Machine Guidance & Automation

Boundary Best Practices

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Scan this QR code or click here for more information about creating, using, and managing boundaries. The resource explains both Autonomy and Not Autonomy Boundaries.

Importance of Boundaries to Machine Guidance & Automation

Boundaries are the foundation of precision agriculture. When created correctly and accurately, boundaries can be a very powerful tool and will provide tremendous value to farmers' operations. An accurate driven boundary is the best option to enable the precision needed to use **Section Control, AutoTrac™ Boundary Fill, AutoTrac Turn Automation**, and **AutoPath™ (boundaries)**. The field boundary is used as the reference point for these products. It is essential that boundaries used for guidance and automation products are created correctly to see high performance with these solutions. Accuracy is key to success and precise machine control.

Figure 1 below, is an example of an acceptable field boundary. It was created accurately as it reflects the shape of the physical field. The boundary was recorded using the proper steps outlined later in this document and gives the display a true understanding of where the field is located and where work will occur.

Figure 1

Figure 2 is an example of an unacceptable field boundary. At first glance it may appear to be accurate, however when you zoom in to review the boundary line placement, it is apparent that it does not accurately reflect the working area of the field. Using this boundary for guidance or machine automation (AutoTrac Turn Automation, Section Control, Boundary Track or AutoPath (boundaries)) will result in poor performance and low accuracy.

Figure 2

Start the boundary journey today! Accurate boundaries offer tremendous value to an operation! Using 24-2 or newer display software, Autonomy Boundaries can be created. These offer the highest verified level of accuracy to the user and are required for any autonomous operation. Autonomy Boundaries can also be used to enable the greatest precision with Machine Guidance and Automation features but are not required. Access the Create and Use Boundaries Guide to learn more about boundary quality - Autonomy and Not Autonomy.

Differences Between “Acceptable” and “Unacceptable” Driven Boundaries for Machine Guidance and Automation Utilization

The chart below illustrates the difference between an acceptable and unacceptable field boundary.

Legend:

- Solid Pink Line = *Acceptable* Field Boundary
- Solid Yellow/Orange Line = *Unacceptable* Field Boundary

ACCEPTABLE FIELD BOUNDARIES	UNACCEPTABLE FIELD BOUNDARIES
	
The northwest corner of the acceptable field boundary accurately reflects where work will occur. Power poles are not inside of the boundary.	The northwest corner of the **unacceptable** field boundary extends onto the road. Using this boundary would allow the machine to operate outside of the intended field area, around power poles, the ditch, and onto the road causing potential machine and property damage.
	
The **acceptable** boundary is recorded along the actual edges of the field and traces around the trees.	The **unacceptable** field boundary is in-set several feet from the edge of the field and does not trace around the trees. Using this boundary would result in work not occuring in the area between the field edge/boundary.
	
The southwest corner of the **acceptable** boundary matches the unique corner profile of this field.	The southwest corner of the **unacceptable** boundary is located too far west and north. The corner shape is square, which does not match the field edge/driveway path between the fields. Using this boundary would result in work not occuring precisely within the intended field area.
	
The southeast corner of the **acceptable** boundary is set precisely to the working area.	The corner of the **unacceptable** boundary is set out 10-15 feet from the actual corner of the field area. Using this boundary will allow work to occur outside of the workable field area, risking equipment damage.

Can I Use my Existing Boundary(s) for Machine Guidance and Automation?

If you are considering using an existing boundary for machine guidance and/or automation, tag the following statements true or false.

1. I know the specific correction signal that was used to create the boundary (or coverage).
2. That correction signal used to create the boundary was either SF3, SF-RTK, or RTK accuracy.
3. The boundary was created on the display (not in the Operations Center).
4. The boundary accurately represents the working field area and shape.

If you answered **true** to every statement above – the boundary is compatible for use with John Deere machine guidance and automation products. Please review the following information in this guide to ensure that any current or future boundary is properly created and matches the actual working area of the field.

Remember: Properly created field boundaries are critical for expected performance. Do not let an unacceptable boundary jeopardize the performance of and your experience with John Deere guidance and automation products.

The 11 Core Principles for Creating Acceptable Boundaries

Below is a more detailed, comprehensive summary of the key components to keep in mind when creating acceptable boundaries for use with Machine Guidance and Automation. If creating Autonomy Boundaries, follow the guidance provided in the Create and Use Boundaries guide. These principles only apply to those who are not currently interested in creating Autonomy Boundaries but are using boundaries with Machine Guidance and Automation.

#1 – Do NOT Create Boundaries in the Operations Center

Operations Center uses Google Maps as the visual reference map. The accuracy of these images can be off by a meter or more. Centimeter accuracy is required for the utilization of machine guidance and automation products.

Operations Center boundary creation options do NOT support the use of Machine Guidance and Automation products and will result in poor performance and customer dissatisfaction.

1. Hand drawn boundaries
2. Created from coverage in the Operations Center

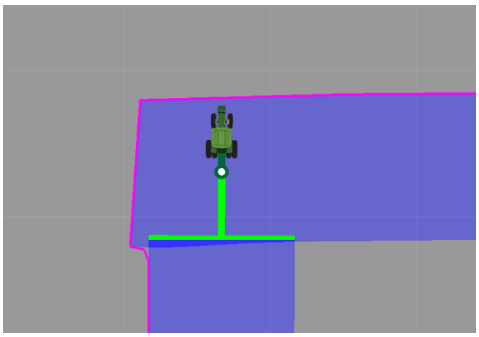
Note: It is acceptable to modify an existing display-created boundary in Operations Center for use with advanced guidance and machine automation. See core principle #9 for more information on how to modify boundaries within the Operations Center.

