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BULLETIN
BUL-051

Shepherd P4S4 Operations

This document covers the procedures needed to operate a Pronto4 Series 4 (P4S4) robot, running IVN or VAK software, from an Operator Control Unit (OCU) with the Shepherd application. For a more comprehensive coverage of the Shepherd application, see the Shepherd Overview documentation.

These procedures require a fully installed and operational P4S4 robot. See installation, maintenance, and qualification documentation for more information on those procedures.

NOTE
If operating a vehicle without a “Park” gear, the system should be configured to use “Neutral” as Park. In such a case, when Shepherd reports that the vehicle is in either Park or Neutral, the vehicle is in Neutral.

Inspections and Preparations

Checks and steps to be performed at the beginning of each day's missions or after modifying the system.

Basic Vehicle Checks

The basic vehicle checks should be run at least once per day, prior to all other checks and operations, and prior to moving the vehicle.

1. Verify all vehicle maintenance is current and documented.
2. Verify there are no operational discrepancies, such as damage, vehicle fluids leaking, servicing needs, or maintenance requirements.
3. On the steering wheel, verify all zip ties or hose clamps are properly located and secure, and are safely secured with F4 self-fusing silicone rubber tape or electrical tape.
4. Verify the vehicle has, at a minimum, sufficient fuel for the day's missions.

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Initial System Set-up and Connections Checks.

The initial system set-up and connections checks should be run after the basic vehicle checks have been completed, prior to the manual operations checks, and prior to moving the vehicle.

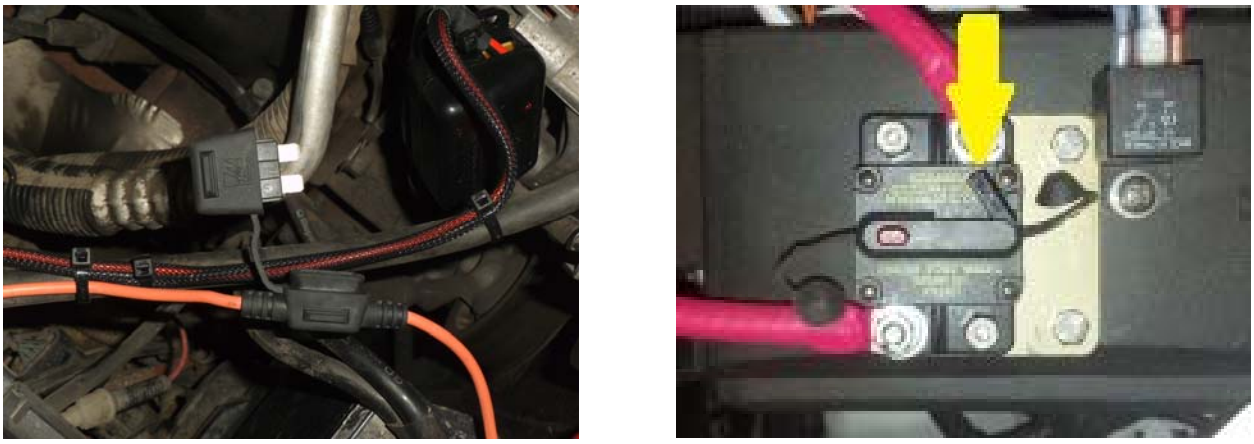


Figure 1: Blade Fuse Holder and Circuit Breaker - Opened Positions



Figure 2: Blade Fuse Holder and Circuit Breaker - Closed Position

1. Safety operator verifies vehicle electrical power is removed from the P4S4. This is accomplished either by opening the system blade fuse holder (in the engine compartment, see Figures 1 and 2) or opening the system power circuit breaker. Vehicle hood may be left open.

2. Safety operator verifies the transmission cable (ACBL-002) is NOT connected to the vehicle's shifter lever.
3. Safety operator verifies all other cables are properly connected to the P4S4 as listed in deployment documentation.
4. Safety operator verifies the P4S4 is properly secured into the P4S4 mounting bracket.

WARNING
Failure to secure the P4S4 into its bracket may result in erratic movement of the vehicle which could result in bodily injury or death.

CAUTION
Driving the vehicle without the P4S4 secured in its bracket WILL result in damage to cables and potentially to the P4S4 itself.

