

Create and Use Field Boundaries



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Boundary Overview

Boundaries are a foundational piece of precision agriculture. When created correctly and accurately, boundaries can be a very powerful tool and provide tremendous value to an operation. Boundaries tell the operator and machine the size, shape, and working area of a field. Whether hand drawn in Operations Center for field detection purposes or driven to achieve Autonomy quality for use with autonomous solutions, boundaries offer a great deal of insights to an operation and are required for many technologies to function.

Definitions

Exterior Boundaries are used to define the outer perimeter of the workable area of the field. Boundaries tell the machine and operator the size and shape of the field. This boundary also is key in mapping field location, utilizing machine guidance, and executing work. Exterior boundaries are essential, whether just starting to implement precision ag technology in an operation or preparing for autonomy. There is value that comes from boundary creation for every customer. Exterior boundaries appear pink within the display and Operations Center. This showcases that the boundary is impassable, and work should only occur within the created shape. A great example of the capabilities of an exterior boundary are seen with Section Control. Work is only completed within the boundary and sections are turned off as they cross outside of the boundary.

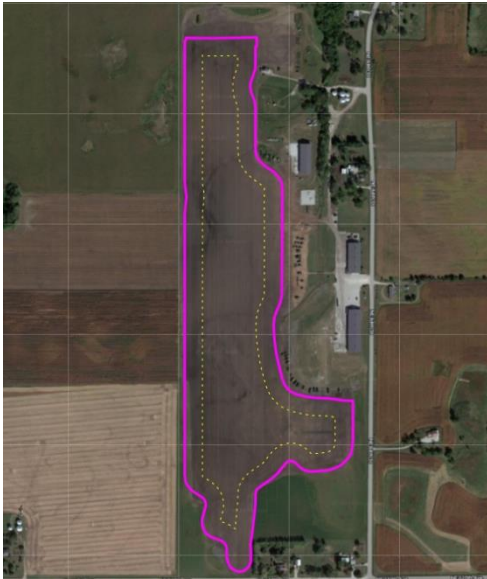


Exterior boundaries can be created in different ways – driven using a receiver and display, created from previous coverage, hand drawn in Operations Center, or imported from another system. More information on each creation type is included later in this document.

An exterior headland is associated with an exterior boundary and tells the machine where end of row turns should occur. Headlands are dashed yellow in the display and Operations Center. Headlands are crucial for technologies like ATTA, AutoPath, and Autonomy.

There are several types of headlands. The first is a driven headland which is created by driving a custom path in the field using a display and receiver. Once driven, that headland can be saved and shared to Operations Center. Driven headlands are not supported with Machine Guidance and Automation.

The two other headland types shown below can be created in the display or within Operations Center.



Constant Offset

Enter the width of the desired headland and the system will automatically offset that distance from the exterior boundary to create the headland.

This headland type is required for Autonomy.



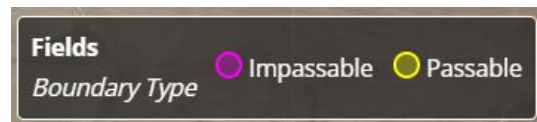
Top and Bottom Offset

Input the heading angle followed by the width of the desired headland. The system will offset that distance from the exterior boundary at each end of the field according to the heading angle.

Interior Boundaries are used to mark the perimeter of a non-operational area in a field.

There are two types of interior boundaries:

1. An impassable boundary represents a line that should not be crossed by a machine or implement. Impassable boundaries are pink within the display and Operations Center. An example would be a tree line, power lines, or a ditch.
2. A passable boundary represents a line that can be crossed by a machine and implement but when crossed, no work should be completed in that area. Passable boundaries are solid yellow within the display and Operations Center. An example would be a shallow waterway that can be driven through but should not be sprayed.



An interior headland is created and paired with an interior impassable boundary. This type of headland is often used with ATTA and compatible guidance tracks to establish a turn area within the field to complete work more efficiently.

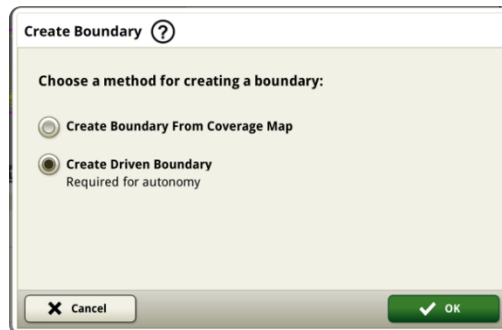


Boundary Creation Methods

Boundaries can be created in multiple ways:

1. Driven

Customers can drive boundaries using a machine equipped with a receiver and display. Using this creation method allows customers to precisely outline the outer edge of the working area of the field. In the display, navigate to Fields and Boundaries, identify the desired Client Farm Field, choose to create boundaries, and select “create driven boundary”. Driven boundaries are required to achieve a verified level of accuracy and system requirements needed for use with autonomy.



Many customers use a Gator equipped with the required technology to map boundaries. This allows for very precise movements around obstacles, curves, and corners to map the most accurate representation of the working area. Ensure that TCM Calibration has been completed prior to recording.



In the example on the left, a ‘buffer bar’ has been added to the front of the Gator. This gives the operator a visual reference as they drive and record a field boundary, of where any implement overhang, like the planter marker, will be located when traveling past an obstacle near the edge of the field.

The operator must position the Gator to avoid the rod contacting the obstacle. When the operator does this, the boundary is recorded a safe distance from the obstacle to prevent damage during later operations completed using that boundary.

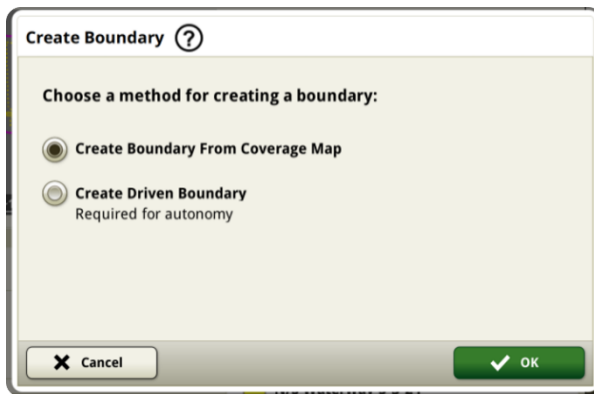
This method is **HIGHLY** recommended when driving a field boundary to prevent machine contact with objects along the border. More information can be found in the best practices section and the appendix.