#2 – Boundaries Must be Created in the Display in the Machine Cab

There are two options to create an acceptable boundary that supports machine guidance and automation.

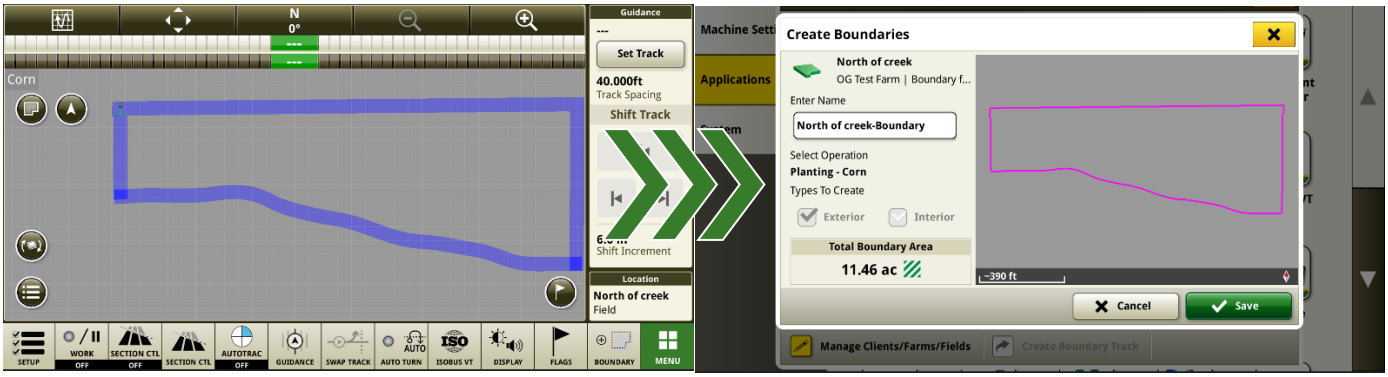
- **Option 1 – Existing coverage:** The boundary is created using the outer shape of a coverage map from a previous field operation.
  Pros:
  - Fastest way to create a boundary.
  - The boundary shape matches the outside of previous coverage.

  Cons:
  - Misaligned coverage overlap can create odd boundary shapes in corners (illustrated below).
  - If coverage does not reflect the shape of the field, the boundary will not either.
    - Example: Avoiding standing water along the edge of a field during an operation will impact the shape/area of the field boundary created from that coverage.



A boundary that is created from previous coverage reflects exactly where the implement documented coverage. Therefore, areas with overlapping or misaligned coverage (as shown in the illustration on the left) will transfer that shape to the field boundary. This is not the result that you want, or one that will provide the best experience with machine guidance and automation products.

For a field with no recorded boundary – an operator can drive the outer field pass to create a complete loop of coverage around the edge of the field. Make sure the start and end of the coverage overlaps, so it is a complete shape. The display can be used to quickly convert this shape to a field boundary using the “create from existing coverage map” option.



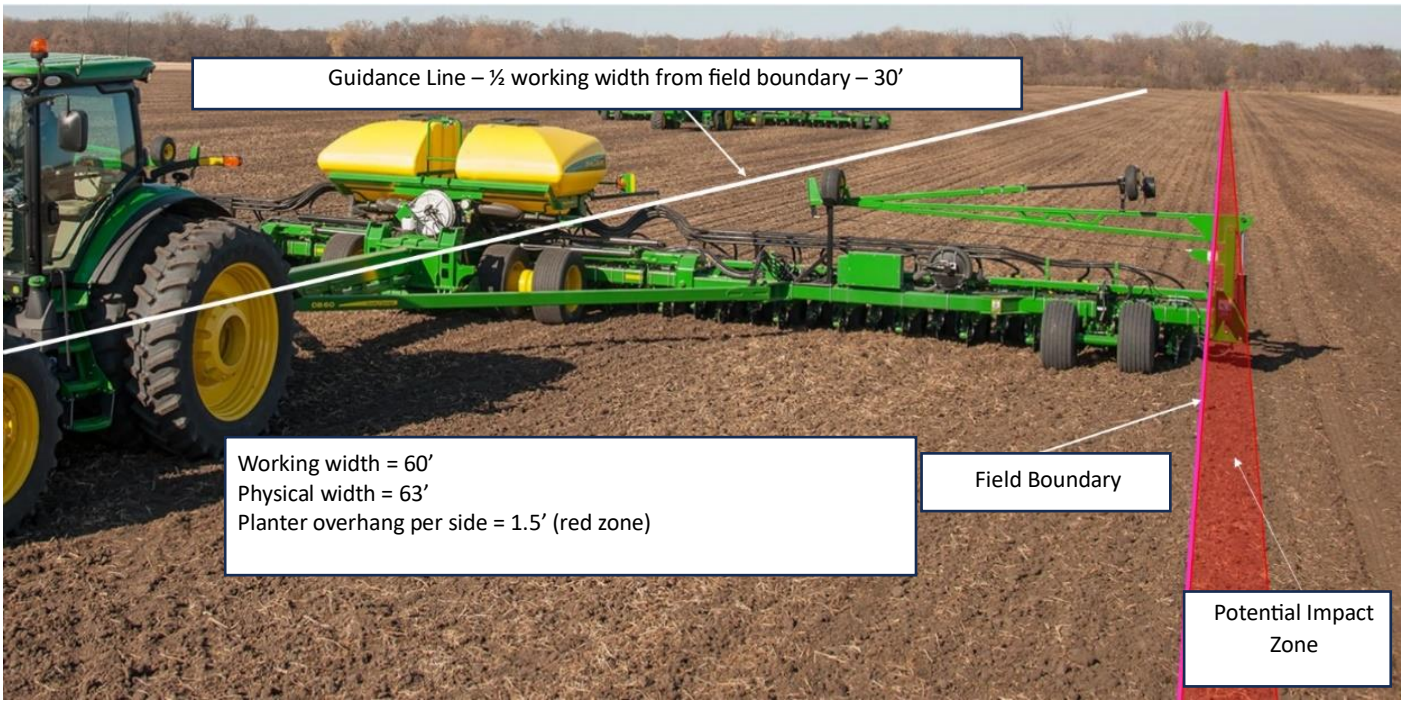
- **Option 2 – Driven Boundary:** The boundary is created using an offset from the receiver while driving around the field’s perimeter.
  Pros:
  - Most accurate way to control a boundary shape.
  - Can be done using the machine or the implement’s GPS.
  - Can be recorded while doing work.

