Field Applicator
User’s Guide

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Disclaimer

Information is subject to change without notice.

Cautions

CAUTION: This symbol indicates that failure to follow directions could result in damage to equipment or loss of information.

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GETTING STARTED

Field Applicator overview

The HarvestMaster Field Applicator system automates the application of treatments on field research plots using multi-boom sprayers, in-furrow applicators, cone planters, and fertilizer applicators in conjunction with a GPS receiver. The Field Applicator Plugin along with Mirus software utilizes HarvestMaster actuator modules to control the equipment hardware. This versatile system can be easily moved from different equipment throughout the year as needed. Compared to using multiple control systems, this system uses a single software program called Mirus and a simplified control system, helping to save time and money by not having to retrain personnel on multiple, different systems. Essentially, a user can use the Mirus software across almost all research data collection and equipment control needs.

Mirus installation

Mirus provides the user interface and software control of the field applicator system and is designed to run on a rugged tablet under the Microsoft Windows 10 operating system.

Step 1: Download Mirus from *www.harvestmaster.com*.

Step 2: Run the Mirus software installation on your rugged tablet computer and follow the prompts on the screen.

Step 3: Activate Mirus online at *www.harvestmaster.com/activate*.

GNSS plugin and Field Applicator plugin installation

Mirus software requires the GNSS plugin and the Field Applicator plugin to control the Field Applicator system. Mirus must be installed before installing these plugins.

Step 1: Download the GNSS plugin and the Field Applicator plugin from *www.harvestmaster.com*. The plugin files use the .mbp file extension.

Step 2: Run the .mbp file for the GNSS plugin, and run the .mbp file the Field applicator plugin.

Step 3: Activate the plugins online at *www.harvestmaster.com/activate*.

Treatment maps

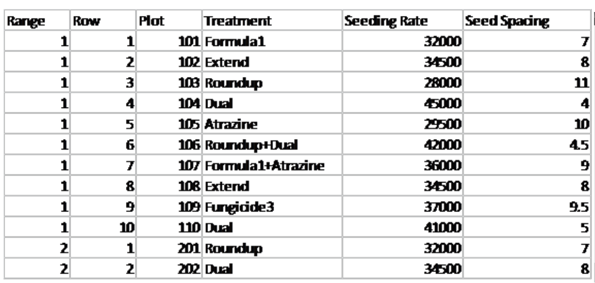
Mirus identifies the treatments for each plot based on a map file. Create your map file outside of Mirus in a spreadsheet or in a text editor, and use Mirus to import the map. Map files must use either the .csv or the .txt format.

Map creation

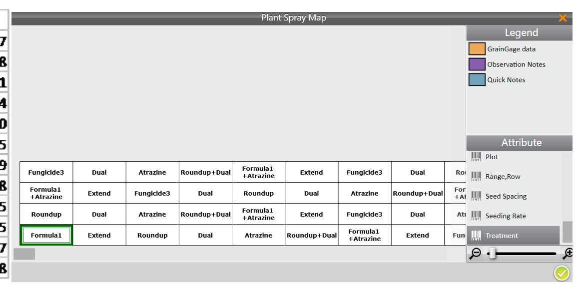
A spreadsheet program or a text editor work well for creating treatment maps.

A treatment is identified by a name consisting of alphanumeric characters (letters and numbers only). To identify multiple treatments for a plot use a plus character between treatment names (e.g. "roundup+formula1").

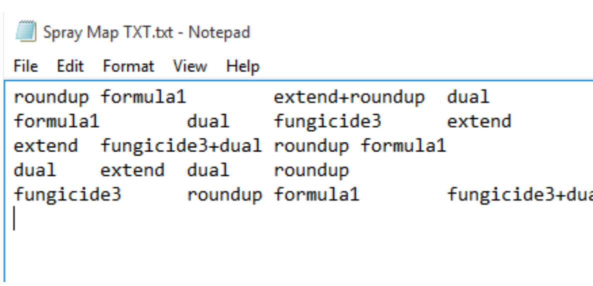
For a map in .csv format, you need to have columns to identify the range, row, and treatments for each plot. The following screenshots show an example of how the information would appear in a spreadsheet, and how the information appears after it is imported into Mirus.



Range	Row	Plot	Treatment	Seeding Rate	Seed Spacing
1	1	101	Formula1	32000	7
1	2	102	Extend	34500	8
1	3	103	Roundup	28000	11
1	4	104	Dual	45000	4
1	5	105	Atrazine	29500	10
1	6	106	Roundup+Dual	42000	4.5
1	7	107	Formula1+Atrazine	36000	9
1	8	108	Extend	34500	8
1	9	109	Fungicide3	37000	9.5
1	10	110	Dual	41000	5
2	1	201	Roundup	32000	7
2	2	202	Dual	34500	8



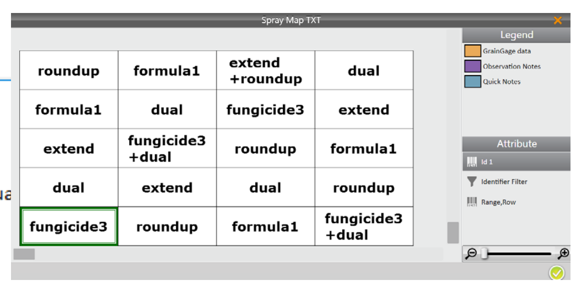
For a map in .txt format, you identify the treatments for each plot in a spatial or grid layout. Plots on a row are separated by a tab. The following screenshots show an example of how the information would appear in a text editor, and how the information appears after it is imported into Mirus.