2. From Previous Operation

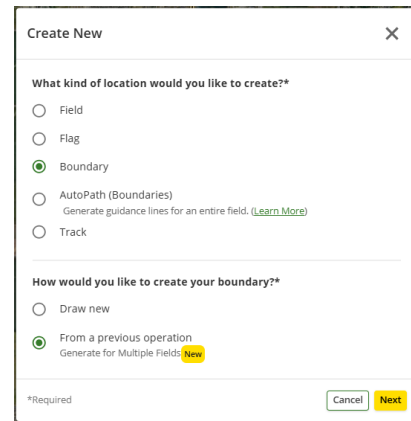
Boundaries can be created from previous coverage in the display or in Operations Center.

In the display, navigate to Fields and Boundaries, identify the desired Client, Farm, and Field, choose to create boundaries, and select “create boundary from coverage map”. Select which past operation in that field should be used to create the boundary. The field boundary will be established from the outer edge of coverage logged in that operation.

In Operations Center, navigate to Land, click the Add icon, select boundary, and choose “from a previous operation”. Preview, create, and save multiple boundaries at once using this tool. Select multiple fields from the list and choose the previous operation that you want the boundaries to be created from. Next, preview the individual fields and, if needed, adjust the operation used to create the boundary. Save when all boundaries reflect the area you desire.



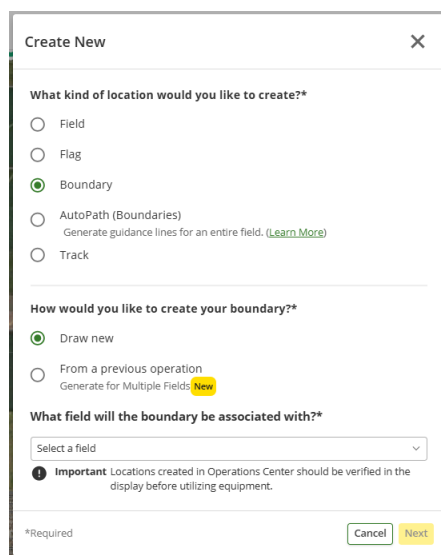
*From coverage map
on the display*



*From a previous operation
in Operations Center*

3. Hand Drawn in Operations Center

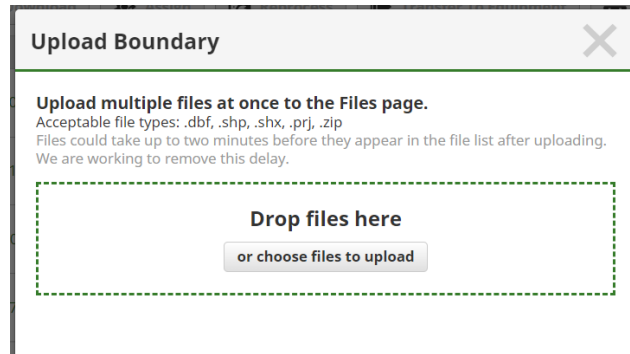
In Operations Center, navigate to Land, click the Add icon, choose to create a new boundary, and select “draw new”. Select the field that you want to create a boundary for. Use the computer mouse to create the shape around the field edge.



Keep in mind that the map in Operations Center is not a live view of the geographical area. Additionally, the map is in reference to meters which is not accurate enough to reflect some changes that can be at the centimeter scale. This creation method is a great way to identify and mark field areas for an organization, but it is not considered accurate enough to use with most technologies.

4. Imported from a legacy or third-party source

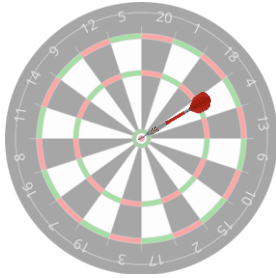
If a boundary was created using a legacy John Deere display or a third-party source, a shape file can be imported into Operations Center. First, you need to export the file that includes the boundary from the other system using a USB. Then use the “Upload Boundary” button on the Operations Center Files page. Upload the shape file from the USB into Operations Center. Once it has been recognized and uploaded, the file type will show as “setup data” and the boundary will appear in Land.



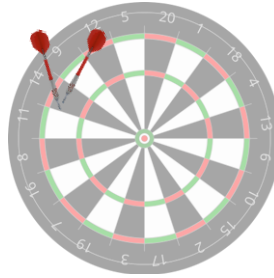
Each of these creation methods offer a different level of accuracy of the data points that make up the boundary. This means that there are different recommended uses and technologies supported for each creation method. This will be explained more later in this resource.

Correction Modes

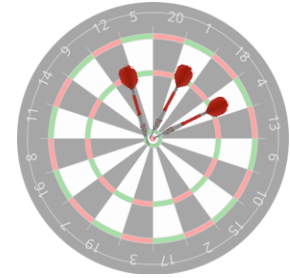
Before looking deeper into boundary quality, it is important to understand signal types. Signal types or correction modes dictate the level of accuracy and repeatability possible for the boundary. Think about playing a game of darts. Accuracy is how close you can get to the bullseye. Repeatability is how many times you can place a dart in the exact same place on the board consecutively. A highly successful dart player has both accuracy and repeatability. They can hit the bullseye every single time.



Accurate



Repeatable



Accurate & Repeatable

For a farmer, accuracy and repeatability are just as important when it comes to preparing, planting, protecting, and harvesting crops. As a farmer records a boundary, they want the line to track exactly where they intended. The reality is that whether hand drawn, created from coverage, or driven, each boundary creation method offers a different level of accuracy. Below is a table that showcases the difference between each signal type.

	SF1	SF2	SF3	Radio RTK	SF-RTK
Pull In Time	10 minutes	90 minutes	30 minutes	Less than 1 minute	8 minutes
Accuracy	+/- 15 cm	+/- 5 cm	+/- 3 cm	+/- 2.5 cm*	+/- 2.5 cm
Repeatability	none	none	9 months	long-term repeatability	long-term repeatability**
Receiver Compatibility	StarFire™ 3000 StarFire™ 6000 StarFire™ 7000 StarFire™ 7500	StarFire™ 3000	StarFire™ 6000	StarFire™ 3000 StarFire™ 6000 StarFire™ 7000 StarFire™ 7500	StarFire™ 7000 StarFire™ 7500

*Within 12 miles of the Base Station

**Refer to sales manual for geographical limitations

Important Notes

- Do not mix and match correction signals. Doing this results in decreased accuracy of field work.
- The same correction mode must be used when creating the boundary and when using the boundary. For example, if a boundary that was created using RTK is loaded into a machine to be used with an operation running SF1, it will only be as good as SF1. The exception to this rule is SF3 and SF-RTK. These signals can be mixed throughout a crop cycle.
- If using Radio RTK, refer to this video to learn how to add, edit, and view Base Station information. You will see how to correctly associate the Base Station with the field and enable “Automatic Base Station Switching” to keep the Base Station up to date when moving between fields.



Boundary Quality

John Deere is developing solutions to support customers wherever they are on their technology journey. Continued work will go into developing further enhancements to boundary creation to better the overall experience for all customers. Let's dig into the boundary quality levels, how to create each type, and the recommended use cases for each.

