

Release Notes

Version 4.1.0 Release - September 6, 2025

General Information

After a year of development and testing, the full release of SPOT 4.1 is ready! This is a **major** software revision, formally moving from **4.0** to **4.1**. This comprehensive release includes all changes from the development cycle, plus new updates since Pre-Release.3:

- **4.1 Pre-Release.1** - Initial major release with core improvements
- **4.1 Pre-Release.1 Hotfix.1** - Critical timing and connection bug fixes
- **4.1 Pre-Release.2** - Bug fixes and quality of life improvements
- **4.1 Pre-Release.3** - Control mixer overhaul and computer vision features
- **4.1 Pre-Release.3 Hotfix.1** - Changes to angular error calculation

This version is compatible with **MATLAB 2024a** and **MATLAB 2024b**, but was last built for **2024b**. It is designed to be used in Windows 11, but simulations can be performed in Linux systems as well. There are **no hardware level** changes in this version which would prevent users from continuing to run experiments using 4.0 (Hotfix #1). However, 4.1 includes significant **improvements to the Simulink diagram logic**, **substantial GUI enhancements**, and several **critical bug fixes**. This version also includes new hardware support such as inertial measurement units, the stereo camera, the laser range finder, and more.

Initializer Changes

- **Change 1:** Added code at the end of the initializer demonstrating how to run simulations without using the GUI by directly manipulating the GUI handle. This enables users to run simulations in loops to facilitate optimization.
- **Change 2:** Added code at the end of the initializer for the GUI animation extension system (thanks **Jeremy Peters!**). This lets you define custom drawing functions that can play with the animations in simulation.

GUI Changes

- **Change 1:** Added a refresh button next to the Simulink selection dropdown menu to refresh available diagrams.
- **Change 2:** Added a button to remotely control the electromagnet state on BLACK (moved to GPIO 482 and confirmed functional).
- **Change 3:** Added automatic checking for continuous-time integrators or derivatives in Simulink diagrams. If found, displays a warning that experiments may not match simulations.
- **Change 4:** Removed the **thruster count threshold** variable from the GUI as it's not commonly edited by users.
- **Change 5:** Added LQR gains to support the new default control law. PID gains remain available.
- **Change 6:** *Kudos to Adam:* Data class labels are now automatically generated based on input signal names to the bus. The ApplyDataClass function has been removed as obsolete.
- **Change 7:** Reworked the data inspector with overplotting support for each plot.
- **Change 8:** Added a debugger that can receive log messages from active platforms.
- **Change 9:** Added toggles to show/hide the cone, dock, solar panels, and spacecraft path in both simulation and experiment views.
- **Change 10:** Updated real-time visualization to display experiment time from all active platforms.
- **Change 11:** Removed noise options to save GUI space; noise is now handled inside the Simulink diagram.
- **Change 12:** Windows command prompt no longer opens every time you start up the PhaseSpace cameras.
- **Change 13:** Starting PhaseSpace cameras no longer automatically starts the live feed, giving users more control.
- **Change 14:** *Kudos to Courtney:* Reworked the animation tool allowing selection of different spacecraft parts to animate (cone, dock, solar panels, path traces).
- **Change 15:** Added public facing function to execute simulations from scripts.
- **Change 16:** Added Computer Vision tab with ZED2 camera support for live streaming, video recording, and still image capture.
- **Change 17:** Added dropdown menu to change IP address, name, and password for any platform or the computer vision computer, removing hard-coded SSH connection information.
- **Change 18:** Added "About" information to the File menu showing software license, authors, contributors, and current version.
- **Change 19:** Added checkboxes for "Save Simulation Data" and "Save Experiment Data" allowing custom file naming.

- **Change 20:** Added dynamic legend option in the plotting tool via “Include Legend” checkbox.
- **Change 21:** Added ability to change docking cone and port faces via GUI (+X, -X, +Y, -Y locations).
- **Change 22:** Added button on Hardware Control tab to search and merge RED, BLACK, and BLUE data sets automatically.
- **Change 23:** Updated color scheme in the *Set Initial States* sub-app to match the rest of the GUI.
- **Change 24:** Simplified the plotting tool (from what was initially in the pre-release software) after feedback indicated multiple plotting panes weren’t useful.
- **Change 25:** Improved the data plotting tool to handle data arrays properly in both experiment and simulation.
- **Change 26:** *Kudos to Jeremy:* Added GUI components to support the new plot extensions system.
- **Change 27:** Updated the mass properties sub-application to support the new CG measurement tool. Also changed the image being used so that it is clear where the scales should be placed.
- **Change 28:** Added animation options for experiments and added the ability to show a simulation at the same time as an experiment is running to see deviations from expected behavior in real-time.
- **Change 29:** Replaced all backslash symbols with `filesep` to improve compatibility across different operating systems.

Simulink Changes

- **Change 1:** Removed leftover termination block in the Check Connections subsystem.
- **Change 2:** Added hardware blocks to support new BMI160 IMUs installed on each platform, providing acceleration and gyroscopic measurements (note, there is a hardware problem on RED preventing the IMU from recording properly. Until fixed, speak to me for a workaround).
- **Change 3:** Reworked data saving to use a single bus, allowing bus inputs to be labeled for automatic data class name generation.
- **Change 4:** Significantly reworked Simulink template layout. Guidance and control are now separate subsystems with flags indicating which control law/path planner to use during experiment segments.
- **Change 5:** Made LQR the default control law, with PD still available.
- **Change 6:** In early pre-releases, APF was implemented as an example path planner – however, it performed poorly. For now, APF has been removed. By default there is no path planner.
- **Change 7:** Removed instances of custom derivative blocks for simulations.

