control:

- Closed-loop PID control using encoder or Hall sensor feedback
- PWM, Direction, and Enable signals from microcontrollers
- 2/6A continuous/peak current capability at 10-24VDC

**LNx Robots Innovation:** Custom PCBs soldered directly onto motor terminals with board-to-board connectors, eliminating the 150+ cables that caused reliability issues in previous generations.

### 3.4 Communication

#### Current Robot-to-Robot Systems:

- **Team Faabs:** NRF24L01+ transceivers for wireless coordination
- **LNX Robots:** NRF24L01+ for multi-robot coordination
- **ZG24Robotics:** Seeed XIAO ESP32-C6 with ESP-NOW protocol for presence, state, and ball position sharing via UART

For SuperTeam competitions, our teams have experience with the **RCJ Communication Module [12]**, which provides standardized referee signal handling (GO/STOP via 3.3V output pins) and inter-robot messaging. This SuperTeam experience is directly applicable to our SSL transition.

#### SSL Communication Strategy:

One of our primary technical challenges is bridging SSL’s centralized communication architecture with our existing robot hardware. Rather than completely redesigning our robot communication systems, we plan to leverage the standardized **RoboCupJunior Soccer Communication Module [12]**—an open-source hardware module already familiar to our teams and widely adopted in the RoboCupJunior community.

The RCJ Communication Module [12] is an open-source hardware standard developed by the RoboCupJunior Soccer Technical Committee. It provides:

- **UART interface:** Configurable 3.3V–5.5V logic levels via LOGV pin, compatible with all our microcontrollers (Teensy, STM32, Raspberry Pi)
- **Wireless channels:** Four selectable radio channels (A0/A1 pins) enabling multiple teams to operate without interference
- **Referee signals:** GO/STOP output pins (OUT1/OUT2) directly usable for game state—we will map SSL Game Controller states to these signals
- **Robot identification:** Each module receives a unique team/robot ID, enabling targeted commands to specific robots
- **Flexible power:** 5.3V–25V input range matches our existing battery systems

The module’s existing protocol supports bidirectional UART messaging, which we will extend to carry SSL-specific data: robot velocity commands, kick/dribbler triggers, and acknowledgments.

#### Middleware Architecture:

We will develop a **base station middleware** that acts as a bridge between the SSL infrastructure and our robots:

1. **SSL-Vision Client:** Receives robot and ball positions from the SSL-Vision shared vision system via UDP multicast
2. **Game Controller Client:** Connects to the SSL Game Controller (autoref) to receive game state commands (halt, stop, force start, ball placement, etc.)
3. **Strategy Engine:** Processes vision data and game state to compute robot commands

4. **RCJ Module Interface:** Translates commands to the RCJ Communication Module protocol and transmits to robots via UART

This approach allows us to retain our proven robot-side communication hardware while implementing SSL protocol compliance at the base station level. The middleware will run on a standard laptop, receiving SSL-Vision and Game Controller data over the network and relaying processed commands to robots through the RCJ Communication Modules. The middleware is currently under development, with incremental testing planned before competition.

## 4 Software Architecture

This section presents our current software approaches and discusses the transition requirements for SSL competition.

### 4.1 Vision & Localization

#### Current Onboard Systems:

**Team Faabs** uses a 360° LiDAR combined with camera vision:

- Camera connected to Jetson Orin Nano for object detection
- BGR to HSV conversion with color thresholding for ball/goal detection
- Morphological operations and contour detection using OpenCV
- Parallel threaded detection for low latency and high reliability

**LNX Robots** employs LiDAR-based localization:

- Point cloud rotation based on real-time heading
- Hough transform for wall detection and position estimation
- Distance and angle calculation for target movement

**ZG24Robotics** implements 360° camera vision:

- Four Sipeed Maix Bit cameras (front, back, left, right) with OV5640 sensors
- 170° FPV lens on front camera for wider forward view
- Custom MaixPy blob detection algorithm for ball and goal tracking
- Four analog LIDARs for distance measurement
- BNO055 compass for heading and SparkFun optical odometry for position

**SSL Transition:** SSL uses the external SSL-Vision system [2], eliminating the need for onboard vision for localization. However, our onboard vision expertise will transfer to:

- Emergency fallback when SSL-Vision data is stale
- Onboard ball detection for close-range dribbling verification
- Obstacle avoidance refinement beyond SSL-Vision data

**SSL-Vision Integration Approach:** Our middleware will receive SSL-Vision data via UDP multicast using the standard protobuf message format (SSL\_WrapperPacket). Key technical considerations include:

- **Latency compensation:** SSL-Vision introduces 50–100ms latency; we will implement state prediction using velocity estimates to compensate when issuing robot commands
- **Frame rate matching:** SSL-Vision typically runs at 60Hz; our RCJ Communication Module operates at lower rates, requiring appropriate downsampling and command smoothing
- **Coordinate transformation:** Converting SSL-Vision’s global field coordinates to robot-local commands for our existing motion control systems

## 4.2 Motion Control

All teams implement PID-based motor velocity control with encoder feedback.