Display Quality	Not Autonomy			Autonomy
Operations Center Quality	Unknown	Basic	Advanced	Autonomy
Method	---	Imported Hand Drawn From Previous Operation Driven	Driven	Driven
Correction Mode	---	Digitized SF1 SF2	SF3 RTK RTKX mRTK SF-RTK	RTK RTKX SF-RTK
Additional Requirements	None	None	None	All items on the Details checklist must be fulfilled
Editing	No editing restrictions	No editing restrictions	No editing restrictions	Edits that shrink the boundary are allowed; Edits that expand the boundary are <u>not</u> allowed.
Recommended Use Cases	Use with discretion	Maps Reporting Field detection Weather Logistics Predictive Ground Speed Automation	All Basic use cases plus: Section Control AutoTrac (Boundary Track) AutoTrac Turn Automation AutoTrac Implement Guidance AutoPath (Rows) AutoPath (Boundaries) Machine Sync	All Advanced use cases plus: Autonomy <i>Autonomy boundary quality is a requirement for use with Autonomous Solutions.</i>

Autonomy Boundaries

Autonomy boundaries achieve the level of accuracy and system requirements that deem them usable for the level of safety and precision needed by autonomy. Autonomy boundaries are required for autonomous operations.

Autonomy boundaries can be used with Premium 3.0, Automation 4.0, and G5 Advanced features but are not required.

Requirements

Display	Gen 4 V2 (Integrated or Universal) G5 / G5 Plus (Integrated or Universal)
Display Software	24-2 or newer
Machine or Implement Receiver*	StarFire™ 7000 or StarFire™ 7500
Correction Mode**	Radio RTK or SF-RTK

*Autonomy Boundaries can be recorded using either a StarFire™ 7000 or StarFire™ 7500. Autonomous machines require a StarFire™ 7500 to run autonomy.

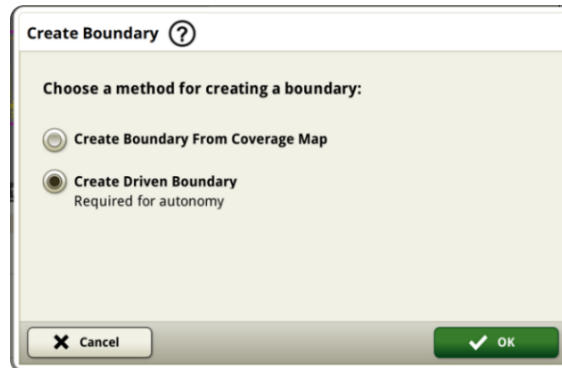
**Shared signal can be used to record an Autonomy Boundary. Refer to the appendix to understand further shared signal requirements to achieve an Autonomy Boundary.

Creating an Autonomy Boundary

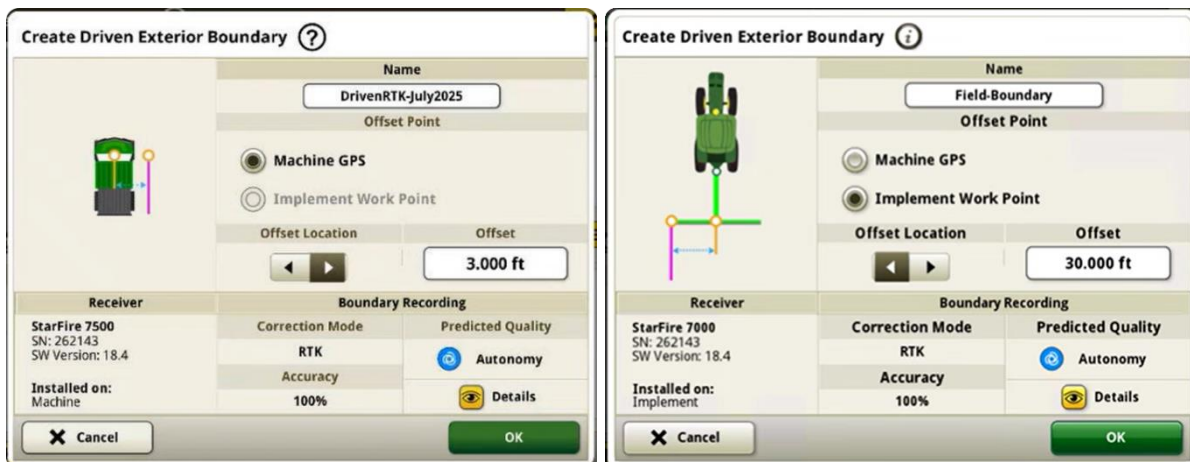
Refer to the best practices and troubleshooting section for further assistance when creating an Autonomy Boundaries.

1. Begin creating a boundary

- Drive to the location in the field where you want to start recording the boundary.
- To record an Autonomy boundary, the driven creation method must be used. All other creation methods will result in a Not Autonomy boundary.