Spray Map TXT.txt - Notepad

File Edit Format View Help

```
roundup formula1        extend+roundup  dual
formula1        dual    fungicide3      extend
extend  fungicide3+dual roundup formula1
dual    extend  dual    roundup
fungicide3      roundup formula1        fungicide3+dua
```



Treatment map import

After creating a treatment map, import it into Mirus.

Step 1: Open the Mirus software.

Step 2: Select Maps on the home screen.

Step 3: Use the new + icon to create a new map.

Step 4: Choose the option to Import Map From File.

Step 5: Select the map file that you created by browsing to the location where you saved the file on the computer.

2

SYSTEM SETUP

Field Applicator System

The Field Applicator system uses a rugged tablet computer connected to a System Controller, and the System Controller connects to two actuator modules, allowing control of up to 16 solenoids or actuators that activate the sprayers.

System parts

The following table lists the system parts.

PN	Qty	Description	Notes / Purpose	Photo / Drawing
n/a	1	H2 actuator modules with wiring and connectors in enclosure	An enclosure with two actuator modules mounted inside. The actuator modules are wired to connector plugs in the wall of the enclosure. A CAN connector on the enclosure is used for connection to the System Controller, and a Deutsch connector is used for connection to the actuators on the sprayer.	
25030	1	H2 System Controller with RAM mount and two button head screws	The System Controller provides the primary interface between the tablet computer and the other components in the system.	
15332	1	HM8 12 VDC Power Cable, 20 ft	The power cable connects between the battery, or other 12 VDC power source, and the System Controller.	
15334	1	HM8 CAN Terminator	The terminator is used to terminate the unused CAN connection on the outside of the enclosure.	
15336	1	HM8 CAN Communications Cable, 20 ft	The CAN communications cable connects to the System Controller to the actuator modules in the enclosure.	

PN	Qty	Description	Notes / Purpose	Photo / Drawing
15374	1	HM8 HMA-400 Remote Enter Button and Cable Assembly	The remote enter button connects to the System Controller, allowing the operator to manually trigger the applicator to start or stop.	
20363	1	HM8 USB CAN Converter Cable	The CAN converter cable connects the tablet PC to the System Controller.	
25477	1	GNSS/GPS Data Cable	This cable connects between the tablet computer and the GNSS receiver	
26965	1	Deutsch Female Connector Kit	The connector kit provides wiring instructions, contact sockets, a size 16 extraction tool, a size 20 extraction tool, a size 12-16 sealing plug, and a Deutsch female connector. This kit is used to wire actuators on the sprayer into the connector, and the connector plugs into the Deutsch male connector on the actuator enclosure.	

Connection and wiring

The system requires these connections:

- Connect the GNSS/GPS data cable between the GNSS/GPS and the tablet computer.
- Connect the USB-CAN cable between the tablet and the System Controller.
- Connect the remote enter cable to the System Controller.
- Connect the 12 VDC power cable between the battery or power source and the System Controller.
- Connect the CAN cable between the System Controller and one of the CAN ports on the actuator module enclosure.
- Connect the CAN terminator to the unused CAN port on the actuator enclosure.

- Wire the actuators on the sprayer in to the Deutsch connector (refer to instructions provided with the kit or the instructions provided later in this chapter).
- Connect the Deutsch connector to the matching connector on the actuator enclosure.
- Verify that chassis ground is wired to the actuators on the booms of the sprayer.

Actuator wiring connections

The actuator modules in the enclosure are wired to the Deutsch connector in the wall of the enclosure. The following table describes the wiring for this connector.

Deutsch connector pinout	Signal	HM module reference	Port	Pin	HM wire color
1	Boom 1	Actuator 1	1	1	red
2	Boom 5	Actuator 1	1	2	black
3	Boom 2	Actuator 1	2	1	red
4	Boom 6	Actuator 1	2	2	black
5	Boom 3	Actuator 1	3	1	red
6	Boom 7	Actuator 1	3	2	black
7	Spare				
8	Boom 4	Actuator 1	4	1	red
9	Boom 8	Actuator 1	4	2	black
10	Boom 9	Actuator 2	1	1	red
11	Power supply, positive				red
12	Boom 13	Actuator 2	1	2	black
13	Boom 10	Actuator 2	2	1	red
14	Power supply, ground				black
15	Boom 14	Actuator 2	2	2	black
16	Boom 11	Actuator 2	3	1	red
17	Boom 15	Actuator 2	3	2	black
18	Boom 12	Actuator 2	4	1	red
19	Boom 16	Actuator 2	4	2	black
20 to 35	Ground				

To wire the actuators to the Deutsch connector, you need wire strippers and the Deutsch HDT-48-00 crimp tool. For instructions on how to set and use the crimp tool, open YouTube and enter the address: *MqXcaNVwpvI*.

