RTK BASE STATION:
CUSTOMER INSTALLATION AND SETUP GUIDE
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A RTK Base Station can be broken down into seven main components. Let’s briefly discuss each component and how it works with the system.

**John Deere Components**

1. **StarFire™ Receiver with RTK Activation**
   - A shared base station receiver works similar to a receiver on a tractor. Using GPS information, the receiver calculates its exact position of the shared base station, and then transmits the correction signal to the vehicles using the system, thus providing sub-inch repeatable accuracy. The receiver must be in an open area to avoid problems like shading and multipathing. Setup procedure, discussed later in this document, will provide more information on these areas. *Note: StarFire iTC receivers are required for the security feature (RTK Base Only) and twelve mile range (RTK Tractor Only).*
2. RTK Radio
   - The RTK Radio converts the signal from the receiver into a 900 MHz frequency which is then pushed on to the antenna. The antenna broadcasts the correction signal out to the vehicles running under it. Sub-inch correction is only guaranteed out to a twelve mile radius. However, vehicles can still receive signal past this distance.

3. RS232 Cable with Ground Rod Static Protection (300 ft.)
   - This cable is used to transmit the correction signal from the StarFire iTC Receiver to the RTK Radio. This cable is 300 feet long allowing the radio to be mounted on top of a structure while keeping the receiver closer to the ground for easier maintenance and updates.

Non John Deere Components

4. Power Source
   - A shared base station requires about three amps of power continuously. Although the power requirement is small, it needs to be continuous, regulated, and consistent to provide good correction signal to the RTK vehicles using it. Any power surges or losses could disrupt the signal and cause line jumps or loss of signal. No matter what type of power sources is used, whether it is solar panels, wind turbines, or a standard 110V connection, make sure to hook everything through a battery for cleaner, more consistent power.

5. RF Cable (Low Loss Coaxial)
   - This cable transfers the radio signal from the RTK Radio to the Antenna. Coaxial cable does lose signal power the greater the distance it is transferred. Make sure you compensate for this loss with a higher gain antenna and high quality low loss coax cable. When constructing your shared base station, the radio and antenna can be mounted at the top of the tower requiring a small coaxial cable or at the bottom of the tower
requiring a longer coaxial cable. Remember, the longer the coaxial cable, the bigger it must be to compensate for the signal loss. The size of the antenna does not matter if the signal cannot get there.

- Example:
  i. 100 ft. of LMR 400 Coax Cable has an estimated loss of 3.8 dB
  ii. 100 ft. of LMR 600 Coax Cable has an estimated loss of 2.5 dB

6. **Antenna**
   - The antenna broadcasts the sub-inch correction signal to all of the vehicles within a 12 mile line of sight radius. Omni-directional antennas are recommended because they put out equal signal in all directions. No matter how you set your SBS RTK Network up, the antenna should be mounted as high as possible to broadcast the correction signal to the vehicles below. All other components, including the RTK radio can be mounted near the ground.

7. **Mounting Structure**
   - All of the above components are mounted on or near some type of structure. These structures could be radio/cell towers, water towers, grain cooperatives, buildings, or other tall structures. Due to their height, all of these options will need to be grounded and have lightning protection to protect the electronic equipment. *Note: If you mount the receiver on the structure itself, make sure it does not move or sway. This movement will shift all of the Guidance lines under the tower.*
Now that we have seen and understand all of the components, let’s move on to the different ways of installing a base station. Depending on the location and structure you are working with, here are five different methods.

1. **Utilizing the 300 ft. RTK Extension Harness**

   This base station setup allows the receiver to be mounted in a secure location while the radio and antenna are mounted together at the top of the structure. The RS232 cable between the receiver and radio provides the connection and power to the rest of the system.

   **Advantage**
   - Good receiver placement
   - Not much coax is needed

   **Disadvantage**
   - Generally harder to replace RTK radio if it is struck by lightning

2. **Utilizing the Low Loss Coax Cable**

   This base station setup leaves the receiver and radio in a secure location while using low loss coax cable to connect to the antenna at an elevated position.

