John Deere RTK
Shared Base Station
Network Binder
900MHz

Updated January 2013
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Is a Shared Base Station Network Needed?

The first step in planning for an RTK Network is to determine if one is needed. RTK Networks can be constructed for many different reasons. Here are three main areas to consider when you begin planning an SBS 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 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 the 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 in to a vehicle kit?
   b. How many customers do you have that 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 with an RTK Network in place?
4 Number of customers per Shared Base Station - When considering establishing or marketing your SBS RTK Network, it is important to know how many customers and RTK vehicle 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 SBS Network. Marketing different pricing structures to different customers is something to consider when you have large customers with five or more vehicles accessing the SBS Network versus a customer with one or two vehicles. 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 vehicle 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 and radio towers as well as 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 increase the cost of a SBS 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 SBS RTK Network. The decision has to be made if you are establishing the SBS RTK Network for the purpose of revenue or as a service to your customers. This decision will drive the way you market access to your SBS RTK Network.
Advantages and Disadvantages of RTK Networks

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 networks 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 don’t 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, 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).
RTK Network Overview

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 shared base station (SBS).

Shared Base Station - Definition

An SBS RTK Network is defined as one or more permanent shared base stations in which access service is sold to customers.

Shared Base Station - Components and How They Work

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

John Deere Components

1. **StarFire ITC or StarFire 300 Receiver**
   - A shared base station receiver works like a receiver on a vehicle. Using GPS satellite information, the base station receiver calculates its exact position. A correction signal is calculated from that position and broadcasted to the vehicles using the base station thus providing sub-inch accuracy. The receiver must be in an open area to avoid problems like shading and multipathing. Setup procedures discussed later in this document will provide more information on these areas.
2. RTK Radio
   - The RTK Radio at a base station broadcasts the correction signal via 900 MHz frequency. Sub-inch correction is guaranteed out to a 12 mile radius; however, vehicles can still receive signal past this distance. John Deere uses 900 MHz radios for several reasons. First, you do not have to license the RTK Radio through the FCC when constructing a shared base station. Second, it is the frequency that all of our RTK products are configured for. Note: in certain areas, tower height might require licensing and/or permits.

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<tr>
<td>Output Power</td>
<td>1 Watt</td>
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<tr>
<td>Spreading Method</td>
<td>Frequency Hopping</td>
</tr>
<tr>
<td>Radio Coax Connector</td>
<td>TNC Female</td>
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- **Repeaters Radios** – More than one repeater can be used with the same base station as long as the vehicle using RTK does not communicate with more than 1 repeater at a time. If this happens, the vehicle cannot differentiate the two signals and line jumps will occur. Make sure to educate your customers about repeaters to reduce problems in the field.

- **Vehicle Repeater Mode** – A vehicle using RTK can be setup as a vehicle repeater. The vehicles will AutoTrac as well as repeat signal to other tractors in the field at the same time. This works great for multiple vehicles operating in nearby fields. Only one vehicle in a group should be set to vehicle repeater mode. All others should be in vehicle mode. If several vehicles are in vehicle repeater mode, the same problems will occur as mentioned above. Also, if there is a separate repeater already being used in the area, all vehicles that can communicate with the repeater should be set on vehicle mode.

3. RTK Base Station Extension Harness (20 ft.)
   - The 20-ft. base station extension harness can be used to extend the StarFire receiver and RTK radio 20-ft. away from the 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.

4. 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 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, 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 300ft per base station. This cable is compatible with both the 900 and 450 MHz RTK systems.

**Non John Deere Components**

5. **Power Source**
- A shared base station requires about 2 Amps or 12 Watts 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. **Note:** When using a trickle charger or inverter, make sure it has a capacity of 3 amps of larger.

  - **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

6. **RF Cable (Low Loss Coaxial)**
- RF cable transfers the correction 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 structure requiring a small coaxial cable, or the radio could be mounted at the bottom of the structure 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.
7. **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.
   - If you have questions on antennas, antenna gain or decibels, this is a great description.
     - [http://www.marcspages.co.uk/tech/antgain.htm](http://www.marcspages.co.uk/tech/antgain.htm)

8. **Mounting Structure**
   - All of these 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 you mount the receiver on the structure itself, make sure it does not move or sway. This movement will shift all of the A/B lines under the tower.*
Shared Base Station - Setup

Now that we have seen and understand all of the 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 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
   - Less investment cost
   - Not much coax is needed

   **Disadvantage**
   - Generally harder to replace radio if a problem should occur due to it being mounted up high.
2. **Utilizing the Low Loss Coax Cable**

This base station set up 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 12 mile range
- Increased investment costs
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 and must be free of Multipathing, and the receiver must not move. Any movement of the receiver will result in movement of the guidance lines/tracks.

**Advantage**
- Lower investment cost

**Disadvantages**
- Hard to access the receiver for updates
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.

- **Finders 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 to mess with moving base stations anymore, and you can use their used equipment on your next shared base station.

- **Convert their Base Station into a Vehicle Kit**
  - Help your customer turn their current RTK base station into a vehicle kit. The customer will have another vehicle 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. After the initial investment, we recommend that you charge a subscription fee to the network. This is similar to how John Deere charges for SF2 and will be advantageous for several reasons. Several areas to look at when setting these prices are:

- **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 we have over the competitors is the service and support offered by our dealers.

- **Multi – Unit Discounts** – For your larger customers that purchase several vehicle kits, you might want to offer them some kind of discount. First, you could charge the annual subscription fee per farm instead of per vehicle. Another method is to reduce the annual subscription fee for each additional vehicle kit they buy.

