John Deere RTK Shared Base Station Network Binder 450MHz

Updated January 2013
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Is an RTK Network Needed?

The first step in planning for an RTK Network is determining if one is needed. RTK Networks can be constructed for many different reasons. Here are seven main items to consider when you begin planning an RTK Network.

1. **Ag applications**
   a. Are there any specialty crops in your area that might require a higher level of guidance, accuracy, or repeatability?
      i. Cotton
      ii. Seed Corn
      iii. Sugar Beets
      iv. Vegetables
   b. Are there any cropping practices that can be improved upon?
      i. Strip Tillage – with the increase in input costs in recent years, this practice is becoming more widely used by producers.
      ii. Drip Tape Irrigation – installation of irrigation lines without AutoTrac caused inconsistencies in width across the fields. To compensate for that, producers may have to set 50 or more A/B lines per field. RTK allows them to set the lines once and reference them in following years.

2. **Competitive Pressure**
   a. Are there any competitors in your area?
      i. Trimble
      ii. Auto Farm
      iii. Leica
   b. What do they charge for their services?
      i. What do their components cost?
      ii. What is the cost to access their network?
      iii. How do their current customers like the network?

3. **AMS Customers/Customer Request**
   a. How many John Deere AMS customers do you currently have?
      i. How many SF1, SF2, and RTK customers do you have?
      ii. Where are these customers located?
      iii. Would they be willing to upgrade to RTK?
      iv. Would your current RTK customers be willing to sell back their RTK base station or turn it into a machine kit?
   b. How many customers use competitive RTK Auto Guidance systems?
      i. Would they be willing to switch?
      ii. Would any of your competitive equipment customers be willing to switch if your dealership installed an RTK Network?
4) **Number of customers per Shared Base Station** - When considering establishing or marketing your RTK Network, it is important to know how many customers and RTK machine kits will be accessing the network. Forecasting your user potential is important information needed to determine which marketing plan or business model(s) will work the best for your Network. Marketing different pricing structures to different customers is something to consider when you have large customers with five or more machines accessing the Network versus a customer with one or two machines. Example: You may want to offer the large customer an annual farm based fee versus allowing the 1-2 vehicle customer to pay a one-time fee or per machine fee.

5) **Investment Costs** - The cost associated with establishing base stations can vary depending on the approach taken.

   a. *Existing Structures* – The use of existing structures can decrease the investment cost of establishing a base station. Cell phone towers, radio towers, grain cooperatives, and water towers can be utilized. Most of these existing structures already have power sources, lightning protection, and security available which help reduce the initial cost. The disadvantages are that the structure may not be in the optimum location for network coverage and correctly positioning the StarFire Receiver could be challenging.

   b. *New Structures* – Building new towers increases the cost of a RTK Network. By erecting towers you are given the flexibility to establish the base station towers where you can optimize the coverage area of each base station. Using newly constructed towers gives you control of what goes on the tower and allows you to dictate how secure your base stations are. It is important when building a new tower that height, location, lightening protection, security, and power source are considered. Another advantage is that other telecommunications companies might want to lease space out from you.

6) **Maintenance Costs** - There are inherent costs associated with the maintenance of a RTK base station. Some of these costs are power, labor, lease cost for tower or land, component failure, etc. If you are using the one-time fee business model, consider charging an annual maintenance fee to help cover these costs.

7) **Goals for ROI** - Return on investment is also important when considering how to market your RTK Network. The decision has to be made whether you either establish the RTK Network for the purpose of revenue or as a service to your customers. This decision will drive the way you advertise access to your RTK Network.
Advantages and Disadvantages of an RTK Network

Pros

- **Being Able To Offer The “Complete Package” To Your Customer**
  ~ Your dealership is the one stop shop for all of your customers’ farming solutions from equipment to GPS.

- **Preserve and Increase AutoTrac Sales**
  ~ Customers “sitting on the fence” due to base station cost and maintenance will purchase.
  ~ Protect AutoTrac sales from competitive RTK dealers in the area.

- **Reduce AutoTrac/RTK support**
  ~ Reduced AutoTrac and RTK signal support issues dealing with improper mobile and permanent base station installations.

- **Added Revenue Stream**
  ~ RTK service and maintenance fees can provide a new revenue stream for your dealership organization.

- **Shared Base Station Security**
  ~ Your investment in a shared base station network will be secure with shared base station network security.

- **Protection Against Competitive Threats**
  ~ A network will ensure your customers that RTK technology is here to stay and they do not need to look anywhere else for their Precision needs.

Cons

- **Initial Investment**
  ~ There are many costs associated with establishing a shared base station RTK network (structures, power source, licensing, land leases, installation, equipment, etc).

- **Planning and Coordination**
  ~ A lot of planning has to be completed before initial setup and installation of the SBS RTK Network begins.

- **Dedicated Dealership AMS Personnel**
  ~ Need to have a dedicated AMS person that can provide on-going maintenance of base stations (power outages, lightning strikes, theft, etc).
Now that you have determined there is a need for an RTK Network in your area, the next step is to understand what components make up an RTK base station.

**Shared Base Station - Components and How They Work**

An RTK base station can be broken down into twelve main components. Let’s briefly review each component and how it works with the system.

**John Deere Components**

1. **StarFire iTC or StarFire 3000 Receiver**

   - A StarFire receiver, whether it is on a base station or machine, works the same way by calculating its position on the ground using GPS data. A base station receiver goes a step further and calculates the RTK correction signal that is broadcasted to the RTK machines using the base station. The base station receiver must be in an open area to avoid problems like shading and multipath. Setup procedures discussed later in this document will provide more information on these areas.

   - **Note:** Original StarFire receivers are NOT compatible with 450 MHz RTK radios. Also, if the 450 MHz RTK radio is mounted to the receiver on a base station and/or machine, a deluxe shroud is required.
2. 450 MHz RTK Radio

- The 450 MHz RTK Radio can be used at a base station to broadcast RTK correction signal via 450 MHz frequency, or on the machine to receive it. One-inch accuracy (2 cm) is guaranteed out to a 12 mile radius (20 km); however, machines can still receive signal past this distance. John Deere uses 450 MHz radios for several reasons. First, you can license a specific frequency and increase the base station power improving signal coverage. Secondly, licensing a specific frequency also decreases the chance of interference from other radio transmitters.

- Diagnostic LEDs – The radio is equipped with diagnostic LEDs that show if the radios are powered and operating correctly as a base station or machine. If the base station and machine radios are operating correctly, the 3 vertical LEDs in the radios must match the 3 LEDs listed below in the 3rd row of the table highlighted in yellow. There is a handy Quick Reference Guide (QRG) available on Stellar Support for reference.

<table>
<thead>
<tr>
<th>450 RTK</th>
<th>Base Station (TX)</th>
<th>Vehicle (RX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searching</td>
<td>Master does not search. See Linked and Master Transmitting</td>
<td>Solid Red</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slow Blinking Red</td>
</tr>
<tr>
<td>Linked and Master Transmitting</td>
<td>Solid Red</td>
<td>Solid Green</td>
</tr>
<tr>
<td></td>
<td>Fast Blinking Red</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>Solid Red</td>
</tr>
<tr>
<td>Configuring</td>
<td>Solid Green</td>
<td>Solid Green</td>
</tr>
<tr>
<td></td>
<td>Solid Green</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td>Solid Green</td>
<td>Solid Red</td>
</tr>
</tbody>
</table>

(TX) = Transmit (RX) = Receiver

- Radio specifications:

<table>
<thead>
<tr>
<th>Frequency</th>
<th>435 - 470 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter Power</td>
<td>2 Watt</td>
</tr>
<tr>
<td>Radio Coax Connector</td>
<td>TNC Female</td>
</tr>
</tbody>
</table>

- Note: 450 MHz RTK Radios do not have to be installed in a box, because they are weatherproof.
3. **50 Watt Amplifier (Base Station Only)**

- The optional 50 Watt Amplifier with sunshade is used only at the base station. Amplifier power is set based on the radio power setting in the Green Star™ Display. A 12 volt power supply rated at 7 amps or more is recommended to power the amplifier. The amp should **NOT** be powered through the receiver or the RS232 cable. The amplifier is also weatherproof and should not be mounted inside a box for risk of overheating. Make sure you mount the amp to a secure fixed structure that has little to no vibration.