   **Advantage**
   - Good receiver location
   - Easy access to the RTK radio

   **Disadvantage**
   - Increased cost due to coax
3. **Utilizing Both the 300 Ft. RTK Extension Harness and Low Loss Coax Cable.**

This base station setup allows the placement of the receiver to be up to 300 ft. away from the radio, giving the receiver an absolute clear view of the sky. The radio at the bottom of the tower is then connected to low loss coax that is ran up the tower to the antenna.

**Advantage**
- Good receiver placement
- Easy access to RTK radio

**Disadvantage**
- Increased costs due to using both the coax and extension harness

4. **Utilizing a Repeater**

This base station setup allows the placement of the receiver and radio in a location with no obstructions. A repeater is placed at an elevated location and broadcasts the correction signal from the base station to the vehicles.

**Advantage**
- Good receiver placement

**Disadvantage**
- 2 power sources are needed
- **Repeaters cannot be used anywhere else in the twelve mile range**
5. **Leaving the Radio and Receiver as a Single Unit.**

   This base station setup keeps the receiver and radio as a single unit usually mounted in an elevated location. Important items to remember with this base station setup are that the receiver must have a clear view of the sky, free of multipathing, and cannot move. Any movement of the receiver will result in movement of the guidance lines.

   **Advantage**
   - Lower cost

   **Disadvantages**
   - Hard to access the receiver for updates
RTK Base Station - Planning

Now it’s time to start planning and constructing the actual base station. Proper planning is the key to a successful base station and will help you avoid many problems in the future. Here are the steps to ensure the base station is set up correctly no matter which route you take.

**Conducting a Site Survey**

Keep the following in mind when looking for structures:

**Structures**

- Grain legs/Concrete Silos
  - Grain legs work the best because there are less multipathing and shading problems due to their height. Power is also usually available on top of a grain leg which helps decrease investment costs even more. *Note: If the leg is supported by guy wires, you should mount the receiver on the ground or in a more stable location due to the sway of the leg.*

- Radio communication towers
  - In some areas, cell phone providers may be willing to lease space out on their tower to other businesses. To determine if the cell towers in your area are available, use cellreception.com to get the location, owner, and contact information. If you can work out an agreement, investment costs will include installation of the equipment on the tower and a monthly or yearly lease in most situations.

**Electronic Equipment**

Some of the electrical equipment on an RTK Base Station, like the RTK radio, StarFire Receiver, and RS232 Cable, is purchased through your local John Deere Dealer. The rest of the components can be ordered through outside suppliers.

- **Power Sources**

  When hooking up power to your base station, always connect it to a battery. A battery releases consistent power and allows for some added run time if a power loss should occur. The battery, however, can be charged any way you want. Whether it is solar panels, trickle charger, or wind generator, make sure you always hook up to a battery. If for some reason, a battery cannot be used, make sure to use some kind of regulated power source. Proper planning and setup now will help cut down on many problems in the future.
- **110 Volt connection**
  - The best option for your base station power source is a standard 110 volt power source. To ensure consistent power, connect the shared base station to a twelve volt battery, and then recharge the battery with a trickle charger plugged into the 110 volt power source.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>- Less maintenance</td>
<td>- Power losses</td>
</tr>
<tr>
<td>- Consistent power source</td>
<td>- Pay a monthly power bill</td>
</tr>
<tr>
<td>(with a battery and trickle charger)</td>
<td></td>
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<tr>
<td>- If power is lost, the battery will allow for extended run time</td>
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- **Trickle Charger Suppliers** – any trickle charger three amps or larger will work in this situation.

- **Battery Suppliers** – any standard twelve volt battery will work in this type of setup. A deep cycle battery is not necessary because the trickle charger will keep the battery charged all the time.

- **RTK Radio Boxes**
  - RTK Radios are provided through your local John Deere Dealer. During installation, we recommend putting the radio in a weatherproof lockable box no matter where they are mounted on the structure. This will not affect their performance, but it will protect against tampering and increase the life of the radio. Whatever kind of box you use, make sure there is good air ventilation at the bottom. The radio itself will not give off heat, but the container it is in will build up heat. If a metal box is used, consider painting the outside a lighter color. These boxes can be found at any local electrical hardware store.