  Cons:
  - Requires intentionally driving around the field’s perimeter.
  - Recording a boundary while doing work along the field edge may be difficult for some operators.

In-cab display screen for driven boundary creation.

A best practice that has been identified when driving boundaries to support advanced guidance and machine automation products, is attaching a 'buffer bar' to the front of the machine that accounts for the additional width of the implement / equipment that will pass through that field. If the additional width is not considered when driving the boundary, you run the risk of damaging your equipment and experiencing downtime. Two things no one wants.

Tips for Taking Measurements to Create a Buffer Bar for Recording Driven Boundaries

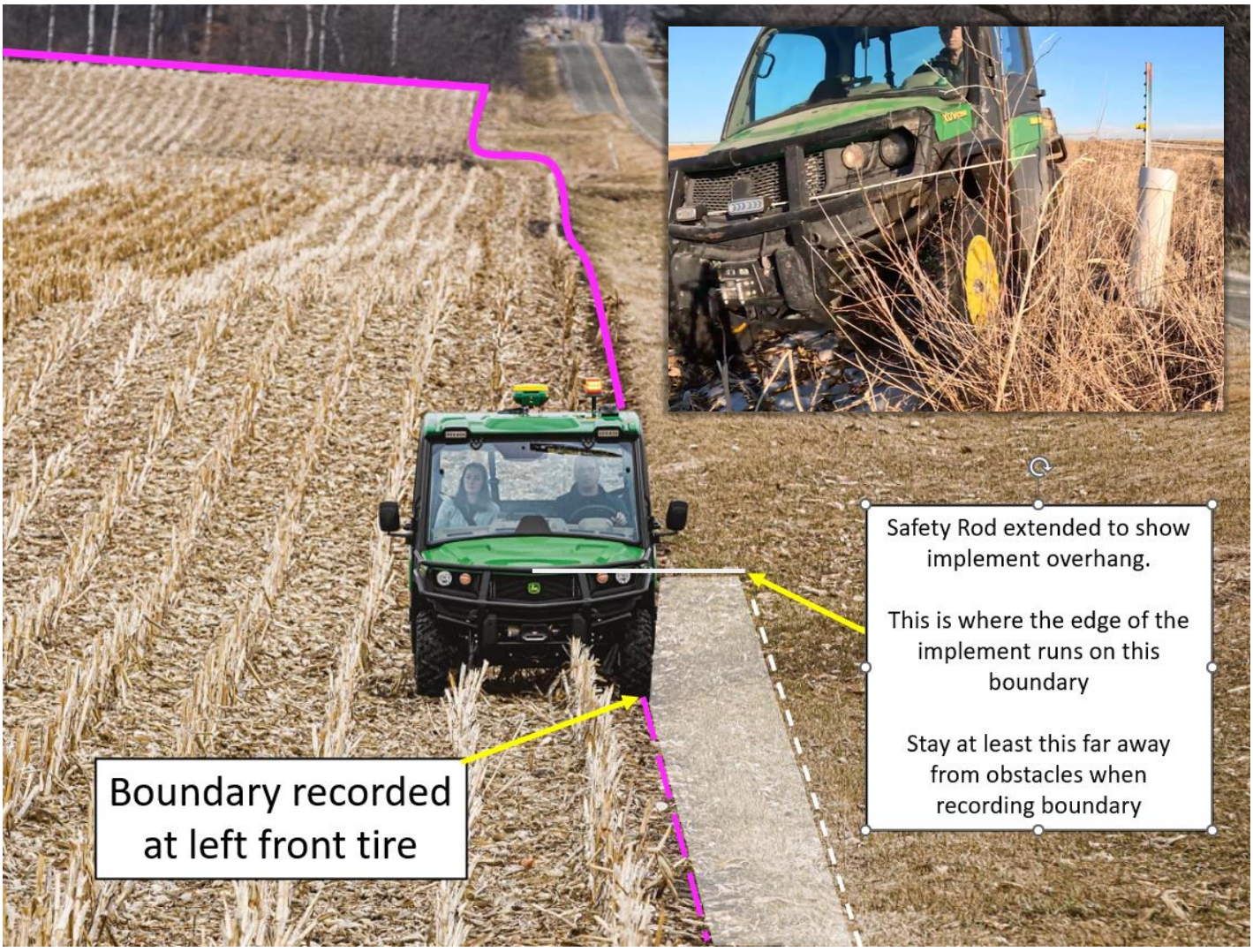


Some implements are wider than their working width. For instance, a planter may have a working width of 60', but a physical width of 63' due to the marker extensions. When recording a boundary, you must know and consider the extra width of the implement. Think about obstacles in/next to the edge of a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

Using a buffer bar, as illustrated below, when recording driven boundaries will result in boundaries that give operators confidence and accuracy as they work their fields.