- **Diagnostic LEDs**
  
  o **PWR** - Indicates that the amplifier has DC power.
  
  o **TX** - Indicates that an RF signal is being actively amplified and transmitted. (Blinks during normal operation)
  
  o **O/T (Over Temp)** - Indicates that the unit has exceeded its internal temperature limits. When this light is on, the unit with stop amplifying until the unit cools to prevent permanent damage.
  
  o **VSWR** - Indicates there is a problem between the amplifier and the antenna. The amp will shut down to prevent the output power from being reflected back into the unit and causing permanent damage.

- **Inputs**
  
  o **RF Out** – Connector for coax from the amplifier to the high gain antenna
  
  o **RF In** – Connector for coax from the radio to the amplifier

  **Note:** *This small piece of coax is included in the amplifier kit. We need this short distance for correct operation of the system. Longer cables will result in poor performance and reduced power/range.*

  o **DC IN** – 12 Volt Power connector
• **Note:** Never power the amplifier when coax and antenna aren't attached. This could permanently damage the amp. Also, never connect a 900 MHz radio to the amplifier.

<table>
<thead>
<tr>
<th>450 MHz Amplifier Specifications (USA and Canada only)</th>
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<tbody>
<tr>
<td>Model Number</td>
</tr>
<tr>
<td>Frequency Range</td>
</tr>
<tr>
<td>Input Power</td>
</tr>
<tr>
<td>Output Power</td>
</tr>
<tr>
<td>Current During Transmission</td>
</tr>
<tr>
<td>Nominal Voltage</td>
</tr>
<tr>
<td>Internal fuse</td>
</tr>
<tr>
<td>In/Out Impedance</td>
</tr>
<tr>
<td>Operating Voltage</td>
</tr>
<tr>
<td>Max Duty Cycle</td>
</tr>
<tr>
<td>Operating Temperature</td>
</tr>
<tr>
<td>In RF Connector</td>
</tr>
<tr>
<td>Out RF Connectors</td>
</tr>
<tr>
<td>Power Connector</td>
</tr>
</tbody>
</table>

4. **20 ft. RTK Base Station Extension Harness (6 m)**
   - The 20-ft. base station extension harness can be used to extend the StarFire receiver and RTK radio 20-ft. away from the Green Star™ display and power leads. This permits mounting the receiver on top of a building, while leaving the display connectors and power source inside the building.
   - **Note:** In certain setups where a longer harness is needed, a maximum of 6 Base Station Harnesses (120 ft.) can be hooked together. This cable is compatible with both the 900 and 450 MHz RTK systems.

5. **50 ft or 300 ft. RS232 RTK Radio Extension Harness with Lightning Protection**
   - This cable is used to transmit the correction signal from the StarFire Receiver to the 450 MHz RTK Radio. This cable allows the radio to be mounted on top of a structure while keeping the receiver close to the ground for easier maintenance and updates. A diode in the harness, grounding wire, and grounding rod are included with this harness to protect the receiver from a lightning strike.
   - **Note:** The **maximum** distance for RS232 cables is **300 ft per base station**. This cable is compatible with both the 900 and 450 MHz RTK systems.
6. RTK Dual Radio Harness
- This harness allows both a 900 MHz and 450 MHz RTK radio to be plugged into one receiver and used at the same time. The harness also has a 3 Amp fuse that protects the receiver if problems should occur. When setting up this type of base station, make sure you follow the procedures in the owner's manual.

- **Note:** Two radios of the same frequency (two 900 MHz radios for example) should not be connected to this harness at the same time.

- **Note:** The maximum distance for RS232 cables is **300ft** per base station. With a dual base the Y-harness here needs to be plugged into the receiver and the extensions can then run to the radios. But the total for both radios cannot exceed 300ft.

7. High Gain Base Station Antenna (7dBi)
- This Omni-directional antenna broadcasts RTK correction signal to all of the machines within a 12 mile radius. Omni-directional antennas are recommended because they put out equal signal in all directions. No matter how you set your RTK base station up, this antenna should be mounted as high as possible to broadcast the correction signal to the machines below. The correction signal from the base station will go through a lot of foliage, but it will not go through hills. All other components including the RTK radio can be mounted near the ground.

  - **Note:** Two things on antennas to keep in mind. First, make sure to mount the antenna away from the actual tower or structure, as placing the antenna close to the structure will block the signal in that direction to machines. The antenna needs a 360 degree clear line of sight. Second, to reduce interference chances with other antennas on towers/structures, place the antenna vertically at a different height than other antennas to prevent some interference issues.

  - **Note:** Also included in this kit are hardware to attach the antenna to a pole and a 15 ft. long low loss coax cable with N type connectors at each end that will connect to the amp and high gain antenna. If you need more than 15 ft. of coax, you will have to order it from a 3rd party supplier. If you are setting up the base without an amp, you will need an N type to TNC adapter to connect this antenna to the radio.
8. **High Gain Machine Antenna (5dBi)**
   - The high gain machine antenna can be beneficial for two reasons. First, it can be relocated to a different part of a machine for better signal reception. Example: Mounting the antenna on top of the grain tank extension of a combine instead of on the side. Secondly, the higher antenna gain increases the signal reception sensitivity allowing the machine to lock-on to a weaker base station signal thus giving better signal coverage (over the standard 2dBi rubber antenna that comes with the radio).
   - **Note:** Check out these antennas in the Sales Manual for more information.

   - If you have questions on antennas, antenna gain or decibels, this is a great website for a complete description.
     - [http://www.marcspages.co.uk/tech/antgain.htm](http://www.marcspages.co.uk/tech/antgain.htm)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>435 - 470 MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>5 dBi</td>
</tr>
<tr>
<td>Coax Connector</td>
<td>TNC Male</td>
</tr>
</tbody>
</table>

**Non-John Deere Components**

9. **Power Source**

   **450 Base Station, without 50W Amplifier**
   - A shared base station using a 450 MHz radio (WITHOUT a 50W Amplifier) requires about 2 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 machines using it. Any power surges or losses could disrupt the signal and cause line jumps or loss of signal.

   - **Note:** When using a trickle charger or inverter, make sure it has a capacity of 3 amps of larger when running the radio and receiver of a base station.

   **Examples**
   - 110 Volt >> Trickle Charger >> 12V Standard Battery >> RTK Base
   - 110 Volt >> 110 to 12V Inverter (3 Amp or larger) w/ Battery Backup >> RTK Base
   - Solar Panels >> 12V Gel Cell Batteries >> RTK Base
   - Wind Turbines >> 12V Gel Cell Batteries >> RTK Base

   **450 Base Station with 50W Amplifier**
   - When using the optional 50W Amplifier on the base station, the power requirement increases. The amplifier requires a 12 Volt power supply:
     - If the amplifier has its own power supply, make sure it can handle at least 7 amps continuously.
If both the base station receiver and amplifier are connected to the same power supply, make sure it can handle at least **10 amps** continuously.

- **Note:** *Because of the increased power load of the amplifier, battery back-up systems will not likely keep the base station running long. You may want to consider using two different power supplies. One battery back-up system for your receiver and then a separate power supply for your amplifier.*

### Dual Base Station (900 MHz and 450 MHz)

- The Power requirements for a dual base station will be similar to that of a 450MHz base station with a 50W Amplifier.