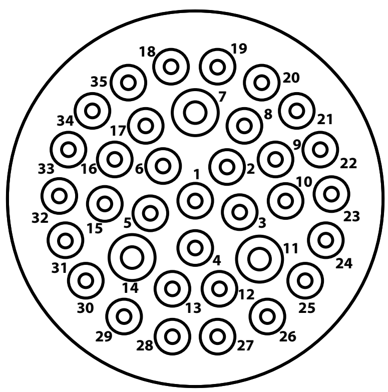
Deutsch HDT-48-00 crimp tool

Use the information in the pinout table to populate the Deutsch HDP26-24-35SN connector.

Install the sealing plug in position 7.

Connect the Deutsch connector to the matching connector on the enclosure.

The following drawing shows the physical layout of the pins in the Deutsch connector.



Back side of connector

GNSS/GPS setup

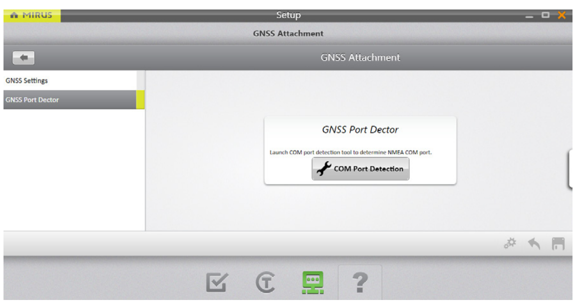
The GNSS/GPS receiver may need to be configured to communicate with Mirus. Follow the instructions provided for your GNSS/GPS receiver. You also need to configure Mirus to communicate with the GNSS/GPS.

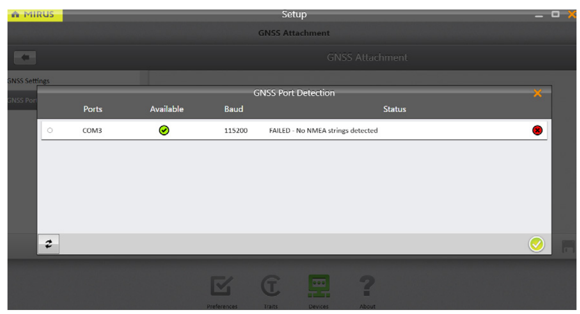
Step 1: Refer to instructions for configuring your GNSS/GPS receiver. On the receiver, enable GGA and VTG for machine control, enable GST or RRE for Estimated Horizontal Error (EHE), and enable GSV to show the satellites.

Step 2: With wiring complete and connected, power on the GNSS/GPS and the HarvestMaster Field Applicator system.

Step 3: Open Mirus, and navigate to the Setup menu without connecting to any plugins.

Step 4: In the Setup menu, select GNSS settings and the GNSS Port Detector. This feature will automatically find the COM port on which the GNSS receiver is connected.

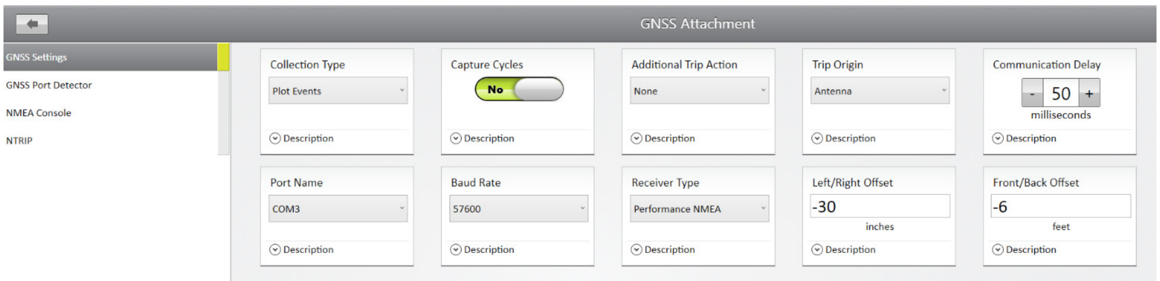




Step 5: Select the port that is detected by the software, and go to GNSS

settings and set the correct COM port. Use these settings:

- Collection Type: Plot Events
- Capture Cycles: no
- Additional Trip Action: None
- Trip Origin: Antenna
- Receiver Type: Performance NMEA

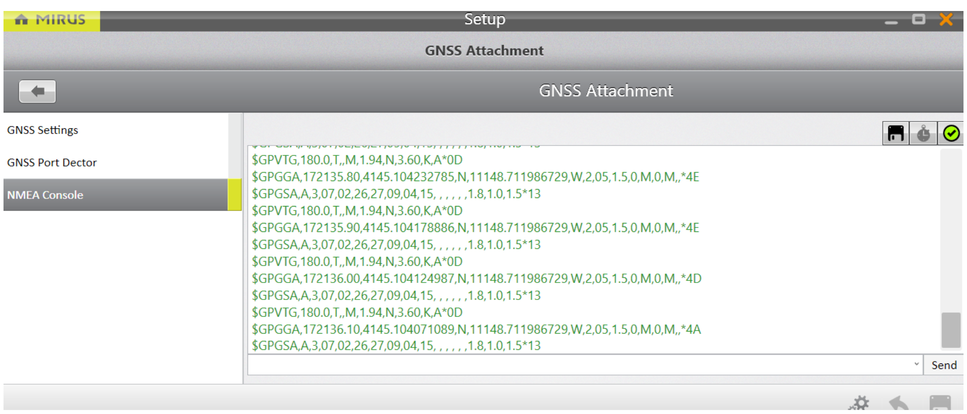


Step 6: Save the settings and then navigate to the Mirus Home screen.