#3 – Boundaries Must be Created with SF3, SF-RTK, or RTK

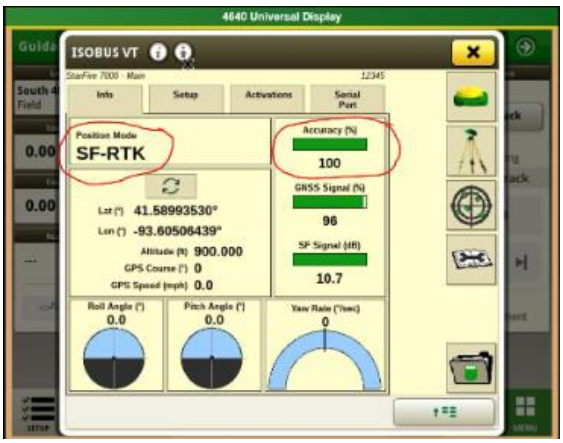
SF3, SF-RTK or RTK must be used when:

- Recording a new, driven boundary.
- Using previous coverage to create a boundary on the display to be used for machine guidance or automation products.
    - You must know the StarFire correction signal that was used when the field coverage was created.

Note: If the correction signal used to create the boundary or coverage is WAAS/EGNOS, SF1, SF2, or unknown, the boundary should not be used for machine guidance or automation products.

#4 – Ensure High GPS Accuracy

GPS accuracy of 90% or higher ensures that GPS signal has been acquired and this will boost accuracy during boundary recording. As GPS accuracy drops, boundary recording accuracy will lower as well.



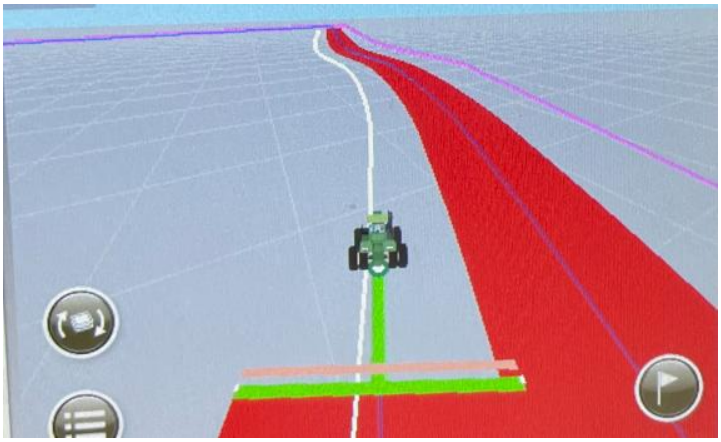
GPS shading, which can occur along tree lines, will impact boundary accuracy in these areas of the field. Shaded boundaries are not prevented from use; however, you should note that accuracy can be reduced in these areas.

The operator is responsible for machine operation at all times and should ensure that shaded boundaries do not cause issues.

#5 – Don't Mix and Match Signals When Creating and Using a Boundary

Use the same correction signal when creating AND using the boundary. DO NOT mix and match correction signals between recording and using a field boundary.

IMPORTANT NOTE: Mobile RTK network base and Radio RTK are different correction signals and should not be mixed between recording and using boundaries.



In the image on the left, the coverage (red) was created at the actual edge of the field using an SF-RTK correction signal. The field boundary line (pink) was recorded with an SF2 correction signal at the edge of the actual field. SF2 drift and the use of different correction modes create a large margin of error from the edge of the field over 3 years' time.

The major difference in boundary locations would result in poor in-field performance and user experience.

#6 – Accurate Machine Dimensions and TCM Calibrations Enable Accurate Boundary Recording

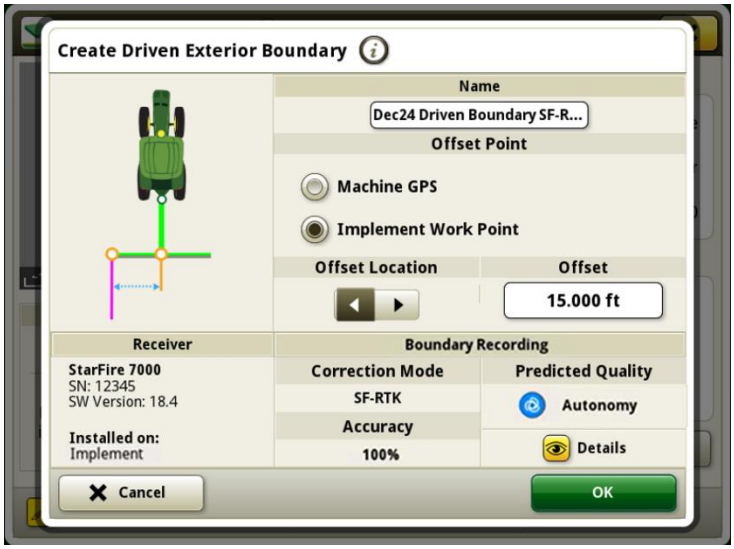
When recording a driven boundary, all equipment and receiver dimensions must be accurate.

Boundary offsets are the distance from the field edge to the receiver. It is important to enter the correct dimension to ensure the boundary is recorded accurately.

1. If using a machine (no implement) to record the boundary:
    a. Choose the “Machine GPS” option.
    b. From there, set the offset location (right or left) and distance from the receiver location to where the field boundary should be placed.

Using a gator to drive a field boundary. With the left tire driven on the edge of the field, there is a 2’ 6” distance from the left from tire to the center of the gator (receiver location).

2. If using an implement with a receiver to record the boundary:
    a. Turn on shared signal.
    b. Choose “Implement Work Point”.
    c. Set the offset direction (right or left) and boundary offset distance to ½ the width of the implement.



A 30’ wide implement with a centered implement receiver, left side of the implement is driven along the edge of the field.