10. **Attenuator**

- An attenuator is an electronic device that reduces the amplitude or power of a signal. A 450 MHz base station broadcasts such a strong signal that a machine within approximately one mile of the base cannot connect to the base station. Machines outside of the 1 mile radius should have no problems. For machines within the 1 mile radius, attenuators will need to be added to the machine radio to decrease the signal reception sensitivity so it can lock onto the base station. The attenuator screws on directly between the 450 MHz radio and the antenna on the machine.

- Attenuators can be ordered through Tessco. Part # 335399 about $30. It is a 20db attenuator with TNC Connectors. It’s a Meca 612 - 20 - 3, if you were able to source from the manufacturer.

- **Note:** *Since attenuators decrease the signal reception sensitivity of the machine, they could start causing signal problems in the 6 – 12 mile radius region. Machines should only use attenuators when operating within 2 miles of the base station. Otherwise, they should be taken off.*

- **Note:** *Since the introduction of the Rev C serial number 450 radios, the need of attenuators has drastically reduced. It is still listed here for informational purposes.*

11. **RF Cable (Low Loss Coaxial Cable)**

- RF cable, or coax, transfers the correction signal from the RTK Radio to the Antenna. The longer the coax cable, the more signal loss there is across the cable. Make sure to reduce this loss as much as possible by using high quality low loss coax cable. When constructing a shared base station with an amplifier, make sure the radio and amplifier are mounted at the bottom of the structure. This will require a longer coax cable, but you will have easier access to the components. If an amplifier is not used, then the radio can be mounted at the top of the structure requiring a shorter coax cable. Remember, the longer the coax cable, the bigger it
must be to compensate for the signal loss. The size of the antenna will not matter if the signal cannot get there.

<table>
<thead>
<tr>
<th>Setup</th>
<th>Length (ft)</th>
<th>Recommended Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>450 MHz RTK Base Station with Amplifier</td>
<td>Less than 100</td>
<td>LMR 400 (3/8 in.)</td>
</tr>
<tr>
<td></td>
<td>100 – 250</td>
<td>LMR 600 (1/2 in.)</td>
</tr>
<tr>
<td></td>
<td>More than 250</td>
<td>LMR 900 (5/8 in.)</td>
</tr>
<tr>
<td>450 MHz RTK Base Station without Amplifier</td>
<td>Less than 100</td>
<td>LMR 600 (1/2 in.)</td>
</tr>
<tr>
<td></td>
<td>100 – 250</td>
<td>LMR 900 (5/8 in.)</td>
</tr>
<tr>
<td></td>
<td>More than 250</td>
<td>LMR 1200 (7/8 in.)</td>
</tr>
</tbody>
</table>

12. **Mounting Structure**
- Most 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, base stations mounted on these structures will need to be grounded and have lighting protection to protect the electronic equipment.
- **Note:** *If mounting the receiver on the structure itself, make sure it does not move or sway. This movement will shift all of the A/B lines that were created using that base station.*
Shared Base Station - Setup

Now that we have reviewed all of the base station components, let’s move on to the different ways of setting up a shared base station. Depending on the location and structure you are working with, here are five different setup methods.

1. **Utilizing the 300 ft. RTK Radio 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.  
   
   **Note:** If you are using the optional amplifier, we recommend you mount the radio and amplifier lower for easier accessibility.
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.

**Note:** This setup is recommended if you are using the optional amplifier. Two power supplies are shown in the chart below. Since the amp and receiver are next to each other in this type of setup, one 10 Amp power supply would work as shown in the picture.

**Note:** The 450 MHz RTK Radio is mounted on the base station receiver in this scenario which requires a deluxe shroud (PF90739).

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![Diagram of components](image)
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 and optional 50W Amplifier, giving the receiver an absolute clear view of the sky. The radio and optional amp at the bottom of the tower is then connected to low loss coax that is run up the tower to the antenna.
4. **Leaving the Radio and Receiver as a Single Unit.**

   This base station setup keeps the receiver, radio, and optional amplifier 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, it must be free of multipath, and it must not move. Any movement of the receiver will result in movement of the guidance lines/tracks.

   **Note:** Two power supplies are shown in the diagram below. Since the amp and receiver are next to each other in this type of setup, one 10 Amp power supply would work.

---

**Components mounted on top of the structure**

- **John Deere Components**
- **Preferred Supplier**
- **John Deere Components**
- **Preferred Supplier**
5. Dual Radio Base Station Setup

This base station setup allows both the 900 MHz and 450 MHz RTK Radios to operate with one StarFire iTC receiver. Neighboring dealer RTK networks using different RTK radios could use this setup on bordering base stations.

**Note:** When setting up this type of base station, make sure you follow the procedures in the owner's manual.
Marketing

New Customers:

- **Recruiting**
  - An easy method to determine what kind of customer potential you have is to send out a letter of intent to all of your AMS customers. The letter will simply ask what their intention is if an RTK network is installed by the dealer.

- **Finder’s Fee**
  - Make a deal with the first customer on the network that for every neighbor they get to join, you take a certain amount off their initial cost or yearly maintenance fee.

- **Free Trial Period**
  - Provide a 2 – 4 month free subscription to see if they like the network. This could be a great way to get potential customers interested.

Current Customers:

- **Buy Back Customer-Owned Base Stations**
  - Simply buy back your customer’s current base station for a reduced price or offer them free access to the network for a specified time period. The customer does not have the hassle of moving base stations any longer, and you can use their used equipment on your next shared base station.

- **Convert their Base Station into a Machine Kit**
  - Help your customer turn their current RTK base station into a machine kit. The customer likely has another machine with auto guidance and will not have to move their base station from now on.

- **Field/Truck Advertisements**
  - Great way to show local producers that RTK is growing in their area. Field signs are an inexpensive way to advertise your dealership as well.
Network Subscription Fees

With RTK Networks, pricing can be set up in a variety of ways. Consider the factors below when setting up your pricing structure:

- **Neighboring John Deere Dealers** – Many customers farm across AOR boundaries. It will be easier for them when neighboring dealers have an agreement in place that allows customers to use both networks.

- **Competitors Pricing** – Be aware of what your competitors are charging so you can be cost competitive. Pricing lower may increase your market share, but it could also increase the amount of time it takes to get your return on investment. Too high and sales could be lost to the competitors. One big advantage John Deere Dealers have over the competitors is their superior service and support.

- **Multi – Unit Discounts** – For larger customers that purchase several machine kits, you might want to offer them some kind of discount. One option would be to charge an annual subscription fee per farm instead of per machine. Another option is to reduce the annual subscription fee for each additional machine kit they buy.