Step 7: Connect the Field Applicator plugin under devices tab.

Step 8: Connect the GNSS Attachment under the attachments tab.

Step 9: Once connected, use the diagnostics view or the NMEA console view to verify that Mirus is receiving live GNSS data.



Applicator setup

In Mirus, navigate to Setup > Planter > Offsets. The applicator settings should be configured as follows:

Offsets

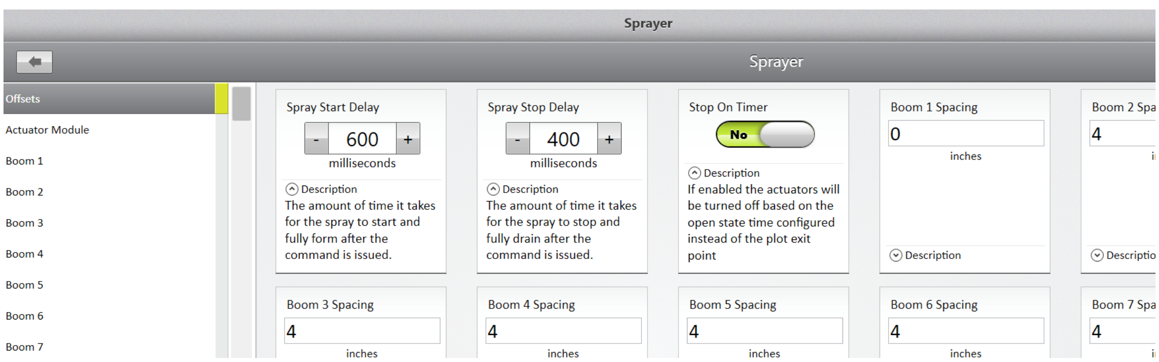
Spray Start Delay: The amount of time it takes for the spray to fully form and reach the target application height (i.e. canopy or ground). To begin, use a setting of 100 to 300 ms, and then calibrate as needed.

Spray Stop Delay: The amount of time it takes for the spray to stop. Use an initial setting of 250 to 500 ms, and then calibrate as needed.

Stop On Timer: If enabled, this uses the Open State Time for each actuator instead of the plot exit point. This setting helps for controlling a cone planter, or instances where the actuator may not need to be open the entire distance of the plot. For example, Mirus will raise the cone to drop seeds and then drop the cone once the Open State Time has expired.

Boom 1 Spacing: Always set this to 0.

Boom X Spacing: For boom 2 and higher, set the spacing to the actual measured distance between the booms.



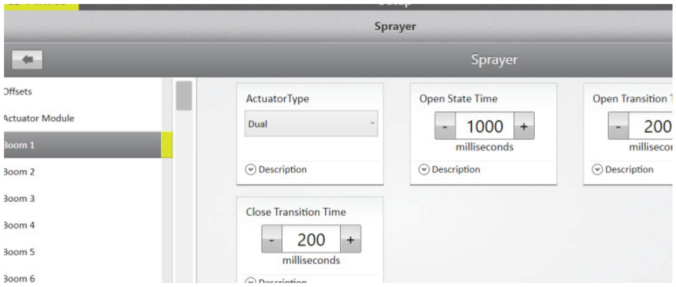
Actuator Module

Flush Enabled: This sets the last actuator enabled to be the flush. This allows multiple treatments to be applied with a single boom. The boom is flushed with water in the alley. For example, if the last actuator is enabled (set to “dual”), that last actuator in the list will be used as the flush. For example, if actuators 1 through 12 are enabled, actuator 12 will be used as the flush.

The actuator that is set to flush will used the sum of the open state time, open transition time, and the close transition time as the amount of time the flush is open. This time and the alley length will determine the maximum speed at which you can travel.

Actuator boom settings

Actuator Type: To enable this actuator, set to Dual. To disable this actuator, set to None.



3

CALIBRATION

Calibration

When properly calibrated, the field applicator works at different speeds and with plots and allies of different dimensions.

The process of calibrating the Field Applicator and GNSS plugins requires two main steps: calibrating the setback (offsets) and aligning the spray.

Generally calibration is only required once. But certain changes to the system could require recalibration. The following factors will require recalibration:

- If the GNSS/GPS receiver is changed to a different model, perform recalibration for the communication delay as it may be different for different models.
- The setback may change if the applicator is being used with a different tractor or if the GNSS/GPS antenna is moved to a new position, and for situations like these the setback needs to be re-calibrated. When the applicator/sprayer is located behind the GNSS/GPS, the front/back offset is negative.
- For new solenoids, actuators, nozzles, or change to system pressure, calibration will need to be performed again.