**Team Faabs** uses RRT-inspired tangent-based path planning with calculated intercept trajectories, approaching the ball from behind for reliable capture and using eccentric rotation around the ball for goal alignment.

**LNX Robots** implements distance and angle calculations for target movement, with the Raspberry Pi’s multi-core architecture enabling separate processes for camera, communication, and sensors.

**ZG24Robotics** uses field-relative movement with compass-based heading for consistent orientation, a state machine for ball catching behavior, and odometry/LIDAR fusion for position determination.

## 4.3 Strategy

### Current Approaches:

**Team Faabs** implements a ball catch algorithm with approach trajectory planning, defensive positioning using LiDAR localization, and robot-to-robot coordination via NRF24L01+.

**LNX Robots** uses LiDAR-based localization with Hough transform for wall detection to enable precise field positioning, with multi-robot coordination via NRF24L01+ transceivers.

**ZG24Robotics** features ball position sharing between robots via ESP-NOW, dynamic role switching (goalkeeper ↔ attacker), goalie positioning based on five preset positions determined by ball angle, and hidden-ball detection using LIDAR to counter opponent tactics.

**Strategy Framework Evolution:** Our current state machine and role-switching approaches from RoboCupJunior provide a functional starting point. For SSL, we plan to evolve this incrementally rather than adopting a complete framework rewrite:

- **Initial approach:** Extend existing state machines to handle SSL game states (halt, stop, running) and set pieces (kickoff, penalties, free kicks)

- **Role assignment:** Scale from 2-robot to 6-robot coordination by generalizing ZG24Robotics’ dynamic role switching (goalkeeper, defenders, attackers)
- **Future consideration:** As complexity grows, we may adopt structured approaches like STP (Skills, Tactics, Plays) [5] or Behavior Trees [6] used by established SSL teams

This incremental approach aligns with our research goal of understanding what RoboCupJunior teams can bring directly to SSL versus what requires fundamental redesign.

#### 4.4 Simulation & Development Tools

Our primary development approach leverages existing physical robots from our RoboCupJunior experience, allowing us to test and iterate with real hardware. However, leading up to the international competition, we may explore simulation tools from the SSL ecosystem:

- **grSim [3]:** The standard SSL simulator could support strategy development and testing multi-robot coordination without requiring all six robots to be physically present
- **SSL-Vision testing:** Running ssl-vision with webcams on smaller test fields to validate our vision client integration
- **Open-source tools:** Several SSL teams publish their software stacks; we may adopt visualization and debugging tools as needed

Given our distributed team structure across three countries, simulation could prove valuable for remote collaboration—allowing team members to test and refine strategies without physical access to all robots. This remains an area for exploration rather than a core dependency of our approach.

## 5 Transition Plan: RoboCupJunior to SSL

This section details the key differences between RoboCupJunior Soccer and SSL Division B, along with our adaptation strategy.

### 5.1 Key Differences

Table 1 summarizes the progression from standard RoboCupJunior through SuperTeam to SSL Division B:

The SuperTeam format serves as a valuable intermediate step, providing experience with larger fields, more robots, and the RCJ Communication Module infrastructure that we plan to leverage for SSL. Crucially, **all three formats use the same 43mm golf ball**, meaning our dribbler and kicker designs require no fundamental changes—only the vision source and communication architecture differ significantly.

**Table 1.** Comparison of RoboCupJunior Soccer, SuperTeam, and SSL Division B

Aspect	RCJ Open	RCJ SuperTeam	SSL Div B
Field Size	1.82m × 2.43m	5.4m × 3.4m	9m × 6m
Ball	Golf ball (43mm)	Golf ball (43mm)	Golf ball (43mm)
Vision	Onboard	Onboard	SSL-Vision
Communication	Robot-to-robot	RCJ Comm Module	Base station
Team Size	2 robots	5 robots	6 robots
Robot Diameter	18cm max	18cm max	18cm max
Robot Height	18cm max	18cm max	15cm max

## 5.2 Ball Handling: A Direct Transfer

A significant advantage of our transition is that **RoboCupJunior Soccer Open (Vision)** already uses the same orange golf ball as **SSL** (43mm, 46g). This means our dribblers and kickers are already designed, tested, and optimized for SSL’s ball.

### What Already Works:

- **Dribbler mechanics:** Our silicone rollers, suspension systems, and dribbler geometries are already optimized for the golf ball’s 43mm diameter, 46g weight, and dimpled surface
- **Kicker calibration:** Our solenoid kickers are already tuned for golf ball dynamics; we only need to verify compliance with SSL’s 6.5m/s speed limit
- **Ball possession sensors:** Break-beam sensors (ZG24Robotics) and dribbler-mounted detection work identically regardless of vision system
- **Chipper performance:** Team Faabs’ vertical kicker is already designed for golf ball chip shots

### What Changes:

- **Ball detection source:** Instead of onboard cameras detecting the orange ball, robots receive ball position from SSL-Vision via our middleware
- **Onboard vision role:** Our camera systems shift from primary ball tracking to backup detection and close-range verification during dribbling
- **Speed compliance:** SSL enforces a strict 6.5m/s kick speed limit; we will measure and calibrate our kickers to ensure compliance, potentially limiting maximum kick power

This ball compatibility supports our approach of transitioning to SSL with minimal mechanical redesign. The primary adaptations are in vision integration and communication, not ball handling.