There are three main ways to charge customers for subscription fees:

1. **Large upfront fee with a small yearly maintenance fee**
   a. **Advantages**
      i. Quicker return on investment
   b. **Disadvantages**
      i. After upgrading to RTK equipment, customers may not want to pay another large fee up front
      ii. If problems should occur in the future, the yearly maintenance fees may not be enough to repair the problem.

| #1a - $3,000 initial fee plus a yearly maintenance fee (4 new customers each year) |
|---------------------------------|-----|-----|-----|-----|
|                                | YR 1 | YR 2 | YR 3 | YR 4 |
| Total Customers                | 4    | 8    | 12   | 16   |
| New Customers                  | 4    | 4    | 4    | 4    |
| Hookup Fee/ per machine        | $3,000 | $3,000 | $3,000 | $3,000 |
| Yearly Maintenance Fee         | $400 | $400 | $400 | $400 |
| **Total**                      | $13,600 | $15,200 | $16,800 | $18,400 |

| #1b - $3,000 initial fee plus a yearly maintenance fee (1 new customer each year) |
|---------------------------------|-----|-----|-----|-----|
|                                | YR 1 | YR 2 | YR 3 | YR 4 |
| Total Customers                | 4    | 5    | 6    | 7    |
| New Customers                  | 4    | 1    | 1    | 1    |
| Hookup Fee/ per machine        | $3,000 | $3,000 | $3,000 | $3,000 |
| Yearly Maintenance Fee         | $400 | $400 | $400 | $400 |
| **Total**                      | $13,600 | $5,000 | $5,400 | $5,800 | **$29,800** |
2. Smaller upfront fee with a larger yearly maintenance fee
   a. Advantages
      i. Quicker return on investment
      ii. A larger yearly maintenance fee ensures good income even if new customers are not joining the network.
   b. Disadvantages
      i. After upgrading to RTK equipment, customers may not want to pay another fee up front

<table>
<thead>
<tr>
<th></th>
<th>YR 1</th>
<th>YR 2</th>
<th>YR 3</th>
<th>YR 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Customers</strong></td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td><strong>New Customers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hookup Fee/ per machine</strong></td>
<td>$2,500</td>
<td>$2,500</td>
<td>$2,500</td>
<td>$2,500</td>
</tr>
<tr>
<td><strong>Yearly Maintenance Fee</strong></td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$14,000</td>
<td>$18,000</td>
<td>$22,000</td>
<td>$26,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>YR 1</th>
<th>YR 2</th>
<th>YR 3</th>
<th>YR 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Customers</strong></td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td><strong>New Customers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hookup Fee/ per machine</strong></td>
<td>$2,500</td>
<td>$2,500</td>
<td>$2,500</td>
<td>$2,500</td>
</tr>
<tr>
<td><strong>Yearly Maintenance Fee</strong></td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
<td>$1,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$14,000</td>
<td>$7,500</td>
<td>$8,500</td>
<td>$9,500</td>
</tr>
</tbody>
</table>
3. Yearly maintenance fee
   a. Advantages
      i. Yearly maintenance fees ensure good income even if new customers are not joining the network.
      ii. If problems do occur, you will have sufficient income to repair the problem.
   b. Disadvantages
      i. Slower return on investment

<table>
<thead>
<tr>
<th>#3a - Yearly maintenance fee of $1,500 (4 new customers each year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Total Customers</td>
</tr>
<tr>
<td>New Customers</td>
</tr>
<tr>
<td>Hookup Fee/ per</td>
</tr>
<tr>
<td>machine</td>
</tr>
<tr>
<td>Yearly Maintenance Fee</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>#3b - Yearly maintenance fee of $1,500 (1 new customer each year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Total Customers</td>
</tr>
<tr>
<td>New Customers</td>
</tr>
<tr>
<td>Hookup Fee/ per</td>
</tr>
<tr>
<td>machine</td>
</tr>
<tr>
<td>Yearly Maintenance Fee</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
With technology constantly changing, one of the most important aspects to consider when installing an SBS RTK Network is the return on investment. Many factors need to be considered when setting your ROI goals. Some are:

- Pricing
- Customer Potential
- Investment Costs for the Network
- Network Maintenance Costs
- Subscription Revenue
- AutoTrac Upgrade Revenue
- Competitive Pressure and Pricing
- ROI Goals

Listed below are a few ROI examples depending how the network is setup.

**Business Model #1 – Existing Structure**

Assume:
- Structure: Ag Cooperative (Existing)
- Customers: 4 1st year, 1 additional each year after that
- Pricing: $1,500 up front with a $500 yearly maintenance fee
- AutoTrac Upgrades: 4 SF2 customers that upgraded to RTK

<table>
<thead>
<tr>
<th>Network Overview</th>
<th># of towers</th>
<th>Cost per network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Structures</td>
<td>1</td>
<td>$12,075</td>
</tr>
<tr>
<td>New Structures</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>$12,075</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment Costs</th>
<th>YR 1</th>
<th>YR 2</th>
<th>YR 3</th>
<th>YR 4</th>
<th>YR 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation, lease, etc</td>
<td>$12,075.09</td>
<td>$650.00</td>
<td>$650.00</td>
<td>$650.00</td>
<td>$650.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revenue</th>
<th>YR 1</th>
<th>YR 2</th>
<th>YR 3</th>
<th>YR 4</th>
<th>YR 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscriptions</td>
<td>$8,000</td>
<td>$4,000</td>
<td>$4,500</td>
<td>$5,000</td>
<td>$5,500</td>
</tr>
<tr>
<td>Sales/Upgrades</td>
<td>$4,411</td>
<td>$1,103</td>
<td>$1,103</td>
<td>$1,103</td>
<td>$1,103</td>
</tr>
<tr>
<td>Total</td>
<td>$12,411</td>
<td>$5,103</td>
<td>$5,603</td>
<td>$6,103</td>
<td>$6,603</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Return on Investment</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$336</td>
<td>$4,789</td>
<td>$9,742</td>
<td>$15,195</td>
<td>$21,148</td>
</tr>
</tbody>
</table>
Advantages:
- Less Investment costs
- Quicker ROI
- If technology changes, easier to move base stations

Disadvantages:
- May not be the optimum location

Business Model #2 – New Structure

- Structure: New tower
- Customers: 4 1st year, 1 additional each year after that
- Pricing: $1,500 up front with a $500 yearly maintenance fee
- AutoTrac Upgrades: 4 SF2 customers that upgraded to RTK

<table>
<thead>
<tr>
<th>Network Overview</th>
<th># of towers</th>
<th>Cost per network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Structures</td>
<td>0</td>
<td>$90</td>
</tr>
<tr>
<td>New Structures</td>
<td>1</td>
<td>$23,275</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>$23,275</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment Costs</th>
<th>YR 1</th>
<th>YR 2</th>
<th>YR 3</th>
<th>YR 4</th>
<th>YR 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation, lease, etc</td>
<td>$23,275.00</td>
<td>$150.00</td>
<td>$150.00</td>
<td>$150.00</td>
<td>$150.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Revenue</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscriptions</td>
<td>$8,000</td>
<td>$4,000</td>
<td>$4,500</td>
<td>$5,000</td>
<td>$5,500</td>
</tr>
<tr>
<td>Sales/Upgrades</td>
<td>$4,411</td>
<td>$1,103</td>
<td>$1,103</td>
<td>$1,103</td>
<td>$1,103</td>
</tr>
<tr>
<td>Total</td>
<td>$12,411</td>
<td>$5,103</td>
<td>$5,603</td>
<td>$6,103</td>
<td>$6,603</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Return on Investment</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(YR 1)</td>
<td>($10,864)</td>
<td>($5,911)</td>
<td>($458)</td>
<td>$5,495</td>
<td>$11,948</td>
</tr>
</tbody>
</table>

Advantages:
- Constructed in optimum location
- No monthly or yearly lease fees
- Option to lease space out on your towers to other companies
  - Wireless internet
  - News Station – weather equipment

Disadvantages:
- Greater Investment costs
- Slower ROI
Constructing an RTK Network

To this point, we have determined the need for an SBS RTK Network, how it works, and the different business models available to make it profitable. Now it’s time to start planning and constructing the actual network. Proper planning is the key to a successful network and will help you avoid many problems in the future. There are several options for planning and installing a RTK Network. You may choose to manage the project yourself or hire a consultant to do it. Here are the steps to ensure the base station is set up correctly no matter which route you take.

Selecting a Base Station Site

After determining where your potential customers are located, you can start looking for tower locations in their area. Keep the following in mind:

Existing Structures - Using existing structures can reduce your initial investment cost, as well as, protect you in the future if technology changes. Some good examples of current structures are:

- Grain Cooperatives/Concrete Silos
  - Concrete Silos work the best because they are less prone to multipath 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 guide wires, you should not mount the receiver on top due to the sway of the leg.*

- Water towers
  - Water towers work well because their height also decreases the chance of multipathing and shading from other objects in the area. Similar to Co-ops, power is usually readily available. For more information, talk to your local city council.