Prepare for calibration

Before calibration, please review these considerations.

- Ensure all solenoids or actuators are in good condition. Valves that are sticky or do not shut off completely adversely affect your application and make calibration extremely difficult.
- Inspect diaphragm check values or ball screen valves for proper shut off. Turn on the boom or spray nozzle and wait for product to come out, and then shut it off. Verify that product stops flowing in less than 1 second.
- Solenoid valves should be located as close to the nozzles as possible to limit the amount of hose or pipe length that is pressurized with product because having an unnecessary amount of product in the hose or piping will increase the amount of time for the system to stop spraying.

Calibrate the setback (offsets)

The setback is the distance between the center of the dome of the GNSS/GPS antenna and the first boom. The first boom refers to the first boom to enter the plot as you are driving.

Please note that the setback is a fixed, real-world value. Do not artificially adjust the setback value to align spray placement because this will cause problems when changing speeds.

Measure the front/back offset

Using a tape measure, find the distance from the GPS/GNSS receiver antenna to boom 1. Boom 1 is the first boom to enter the plot in the direction of travel.

The front/back offset distance is positive if boom 1 is located in front of the GPS/GNSS receiver antenna. The front/back offset distance is negative if boom 1 is located behind the GPS/GNSS receiver antenna.

Enter the offset distance into the GNSS setup menu for the Front/Back Offset.

Measure the left/right offset

Using a tape measure, find the distance from the GPS/GNSS receiver antenna to the center of the working equipment. For a distance to the left of center, the offset is negative, and for a distance to the right of center, the distance is positive.

Enter the offset distance into the GNSS setup menu for the Left/Right Offset.

Spray alignment with plots

With setback and offsets properly set, make sure the spray is calibrated to start as the boom enters the plot and to stop as the boom leaves the plot.

Three key factors influence how well the spray can be aligned to start as the boom enters the plot and stop as the boom leaves the plot: GNSS/GPS accuracy, GNSS/GPS communication delay, and spray start/stop delay associated with the mechanics of the actuator.

GNSS/GPS accuracy

The accuracy of the GNSS/GPS receiver affects how well the sprayer aligns to the plots. Mirus cannot compensate for misalignment that is due to lack of accuracy from the GNSS/GPS receiver. For example, consider a scenario in which an RTK receiver provides accuracy of 2 cm, the system will have up to 2 cm of stagger in both directions and could appear to be off by as much as 4 cm. Because of this factor, allow for a certain degree of imperfection in aligning the spray with the plot.

GNSS/GPS communication delay

The time for the GNSS/GPS receiver to transmit the current position to the tablet computer is a critical factor, and Mirus provides the capability to calibrate for this delay.

Actuator start/stop delay

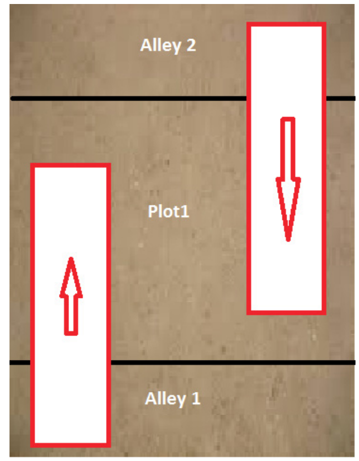
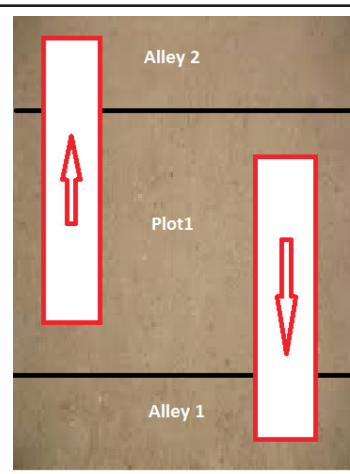
The mechanics of the actuator introduce delay from when Mirus sends the signal to start or stop spraying to when spray actually starts or stops, and the delay can be different for starting spray and stopping spray. Mirus provides settings to adjust the Spray Start Delay and the Spray Stop Delay.

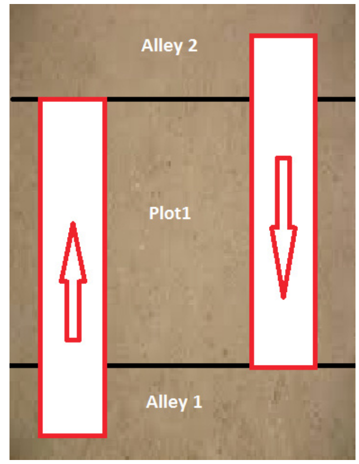
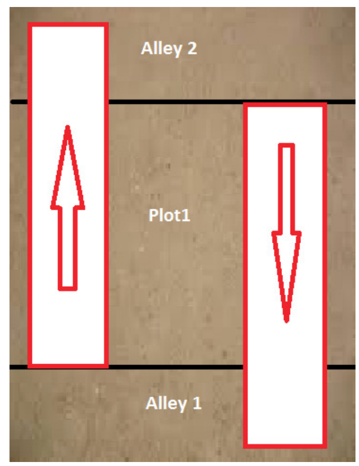
Setting delays in Mirus