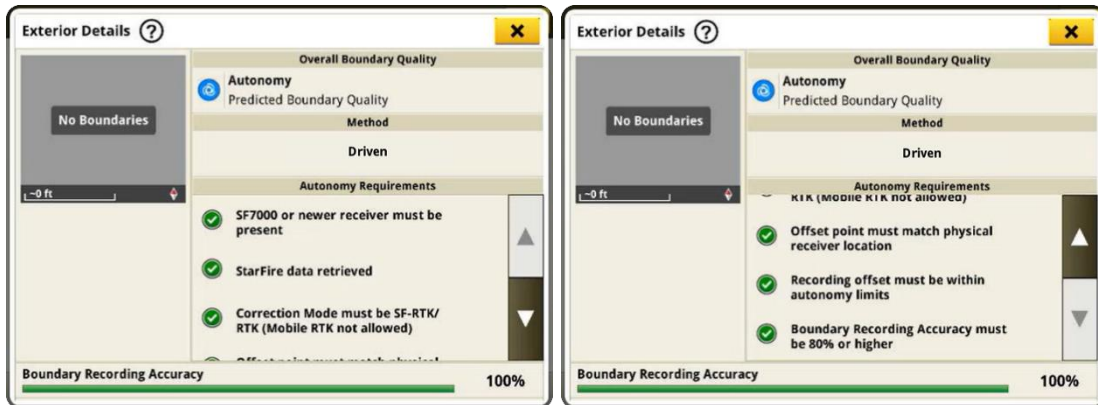


2. Complete setup and verification steps prior to recording



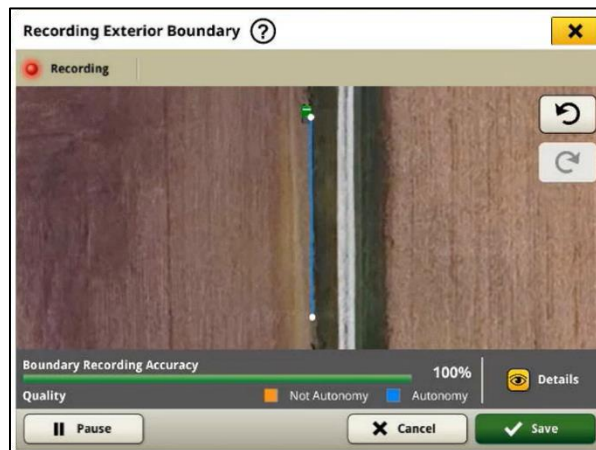
- Input a boundary name. Consider including Details about creation method, correction mode, or recording date to assist with ease of use later on.
- Determine if you are using a machine or implement mounted receiver for recording. Ensure that the receiver is mounted on that selected location – machine or implement. The correct selection must be made so that an accurate reference point is used during recording.
- Set a left or right offset if needed and input the correct offset measurement. The offset is based on where the center of the receiver is located to the outermost point of the machine/implement - where the boundary should be placed while recording. Input zero into the offset measurement if no offset is being used and the boundary should be placed at the center of the receiver location.
 - If using a machine receiver, the offset should be $\frac{1}{2}$ the machine width measurement. The overall entered offset must be less than 4 meters (13 feet).
 - If using an implement receiver, the offset should be $\frac{1}{2}$ the working width measurement. The overall entered offset must be less than 16 meters (52 feet).
 - Refer to the best practices section for more information about using a 'buffer bar' when recording.
- The Receiver and Correction Mode will automatically populate based on the Offset Point selected.
- Accuracy refers to the overall boundary recording accuracy, not the signal accuracy that is found in the receiver settings. Boundary recording accuracy factors in different data inputs that allow the system to adequately determine each point's reference location when recording. This percentage can also be found on the Details page by clicking the Details button.

- Ensure that the predicted quality shows “Autonomy”.
 - If predicted quality shows “Not Autonomy”, click the details button to review the specific system requirements and fix any qualifications that do not show a green check mark prior to recording.
 - Prior to recording, the Details page shows the predicted quality based on current prerequisites met.

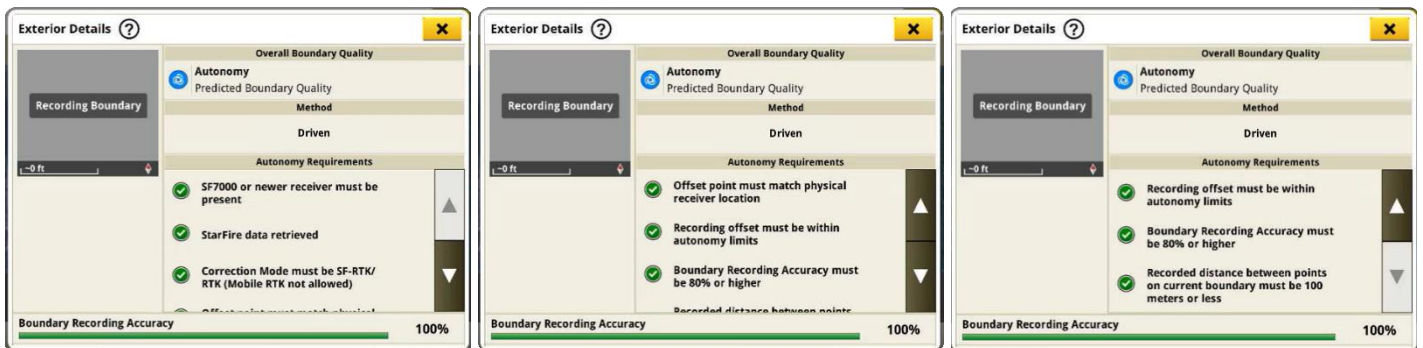


3. Record the boundary

- Begin driving the boundary. Keep in mind that you can review the Details page at any time to ensure all system requirements remain checked.



- While recording the boundary, the top half of the Details page shows a summary of the status for the entire recorded boundary thus far. While the Autonomy Requirements section shows the status of current requirements that are or are not met at that particular moment of recording.



- While recording, a dashed line will showcase a connection from the current point to the starting point.
 - If the dashed line is **orange**, the distance between points is greater than 100 meters and/or prerequisites are not met
 - If the dashed line is **blue**, the distance between points is less than 100 meters and all prerequisites are met.



If saved at this time, the **orange** portion of the boundary would be Not Autonomy meaning the entire boundary would be Not Autonomy.

If saved at this time, the **blue** portion of the boundary would be Autonomy and the entire boundary would be classified as Autonomy.

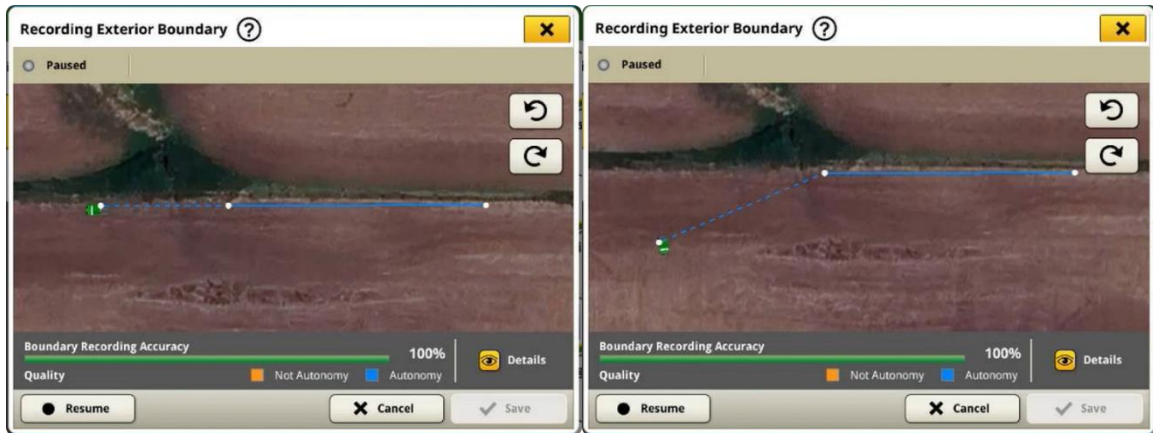
- This same dashed line will appear when using the pause/resume functionality.
 - If the dashed line is **orange**, the distance between points is greater than 100 meters and/or prerequisites are not met.
 - If the dashed line is **blue**, the distance between points is less than 100 meters and all prerequisites are met.



If you resume recording at this time, the **blue** portion of the boundary would be classified as Autonomy.