- Cell phone towers
  - In some areas, cell phone providers may be willing to lease space out on their towers. To determine if the cell towers in your area are available, use [http://www.cellreception.com/towers/](http://www.cellreception.com/towers/) 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. *Note: For towers that only have an FCC Registration Number, visit the FCC website for contact information.*
    - [http://wireless2.fcc.gov/ULsApp/AsrSearch/asrRegistrationSearch.jsp](http://wireless2.fcc.gov/ULsApp/AsrSearch/asrRegistrationSearch.jsp)
New Structures

When there are no existing structures to use in the area of interest, a new tower might need to be constructed. Careful planning and consideration should be taken to ensure the tower is placed in the optimum location. The steps below will help you determine this location.

- **AOR**
  - When deciding on the location of the tower, work with your Territory Manager to ensure that all shared base stations are constructed within your AOR.

- **Power**
  - Is there power available at the location you’re looking at? A 110 volt power source works best for a base station. If power is not available, you might want to consider alternative power sources like batteries or solar panels. Running power from the nearest source can increase initial investment costs due to the expense of installation.

**Signal Propagation Surveys**

Once you have selected several potential sites, you need to find out which ones will work the best. The easiest way to do this is to conduct a signal propagation test. From these tests you will see which sites will offer the best coverage. After that, you can set up temporary base stations at these sites and do a final test to make sure they will work. Several options are listed below:

- **Signal Coverage Programs**
  - John Deere Service – Signal coverage maps can be generated at AMS free of charge. Send the latitude and longitude coordinates (decimal format) and the height of the antenna from the ground. We also need to know the type of setup you are wanting. 900MHz, 450MHz, or 450MHz with an Amp. This needs to be filed in a DTAC Case. See DTAC Solution 92570 for more information.

  - Free Online Programs – Click on the link below and download these free computer programs
    - [http://earth.google.com/](http://earth.google.com/)
      - Google Earth allows you to plot possible base station locations and look at the terrain in your area.
    - [http://www.cplus.org/rmw/english1.html](http://www.cplus.org/rmw/english1.html)
      - Radio Mobile allows you to input the base station location and other key aspects including antenna gain, coax, etc. It will then display a signal coverage map for the area.

  - Note: This program is not 100% accurate, and in-field testing should be done to verify the results before any equipment is permanently installed.
Tower Companies

Now that you have planned out the location of your base stations, you can decide how you want to construct it.

- If you are installing components on an existing structure, you can work with your local communications company or with one of the suppliers listed below.
- If you decide that a new tower is the best option for your dealership, the two tower companies below can help you with this service. Each company will help determine what type of tower and equipment you need to buy depending on the terrain, foliage, and other factors in your area.

- **Sabre Communications Corporation**
  - **Overview**
    - This tower manufacturer offers tower and equipment sizing, construction, and installation services. Once you know the area of the tower location, Sabre can help you choose the right tower and equipment to meet your requirements. Sabre also has contractors throughout the country that will install your tower if need be. Here are some of the solutions they can provide:
      - **Services**
        - Determine the size of the tower due to wind, soil, location, etc
        - Size all hardware and electrical components
        - Contractors nation-wide to install the tower and components

- **Tessco**
  - **Overview**
    - Tessco is a nation-wide supplier of towers, antennas, coax, and many other accessories. When you contact Tessco, they will help size the tower with all of the recommended electrical components. From there, Tessco will ship everything to your dealership or field site. You can choose to construct the tower, or hire a contractor to do it for you. Tessco does not provide this service.
      - **Services**
        - Determine size of tower due to wind, soil, location, etc
        - Determine which components are needed – lightning rods, coax, etc.
        - Preferred pricing for John Deere Dealers
        - Does not offer construction services

Electronic Equipment

Some of the electrical equipment on an RTK shared base station, like the 450 MHz RTK radio, StarFire Receiver, and RS232 Cable, is purchased through John Deere. The rest of the components can be ordered through our preferred suppliers listed below.
Power Sources

- **110 Volt connection** – If a 110 Volt connection is available, simply use a 12 Volt power inverter to provide the power needed for the base station. Depending on your base station setup, the amp requirements may be different. Use the table below to ensure your power supply has enough amps to power the base station and optional 50W Amplifier. Proper setup will reduce problems in the future.

<table>
<thead>
<tr>
<th>Setup</th>
<th>Volts</th>
<th>Amps Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>450 MHz Base Station w/o Amplifier</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>450 MHz Base Station w Amplifier</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Dual Radio 900 MHz and 450 MHz Base Station w/o Amplifier</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Dual Radio 900 MHz and 450 MHz Base Station w Amplifier</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

**Note:** When possible, try to connect the base station receiver to a battery back-up system. A battery releases consistent power and allows for some added run time if a power loss should occur. If the optional 50W Amplifier is used, it is recommended that a separate power source be used so the receiver can still have battery back-up.

- **John Deere Parts**
- **CB World**

**Alternative Power** – If the optional 50W Amplifier is used, **DO NOT** use an alternative power source to power it. The increased power load needed for the amplifier will triple (3x) the power consumption compared to a setup with no amplifier. Cost for the alternative power system will also triple.

  - **Wind Turbines**
    - Wind turbines only need an average speed of 5 mph to generate enough electricity to power a base station. This, in combination with a solar panel would be a good solution. **Note:** Deep cycle batteries would be the best choice for this type of setup. Deep cycle batteries would be more resistant to the damage from constant charging and discharging.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No power bills</td>
<td>- Large initial cost</td>
</tr>
<tr>
<td>- Consistent power source</td>
<td>- Service/support may be slow</td>
</tr>
<tr>
<td>- Little to no maintenance</td>
<td></td>
</tr>
</tbody>
</table>

- **Northern Tool Company**
o Solar Panels

- Many areas of the U.S and Canada are using solar panels for power when electricity is not readily available. Depending on the location, a solar panel can be sized to meet the needs of your shared base station. Note: Gel cell batteries would be the best choice for this type of setup. Gel cell batteries would be more resistant to the damage from constant charging and discharging.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No power bills</td>
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</tr>
<tr>
<td>- Little to no maintenance</td>
<td></td>
</tr>
</tbody>
</table>

- Tessco

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 or our preferred suppliers 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 runoff (see picture). When using connectors and adapters, follow the guidelines below to insulate and protect them properly.
  - Wrap connector with ¾” electrical tape sticky side out. (For easy removal at a later date.)
  - Wrap with one wrap of butyl tape and make sure the putty molds into the cable.
  - Wrap with 4 wraps of ¾” electrical tape.
  - Wrap final wrap with 2” electrical tape make sure that the tape is shingled like the shingles on a house, so that moisture is shed downward.
  - TNC male connector needed to connect to radio

- Coax must be 50 Ω cables.
- N-type connections for the cable types are recommended. Due to the rigidity of these low-loss cables, a TNC to N-type adapter cable will be required to alleviate strain on the RTK Radio TNC connector.

- Tessco


**Lighting Rods/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. Whether you are constructing the tower yourself or working with a tower company, make sure this accessory is included.

- **Tessco** ................................................................. Ref. – B
- **Sabre Communications Corporation** ................................... Ref. – A
Now that the RTK Shared Base Station has been constructed, it is now time to configure the base station.

**GS2 2600/GS3 2630 Display - RTK Activation**

1) To Begin, select the “StarFire iTC/SF3000” button on the GS2/GS3.

2) On the Activations Tab, enter the RTK Activation Code.

**RTK Radio Configuration**

1) The next step is to configure the radio to the RTK Base Station. To Begin, select the “StarFire iTC” button on the GS2.
2) Then press “G” on the right hand side of the screen.