5. Safety operator ensures the vehicle's shift lever is in the Park position (or Neutral position, if applicable).
6. Safety operator ensures the vehicle's parking brake is engaged.

Manual Operations Checks

The manual operation checks should be run after the initial system set-up and connections checks have been completed, prior to any tele-op operations, and prior to moving the vehicle.

1. Using the vehicle key, safety operator manually starts the vehicle engine, leaving the transmission in Park (or Neutral, if applicable).
2. Safety operator manually turns the Vehicle Steering Wheel full left, then full right, then back to center.
    a. Safety operator verifies that the steering wheel and steering ring does not bind throughout the whole range of motion.
    b. OCU operator or another outside observer verifies that the front wheels steer freely lock-to-lock.

NOTE
If range of motion is not smooth, check bearings for free movement, and steering wheel tilt for appropriate angle.

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P4S4 Start-up

The system start-up should be run after all manual checks have been verified, and prior to moving the vehicle. All steps in the system start-up are performed by the safety operator.



1. Ensure VIM switches are in the following states:
    a. E-Stop is NOT activated (i.e., not depressed). Rotate the red button 1/4 turn clockwise and up to release, and to verify the E-Stop is not depressed.
    b. On/Off switch is in the "Off" position.
    c. Auto/Man switch is in the "Man" position. The “Man” position is in the center of the Auto/Man switch.
    d. Pause/Run switch is in the "Run" position.
2. Apply power to the P4S4 and verify that the system boots up normally *as follows*:
    a. Safety operator applies vehicle electrical power to the P4S4. This is accomplished either by connecting the system blade fuse holder or closing the system power circuit breaker (see Figures 1 and 2).
    b. Close vehicle hood. Verify hood is securely closed.
    c. Ensure safety operator is in the driver’s seat, with seat belt secured, clear of all controls, including the steering wheel, and in a position to activate controls.
    d. Using the vehicle key, manually start the vehicle engine.
    e. Switch the VIM ON/OFF switch to the “ON” position.
    f. Verify that there are NO LED indicators on the VIM.
    g. Verify that the following LEDs are lit on the P4S4:
        - Batt OK
        - 6vdc OK
        - 12vdc OK
        - UPS OK
        - PWR switch

NOTE
The LEDs listed in 2.g MUST be lit; other LEDs may be illuminated.

h. The Pronto4 system is now booting. It will take approximately 3-4 minutes to fully boot.

OCU Set-up

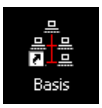
The OCU start-up procedure should be run after the P4S4 has been started, prior to any operations, and prior to moving the vehicle. Unless otherwise stated, all steps in the OCU set-up are performed by the OCU operator.

1. Ensure the Tele-op controller is connected properly, *as follows*:
   a. Main controller (e.g., Logitech Steering Wheel or Joystick) is connected to an available USB port on the OCU laptop.
   b. If using a Logitech Steering Wheel, foot pedals are connected to the Steering Wheel controller.
   c. If using a Logitech Steering Wheel, steering wheel connected to 100-250 VAC, 50-60 Hz wall outlet or power inverter.
2. Ensure the OCU USB E-Stop is connected to an available USB port on the OCU laptop.
3. Ensure OCU switches are in the following states:
   a. E-Stop is NOT activated (i.e., not depressed). Rotate the red button 1/4 turn clockwise and up to release, and to verify the E-Stop is not depressed.
   b. ON/OFF switch is in the "ON" position.
   c. PAUSE/RUN switch is in the "RUN" position. Until the OCU is fully booted, no LEDs should be illuminated.



WARNING
If using a Logitech Steering Wheel, keep hands clear until the OCU is fully booted up. It will randomly rotate twice during OCU boot-up. Failure to keep clear can result in injury.

4. Press the OCU computer power button to turn the OCU on. If the OCU fails to boot within a minute, plug it into an AC outlet. If it still fails to boot, contact Kairos Autonomi.
5. Verify djBasis starts up. If djBasis fails to start, double-click the djBasis icon on the desktop.