IMPORTANT NOTES:

- Recording a field boundary with an implement is more difficult than recording with the machine-only, as the recording point is harder to control. It can be done but is not the simplest or recommended method for recording boundaries. It is also not recommended to record a field boundary with an implement that does not have an implement receiver mounted to it.
- A Gator is a great machine for recording field boundaries, as they are smaller and nimbler than a tractor or tractor with an implement.

#7 – Pause and Resume for Clean and Accurate Boundary Shapes

Use the pause and resume buttons to stop and start the boundary recording as needed, especially when working in corners. If you do not use the pause and resume functions, you may end up with an odd-shaped boundary like the one pictured below. Don't worry, outlined below are details on how to properly use the pause/resume functionality to create a clean and accurate driven boundary in a couple of common farming scenarios.

What not to do.

When driving a boundary manually, it can be easy to record small variations in the boundary. In the scenario below, the operator is driving a field boundary with a Gator between power poles. Small variations between the poles cause an irregular shape in the boundary.

Hand Driving a Boundary Between Power Poles

To avoid this variation, the operator can pause the recording when driving from pole to pole for a cleaner, better-looking. boundary. Let's walk through how this is done:

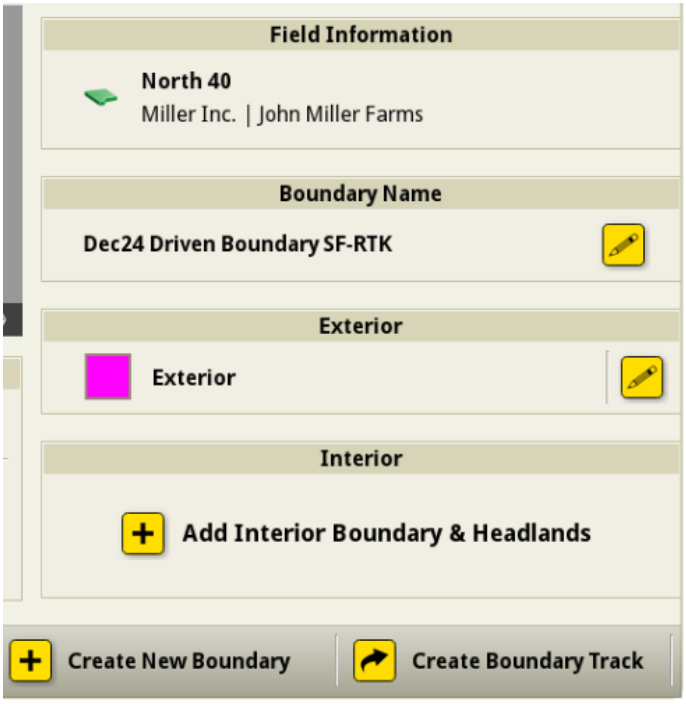
1. Stop the Gator next to a power pole at the correct distance from the pole and press **pause**.
2. **With recording paused,** drive to the next pole and stop at the correct distance from the pole.
3. Press "**resume"** to create a straight boundary segment between the two poles. Press "**pause"**.
4. **With recording paused**, drive to the next pole and stop at the correct distance from the pole.

Using the Pause/Resume Functions Hand Driving a Boundary Between Power Poles

#8 – Accurate Boundary Naming = Successful Performance

Detailed naming is critical for success. Below are some tips for success:

- Ensure each field has an accurate Client, Farm, and Field named.
- Do **NOT** use “A” or “-” as the name. Be specific so the boundary can be recognized and used with ease.
- Rename the field boundary if needed. Add relevant information to clearly identify when and how the boundary was created, along with the StarFire correction signal used, to help future users understand how the boundary can be used in the future. Consider adding the following information when renaming boundaries:
    - Date created
    - Creation type (from coverage or driven boundary)
    - StarFire correction signal



#9 – Edit Small Boundary Errors in the Operations Center

When creating a boundary (driven or from previous display coverage) it is normal to make some mistakes.

Driven boundary examples:

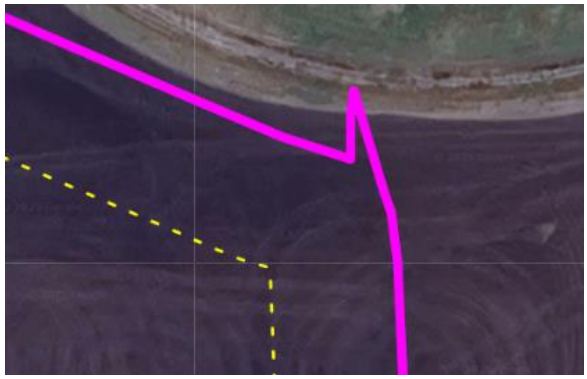
- The implement edge is not properly aligned to the start point when finishing the outer boundary recording pass.
- Resuming recording when the machine or implement is incorrectly positioned.

Boundary from previous coverage examples:

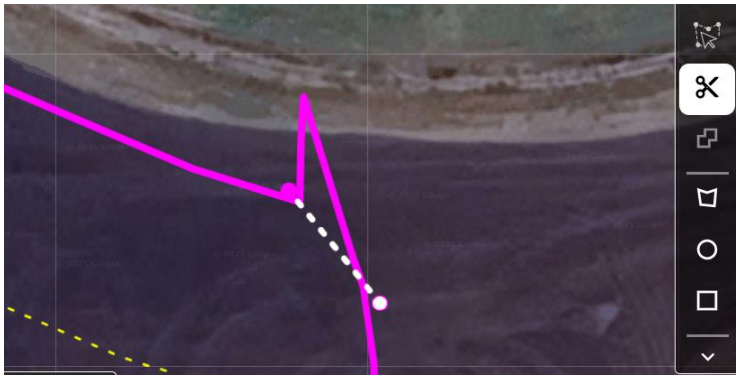
- The planter pass went outside of the field area.
- The seeding pass moved away from the field edge due to a large wet spot that was undrivable.