3) Make sure the operating mode is set on “Absolute Base”. Enter the Network ID and then press the “Configure” button.

4) Enter in the Radio Frequency and Bandwidth from the FCC license. If the bandwidth is set to 12.5 kHz, use a data rate setting of L2 9600. If the bandwidth is set to 25 kHz, use a data rate of L4 38400. Use the Radio Power table in the owner’s manual or use the “450 MHz Base Station Radio Power Calculator” on Dealer Corner in Stellar Support to determine at what power the radio should be set. Once all four values are selected, Press the enter button at the bottom right hand corner.
5) A “Licensed Parameters” warning will appear. Make sure all of the radio settings are consistent with your FCC license and local licensing requirements. If correct, press the enter button at the bottom right hand corner.

**Absolute Base Survey**

1) In the RTK screen where you just configured the radio, push the “Start” button under “Edit Stored RTK base.”

2) Push the “Start” button under “Survey RTK Base Location.”
3) Enter the storage location number and then start the survey.

**Recording the Base Station Coordinates**

When recording the information for the absolute base location, make sure to document the latitude and longitude coordinates and the altitude. *Note: It is important to manually record the absolute base surveyed (stored base location) position as a back-up in case a base station receiver 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

1) To Begin, select the “StarFire iTC” button on the GS2. Then press “G” on the right hand side of the screen.

2) Set the Operating Mode to “Absolute Base.” Then set the RTK Network ID to anything from 4001 – 4090.
3) This will cause the security feature to appear below button H on the right hand side of the screen. Once it is visible, select it.

4) Press the “Access List” button to enter the Rover Number and Rover Hardware Serial Number (1 - 200). Use the toggle switch at the bottom left hand corner to make the network secure or private.
John Deere 450 MHz RTK Radios can operate anywhere in the 435 – 470 MHz range. In the United States, the range for private land mobile licenses is in the 450 – 470 MHz range. John Deere has setup a partnership with the Enterprise Wireless Alliance, EWA to apply for the licenses and obtain them from the FCC. This process should be completed in a couple of weeks and has been found to be much easier and faster than going through the FCC directly. For the application forms visit Dealer Corner in Stellar Support and select the “RTK Radio Tools: 450 & 900” link under StarFire Information.
Note: It is the Dealer's responsibility to follow all FCC rules and regulations for the 450 – 470 MHz band. You can find more information at http://www.fcc.gov/

Once the license has been obtained, you will need to report the construction of the base station within one year of construction. If not, the FCC has the right to take that licensed frequency back and resell. So it is important that you follow the instructions given to report this information.

There have been reports that you will receive letters that say that you need to join a membership, or buy a rules book or other solicitation. No other items are required to run a 450MHz base station. The rules book is available for free on the FCC website, and any memberships are 100% voluntary. The only item that would be important is the license renewal required in 10 years.
Troubleshooting

Installation and operation of the Base Station Receiver:
The base station 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 Multipathing.

Shading:
In order to insure proper operation of a RTK base station, the GPS Receiver must have a clear view of the sky in all directions above 7 degrees off the horizon. Both the base receiver and the machine receiver will use any satellites that are above 7 degrees off the horizon. If a base station receiver can’t use a satellite above 7 degrees, then all machines 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.

Many things can cause shading: Buildings, towers, poles, grain legs, and many other things. Below is an “obstruction diagram” to help determine if the base station location you are choosing will be obstructed.

Note: The closer the obstruction, the more degrees it will cover on the diagram. You must also include the tower that will elevate the RTK radio and/or antenna. The tower can also cause shading of the receiver. The closer the receiver is to the tower, the more it will shade the receiver. Any building will also cover a large part of the diagram. If Shading is unavoidable, ensure that the receiver is mounted on the south side in the northern hemisphere of any obstruction. To determine the minimum distance, use the receiver distance tool available on Stellar Support.

Try and mark any part of the diagram that has an obstruction above 7 degrees in elevation. This information will be very helpful in diagnosing a problem with a system. It would also be helpful in listing these obstructions below.
Note: The 7 degrees was true for StarFire iTC Receivers. With the SF3000 Receiver, the number was changed to 5 degrees.

A—Hill, North  B—Trees, Northeast  C—Powerlines, Overhead  D—House, Southwest

Many things can cause shading such as buildings, towers, poles, and grain legs. The diagram above is often used in the survey industry to help determine the best base location available. The outer ring is the direction from the base to obstruction (North = 0). The concentric rings in the center are used to show the angle from the horizon to the top of the obstruction—measured from the base station location. Use the obstruction diagram to determine if the base station location you are choosing will be obstructed. Minimize obstructions to maximize RTK performance and up-time.

Mark any part of the diagram that has an obstruction above the receiver. Not only is this very useful for determining the initial base station location, it is also very helpful in diagnosing a problem with a system. It would also be helpful listing any of these obstructions shown in the following pictures.
In the picture above, the objects around it will shade the base station. The telephone poles, tree and the close buildings in the background 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 and cause multipath.
In the pictures above, 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.

- **Multipathing**
Before explaining how to protect against Multipathing, let's discuss exactly what Multipathing 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
- Machines 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 7 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°.

Below, 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 1 ft. off the top of the tower. The customers would experience the following: Two machines would be operating at the same time. One machine would go from RTK into RTK-X and see a line jump of up to 6 inches for a couple of minutes, while the other machine would be operating without incident. At a later time, the situation would reverse, and the machine without incident earlier would go into RTK-X and experience a line jump, while the other machine wouldn’t.

The picture above (right) was taken after the base station was elevated 5 feet off the top of the tower. Since then this base station has operated without incident. In the picture on the left, the receiver is 1 foot of the top of the tower. In the right, 5 feet off the top of the tower.

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 insure 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 machine.

Avoid any obstructions above 7 degrees from the dome of the receiver as much as possible to help prevent shading issues of the receiver.
When setting up the tower network, use the receiver distance tool to ensure proper placement of the StarFire Receiver to protect your system from multipath.

When installing a receiver on a shed, grain leg, water tower, or other tall structure, ensure the receiver is 5 feet above the peak of the structure. This placement will help reduce multipathing of the receiver.
RTK Base Station Network Areas Utilizing Straight, Curves or Circle
AutoTrac

Symptoms:
- Customer changes base stations and/or fields and the machine does not align to the previous track or bed.
- Customer utilizes multiple base stations for the same field and does not see the desired AB line repeatability among machines or field passes.

Note: When the term AB line is used, it also encompasses Circle track and Curve track lines.

Solution:
RTK is designed to provide repeatability pass after pass and from season to season. This repeatability is a function of the Base Station location and it's correlation to a field specific AB line driven by the machine.

AB lines and field operations **must** be linked to the specific base station that they were originally created with. Every AB line in the field is created while utilizing a specific RTK base station. Every pass in that field for a particular season or set of beds must utilize the same original base station and location that was used to create that specific AB line(s).

**Example A**
As you see in the picture on the next page, Field A has 3 base stations located within a 12 mile radius of the field. Although 3 base stations could be used to operate machines within this field, one base station must be selected to perform all field operations for that season and assigned/created AB lines. In this instance, the customer selected base station # 1 as it was centrally located to other farms.

This means that when AB lines are being created, all machines and operations for that cropping season **MUST** use the same base station and location. Also, if AB lines were set up during subsequent seasons, the same original base station that was utilized in subsequent seasons must be used again at the same base location.

AB lines must be assigned and associated to a specific base station in order to achieve absolute accuracy and repeatability. This absolute accuracy and repeatability is obtained during the base stations 24 hour absolute survey.

Any time a base station is used to perform a field operation and it **IS NOT** the base station that was used to create that original AB line, errors will exist in the AB line position. These errors will vary from location to location, but may be as much as 3 to 5 inches off.