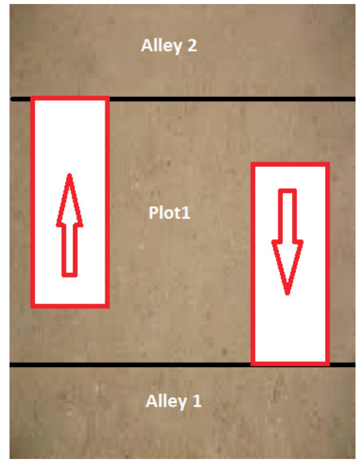
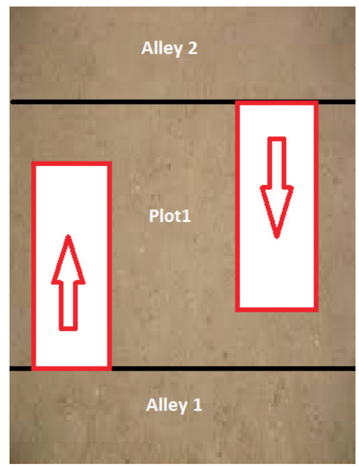
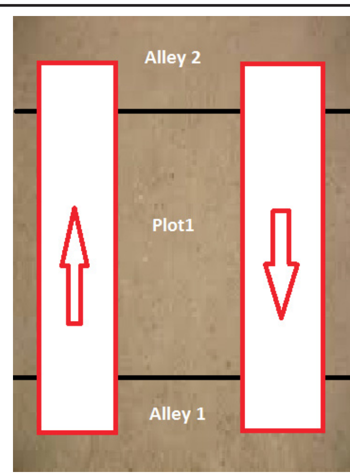
Considering the stagger that can be introduced from GNSS/GPS accuracy, it can be difficult to determine which delays need to be adjusted. And if the spray start delay and spray stop delay happen to be exactly the same, it can be difficult to tell whether to adjust the start/stop delays or to adjust the communications delay because the end result is the same. But changing the communications delay also affects the GPS positions that are saved to the database, and so it is important to adjust the right parameters.

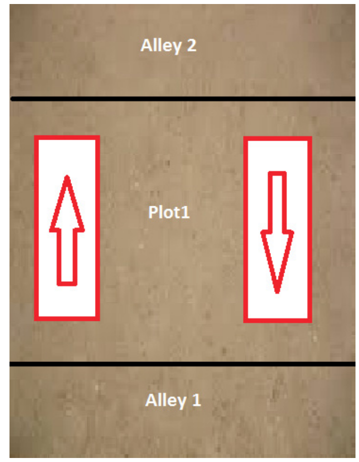
To calibrate the spray properly, make sure to drive at least 2 passes at the same speed, preferably the same speed as when you actually spray the plots.

The following scenarios outline likely issues and provide guidance for making adjustments in the Mirus settings.

Issue description	Possible causes	Diagram
Scenario 1: The spray starts too early (before entering the plot) and ends too early (before leaving the plot). But the spray length is correct and is staggered backward.	This could be due to: • communication delay set too long, • both spray start delay and spray stop delay set too long, or • setback set too short. Note: Communication delay being too long is more likely than having both the spray start delay and spray stop delay off by the exact same amount. Note: Setback is unlikely, if you properly calibrated the setback previously. But you can tell if set back is the issue by testing at different speeds (fast and slow). Setback is the problem if the stagger remains the same at fast and slow speeds. Delay settings are the problem if the spray becomes longer at higher speeds.	
Scenario 2: The spray starts too late (after entering the plot) and ends too late (after leaving the plot). But the spray length is correct and is staggered forward.	This could be due to: • communication delay set too short, • both spray start delay and spray stop delay set too short, or • setback set too long. Note: Communication delay being too short is more likely than having both the spray start delay and spray stop delay off by the exact same amount. Note: Setback is unlikely, if you properly calibrated the setback previously. But you can tell if set back is the issue by testing at different speeds (fast and slow). Setback is the problem if the stagger remains the same at fast and slow speeds. Delay settings are the problem if the spray becomes longer at higher speeds.	

Issue description	Possible causes	Diagram
Scenario 3: The spray starts too early (before entering the plot) and stops correctly at the end of the plot. The spray length is too long.	The spray start delay is too long. It takes less time to start spraying than what the open transition time is indicating on the sprayer actuator. Note: Be sure to measure the spray length because this scenario could be confused with scenario 1, especially if you do not know exactly where the true alleys should be.	
Scenario 4: The spray starts correctly at the beginning of the plot but ends too late (after leaving the plot). The spray length is too long.	The spray stop delay is too short. It takes less time to stop spraying than what the close transition time is indicating on the sprayer actuator. Note: Be sure to measure the spray length because this scenario could be confused with scenario 2, especially if you do not know exactly where your true alleys should be.	