- **Change 8:** Implemented new control mixer that iteratively adjusts spacecraft thruster duty cycles using constrained least squares with a thrust decay update to match a desired force-torque vector. This has advantages over the original `pseudo-inverse` method by enforcing physical duty cycle limits and modeling nonlinear thrust decay effects. Note, a `quadprog` approach was also present in previous pre-releases, but this caused a jump in compile time. This least squares approach seems to be a happy middle ground for now between optimality and speed.
- **Change 9:** Greatly reduced the number of If-Else blocks, improving simulation performance.
- **Change 10:** Updated Send Data to TX2 subsystem to support the new Orin vision computer.
- **Change 11:** In the default LQR and PD controllers, the angular error is corrected to the equation below, which should eliminate when platforms try to complete a full rotation to reach the same attitude.

$$\theta_e = \text{mod}((\theta_{\text{current}} - \theta_{\text{target}} + \pi, 2\pi) - \pi, 2\pi) \quad (1)$$

- **Change 12:** Added color coding to distinguish memory store blocks: RED (chaser), BLACK (target), BLUE (obstacle), GREEN (arm).
- **Change 13:** Created duty cycle zero-order hold subsystem for three platforms in simulation, holding values at the `dataRate` to better match experimental behavior.
- **Change 14:** Set default diagram rate to 20 Hz for most consistent performance.
- **Change 15:** Moved the calculation of velocity to the PhaseSpace code, which receives data at a much higher rate. This provides us with a much cleaner ground truth velocity to use.
- **Change 16:** Replaced PhaseSpace clock (determined to be inconsistent) with internal Simulink clock while maintaining platform synchronization.
- **Change 17:** Added check highlighting that robotic arm simulations require rates above 1000 Hz.
- **Change 18:** Changed data movement throughout diagram from scalars to vectors, greatly reducing the number of memory store blocks needed.
- **Change 19:** Improved simulation data handling to better reflect reality with downsampling and noise addition to measurements only. Added separate “truth” and “measured” state sources.
- **Change 20:** Added code to support the new real-time log feature so that users can see real-time messages from the Simulink diagram during an experiment. This should help with debugging.

Bug Fixes

- **Bug 1:** Fixed GitHub issue #53 regarding incorrect warning message.
- **Bug 2:** Updated default SPOT GUI mat file to correct errors and ensure compatibility with new features.

- **Bug 3:** Fixed arm showing in experiment live preview but not moving due to lack of arm data feedback.
- **Bug 4:** Fixed typo in BLACK pucks loading bar.
- **Bug 5:** Fixed GUI freezing when PhaseSpace executable crashes.
- **Bug 6:** Corrected incorrect labels in the save data section.
- **Bug 7:** Fixed typo mislabeling the nominal forces parameter.
- **Bug 8:** Fixed PWM code issue where pulse timing was dependent on duty cycle.
- **Bug 9:** Fixed broken “jump to” animation dial that would output errors.
- **Bug 10:** Addressed many code warnings to improve overall code quality.
- **Bug 11:** Updated Carleton logo in Simulink diagram to match GUI.
- **Bug 12:** Fixed incorrect error messages provided by the GUI.
- **Bug 13:** Fixed broken animation speed slider and added linear function to find ideal packet size based on sample rate.
- **Bug 14:** Updated all MATLAB version-dependent instances to work with any MATLAB version.
- **Bug 15:** Fixed accelerations for BLACK and BLUE not being filtered the same way as RED.
- **Bug 16:** Fixed PWM mixer bug for RED using thruster positions for BLACK.
- **Bug 17:** Fixed animation hitching when platform attitude crosses singularities.
- **Bug 18:** Fixed issue preventing live feed after stopping an experiment.
- **Bug 19:** Fixed platforms not displaying correctly in live view.
- **Bug 20:** Fixed backend issue where thruster force vector was only created when clicking specific buttons.
- **Bug 21:** Fixed issue preventing ExpLog CSV to MAT file processing when Memory Store Block contains vectors.
- **Bug 22:** Fixed filter checkbox not actually filtering primary dataset.
- **Bug 23:** Fixed **major bug** in control mixer identified by **Jeremy Peters** that caused experiment/simulation mismatch.
- **Bug 24:** Updated the SRCL logo to be the new SRL logo.
- **Bug 25:** *Kudos to Adam:* Fixed a bug in the arm device drivers that would result in no velocity limits being applied to the actuators.

Future Improvements

- **Feature 1:** Performance of the video streaming from the ZED camera is poor, with streaming happening at about 1-2 FPS. Hopefully, we can improve this in the next release, but it is not a critical feature.

Acknowledgments

Special thanks to the following people who have made this release possible:

- **Adam Vigneron:** Your contributions to this release are many, but thank you for fixing the bug in the arm software that will surely make it safer to use.
- **Courtney Savytska:** Your animation code in particular is a big improvement to the GUI.
- **Jeremy Peters:** For fixing various bugs, and for many included–custom animations–and not included–better data saving–features. Looking forward to all your future contributions!

Additionally, thanks to the 2024-2025 DOT Capstone team for being the software guinea pigs and putting it through it's paces.