A recommended practice is to assign every field to a specific base station. This will ensure that every operation performed in that field, including AB line creation, is utilizing the most accurate and repeatable correction signal possible.
EXAMPLE A

**StarFire iTC or Gen II Receiver Operating Parameters for ALL AutoTrac, SF1, SF2, and RTK:**

Several factors can attribute to a less than optimal performance of the GPS receiver, whether it is operating in SF1, SF2 or RTK mode. Any lack of performance while operating in RTK mode will display symptoms sooner then operating with SF1 and SF2. RTK operations require higher precision and many applications are in preexisting tracks, so the operator will notice unsatisfactory performance sooner by visually comparing against the previous tracks.

When operating with RTK, there are always 2 critical components that come into play:
1. Base Station Setup and any possible obstructions
2. Machine Setup and any possible obstructions

RTK machine operation is directly affected by the quality of the base station location and setup, *not* just machine GPS receiver interferences. The base station is feeding satellite correction information to the machine (rovers) at all times. If any of the GPS signal being received at the base station is distorted or corrupted in any way, that incorrect information will in turn be fed directly to the machine (rover) leading to a loss in accuracy and repeatability.
PDOP Definition

The Position Dilution of Precision (PDOP) is likely one of the most critical GPS AutoTrac values to monitor. As the PDOP value increases, both the horizontal and vertical precision (guidance accuracy) of your data points decreases.

To help illustrate this relationship, please review the following graph, which plots the PDOP value against the horizontal precision points collected on and around the University of Montana campus. Ten locations were collected to serve as ground control points to register an April 4, 1999 aerial photograph of the University area. You can see that as the PDOP value climbs from a minimum of 1.15 to a maximum of approximately 4.5, the horizontal precision and accuracy decreases from about 1.15 meters to about 1.9 meters. PDOP values below 7 are generally required to collect data at a 1 meter accuracy range (as determined by the PDOP mask set on your data logger) and any value below 3.5 is considered in-range for AutoTrac applications.
Keep in mind that PDOP (Position Dilution of Precision) is the measure of the geometrical strength of the GPS satellite configuration. 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 machine operation, the PDOP can be viewed under the StarFire information pages in both the Original Greenstar Display and GS2/3 Display.

*Pictures from GS Display*

PDOP operating values should remain BELOW 3.5 DURING ALL AUTOTRAC OPERATIONS, especially RTK high precision operations. As the value of PDOP rises above 3.5, signal quality will begin to degrade and position accuracy will be compromised. The DTAC solution(s) explain situations and factors that will directly affect the PDOP number.
As a rule, when the GPS receiver is warming up from being in a powered off state and gathering satellite signals high PDOP values (4 to 20+) will be experienced for upwards of 15 minutes (under normal conditions).

GPS signal quality is not directly related to PDOP in a 1-to-1 relationship. As PDOP rises above 3.5, it can take significantly longer for signal quality to start to degrade. Therefore, it is important to monitor PDOP along with signal quality while performing field operations.

**GS Display – Signal Quality**

**DTAC Solution 79639 – RTK Radio Self Test**

<table>
<thead>
<tr>
<th>450 mhz Radio</th>
<th>Base Station</th>
<th>Rover (Vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Distance (m)</td>
<td>Invalid Reading on Base</td>
<td>Distance from base (only accurate when past 1 mile)</td>
</tr>
<tr>
<td>Number of disconnects</td>
<td>0</td>
<td>0-2</td>
</tr>
<tr>
<td>RadioTemp (°C)</td>
<td>0 - 10 = Good</td>
<td>0 - 10 = Good</td>
</tr>
<tr>
<td>Antenna Reflected Power</td>
<td>11 - 30 = Marginal</td>
<td>11 - 30 = Marginal</td>
</tr>
<tr>
<td>Transmit Current</td>
<td>100 - 750 ma</td>
<td>Invalid Reading on Rover</td>
</tr>
<tr>
<td>Avg Signal Level</td>
<td>Invalid Reading on Base</td>
<td>60 - 100 = Good</td>
</tr>
<tr>
<td>Avg Noise Level</td>
<td>Will vary</td>
<td>100 = Greater = Marginal to No Radio Link</td>
</tr>
<tr>
<td>Difference between signal and noise</td>
<td>30 - Greater = Good</td>
<td>30 - Greater = Good</td>
</tr>
<tr>
<td>Overall Receive Rate</td>
<td>Invalid Reading on Base</td>
<td>90 - 100 % = Good</td>
</tr>
</tbody>
</table>
Note: Information provided below are recommendations provided to give you ideas and the types of components that are available from 3rd party suppliers.

### Preferred Suppliers

**Sabre Site Solutions**  
2301 Bridgeport Drive P.O. Box 658  
Sioux City, IA 51102-0658  
(866) 428-6937  
Email: catalog@sabrecom.com

**History:**  
Sabre Communications Corporation is a privately held company founded in Sioux City, Iowa in 1977 by D. Bailey Aalfs. In business for more than 25 years, Sabre has provided towers and HF antenna systems to more than 50 countries worldwide. A leading manufacturer in the tower industry, Sabre manufactures guyed towers, self-supporting towers, monopoles and tower components. Operating manufacturing facilities in Sioux City, Iowa and Fort Worth, Texas, Sabre has the highest volume manufacturing capacity in the industry.

**Overview:**  
Sabre Communications Corporation is one of the world's largest manufacturers of communication towers. Sabre engineers and manufactures guyed towers, self-supporting towers, and monopoles for a number of different applications. Our in-house engineering staff custom engineers each tower to your specifications. We also offer turnkey construction services worldwide, structural analyses, and tower modifications.

**Services:**  
- Largest supplier in the industry  
- Tower sizing and recommendations based on location  
- Contractors nationwide to erect the tower.  
- Old or damaged tower repairs
Preferred Suppliers

TESSCO Technologies Incorporated
John Deere Support Team
11126 McCormick Road
Hunt Valley, MD 21031-1494
Phone: 866.352.9671
Web site: http://www.tessco.com/go/deere
Email: johndeere@tessco.com

TESSCO Component Source for John Deere StarFire™ RTK

With an overall product and service portfolio exceeding 30,000 wireless products from more than 350 world-class manufacturers, you can be assured that TESSCO can consistently and efficiently provide you with all your John Deere recommended StarFire Components, including:

- Power Source Solutions
- RF Cable Solutions
- Antenna Solutions
- Mounting Structure Solutions

Step #1 - Power Source Solutions for John Deere RTK

Is there Power Available at Shared Base Station Site?

- Yes – 120 Volt AC or 240 Volt AC

Recommended Solution:

- Battery and Battery Charger Solution

A shared base station requires about 1-3 Amps or 12 Watts of continuous power. Although the power requirement is minimal, it needs to be regulated and consistent in order to ensure a proper correction signal to the RTK machines.

Discover the battery chargers and other battery solutions that TESSCO can offer to alleviate power surges or losses that could cause signal loss and/or line jumps; these include: NewMar Phase Three Chargers that employ switching technology to charge batteries in a 3-step process; various
batteries for remote communication sites; as well as rack-mounted power supplies with meters by NewMar.

**Is their Power Available at Shared Base Station Site?**

- No - AC Power is not available at the site

**Recommended Solution:**

- StarFire RTK Solar Power System

TESSCO’s product offering also features the **StarFire RTK Solar Power System** – a leading solar solution that has been designed specifically for the John Deere StarFire RTK system and is available to you **off-the-shelf and ready to ship**. Simply choose your geographic location and get started!