## 5.3 Adaptation Strategy

### Mechanical Adaptations:

- Adapt dribbler and kicker designs for golf ball characteristics (see above)
- Ensure ball coverage compliance (<20% from above)
- Calibrate kicker for SSL speed limits (6.5m/s max)

**Vision System Transition:**

- Implement SSL-Vision protocol client for receiving external vision data
- Develop state estimation and tracking with Kalman filtering
- Handle vision latency compensation in control loops
- Retain onboard sensing as backup and for close-range ball detection

**Communication Infrastructure:**

- Implement SSL protocol stack for base station communication
- Develop base station software for game controller integration
- Handle referee commands (halt, stop, force start, etc.)
- Implement ball placement procedures

**Strategy Scaling:**

- Scale from 2-robot to 6-robot coordination
- Implement role assignment and formation management
- Develop set-piece plays (kickoff, penalties, free kicks)
- Integrate with open-source SSL strategy frameworks

## 5.4 Development Timeline

Given our geographically distributed team structure, development will proceed in parallel across locations with coordination via online collaboration tools. Key phases leading to the competition include:

1. **Middleware development** (remote): SSL-Vision client and Game Controller integration, testable independently of physical robots
2. **Local robot adaptation**: Each team adapts their existing robots for SSL compliance (height, ball coverage) using their local facilities
3. **Communication integration**: Connect middleware to RCJ Communication Modules, initially tested with subset of robots at each location
4. **Joint integration meeting**: Physical gathering of all teams and robots to test full 6-robot coordination
5. **Refinement**: Strategy tuning and reliability improvements based on integration testing

This distributed approach is itself part of our experiment—demonstrating whether remote collaboration can be viable for SSL team development.

## 6 Conclusion & Future Work

RoboCupJunior SSL Team represents both a competitive entry and an experiment in RoboCupJunior-to-SSL league transition. By deliberately building upon our existing RoboCupJunior hardware and expertise rather than starting from SSL-specific designs, we aim to answer fundamental questions about the accessibility of SSL competition and the value of the RoboCupJunior development pathway.

### 6.1 Technical Foundation

Our teams bring diverse technical approaches developed over years of RoboCupJunior competition:

- **Hardware:** SSL-inspired dribblers with suspension systems, custom solenoid kickers, precision-milled omni-wheels, and Maxon brushless drive systems—all developed within the RoboCupJunior ecosystem
- **Embedded:** Architectures ranging from Teensy microcontrollers to Raspberry Pi with AI accelerators, demonstrating that RoboCupJunior teams already work with modern embedded platforms
- **Software:** Experience with vision processing, path planning, and multi-robot coordination that we hypothesize will transfer effectively to SSL competition

### 6.2 Expected Contributions

Beyond competitive participation, we anticipate our experience will contribute to the broader RoboCup community in several ways:

- **Transition Documentation:** We will openly document which aspects of our RoboCupJunior robots transferred successfully to SSL and which required significant adaptation, providing a roadmap for future transitioning teams
- **Middleware Solutions:** Our RCJ Communication Module middleware approach, if successful, could provide a reusable bridge for other RoboCupJunior teams entering SSL
- **Gameplay Observations:** Robots developed in the RoboCupJunior ecosystem may exhibit different characteristics in SSL play, potentially introducing novel approaches or highlighting areas where RoboCupJunior development could better align with Major league requirements
- **Remote Collaboration Model:** As a geographically distributed team spanning Germany, Slovakia, and Croatia, we will document the tools, practices, and challenges of remote collaboration for SSL development—potentially enabling future joint teams that would otherwise be constrained by geographic proximity
- **Pathway Recommendations:** Based on our experience, we will provide recommendations for both RoboCupJunior and SSL communities on creating more accessible transition pathways

### 6.3 Immediate Development Priorities

- Complete SSL-Vision protocol integration and middleware development
- Test RCJ Communication Module bridge with grSim simulation
- Scale coordination algorithms from 2-robot to 6-robot teams
- Validate mechanical compliance with SSL dimension and coverage requirements

### 6.4 Open Source Resources

In the spirit of RoboCup’s knowledge-sharing tradition, our member teams have published their RoboCupJunior designs openly:

- **LNx Robots:** Software at <https://github.com/lrxrobots/rcj-soccer-open-gen3>, hardware/CAD at <https://github.com/lrxrobots/hw-rcj-soccer-open>
- **ZG24Robotics:** Full design repository at <https://github.com/BorutPatcev/ZG24Robotics>
- **Team Faabs:** Documentation and resources at <https://technulgy.com>

We commit to open-sourcing our SSL middleware—the bridge between SSL-Vision/Game Controller and the RCJ Communication Module—to benefit future RoboCupJunior teams considering SSL transition.

We are committed to meeting all Division B requirements while treating this transition as a learning opportunity for the entire RoboCup community. Regardless of competitive outcomes, we will openly share our findings on what worked, what required adaptation, and what lessons can inform future RoboCupJunior-to-SSL pathways.

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