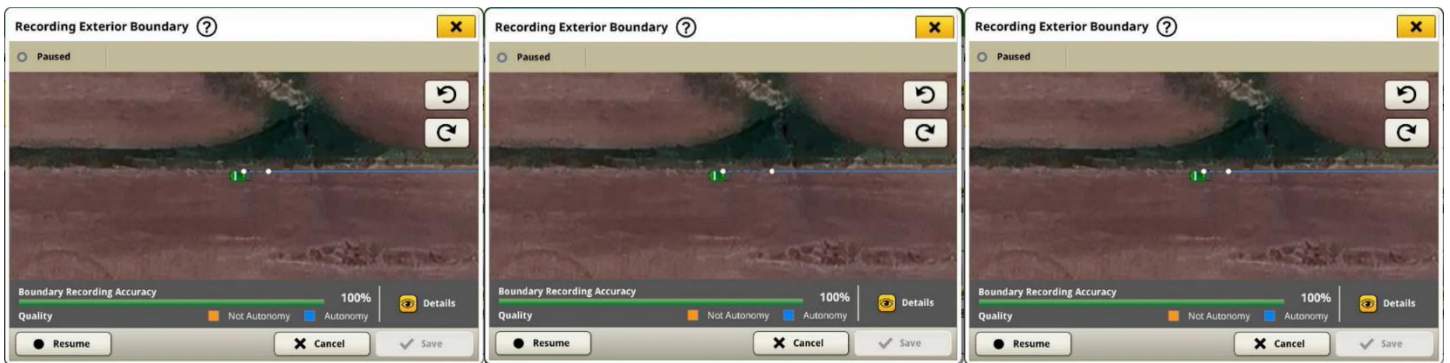
If you resume recording at this time, the **orange** portion of the boundary would be Not Autonomy. If trying to achieve an Autonomy Boundary, return to a 100-meter distance from the pause point before resuming (indicated by blue dashes).

- If at any time, a portion of the boundary is recorded as Not Autonomy. Select the undo button to remove the last 5-meter segment of the recorded boundary. Select undo multiple times to remove longer segments. Use the Details page during this time to understand what requirements are not met. Drive back to the last recorded point and once all items on the Details page are met, resume recording an Autonomy Boundary.



Undo boundary segments, drive back to the last recorded point, and resume recording

- Select the redo button to replace a segment of the boundary that was previously removed using the undo button.



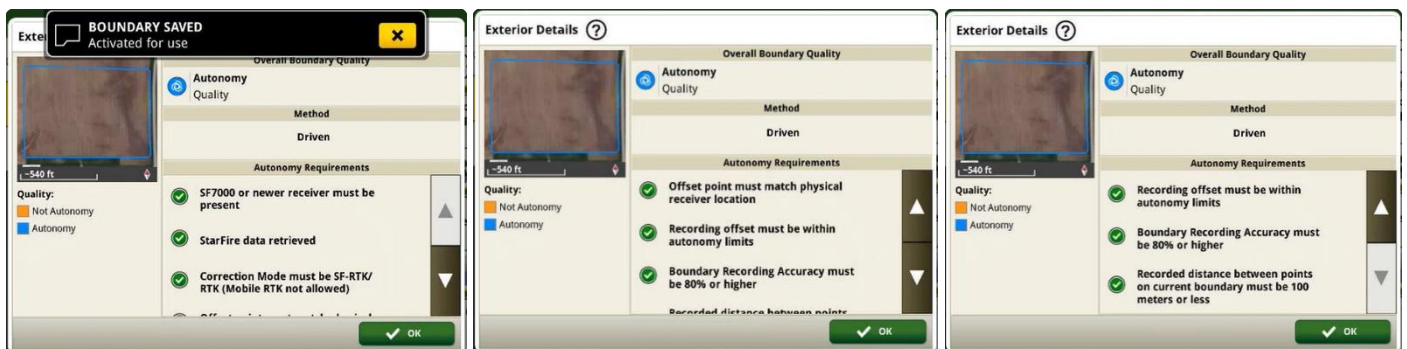
Select undo once

Select undo a second time

Select redo to replace the last removed segment

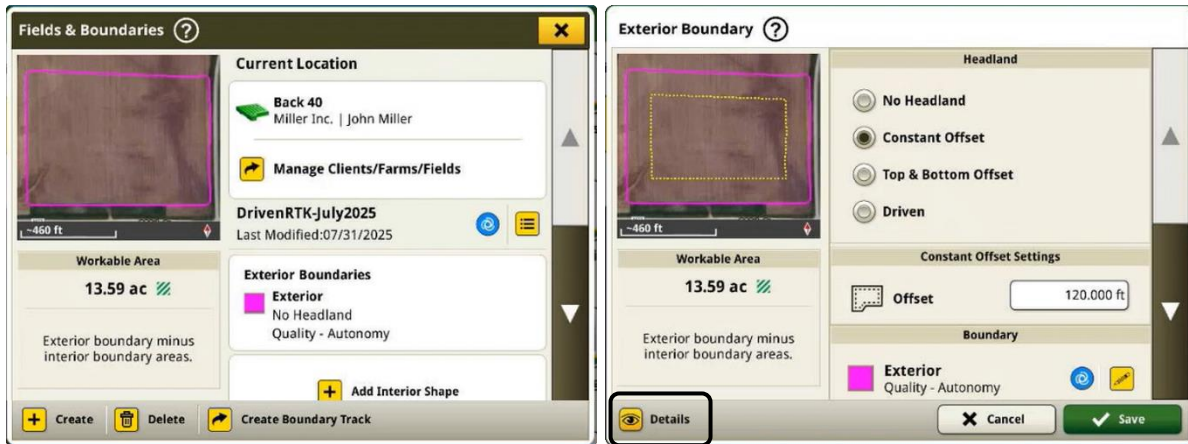
4. Review the map and Details page prior to saving

- After saving the boundary, the quality map can be viewed on the Details page.
- After recording is saved, the boundary summary page showcases the cumulative quality and system requirements for the entire boundary.



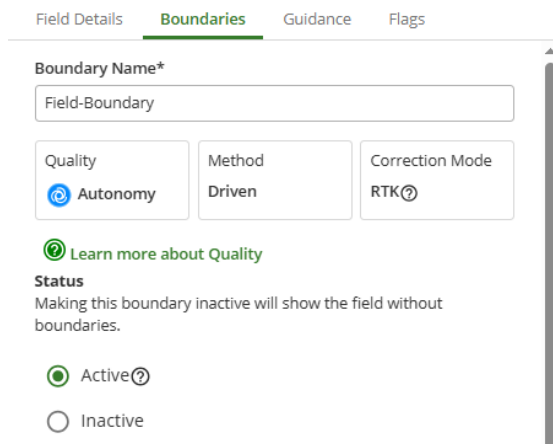
5. Review the boundary quality on the display

- Autonomy quality is only associated to the exterior boundary. Any interior boundaries that fall within that boundary will also be usable by autonomy; no system requirements need to be met for interior boundaries.
- After saving a boundary, a blue Autonomy icon will indicate that the boundary achieves Autonomy quality requirements and is compatible for use with autonomous solutions.
- The boundary recording checklist will be accessible, any time after the boundary is saved, by clicking the “Details” button within the Exterior Boundary page of Fields and Boundaries



6. Review the boundary quality in Operations Center

The Autonomy Capable icon will also be associated with any Autonomy Boundaries in Operations Center.