- **RF Cable (Coaxial)**
  - The next step is defining the parts needed to maintain signal integrity between the RTK radio and the antenna. If the radio and antenna are mounted in separate areas, low loss coax will have to be used to connect them. Your local communications company can help you size the right coax
and connectors for your structure. Keep the following recommendations in mind:

- During rainfall, water can run down the coax and into the RTK Radio damaging it. To avoid this problem, always leave a drip loop in the coax for water run off (see picture).

- **Lightning Protection**
  
  - Lightning rods and/or other forms of lightning protection are strongly recommended to protect your investment. Lightning protection will increase the life of your antennas, coax, and RTK radios.
RTK Base Station - Setup

Now that the RTK Base Station has been constructed, it is now time to set everything up. The RTK activation must be submitted, the radio must be configured correctly, and an absolute Base Survey must be completed.

RTK Activation

<table>
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<tr>
<th>GS2 Display</th>
<th>Original GS Display</th>
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<tr>
<td><strong>To Begin, select the StarFire iTC button on the GS2.</strong></td>
<td><strong>To Activate, press Setup &gt;&gt; StarFire iTC &gt;&gt; License/Activate</strong></td>
</tr>
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To Begin, select the StarFire iTC button on the GS2.

To Activate, press Setup >> StarFire iTC >> License/Activate

On the Activations Tab, enter the RTK Activation Code.

Enter the 24 Digit Activation Code
RTK Radio Configuration

The next step is to configure the radio to the RTK Base Station. Before starting, wait until the receiver has 3DGPS.

To Begin, select the StarFire iTC button on the GS2.

To begin, select SETUP >> StarFire iTC >> Diff Correction Setup >> RTK Setup

Then press G on the left hand side of the screen.

Select the letter button next to RTK Operating Mode. Make sure it is set on Absolute Base. Enter the Radio Channel and Network ID numbers for the base. Then press the letter button next to Radio and Repeater Configuration.
Make sure the operating mode is set on Absolute Base. Enter the Radio Channel and Network ID numbers for the base. Then press the Configure button.

Select the letter button beside Configure RTK Radio.

Press the Start button under Configure RTK Radio.

The Radio will then be configured to the RTK Base Station.
**Absolute Base Survey**

In the same screen where you just configured the radio, push the start button under Edit Stored RTK base.

To begin, select SETUP >> StarFire iTC >> Diff Correction Setup >> RTK Setup >> Edit Stored RTK Base Locations

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### Instructions

1. **Push the start button under Survey RTK Base Location. This will start the 24 hour survey.**

2. **Press letter button next to Survey RTK Base Location.**

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**Image 1:** Operating mode screen showing Absolute Base mode.

**Image 2:** Survey RTK Base Location screen.

**Image 3:** Screen showing Edit Stored RTK Base Locations.
Enter the storage location number and then start the survey.

Push letter button next to “Survey RTK Base Location.” Then press the letter button next to “Start Self Survey.”

Recording the Base Station Coordinates

When you record the base station coordinates for the absolute base location, make sure to record the coordinates found under stored base location. Note: It is important to manually record the Absolute base surveyed (stored base location) position in a spreadsheet or on paper in a file to retain as a backup in case a base station fails or is stolen.
• Do **NOT** use the following screens to record the receivers’ position for the Absolute Base stored location. These screens are found on the INFO pages.

**RTK Base Station Security**

To Begin, select the StarFire iTC button on the GS2. Then press G on the left hand side of the screen.

To begin, select SETUP>> StarFire iTC >> Diff Correction Setup >> RTK Setup
Make sure the RTK Operating Mode is set to Absolute Base. Then set the RTK Network ID to anything from 4001 – 4090. This will cause the security feature to come up below button H on the right hand side of the screen.

Once it is showing, push letter button I on the right hand side of the screen.

Make sure the RTK Operating Mode is set to Absolute Base. Then set the RTK Network ID to anything from 4001 – 4090. This will cause the security feature to come up beside button F.

Once it is showing, select the letter button next to it.
Press the Access list button to enter the Rover Number and Rover Hardware Serial Number. Use the toggle switch at the bottom left hand corner to make the network secure or private.