6. Verify the appropriate programs start-up, *as follows*:
    a. If djBasis is not visible, restore it from the taskbar.
    b. On the “Executable Manager” tab, verify the following “Module Name” entries are listed and their “Status” is listed as “Active”.
        - djBasis.exe
        - djSharedLinkF.exe
        - djEtherMap.exe
        - djShepard.exe

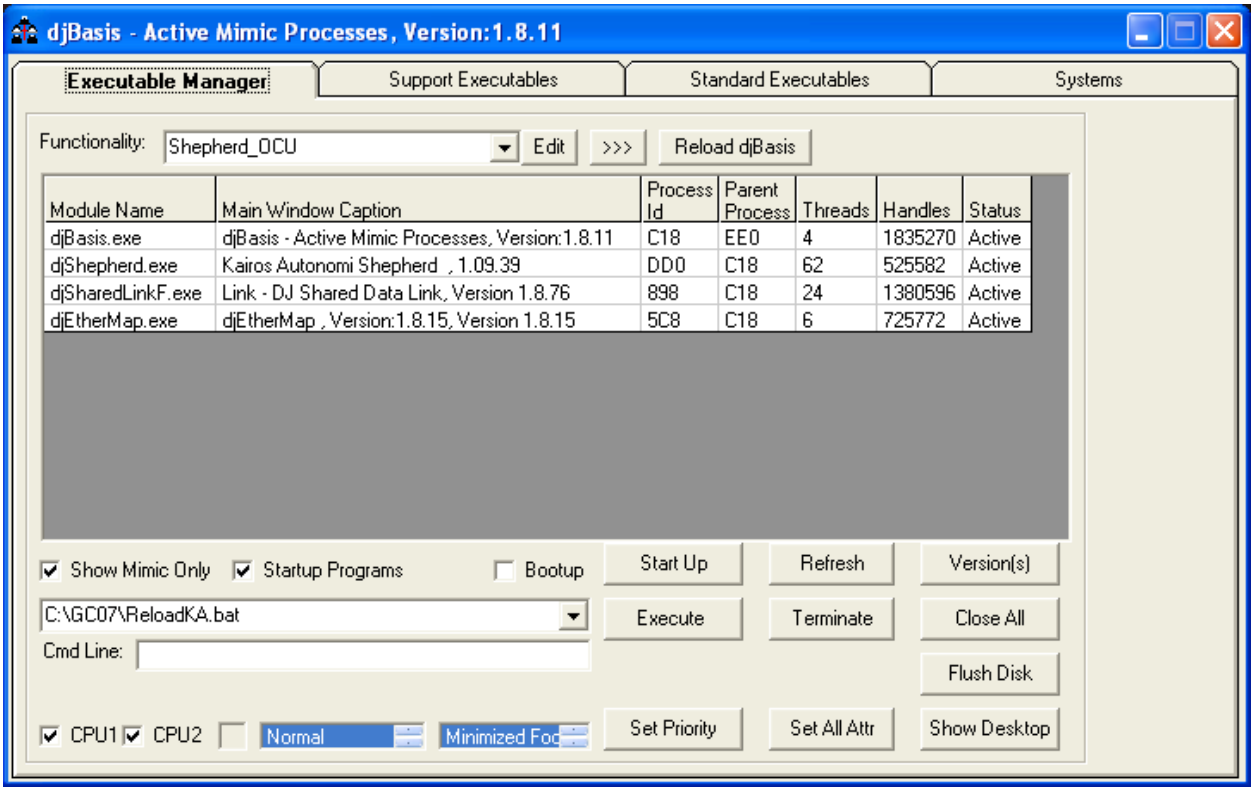


Figure 3: djBasis' Executable Manager tab displaying all appropriate programs with an Active status. Note: Version numbers may differ and additional programs may be listed.

    c. If an entry displays a status other than “Active”:
        i. Single click on its entry. The entry's program path should be displayed in the drop-down at the bottom of the window.
        ii. Click the Execute button to the right of the drop-down.
        iii. Wait approximately 15 seconds. If the entry is still not “Active” contact Kairos Autonomi support.

7. On the OCU USB E-Stop verify the green LED is flashing, which indicates the system is broadcasting, and the red LED is NOT illuminated.
8. If Shepherd is not visible, restore it from the taskbar. Maximize the Shepherd window.