Some boundary edits can be made within Operations Center and **will not** impact Autonomy status:

- Changing the boundary name
- Copying the boundary
- Adding an interior boundary
- Shrinking the boundary as long as no new areas outside the initial boundary are included in the new boundary area

Keep in mind that the Operations Center map is not a real-life replica of land so use caution when making changes based on digital imagery.

Loss of Autonomy Quality
Edits expanding the boundary or adding exterior shapes will reduce quality and make this boundary no longer capable of autonomy.

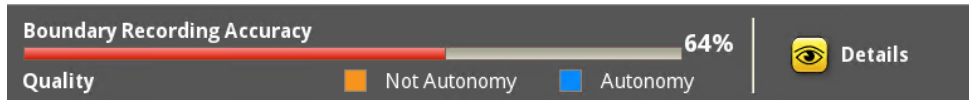
[Undo Edits to Autonomy Quality](#)

IMPORTANT: Moving or adding points outside of the original boundary will result in the boundary becoming Not Autonomy. This includes usage of tools like Merge that expand the original area of the boundary. A warning message will appear to notify the user that saving will change the boundary to Not Autonomy and cannot be reverted.

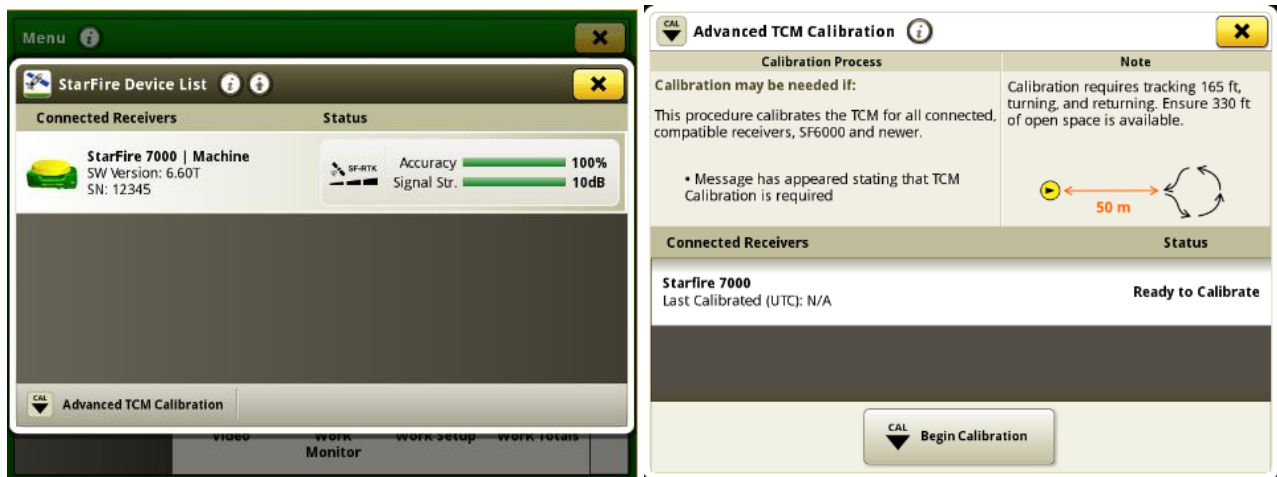
If using a setup file to export boundaries from Operations Center and import them to displays, the current system file format must be utilized. If the legacy file format is used, the Autonomy quality will change to Not Autonomy when loaded onto the display.

Troubleshooting

1. If the boundary recording accuracy is less than 80%, consider:



- Shading can cause the boundary recording accuracy to drop below 80%.
- Allow the receiver adequate time to reach full signal accuracy. This can be verified by going to the StarFire page in the Menu. Ensure that receiver accuracy has reached 100%.
- If any changes have been made to the receiver (changed mounting direction, installed a new receiver, reconnected a receiver). Be sure to drive a short distance to collect some GPS points before recording to achieve higher boundary recording accuracy.
- A TCM calibration is required to create an Autonomy Boundary. Go to Menu > Applications > StarFire™ > Advanced TCM Calibration. Access [this video](#) to learn how to complete an Advanced TCM Calibration.



TCM calibration is specific to machine, so moving a receiver to a different machine will require the calibration to be done again. Additionally, anytime the receiver direction is changed or location on a machine is altered, the TCM calibration will need done again. If a DTC appears in the diagnostics center showing that the TCM has not been calibrated, you will see an unmet prerequisite appear in the Details page showing that TCM must be calibrated.



2. Within the Details page, if the prerequisite “StarFire data retrieved” is not met, ensure that:
 - RTKX is enabled.
 - Mobile RTK is not being used.
 - The correction mode has not been changed while recording.
 - The base station has not been changed while recording (if using Radio RTK).
 - Geographical fault lines can affect boundary creation.
 - Autonomy boundaries cannot be created within 30 km of fault lines. An error will showcase for the receiver.
 - Autonomy boundaries can be created within 30-100 km of fault lines but are not guaranteed. RTK is the recommended signal to use when trying to create Autonomy Boundaries in these areas.

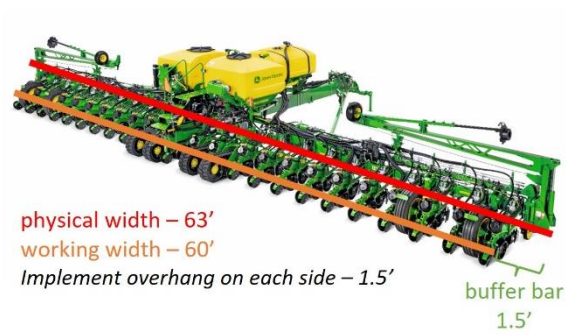
Tips to Measure and Use a Buffer Bar - Refer to the appendix for further assistance with taking these measurements

Using a buffer bar to record boundaries is considered a best practice for all users. The purpose of the buffer bar is to give the operator who is recording the boundary with a gator a visual of where any implement overhang will fall when later using the boundary for work.



Step 1: Measure the difference in working width and physical width of your implements. Determine the biggest difference that exists in your fleet.

Step 2: Create a buffer bar that extends past the machine width by the distance you measured in step 1.