Now plug in the Rover Number and the Rover Hardware Serial Number. You can also make the network secure or public whenever you want. Push letter button E next to ‘RTK Network is currently’ to change it.
Vehicle Setup

Now that the RTK Base Station is setup, we need to activate and setup the vehicle. The RTK activation must be submitted and the radio must be configured to the Base Station.

RTK Activation

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On the Activations Tab, enter the RTK Activation Code. Enter the 24 Digit Activation Code.
RTK Radio Configuration

The next step is to configure the RTK radio in the tractor to the Base Station radio.

To Begin, select the StarFire iTC button on the GS2.

To begin, select SETUP >> StarFire iTC >> Diff Correction Setup >> RTK Setup

Then press G on the left hand side of the screen.

Select the letter button next to RTK Operating Mode. Make sure it is set on Vehicle. Enter the Radio Channel and Network ID numbers for the base. Then press the letter button next to Radio and Repeater Configuration.
Make sure the operating mode is set on Vehicle. Enter the Radio Channel and Network ID numbers for the base. Then press the Configure button.

Select the letter button beside Configure RTK Radio.

Press the Start button under Configure RTK Radio.

The Radio will then be configured to the RTK Base Station.

The tractor should now be communicating with the base station.

The tractor should now be communicating with the base station.
Troubleshooting

Potential RTK Base Station Problems

Installation and operation of the Base Station Receiver:
The receiver is the most critical part of the RTK operation, so setting up a base station correctly is vital to the operation of the RTK system. If the Base Station Receiver is setup in a questionable location, the receiver could have two separate issues; Shading and Multipath.

- **Shading:**

In order to ensure proper operation of a RTK base station, the GPS Receiver must have a clear view of the sky in all directions above seven degrees off the horizon. Both the base receiver and the vehicle receiver will use any satellites that are above seven degrees off the horizon. If a base station receiver can’t use a satellite above seven degrees, then all vehicles operating on that base station also can’t use that blocked satellite. This is call “Shading” of the base station. If enough of this occurs, your RTK system will become inaccurate.

![Image of a RTK receiver with 7 Degrees shading]

Many things can cause shading such as buildings, towers, poles, and grain legs. Minimizing obstructions will help maximize RTK performance and up-time.

In this picture, the objects around it will shade the base station. In the picture on the left, the towers in the background will block GPS satellites as they pass behind it. In the picture on the right, both the grain tubes and the bin on the right will shade the base station.
The receiver is located in the center of the picture on top of the building. This receiver could be affected by both Multipathing (discussed in the next segment) and by shading. All the grain legs in the picture will shade the receiver from satellites.

In the pictures to the right, both receivers will experience shading. The tower will shade the receiver on the left and the pole will shade the receiver on the right. The receiver on the right will have more shading issues than the receiver on the left. This is because the pole is right up against the receiver shading a large portion of the sky. The receiver on the left has been moved further away from the tower to try and improve shading issues.
Before explaining how to protect against Multipathing, let’s discuss exactly what it is: Each satellite sends down time coded messages for any receiver to pick up. If a receiver sees multiple time coded messages from the same satellite, it determines there is a problem with the satellite and discontinues using that satellite until it determines the problem is corrected. This could take several minutes before the situation corrects itself. The following are some examples of what causes multipath.

- Metal roofs
- Center pivots
- Water towers
- Vehicles parked too close
- Grain bins
- Bodies of water
- Chain link fence

In the pictures below, we have provided illustrations to help show how Multipathing occurs. The time coded signal from the GPS satellite is being beamed down in all directions, so if the same time coded signal is reflected off of an object back towards a receiver, the receiver will see the same message many times. If this occurs, you could see A/B line jumps while operating in the field. Even though the multipath signal may be reflected in below the 7 degree elevation mask, the receiver doesn’t know it, that is because the time coded message tell the receiver that it is actually above seven degrees (i.e. Sat 1; Elev. 35 degrees, Azm 255 degrees) Note: Azimuth is referenced here as a navigation point. True north is considered 0° azimuth. Moving clockwise, a point due east would have an azimuth of 90°, south 180°, and west 270°.
In the pictures above, both the roof of the car and the building are Multipathing their base station receiver. The signal is bouncing along the car and building and enter the receiver a few milliseconds after the correct GPS message.