Editing a Boundary in Operations Center using the Split Tool:

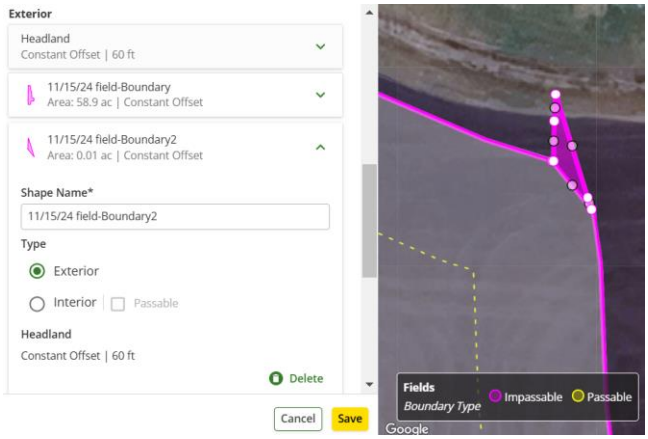
1. Open Operations Center, select Setup, and choose Land from the dropdown menu.
2. Select Boundaries and click on the desired boundary.
3. Determine the portion of the boundary that you want to separate into a new, separate shape.
4. Select the Split tool (pair of scissors) in the right-hand menu.
5. Click a point outside the boundary to start the split.
6. Click another point outside the boundary on the other side to proceed with the split. A dashed white line will represent where the split will occur.
7. In the boundary shape list, delete the new shape that represents the area that should be removed from the boundary.
8. Save the boundary.



The boundary prior to editing.



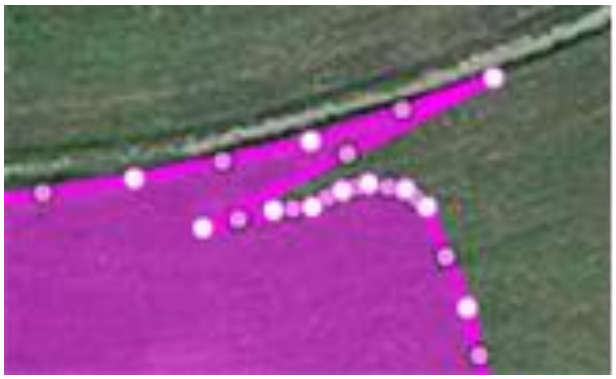
The boundary during editing with the split tool.



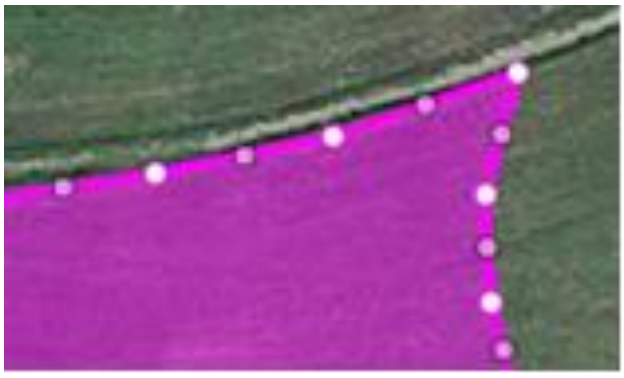
Using delete to remove the shape that represents an error during driving.

Editing a Boundary in Operations Center using <u>Delete</u>:

9. Open Operations Center, select Setup, and choose Land from the dropdown menu.
10. Select Boundaries and click on the desired boundary to preview data points.
11. Click on any white dot within the irregular field boundary and click on the trash can icon to delete.
12. Although <u>not recommended</u>, white dots can be moved.
13. Save the boundary when editing is complete to be used for future field work.



The boundary prior to editing.



The boundary after editing data points.

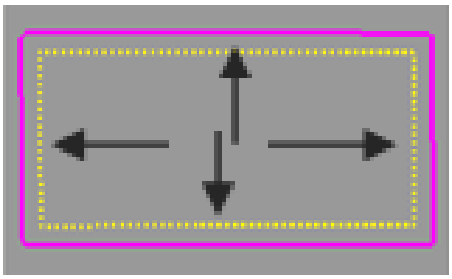
The Accuracy of Edited Boundaries:

- Any white dots that are moved will have relative accuracy to neighboring white dots. In other words, <u>they will not be accurate to the satellite image.</u> This is why it is not recommended to move the white dots if machine guidance and automation products are used in the farming operation.
- Any white dots that are not moved will maintain their original location and will not be impacted. I.E. If white dots are removed to edit a boundary, it will have no effect on the remaining white dots.

#10 – Headlands Represent the Area of the Field Where Turns Occur– Use the Right Type for your Application

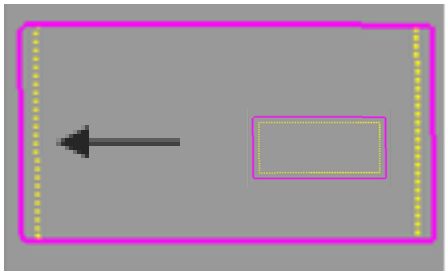
Headlands (**represented with yellow dashed lines**) are required to use AutoTrac Turn Automation; they represent the area of the field where turns occur. There are 3 types of headlands, however, only two can be used with machine guidance and automation products - Constant offset headlands and Top and Bottom offset headlands.

- **Constant offset** headlands set a constant width around the entire field boundary a specified dimension (set by the operator) away from the exterior field boundary (represented with a solid pink). Constant offsets allow turns to occur anywhere around the edge of the field, regardless of the machine heading angle.

