

Radio Communications Technical Challenge

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References to the male gender in the rules with respect to referees, team members, officials, etc., are for simplification and apply to both males and females.

Goal and Motivation

We want teams to collaborate directly to profile quantitative radio performance and open-source their solutions to help make the SSL friendly to new teams. We are not going to mandate the use of a specific radio technology.

The SSL leadership wants to provide known good radio solutions to teams in the league to:

1. Lower the barrier of entry for new teams
2. Encourage the adoption of solutions that perform well, reducing overall variety and likelihood that any team has a radio related failure
3. Provide documented, open-source modules that may be usable by other leagues

This goal is driven by the fact that radio related failures (for any team new or returning) often have a very high impact on gameplay. While there is substantial educational value in designing and integrating solutions, three things seem apparent:

1. Using a radio technology the league has established as "effective" does not meaningfully diminish the educational value of integrating that technology into a custom stack
2. Effective radio technologies exist within the league, but lack sufficient data and open source information to be effectively replicated
3. There are few, if any, teams using non-commercial radio technologies.

The league does not seek to mandate a solution, but offer options well characterized by data

collected in a competition environment, with substantial open-source artifacts to make replication quick, easy, and deterministic.

We are committed to offering this challenge for at least 3 years. Teams may take lessons learned and collaborations from the end of each year and re-submit or evolve the technology.

Technical Challenge Details

Radio technologies are divided into two submission categories, Wi-Fi (802.11) and ISM.

Submissions are required to release editable documentation, firmware, and hardware artifacts. For example, PDF, binary, and gerber files are not accepted if the accompanying editable file format is also not included.

If commercial modules are used, firmware and hardware artifacts may be unavailable. This is okay, but any firmware and hardware used to interface with the commercial module must be released. Teams do not need to release any other parts of their firmware or hardware designs if they do not wish to do so. If you have a particularly effective technology that's broadly available, but requires a non-disclosure or other legal agreement, please contact the TC. Our main objective is to find effective solutions, so we don't want to exclude such options.

The use of open-source tools is strongly encouraged. E.g. We strongly prefer documentation in LaTeX or markdown instead of Microsoft Word (for example). We strongly prefer the use of open source compilers like gcc, clang, and rustc over closed source compilers like Kiel or Intel. We prefer electrical schematics and board layouts in KiCad over Altium or EAGLE. Strong open source submissions should include IDE agnostic build environments and compilers, targeting Ubuntu 24.04 or WSL equivalent. Environments should provide as much automation as possible for package installation for compilers and libraries. Consider using environment management techniques that guarantee reproduction across operating systems like [Nix](#) or [Docker](#).

Wi-Fi Technical Challenge

The Wi-Fi facet of this challenge covers any 802.11 standard supporting at least 4 channels. We exclude 2.4GHz Wi-Fi because channels other than 1, 6, and 11 are fake channels, so it cannot support 4 concurrent matches and cannot support each team having its own channel. Wi-Fi standards in the 5GHz and 6Ghz bands are allowed. Any future standards covering frequency bands >6GHz are also likely to be allowed. The TC will provide a shared Wi-Fi network as described by [this document](#) that teams are encouraged to use as **part** of their submission. We are interested in comparing performance data with the shared network in various configurations against the Wi-Fi routers and networks the teams currently use.

Teams must demonstrate the ability to quickly switch between wireless networks at the same or different fields. Data should be collected during a short friendly match.

Teams must communicate their methodology to gather radio performance data as described in the evaluation section.

ISM Technical Challenge

ISM facet of the challenge covers any legal communication method not using the 802.11 standard. Radios in this category are legal entries if they:

1. Can be forced to a fixed frequency (prohibits Bluetooth and any frequency hopping standards)
2. Supports at least 8 non-overlapping channels (4 concurrent matches)

Examples of radios we know teams used: Nordic 2.4GHz ICs and modules, 900MHz modules (800Mhz european equivalent), etc. 400/500MHz and other not currently used technologies are also in scope as long as they meet the above requirements.

Ultra-WideBand (UWB) technologies are exempt from the fixed frequency requirement due the nature of their functionality, as long as they provide an equivalent of "channels" and a reasonable bound can be provided on the data rate and channel allocation for 4 concurrent matches (8 concurrent teams).

The TC is primarily interested in understanding where the data-rate limits occur in ISM technologies, and if there are options to standardize on specific bandwidths and modulations for common modules. If the league can standardize bandwidths and modulations for popular modules, then detecting conflicts and interference at large competitions becomes substantially easier.

Evaluation

Evaluation is based on the quality of the data of the submission, not the performance of the radio itself. The TC wants the league to show well characterized options for radios so a team can pick something that meets their needs.

Teams should, to the extent possible, fill out this table **before and during competition**. The table should be posted in an open-source repository. A brief description of how the data points were estimated/computed should be included. For year one, we are not mandating a data collection method. We may impose requirements in future years based on methods that work the best.

Metric	Reporting Metric
Round-Trip Latency ¹	Mean: ms, Variance: ms, Max ² : ms
Average Packet Loss	Percentage
Data Rate ³	Mean: kbit/s, Variance: kbit/s
Detect Interference	Yes/No
Start Up Time	ms
Power Consumption	Mean: mW, Variance: mW
Cost	USD (estimate exchange rate)
Firmware Source	Text (ASCII or UTF)
eCAD	KiCAD Preferred

¹ If a radio solution is one direction, report one-way latency

² If your radio has a hardware priority queueing capability, report max latency as well

³ Report from the perspective of the base station

Scoring

Category	Poor (1-3)	Acceptable (4-6)	Excellent (7-10)
Quality of Data	Metrics are not reported or description is not given as to how they were computed.	Some metrics are reported and descriptions are available.	All metrics reported, with statistics, and methodology is strongly justified.
Quality of Firmware	Firmware was not released.	Firmware was released but lacked documentation and setup instructions.	Firmware released, documentation and environment setup provided.
Quality of eCAD	Open source hardware not released, or released only as production artifacts.	Hardware released, but no documentation or production artifacts.	Hardware released, production artifacts included, documentation included.
A team is able to partially or fully use another team's radio technology during competition.	0-15 points awarded		

A survey will be sent to competition participants to rank teams in the above areas. The overall score will be a sum of the quality sections (1-9 point each), and the sharing section. The minimum score is 3, and the maximum score is 45. Because radio technologies differ, methods to measure key data may also differ. If a team feels that a methodology lacks merit, it should be reflected in the assigned score. A free response section is included to provide detail. **To be clear, teams are scoring the quality of the data and the ease of understanding, not the performance of the radio.**

Submission Information

Submission

Teams are highly encouraged to submit partial solutions. This helps find future points of collaboration.

Teams should submit a link to any preliminary data, firmware and hardware to the mailing list by 26 JUN 2026. Teams may begin reviewing at this point.

Teams should be prepared to give a brief presentation during the event summarizing lab and/or event radio data, collection/computation methodology, and a brief overview of the firmware and

hardware submitted. The TC will clarify at the event the maximum presentation duration based on the number of submissions, but plan for ~10 minutes. **The TC will try to schedule the presentations around 3 JUL 2026.**

Teaming

Because this technical challenge is intended to be collaborative, we are changing the typical submission guidance.

- Individual teams may submit up to three (3) entries.
- Teams may submit collaborative entries.
- Collaborative entries count as a submission for all teams involved.

For example if ER-Force works with TIGERs on Radio technology A, and ER-Force works with The A-Team on radio technology B, then ER-Force has used two (2) submission entries, and TIGERs and The A-Team one (1) each.