Issue description	Possible causes	Diagram
Scenario 5: The spray starts too late and is too short, but ends correctly.	The spray start delay is too short. It takes more time for the actuator to move and the spray to form than what the open transition time is indicating on the sprayer actuator. Note: Be sure to measure the spray length because this scenario could be confused with scenario 2 or scenario 4, especially if you do not know exactly where the true alleys should be.	
Scenario 6: The spray starts correctly at the beginning of the plot, but stops too early, and the spray length is too short.	The spray stop delay is too long. It takes less time for the actuator to move and the spray to form than what the close transition time is indicating on the sprayer actuator. Note: Be sure to measure the spray length because this scenario could be confused with scenario 1 or scenario 3, especially if you do not know exactly where the true alleys should be.	
Scenario 7: The spray starts early and ends late, but does not stagger.	The spray start delay is too long, and the spray stop delay is too short. Note: This scenario is unlikely. Make sure the issue is not one of the other scenarios before making changes.	

Issue description	Possible causes	Diagram
Scenario 8: The spray starts too late and ends too early, but does not stagger.	The spray start delay is too short, and the spray stop delay is too long. Note: This scenario is unlikely. Make sure the issue is not one of the other scenarios before making changes.	

4

OPERATION

Operation

This section covers instructions for field application. Be sure that calibration and system setup have already been completed.

Map selection and treatment setup

For manual cycling and automatic GNSS/GPS cycling, you need to open the map and identify the treatments.

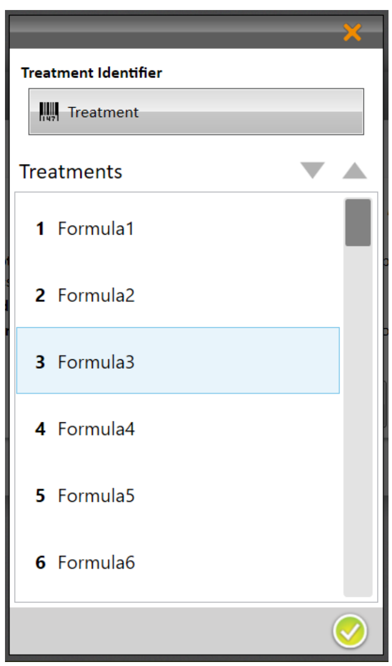
Step 1: Open Mirus.

Step 2: On the Mirus home screen, select the Maps icon and then choose the map for the field you would like to spray.

Step 3: Choose the option for Sprayer Setup.

Step 4: Mirus displays a treatment identifier window. If the map was imported from a .csv file, select the column heading for the column that lists the treatments. In the screen shot that follows, the column is labeled "Treatment." If the map was imported from a .txt file, the identifier will be "ID1."

Step 5: Mirus displays all of the treatment names from the map file and associates them with a boom number. Move the treatments to the correct booms by highlighting a treatment and using the up/down arrows to move to the desired boom number.



Step 6: When the treatments are listed with the correct boom numbers, use the green check mark icon in the bottom corner of the window to save these settings.

After selecting a map and setting up treatments, you can setup the system for automatic cycling or manual cycling. Automatic cycling triggers the sprayer system automatically, using GNSS/GPS. Manual cycling triggers the sprayer system when using the remote enter button. The following sections provide instructions for using these modes.

Automatic GNSS/GPS cycling

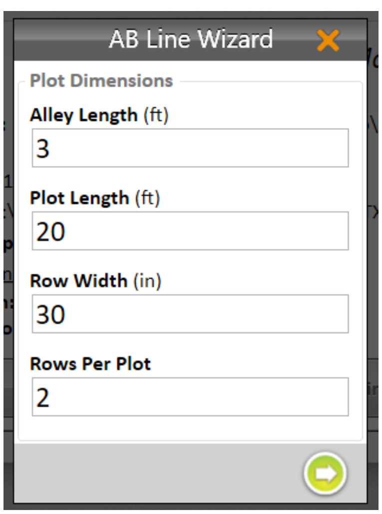
Follow these instructions after completing the instructions in the previous section for selecting a map and setting up treatments in Mirus.

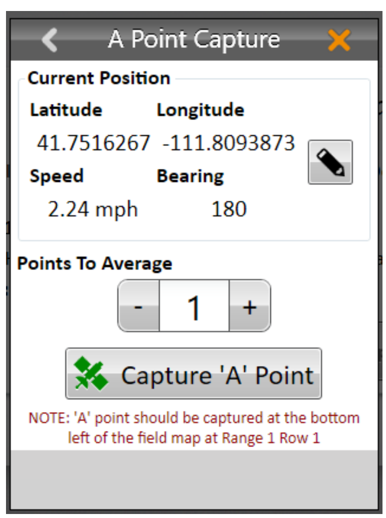
Step 1: Select the AB Line button to open the AB Line Wizard. Mirus uses the AB line to calculate the locations of plots in the field to automatically start the sprayer when entering a plot and to automatically stop the sprayer when leaving a plot.