Step 3: Use the buffer bar to record boundaries. When recording, the operator will need to navigate around obstacles to ensure there is space for the buffer bar to avoid colliding with the obstacle. When later using the recorded boundary, the implement overhang will also avoid obstacles by that same distance.



Correct Usage of Buffer Bar

Implement overhang will not hit this tree because the operator is using the buffer bar to navigate a safe distance around the obstacle during recording.



Incorrect Usage of Buffer Bar

Implement overhang will hit this tree if the operator proceeds straight because the buffer bar was not used to move a safe distance away from the obstacle.

Additional Best Practice for Autonomy Users - Autonomous machines create a buffer zone 1.5 meters around the outside of the boundary as an added perimeter of safety for the machine. This area is safeguarded by the camera system. When you are creating a boundary, to use with an autonomous machine, it is recommended to record at least 1.5 meters away from:

- areas of sloped land exceeding 11 degrees / 20 percent grade
- holes, ditches, gullies, steep embankments, bodies of water, other drop-offs
- dwellings, private properties, buildings, public roadways
- wind turbines, center pivot irrigation equipment
- anything low hanging that could interfere with the cab - cables, guywires, branches
- propane / natural gas inlets or storage

Not all conditions that can cause a hazard are listed above. Be alert for any situation in which stability may be compromised, or hazards are not clearly visible.

Note: The 1.5-meter consideration above should be made when recording both exterior and interior impassable boundaries.

Not Autonomy Boundaries

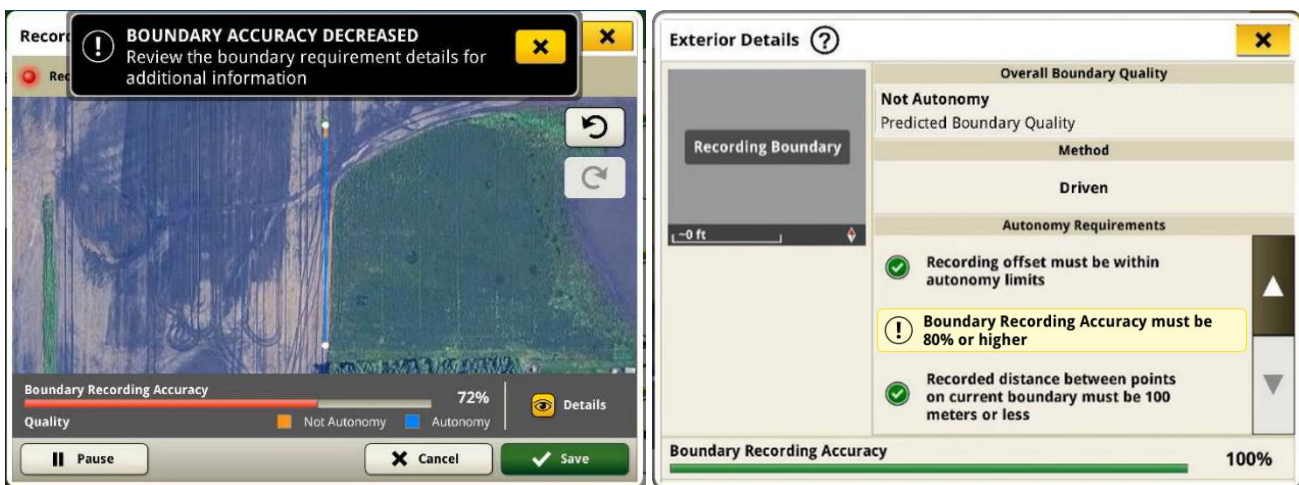
Not Autonomy boundaries do not include the level of data accuracy or system checks required for use with autonomous solutions. Keep in mind that Not Autonomy Boundaries can range from inaccurate to very precise. For instance, think of a boundary that was hand drawn in Operations Center versus one that was driven using a G5 display, StarFire™ 7500 receiver, and SF-RTK signal. The hand drawn one cannot be deemed as accurate because the Operations Center map is not a real-life replica of land and it is important to use caution when basing boundaries off of digital imagery. Although, the driven boundary is considered much more advanced due to the correction mode and creation method used during creation. This boundary could be used with solutions like Section Control, AutoTrac, AutoPath, Turn Automation, Implement Guidance, Machine Sync, etc.

Due to the varying levels of accuracy associated with Not Autonomy Boundaries, they are further classified as Unknown, Basic, and Advanced within Operations Center. This is to more clearly outline the recommended use cases for each boundary, ensuring the desired level of accuracy is present to optimize technology performance when using it for work.

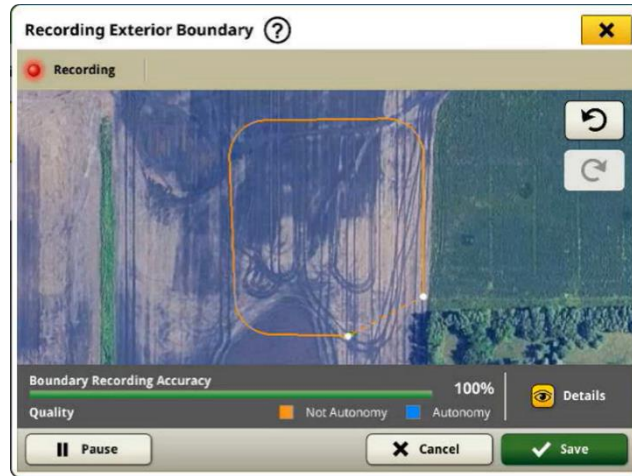
Display Quality	Not Autonomy			Autonomy
Operations Center Quality	Unknown	Basic	Advanced	Autonomy
Method	---	Imported Hand Drawn From Previous Operation Driven	Driven	Driven
Correction Mode	---	Digitized SF1 SF2	SF3 RTK RTKX mRTK SF-RTK	RTK RTKX SF-RTK
Additional Requirements	None	None	None	All items on the Details checklist must be fulfilled
Editing	No editing restrictions	No editing restrictions	No editing restrictions	Edits that shrink the boundary are allowed; Edits that expand the boundary are <u>not</u> allowed.
Recommended Use Cases	Use with discretion	Maps Reporting Field detection Weather Logistics Predictive Ground Speed Automation	All Basic use cases plus: Section Control AutoTrac (Boundary Track) AutoTrac Turn Automation AutoTrac Implement Guidance AutoPath (Rows) AutoPath (Boundaries) Machine Sync	All Advanced use cases plus: Autonomy <i>Autonomy boundary quality is a requirement for use with Autonomous Solutions.</i>

On the Display

The boundary will be classified as Not Autonomy if any segments are Not Autonomy (orange) when saved - meaning that one or more Details checklist items were not met. The undo and redo buttons can be used prior to saving the boundary in order to redrive segments and make adjustments to the boundary, if desired.