Basic Robotic Control

1. Manually position and park the robotic vehicle with its wheels straight and steering wheel centered.
2. Clean camera/s, *as follows*:
    a. If the system is equipped with a camera roll-off, single-click the headlights button to start the roll-off. The roll-off will stop after 2-3 seconds. Single-click the headlights button a second time to reset the roll-off
    b. If the system is not equipped with a camera roll-off, manually clean the camera/s with a clean cloth.
3. Activate the desired robot, *as follows*:
    a. In Shepherd's “Asset” tab area, click on the robot's name (e.g., VEH_SN001H1).
    b. Click Login.
    c. In Shepherd's “P4S4” tab area, verify the robot's name appears at the top and the “Link Quality” does not have a red background.
4. Calibrate steering, *as follows*:
    a. With the vehicle logged in to Shepherd, safety operator drives the vehicle straight forward for 5-10 feet.
    b. Safety operator switches the VIM Auto/Man switch to the "Auto" position, and verifies the following:
        i. Brake engages autonomously (brake pedal fully depressed).
        ii. VIM “Enable” and “Ready” LEDs illuminated.

WARNING
When running Shepherd's Calibrate Steering function, the safety operator shall keep hands and arms away from the steering wheel. Failure to do so can cause injury to the operator's hands and arms.

    c. In Shepherd's “Teleop/Remote” tab, click the “Calibrate Steering” button. The steering wheel should NOT turn all the way around. If it does, ensure the wheels are aligned straight forward and click the “Calibrate Steering” button again.
5. Set view tabs as desired. See the Shepherd Overview documentation, particularly the “View Tabs” section, for more detail.
6. Switch the VIM Pause/Run switch to the 'Pause' position.

7. Connect the transmission cable to the vehicle shifter and transmission servo.
8. Switch the VIM Pause/Run switch to the 'Run' position.

The robot is ready to be tele-operated, record a path, or playback a path by this OCU.

Robotic Operations

Ongoing Safety Procedures

Ensure all operators have read and understand all related safety documentation, including the Shepherd Overview sub-sections: “Safety Summary” and “Notes, Cautions, and Warnings that apply to all operations”.

Tele-Operations

CAUTION
If an E-Stop switch, either the VIM or the OCU, is engaged, release all tele-op controller controls, including the Deadman, prior to releasing the E-Stop. Failure to do so can result in erratic robotic response.

1. Verify the safety operator is in the driver’s seat, with seat belt secured, clear of all controls, including the steering wheel, and in a position to activate controls, including the brake pedal.
2. Ensure the vehicle parking brake is released.
3. With the robot checked-in and calibrated (see Basic Robotic Control section), safety operator switches the VIM AUTO/MAN switch to 'Auto'. Verify the vehicle brakes fully engage.
4. In Shepherd, on the “Teleop/Remote” tab, click the “Teleop On” button.
5. Verify the vehicle engine is running and the transmission is in Park (or Neutral, if applicable). If the engine is not running, in Shepherd, on the “Tele•Op/Remote” tab, click the “Engine Start” button.
6. Unless otherwise specified, use the tele-op controller (see the document “Reference for Tele-op Controller Functions”) to verify each function, *as follows*:
    a. Press and hold one of the 'Deadman' buttons until directed otherwise.
        - On the “Teleop/Remote” tab, in the Joystick/Gamepad Input area, verify the “Brake” gauge is at 0.
        - On the “P4S4” tab, verify the “Brake” gauge and percentage values are 0.

CAUTION
The vehicle engine is running and throttle is being applied. Apply the Tele•Op Controller throttle slowly and with the minimal force necessary to verify an increase in RPM. Failure to do so can cause engine damage.

b. Slightly apply throttle.
   - On the “Teleop/Remote” tab, in the Joystick/Gamepad Input area, verify the “Throttle” gauge corresponds to stick movement.
   - On the “P4S4”tab, verify the “Throttle” gauge and percentage values correspond to stick movement.
   - In the vehicle, verify throttle movement corresponds to stick movement.

c. Slightly apply brake.
   - On the “Teleop/Remote” tab, in the Joystick/Gamepad Input area, verify the “Brake” gauge corresponds to stick movement.
   - On the “P4S4”tab, verify the “Brake” gauge and percentage values correspond to stick movement.
   - In the vehicle, verify brake movement corresponds to stick movement.