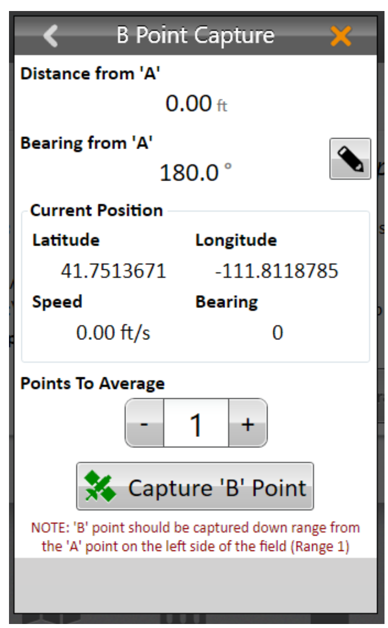
Step 2: Enter the plot dimensions, and save this information by selecting the green arrow button (see the following screenshot).

Step 3: Capture the A point by positioning the GNSS/GPS at the lower left corner of the plot (Range 1, Row 1).

Step 4: Establish a bearing by either entering a bearing, if it is known, or by moving several plots through the field to capture the B point along the left edge of the field. The accuracy of the bearing will tend to be better when there is a long distance between the A point and the B point. If these points are captured at a short distance, the bearing could have some error in it (see screen shot below).

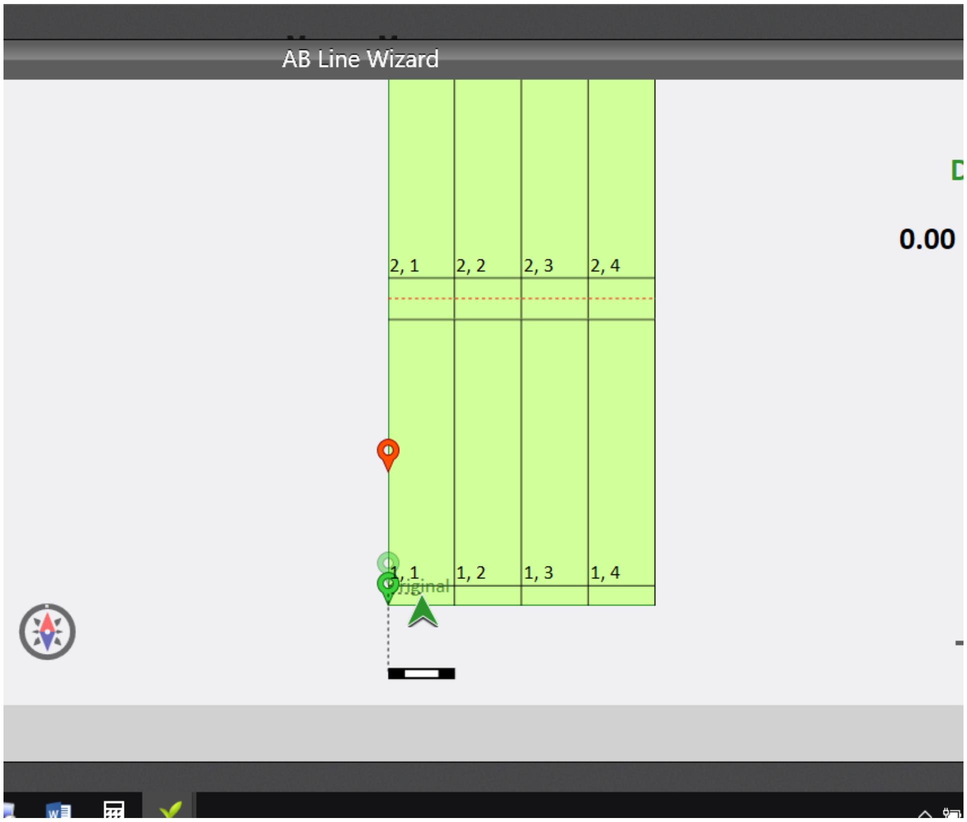






Step 5: After saving the AB line, use the Spray button.

Step 6: In the Harvest Setup window, select the starting plot, and then use the green arrow button to proceed to the next step.



Step 7: Select the green arrow again in the data sources window.

Step 8: In the sprayer configuration window, select Auto, and then use the green check mark.

Note: Manual operation is covered in the following section.

Step 9: In the Harvest view (quad view), choose the views that you would like to display, and then press the flashing Start button. Be sure that you are not in the field when you select start because the system will begin spraying. For best results, move the sprayer back to a position outside of the plots (near your starting location), and start moving into and through the plots at your target speed.

Step 10: Proceed through the plots at a consistent speed, and Mirus triggers the sprayers automatically.

Manual cycling

Use these instructions after completing the instructions in the previous section for selecting a map and setting up treatments in Mirus.

Be sure that the remote enter button is connected to the System Controller.

Step 1: Select Manual (instead of Auto) in the collection setup window.

Step 2: In the quad view, select the Start button to initiate the system.

Step 3: A button press on the remote button starts the spray application for the plot.

Step 4: Drive through the plot while spraying, and then press the remote enter button again to stop the spray application.

Step 5: When entering the next plot, press the remote enter button again to start the application.

Step 6: Drive though the plot, and then press the remote enter button to stop the application.

Step 7: Continue to drive through the plots, using the remote enter button to cycle the sprayer on and off.