If creating a driven boundary using SF1, SF2, SF3, or mobile RTK signal, the entire boundary will be mapped in orange and will be classified as Not Autonomy.

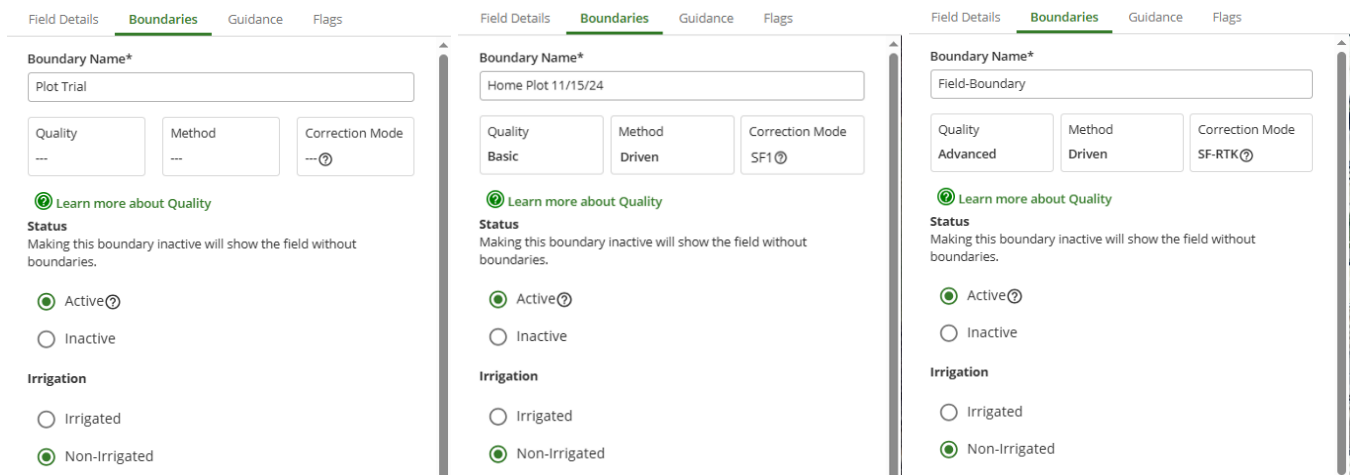


Refer to the Autonomy section of this guide to better understand the recording requirements if striving to achieve Autonomy quality.

In Operations Center

Boundary Quality will be associated with each boundary in Land. After a boundary is imported to Operations Center, it will be classified as Unknown, Basic, Advanced, or Autonomy. A boundary that was classified as Not Autonomy on the display will be further defined as Unknown, Basic, or Advanced Quality within Operations Center.

- **Unknown or “---”** – Boundaries that are created and/or imported from a competitive system or any display that fails to record a correction mode. They may be accurate but due to the data processing system used to analyze the boundary shape file, there is not a way to verify the overall accuracy of the shape. This means it is very important to use discretion when using unknown boundaries for precision ag practices.
- **Basic** – Boundaries that have been created and/or imported from a legacy John Deere display, hand drawn, created from previous coverage, or driven using SF1 or SF2 correction mode. These boundaries do not include the level of accuracy recommended for use with most precision technology products but can be used for more basic mapping, tracking, and reporting needs.
- **Advanced** – Boundaries that have been driven using SF3, RTK, mRTK, or SF-RTK. These boundaries offer a higher level of accuracy which is recommended for use with advanced guidance and machine automation technology.



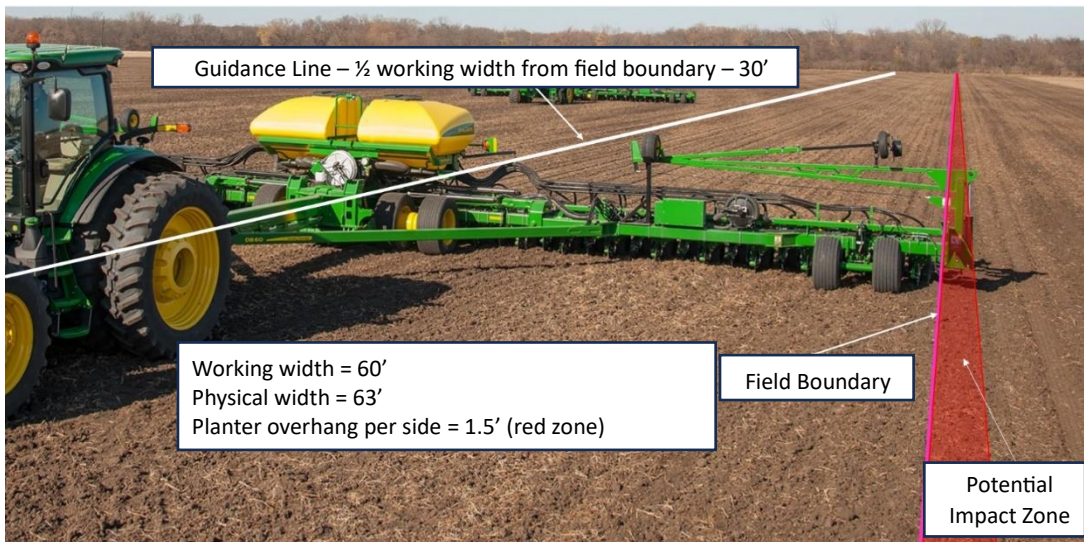
Appendix

Shared Signal Requirements

Shared Signal can be used when recording an Autonomy Boundary. It is important to note that a StarFire™ 7000 or StarFire™ 7500 must be present on both the machine and implement if using shared signal.

Machine	Implement	Can this shared signal pairing work to achieve an Autonomy Boundary?
StarFire 3000 or StarFire 6000 with SF1, SF2, or SF3	StarFire 7000 or StarFire 7500 with RTK or SF-RTK	No
StarFire 7000 or StarFire 7500 with RTK or SF-RTK	StarFire 3000 or StarFire 6000 with SF1, SF2, or SF3	No
StarFire 7000 or StarFire 7500 with RTK or SF-RTK	StarFire 7000 or StarFire 7500 with SF1	Yes – Shared Signal running off of the machine receiver
StarFire 7000 or StarFire 7500 with SF1	StarFire 7000 or StarFire 7500 with RTK or SF-RTK	Yes – Shared Signal running off of the implement receiver

Additional Information - Measuring for a Buffer Bar



Some implements are wider than their working width. For instance, a planter may have a working width of 60', but a physical width of 63' due to the marker extensions. When recording a boundary, you must know and consider the extra width of the implement. Think about obstacles in/next to the edge of a field. You need to allow for that additional implement width to prevent machine damage.



To accomplish this, measure how far the marker extension protrudes from the edge of the working width.



Similarly, this customer records the boundary at the left front tire, so the boundary is recorded wherever the outside of that tire drives.