TESSCO has partnered with the experts at John Deere to design these pre-sized, complete, solar power solutions for RTK StarFire shared base station deployments throughout the United States. There are two easy-to-select solar & wind power system designs – one for the Northern US and another for the Southern US – both of which are complete kits that included all necessary hardware for fast and easy installation. Get started today by choosing your geographic location:


**Step #2 - RF Cable Solutions for John Deere RTK**

**Will you be using Coax on your RTK Shared base Station?**

- No – Continue to step #3
- Yes – TESSCO offers the latest in RF Cable, also known as Low Loss Coaxial – the type of cable that is trusted to transfer the radio signal from the RTK Radio to the Antenna. The distance between the RTK Radio and the Antenna dictates the thickness of cable that needs to be used. Coaxial cable does loose signal power the greater the distance it is transferred. The greater the distance, the thicker the cable needed. The goal when choosing your cable is to select the cable with the lowest signal loss (dB) while keeping the expense in check. Remember, the thicker the cable, the more expensive it is. Make certain to compensate the signal loss with a higher-gain antenna for increased signal broadcast strength. If you are unsure what size coax to use, contact the John Deere Support Team at TESSCO. They will help you size the correct type of coax and connectors for your specific needs. Please remember to order the accompanying connectors when ordering your coax cable.
### Step #3 - Antenna Solutions for John Deere RTK

**Omni-Directional Antennas:**

TESSCO also delivers the latest omni-directional antennas to broadcast the sub-inch correction signal to all your machines within a 12-mile line-of-sight radius. These are recommended by John Deere and TESSCO because they emit equal signal in all directions. And regardless of how you set-up your SBS RTK Network, this antenna should be mounted as high as possible to ensure better signal coverage to the machines below. All other components, including the RTK radio, can be mounted near the ground if desired.

### Step #4 - Mounting Structure Solutions – Including Stock Towers Designed for John Deere RTK

All components are mounted on or near some type of structure, including radio/cell towers, water towers, grain elevators, buildings, or other tall structures. And due to their height, all of these options need to be grounded, as well as protected against lightning. You should also make an important note that if you opt to mount the receiver on the structure itself, take care to ensure that it does not move or sway.

### Lightning Protection with Polyphaser SX High-powered DC Protector

TESSCO also offers reliable lightning protection with Coax, Network & AC Protectors featuring the PolyPhaser SX patented DC-blocked filter design that provides total equipment protection. Available in various connector configurations and in frequencies ranging from 350MHz to 10GHz, the result is extremely low let-through voltage and throughput energy. Other features include:

- Multi-strike
- Maintenance-free

<table>
<thead>
<tr>
<th>Cable Length</th>
<th>Model</th>
<th>Model</th>
<th>Model</th>
<th>Model</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LMR-400 (3/8&quot;)</td>
<td>LMR-500 (1/2&quot;)</td>
<td>LMR-600 (1/2&quot;)</td>
<td>LMR-900DB (5/8&quot;)</td>
<td>LMR-1200DB (7/8&quot;)</td>
</tr>
<tr>
<td>26-50'</td>
<td>2.0 dB</td>
<td>1.6 dB</td>
<td>1.3 dB</td>
<td>.9 dB</td>
<td>.6 dB</td>
</tr>
<tr>
<td>76-100'</td>
<td>4.0 dB</td>
<td>3.2 dB</td>
<td>2.5 dB</td>
<td>1.7 dB</td>
<td>1.3 dB</td>
</tr>
<tr>
<td>101’-150’</td>
<td>5.9 dB</td>
<td>4.8 dB</td>
<td>3.8 dB</td>
<td>2.6 dB</td>
<td>1.9 dB</td>
</tr>
<tr>
<td>151’-200’</td>
<td>7.9 dB</td>
<td>6.4 dB</td>
<td>5.1 dB</td>
<td>3.5 dB</td>
<td>2.6 dB</td>
</tr>
</tbody>
</table>
- Fully weatherized
- Surge rating of 20kA
- Elongated female connectors allow mounting of units through ¼” bulkhead or grounding bar
- Uses BFN or BFD adapters for flange mounting

TESSCO also offers a comprehensive collection of the latest products for your grounding solutions needs.

**Towers:**

TESSCO’s latest product and service offering now features stock towers from industry leader Trylon – which can be configured to support a wide array of products.

Just tell us what you need to put in the air, and TESSCO will get you there with a tower customized to meet your unique requirements! Simply fill-out a Tower Calculation Form and TESSCO’s team of technical experts will determine what tower style you need for your application. Most importantly – most tower solutions ship from stock, and arrive within 3-5 days of your order!

**TESSCO partners with Trylon to provide you with rugged, high-communications towers. From concept to completion, from design to long-term operation, TESSCO is here to help!**

**Power Supplies**

![Innovative Circuit Tech. - Power Supply, 13A, 7.1"W](image)

<table>
<thead>
<tr>
<th>GSA</th>
<th>Innovative Circuit Tech. - Power Supply, 13A, 7.1&quot;W</th>
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</thead>
<tbody>
<tr>
<td>Mfg Part #: ICT1201215A</td>
<td>TESSCO SKU: 57921</td>
</tr>
<tr>
<td>Qty/UOM: 1 EACH</td>
<td>UPC: 720196579210</td>
</tr>
</tbody>
</table>

The Innovative Circuit Tech ICT1201215A 7.1 inch wide switching power supply delivers continuous, trouble-free operation. Extra filtering provides a virtually noise-free environment. This desktop power supply uses 115 VAC input for a 13.8 VDC output to produce 13 amp continuous and 15 amps intermittent current.

The ICT 13 amp switching power supply offers current limiting and fuse protection. To match your mobile radio, the power supply is 7.1 inches wide.

Add-on options include radio specific hoods (not included).
Preferred Suppliers

Northern Tool + Equipment
2800 Southcross Drive West
Burnsville, Minnesota 55306
(952) 894 - 9510
http://www.northerntool.com/

Sunforce Wind Generator — 400 Watts

- Item# 44444
- Features
  - Delivers up to 400 Watts or 27 Amps in ideal conditions
  - Blades are 13in. Long and overall diameter is 46in.
  - Integrated regulator automatically shuts down when batteries are charged to minimize wear
  - Weatherproof, maintenance-free unit with only 2 moving parts
  - Tower mounting kit Item# 339982 sold separately
  - Dimensions: 24in.L x 15in.W x 9in.H
Batteries for base stations using trickle chargers and battery backup systems.

Features:
- 12-volt, 608 CCA, 730 CA, 160 RC, 27 BCI
- Deep cycle antimony chemistry
- Contains both pillar and threaded top posts
- Dry charged from the factory for freshness
- Extra-heavy grid plates for extra reserve power
- Can be ordered on the John Deere dry battery program
- Warranty code A
- 36 hours of operation at 3 Ah draw

Batteries for base stations using solar panels and wind generators.

Features:
- 12-volt, 750 CCA, 950 CA, 100 RC, 34 BCI
- Contains both pillar and threaded top posts
- John Deere StrongBox Spiral Energy battery grid design and absorbent glass-mat (AGM) separator virtually damage and capacity loss by resisting vibration
- Patented separator technology allows for faster recharge than conventional batteries
- Overcharge gas escapes safely, while retaining a sealed quality making it ideal for use in a wide variety of applications
- Heavy-duty components and innovative design provide superior conductivity, durability, and off-season power retention
- Can be ordered on the John Deere wet battery program
- 36 month total warranty, 18 month free replacement
- 16 hours of operation at 3 Ah draw
Features:

- 4 Amp Constant - 6 Amp Surge
- Output 13.8 Volts (+/- 0.05 V)
- Short Circuit and Over Voltage Protection
- Ripple Less than 10 Mv
- Binding Post Terminals and Cigarette Lighter Socket
- External Fuse Access
- Dimensions 3.5" (H) x 5.1" (W) x 7.3" (D)
- Shipping Weight 6 Lbs