d. Alternate steering left and right.
   - On the “Teleop/Remote” tab, in the Joystick/Gamepad Input area, verify the “Steering” gauge corresponds to stick movement.
   - On the “P4S4”tab, verify the “Steering” gauge and percentage values correspond to stick movement.
   - In the vehicle, verify steering wheel movement corresponds to stick movement.

e. Press the 'Engine Stop' button.
   - On the “Teleop/Remote” tab, in the Engine area, verify the “Enabled” button indicator is NOT highlighted.
   - On the “P4S4”tab, verify the RPM gauge/indicator shows 0 RPM.
   - In the vehicle, verify the engine stopped.

f. Press the 'Engine Start' button.
   - On the “Teleop/Remote” tab, in the Engine area, verify the “Enabled” & “Start” button indicators are highlighted.
   - Verify the “Teleop On” button indicator highlights.
   - On the “P4S4”tab, verify the RPM gauge/indicator shows > 100 RPM.
   - In the vehicle, verify the engine started.

g. Press the 'Gear Up' button once.
   - On the “P4S4”tab, verify the “Rev” button indicator is highlighted.
   - Verify the vehicle shifted to Reverse.

h. Press the 'Gear Up' button once.
   - On the “P4S4”tab, verify the “Neu” button indicator is highlighted.
   - Verify the vehicle shifted to Neutral.

i. Press the 'Gear Up' button once.
   - On the “P4S4”tab, verify the “Drv” button indicator is highlighted.
   - Verify the vehicle shifted to Drive.

j. Press the 'Gear Down' button once.
   - On the “P4S4”tab, verify the “Neu” button indicator is highlighted.
   - Verify the vehicle shifted to Neutral.

k. Press the 'Gear Down' button once.
   - On the “P4S4”tab, verify the “Rev” button indicator is highlighted.
   - Verify the vehicle shifted to Reverse.

l. Press the 'Gear Down' button once.
   - On the “P4S4”tab, verify the “Park” button indicator is highlighted.
   - Verify the vehicle shifted to Park (or Neutral, if applicable).

m. Press the 'Gear Up' button three (3) times, with a one (1) second pause between each press.
   - On the “P4S4”tab, verify the “Drv” button indicator is highlighted.
   - Verify the vehicle shifted to Drive.

n. Release the Deadman button.
   - On the “P4S4”tab, verify the “Brake” gauge and percentage go to “100”.
   - In the vehicle, verify the brake is fully engaged.
   - On the “P4S4” tab, verify the “Park” button indicator is highlighted.
   - Verify the vehicle shifted to Park (or Neutral, if applicable).

NOTE
In the Kairos Autonomi software package, there is an option to change the default Deadman button actions. This includes the option to NOT shift to Park when the Deadman is released. If this option is changed, a note should be made indicating the “Verify the vehicle shifted to Park.” is not applicable for the local deployment. If there is a need to change the default Deadman button actions, contact Kairos.

7. If driving a live mission, the Safety Operator safely exits the vehicle, *as follows*:
   a. In Shepherd, on the “Teleop/Remote” tab, the OCU operator clicks the “Engine Stop” button.
   b. When the engine has stopped, the Safety Operator exits the vehicle and moves to a safe location.

   c. In Shepherd, on the “Teleop/Remote” tab, the OCU operator clicks the “Engine Start” button.
8. Drive the vehicle, as desired. Follow the progress and status of the vehicle in Shepherd.
9. Upon completion of Full Tele-Op, bring the vehicle to a complete, controlled stop by releasing steering and accelerator, then slowly and completely engage the brake.
10. When the vehicle is completely stopped the OCU operator secures the vehicle, *as follows*:
    a. On the Tele-Op Controller, press the “Gear Down” button three (3) times, to Park.
    b. In Shepherd on the “P4S4” tab, ensure the vehicle shifts to “Park”.
    c. On the Tele-Op Controller, release the Brake.
    d. On the Tele-Op Controller, press the “Engine Off” button.
    e. On the Tele-Op Controller, release the Deadman.
    f. In Shepherd, in the “Teleop/Remote” tab, click the Tele-op Off button. The “Tele-op On” button should return to non-highlighted state (i.e. disabled).
11. If this completes operations for the day, proceed to the Operation Termination section of this document.