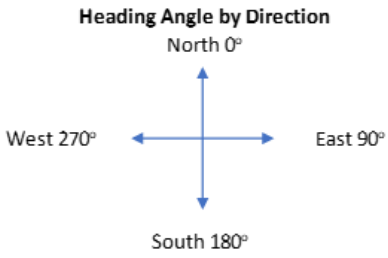


Constant offset

- **Top and Bottom offset** headlands are placed at opposite ends of the field, based on machine heading angle.



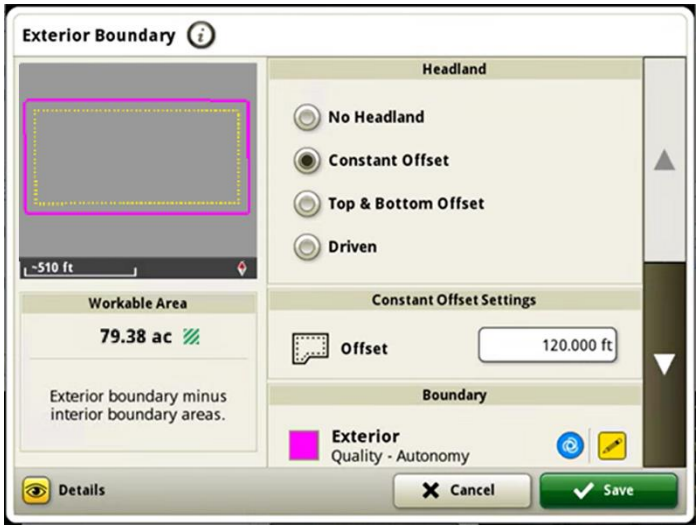
Top and Bottom offset



- **Driven** headlands allow the operator to drive to record the headland area. These headlands **are not supported** for use with machine guidance or automation products.

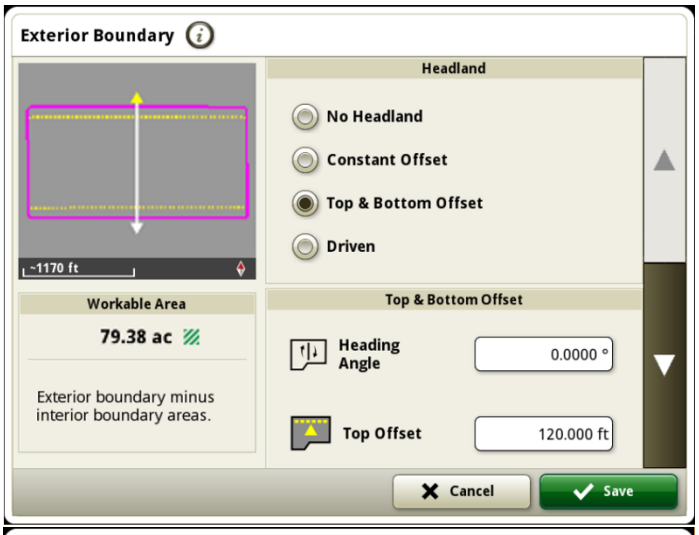
How to Set Up Machine Guidance and Automation Supported Headlands:

Constant Offset Headlands



To create a headland with a constant offset, navigate to the exterior field boundary display page. Ensure the radio button next to constant offset is selected and input the offset dimension. Again, a constant offset headland matches the shape of the field boundary and is the same size around the entire field

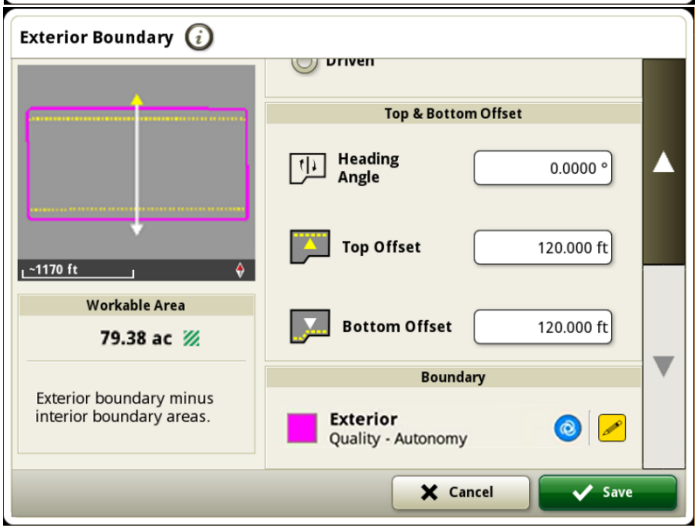
Top and Bottom Offset Headlands



The top headland is placed along the boundary that is approached when driving with the heading angle (represented with a yellow arrow).

The bottom headland is placed along the boundary that is approached when driving opposite of the heading angle (represented with a white arrow).

If the field is “square” and the heading angle is an angle to the sides, or if the heading angle is not parallel to a field side, headlands will be placed around the entire field.



Top and Bottom offset headlands are placed at opposite ends of the field, again, based on the machine’s heading angle.

The heading angle must be set to match the AutoTrac heading angle. It does not auto match the heading angle.

The Top and Bottom offsets can be set to the same or different widths.

If the heading angle is not parallel to a field side, Top and Bottom offset headlands may be created around the entire field area.

#11 – Use Interior Boundaries to Document Where Work Should NOT Happen

Interior boundaries are used to document areas of the field where work will not and should not be done.
Examples include waterways, creek bottoms, old access roads, windmill sites, etc.

Interior boundaries should be recorded as a driven boundary. The use of a smaller vehicle, such as a Gator, when recording these boundaries may be beneficial, especially with complex interior boundary shapes.