In the picture above (left), the base station was being multipathed by the dome of the water tower. The receiver was one foot off the top of the tower. The customers would experience the following: Two vehicles would be operating at the same time. One vehicle would go from RTK into RTK-X and see a line jump of up to six inches for a couple of minutes, while the other vehicle would be operating without incident. At a later time, the situation would reverse, and the vehicle without incident earlier would go into RTK-X and experience a line jump, while the other vehicle wouldn’t.
The picture above (left) was taken after the base station was elevated five feet off the top of the tower. Since then this base station has operated without incident. In the picture on the right, the receiver is one foot of the top of the tower and is more prone to multipath problems.

To avoid both Multipathing and shading, elevate the base station receiver above any structure that it is mounted on. For best results, three to five feet from the highest point of the structure is recommended. The higher the better, but you must also ensure that the base station receiver is mounted solidly so there is no movement of the receiver. Movement of the base station receiver will result in the same movement in your tractor.

When installing a receiver on a shed, grain leg, water tower, or other tall structure, ensure the receiver is five feet above the peak of the structure. This placement will help reduce multipathing of the receiver.

- **PDOP**

Another important number to be aware of at the base station and vehicle is the Position Dilution of Precision (PDOP). PDOP is the measure of the geometrical strength of the GPS satellite configuration.
In the picture above on the left, the satellites are spread out over the horizon giving them wider angular separation and more accurate calculation on a GPS unit’s position. This equates to a lower PDOP number and the tractor driving more accurately. The picture on the right shows the satellites grouped together resulting in GPS calculations that are not quite as accurate and have a higher PDOP number. As a general rule, any PDOP value below 3.5 is acceptable to use while operating AutoTrac but, the lower the number, the more precise the steering accuracy will be. During vehicle operation, the PDOP can be viewed under the StarFire information pages in both the Original GreenStar Display and GS2 Display.

Potential RTK Vehicle Problems

- **Scenario 1: The tractor is S-ing in the field.**
  - **PDOP** – If PDOP is higher than 3.5, inaccuracies in the steering may occur. There is no solution for this except to wait for the PDOP to improve.
  - **TCM** - Make sure the TCM is configured especially when you put a receiver on a different vehicle (i.e. tractor to a sprayer).
  - **Receiver Mount** - Check the base station receiver to see if it is moving. Whatever distance the base receiver moves, the tractor receiver will move the same as well.
  - **Implement Draft** – Make sure your implement is pulling evenly. Uneven row spacing or wear will cause the implement to pull unevenly.

- **Scenario 2: The guidance lines move or shift.**
  - **Receiver Mount** - Check the base station receiver to see if it is moving. Whatever distance the base receiver moves, the tractor receiver will move the same as well.
  - **Shift Track** – If shift track is used in RTK, it moves all of the guidance lines resulting in no repeatability. Shift track should not be used in RTK at any time especially if repeatability is desired from year to year.
  - **Multipath/Shading** – Multipath and satellite shading at the base can affect the correction signal it is delivering to the vehicle. Check the installation of the receiver and make sure all of the guidelines for receiver installation are being followed.
Scenario 3: My tractor will not communicate with the base station.

- **Radio configuration** – Make sure the correct Network ID and Radio Channel are in the display. If these values are incorrect, the radio will not lock on.

- **Antennas** – Make sure the antenna is screwed in tightly at the base and the vehicle. Loose antennas can reduce and even stop the signal being broadcasted.

- **Base Station** – A power loss may have occurred which shut the base station off.

Scenario 4: The vehicle is communicating with the base station, but I can not get 3D RTK.

- **Shading** – The vehicle must be locked on to satellites before it will go into 3D RTK. When you enter a field, make sure to stay away from tree lines until the tractor locks on to 3D RTK.

- **Radio configuration** – The RTK Radio may have not configured correctly the first time it was setup. Make sure the Network ID and Radio Channel are correct and configure it again.

References

- 1 – 888 - GRNSTAR
- Local John Deere Dealer