Path Recording

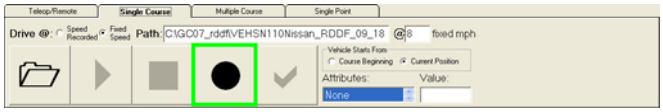
Before a path can be played back, either in Single-Course mode or Multi-Course mode, it must be recorded. If a path is intended as a Multi-Course ingress or egress, it will have different start and end points. If a path is intended as a Multi-Course loop the start and end points should be as close to each other as is reasonably possible.

Paths can be recorded either in Manual mode or in Tele•Op/Remote mode. These procedures cover recording in Manual mode. Adjust as appropriate for recording in Tele-Op/Remote mode.

NOTE
The only options available on the “Single Course” tab that are relevant during recording are the “Attributes” and “Value” fields. These options are for features that are actively being developed (as of 2013-09-23), but not yet functional. When these features are functional, a revised Shepherd P4S4 Operations document will be made available.

1. Ensure the VIM AUTO/MAN switch is in 'Man' and the Transmission Cable is NOT connected.
2. Manually position at the start point and in the starting direction and park the robotic vehicle with its wheels straight and steering wheel centered.

3. Activate the desired robot, *as follows*:
    a. In Shepherd's "Asset" tab area, click on the robot's name (e.g., VEH_SN001H1).
    b. Click Login.
    c. In Shepherd's "P4S4" tab area, verify the robot's name appears at the top and the "Link Quality" does not have a red background.
4. In Shepherd's "Single Course" tab, click the record button (i.e., black circle). The record icon will chance from black to red and the play and stop buttons will change from grey to black. This puts Shepherd into a recording state, but it does not actually start the recording.



5. Shift the vehicle to Drive.
6. Still in Shepherd's "Single Course" tab, click the play button (i.e., black triangle). The play button will change from black to green. When in a recording state, the play button starts the actual recording.



7. Drive the desired path. If recording a loop, stop approximately two (2) meters shy of the starting point.
8. Still in Shepherd's "Single Course" tab, click the stop button (i.e., black square). A CMD window will briefly flash. The CMD window is an automatic process that transfers the recorded Route Data Definition Format (RDDF) file from the Pronto4 unit to the OCU. The file is automatically named based on the vehicle recording the path, the date, and a daily sequential recording number. If the file is not automatically transferred, the path is unavailable to the OCU and will either need to be recorded again or manually copied (contact a Kairos technician or engineer for assistance). The "Path" field, on the "Single Course" tab, is automatically populated with the file path and name, but the file is NOT functionally loaded.



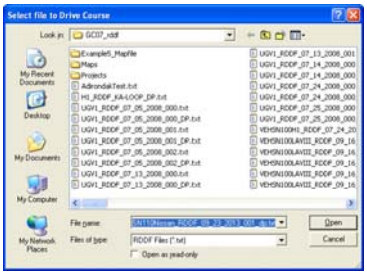
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Path Playback

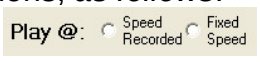
1. Verify the safety operator is in the driver's seat, with seat belt secured, clear of all controls, including the steering wheel, and in a position to activate controls, including the brake pedal.
2. Manually position the vehicle 5-20 feet behind the starting point and aligned with the starting direction.
3. Ensure the vehicle parking brake is released.
4. With the robot checked-in and calibrated (see Basic Robotic Control section), safety operator switches the VIM AUTO/MAN switch to 'Auto'. Verify the vehicle brakes fully engage.
5. Verify the transmission is in Park (or Neutral, if applicable).
6. If driving a live mission, the Safety Operator safely exits the vehicle, *as follows*:
    a. In Shepherd, on the "Teleop/Remote" tab, the OCU operator clicks the "Engine Stop" button.
    b. When the engine has stopped, the Safety Operator exits the vehicle and moves to a safe location.
    c. In Shepherd, on the "Teleop/Remote" tab, the OCU operator clicks the "Engine Start" button.
7. In Shepherd, on the "Single Course" tab, click the open button (i.e. black file folder). This will open a "Select file to Drive Course" window, where the default selected file is the last file that was recorded or played back.