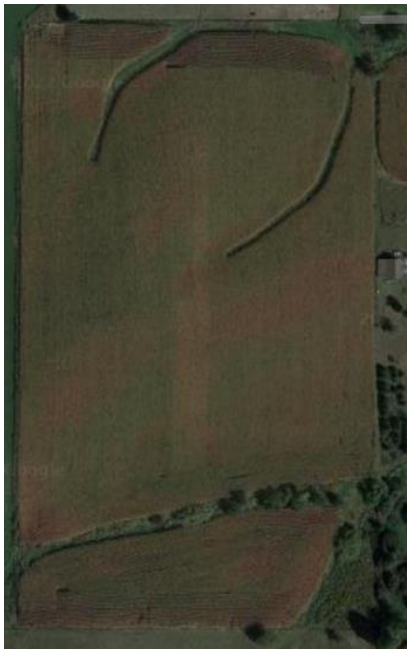
There are two types of interior boundaries:

1. **Interior impassable** - These areas of the field are “impassable”, meaning they should not be passed through by the machine. They are represented by a solid pink line.

   Examples of when to use an interior impassable boundary include, but are not limited to:
   a. Farmstead
   b. Windmill or rocked access roads.
   c. Deep washout or creek areas.
   d. Ponds.
   e. Tree lines.
   f. Any area of a field that a machine should not access to prevent machine damage or damage to the land.

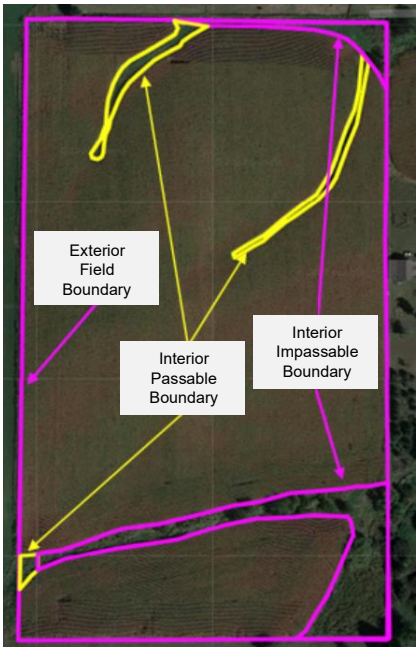
2. **Interior passable** - These areas of the field are safe to drive through, but no work should be done here. They are represented by a solid yellow line.

   One example of when to use an interior passable boundary is when there is a waterway in the field.



Aerial view of the field.

Field/Interior Passable Boundaries = Workable Area



Field/Interior Impassable Boundaries = Workable / Non-Workable Areas

Helpful Video Resources

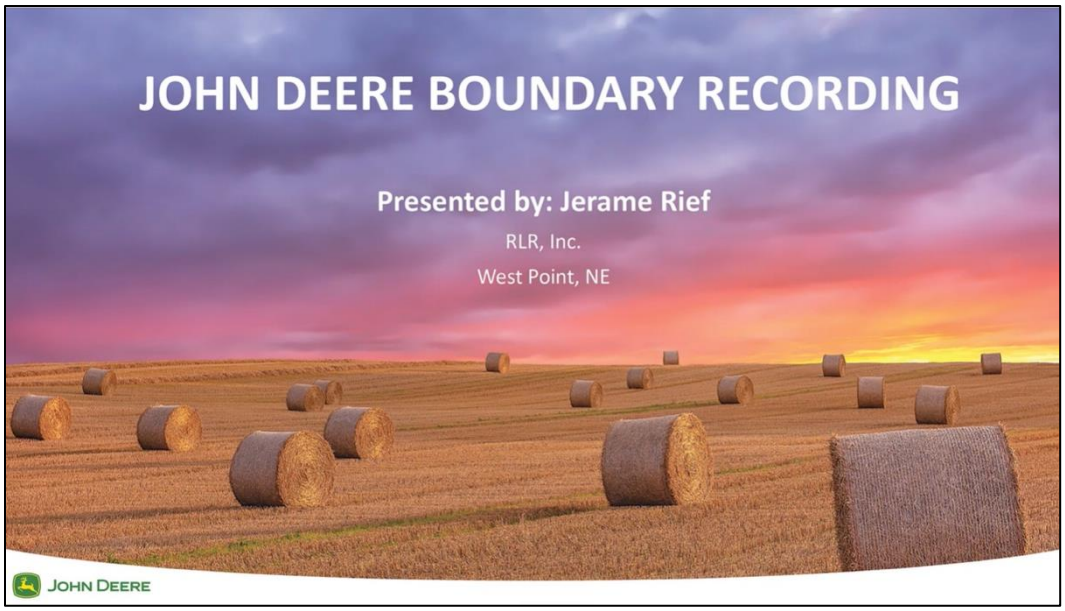
Boundary Creation for Machine Guidance and Automation Use

If you have further questions about creating boundaries that are able to be utilized for Machine Guidance and Automation, refer to the following YouTube videos outlining some of the principles above.

Scan the QR codes with your mobile device to watch these videos.

Customer Video – John Deere Boundary Recording in Action

THE POWER OF PRECISE, ADVANCED BOUNDARIES



If you're not viewing this guide on your mobile device, scan the QR code to watch the video, or click here.

This video was created by customer, Jerame Rief. He showcases the power of properly recording field boundaries and how they are used in his farming operation. Please reference this video or share it with anyone who has questions on the use or creation of field boundaries.

The first portion of the video reviews helpful information and best practices to follow when creating accurate, driven boundaries. The concepts discussed in this section of the video are covered in greater detail within this document.

The second portion of the video shows real scenarios of field boundaries in practice. The customer shows how accurate, acceptable boundaries can result in higher performance, even with less skilled operators.