8. Select the file to be driven, then click the "Open" button. This will close the file selection window and load the selected path into Shepherd. It will also change the open button from black to blue and change the play and stop buttons from grey to black.



9. Still in Shepherd, on the "Single Course" tab, select desired options, *as follows*:
    - Play@ "Speed Recorded" or "Fixed Speed" – Play the path either at the recorded speeds or at a single, fixed speed.
    - @ x "max mph" or "fixed mph" – If playing at "Speed Recorded" a maximum playback speed can be set. If playing at "Fixed Speed" this is the fixed speed for playback.



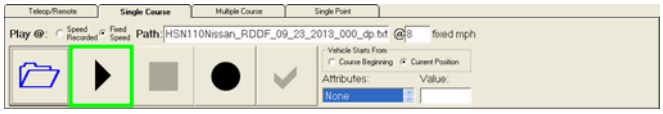




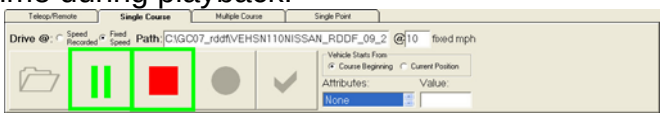
- Vehicle starts from “Course Beginning” or “Current Position” – The path can start and run with one of two goal sets. Playing the course from the current position will cause the Pronto4 to find the shortest path from its current position to the path and then to continue playback to the end of the path. Playing the course from the course beginning will cause the Pronto4 to find the shortest path from its current position to the start of the path and then run the entire course. The system does not have data on the drivability of the terrain, so if there is an obstacle between the vehicle’s current position and the start point, the best option is “Current Position”. If the vehicle has a clear and short path toward the start and end of a loop, starting from the current position would result in only the end of the path being played back. In this case, “Course Beginning” is the better option.

CAUTION
The Pronto4 system does not have data on the drivability of terrain. If there is an obstacle between the vehicle’s current position and the start point, selecting “Course Beginning” may result in damage to the vehicle and terrain.

10. Still in Shepherd, on the “Single Course” tab, click the play button (i.e. black triangle). This will cause the vehicle to release the brake, shift into the appropriate gear and playback the path. In Shepherd it will also cause the play button to turn into a green pause button and the stop button to turn from grey to red.



a. At anytime during playback:

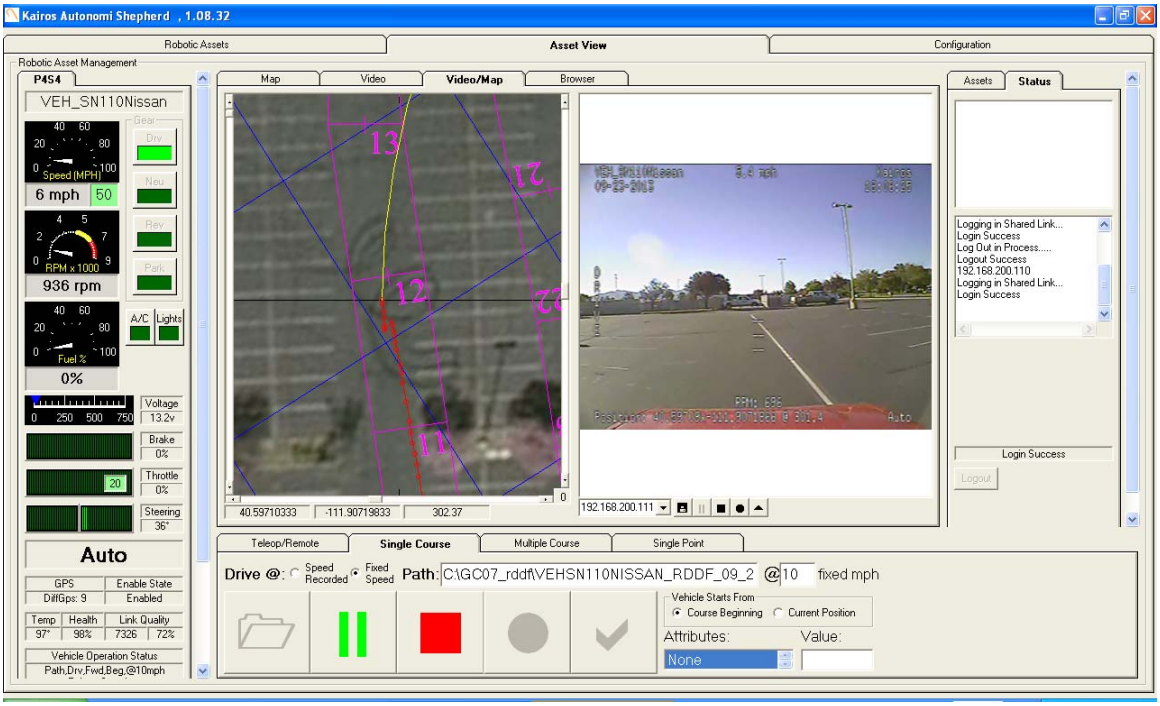


- Path playback can be temporarily paused via the pause button in Shepherd (i.e. double green bars), the OCU E-Stop’s Run/Pause switch, or the VIM’s Run/Pause switch. A VIM pause will cause the vehicle to fully brake and shift to park (or neutral, if applicable). A Shepherd or OCU E-Stop pause will cause the vehicle to fully brake, but stay in its current gear. The path will still be active in the “Single Course” window, and can be resumed from the current location with the corresponding play button or “Run” switch.

- Path playback can be stopped at its current location via the stop button in Shepherd (i.e., red square). This will cause the vehicle to fully brake and shift to park (or neutral, if applicable). The path will no longer be active in the “Single Course” window.
- An emergency stop can be activated from the OCU or VIM E-Stop. This will cause the vehicle to rapidly and fully brake and the engine to be turned off. The path will no longer be active in the “Single Course” window, and the vehicle will need to be restarted.

b. Map interface notes:

- The small red circles indicate current and past logged points.
- The fuchsia lines indicate previous and upcoming sections.
- The crosshairs on the fuchsia lines indicate upcoming target waypoints.
- The yellow line indicates the projected trajectory. If no steering corrections are made by the system, this is the path the vehicle will follow.



11. When playback is complete the vehicle comes to a full stop then shifts to park (or neutral, if applicable), and Shepherd returns to its default state.



12. When the vehicle is completely stopped the OCU operator secures the vehicle, *as follows*:
    a. In Shepherd on the “P4S4” tab, ensure the vehicle shifts to “Park”.
    b. In Shepherd on the “Tele•Op/Remote” tab or via the Tele•Op Controller, ensure the engine is off.
13. If this completes operations for the day, proceed to the Operation Termination section of this document.

Operation Termination

At the end of operations the vehicle shall be secured and stowed.

1. When the vehicle is completely stopped the OCU operator secures the vehicle, *as follows*:
    a. In Shepherd on the “P4S4” tab or via the Tele•Op Controller, ensure the vehicle is in “Park” with brakes at 100%.
    b. In Shepherd on the “Tele•Op/Remote” tab or via the Tele•Op Controller, ensure the engine is off.
    c. In Shepherd, on the “Teleop/Remote” tab, ensure Tele-op is off. The “Tele-op On” button should be in a non-highlighted state (i.e. disabled).
2. When control of the vehicle has been relinquished by the OCU operator, the Safety Operator secures the vehicle, *as follows*:
    a. Ensure safety operator is in the driver’s seat, with seat belt secured, clear of all controls, including the steering wheel, and in a position to activate controls.
    b. Hold the VIM AUTO/MAN switch to the manual override position (past “MAN”) until brake fully releases.
    c. Switch the VIM ON/OFF switch to the “OFF” position.
    d. Disconnect the Transmission Cable.
    e. Manually start and drive the vehicle to its stow location.
    f. Ensure the transmission is in 'Park' (or ‘Neutral’, if applicable).
    g. Engage the parking brake.
    h. Turn off the vehicle engine.

3. Safety operator removes vehicle electrical power from the P4S4 (i.e. disconnect fuse blade holder or open circuit breaker; see Initial System Set-up and Connections Checks step 1).

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