There are three main ways you can charge your customers for the 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   | 16   |
| New Customers                  | 4    | 4    | 4    | 4    |
| Hookup Fee/ per vehicle        | $3,000 | $3,000 | $3,000 | $3,000 |
| Yearly Maintenance Fee         | $400 | $400 | $400 | $400 |
|                                | $13,600 | $15,200 | $16,800 | $18,400 | $64,000 |

| #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    | 7    |
| New Customers                  | 4    | 1    | 1    | 1    |
| Hookup Fee/ per vehicle        | $3,000 | $3,000 | $3,000 | $3,000 |
| Yearly Maintenance Fee         | $400 | $400 | $400 | $400 |
|                                | $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

| #2a - $2,500 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 vehicle             | $2,500 | $2,500 | $2,500 | $2,500 |
| Yearly Maintenance Fee              | $1,000 | $1,000 | $1,000 | $1,000 |
| $14,000                               | $18,000 | $22,000 | $26,000 | $80,000 |

| #2b - $2,500 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 vehicle             | $2,500 | $2,500 | $2,500 | $2,500 |
| Yearly Maintenance Fee              | $1,000 | $1,000 | $1,000 | $1,000 |
| $14,000                               | $7,500 | $8,500 | $9,500 | $39,500 |
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

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<td><strong>Total Customers</strong></td>
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<td>Hookup Fee/ per vehicle</td>
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<th>#3b - Yearly maintenance fee of $1,500 (1 new customer each year)</th>
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Return on Investment

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

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<tr>
<th>Network Overview</th>
<th># of towers</th>
<th>Cost per network</th>
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<td>$12,075</td>
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<td>$550.00</td>
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<th>Return on Investment</th>
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</table>

- $336
- $4,789
- $9,742
- $15,195
- $21,148
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

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<thead>
<tr>
<th>Network Overview</th>
<th># of towers</th>
<th>Cost per network</th>
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<tr>
<td>Existing Structures</td>
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<tr>
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<thead>
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<td>Subscriptions</td>
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<td>$4,500</td>
<td>$5,000</td>
<td>$5,500</td>
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<tr>
<td>Sales/Upgrades</td>
<td>$4,411</td>
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<td>$(458)</td>
<td>$5,495</td>
<td>$11,948</td>
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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 a Shared Base Station 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 overall project or hire a consultant to manage the entire project. 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
  - 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 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 Coops, 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 [www.cellreception.com](http://www.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. *Note: For towers that only have an FCC Registration Number, visit the FCC website for contact information.*
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 locations. 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 also 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
      - Do not offer construction services

**Electronic Equipment**

Some of the electrical equipment on an RTK shared base station, like the 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

When hooking up power to your shared 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. If for some reason, a battery cannot be used, make sure to use some kind of regulated power source. Proper setup will help cut down on problems in the future.

- **110 Volt connection**
  - The best option for your shared base station power source is a standard 110 volt power source. To ensure consistent power, connect the shared base station to a 12 volt battery, and then recharge the battery with a trickle charger (3 Amp or larger) plugged into the 110 volt power source.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Less maintenance</td>
<td>- Power losses</td>
</tr>
<tr>
<td>- Consistent power source (with a battery and trickle charger)</td>
<td>- Pay a monthly power bill</td>
</tr>
<tr>
<td>- If power is lost, the battery will allow for extended run time</td>
<td></td>
</tr>
</tbody>
</table>

- Check with your local power company on prices to run a new line to your tower. Depending on how far you have to go, running a new power line can be expensive.

- Battery Suppliers – any standard 12 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 for the majority of time.

  - **John Deere Parts**

- **Alternative Power**

  - 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**
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..........................................................Ref. - B

RTK Radio Boxes

- RTK Radios are provided through John Deere. During installation, we recommend putting the radios in weatherproof lockable boxes 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 does not give off heat, but the container it is in could 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. Here is an example:

- Aubuchon Hardware...............................Ref. – E

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 as well as 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 run off (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 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**

**Antennas**

Finally, we need to select the right antenna to broadcast the signal. A 6 dBi Omni directional antenna when paired with an RTK Radio is the maximum strength antenna we can use to stay within FCC Regulations (see below). If coax is used in the setup, make sure to calculate the cable dB loss and add that number to the total antenna dBi. As discussed earlier, the antenna will transmit the signal equally in all directions except vertically. Make sure the antenna is installed vertically to avoid signal coverage problems. Keep the following recommendations in mind:

- 900 MHz (902-928) Omni-Directional Antennas with vertical polarization.
- Antenna connector must mate to connector on cable. Antennas commonly have N-type connectors, but you should check with the supplier when selecting parts.
- Antenna Gain is given in dB or dBi. To convert from dB to dBi, add 2.15 to the dB number.
- If connecting antenna to RTK radio a TNC male connector is required.

**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**

**Sabre Communications Corporation**
Now that the RTK Shared Base Station has been constructed, it is now time to set everything up and get your customers going. Before this can happen, several things must happen. The RTK Activation must be submitted, the radio must be configured correctly, and an absolute Base Survey must be completed.

### RTK Activation GS2/GS3 Display

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

### Original GS Display

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

![Original GS Display Image]
RTK Radio Configuration

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

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 right hand side of the screen.

Select the letter button next to RTK Operating Mode. Make sure it is set on Absolute 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

<table>
<thead>
<tr>
<th>RTK Network Configuration</th>
<th>Base Station Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio X - Y</td>
<td>Status</td>
</tr>
<tr>
<td>Network Z - 000000</td>
<td>Sat. Corrections</td>
</tr>
<tr>
<td>Radio/Repeater</td>
<td>Distance (ft)</td>
</tr>
<tr>
<td></td>
<td>Direction (°)</td>
</tr>
<tr>
<td></td>
<td>Base Battery (V)</td>
</tr>
<tr>
<td></td>
<td>Location #</td>
</tr>
</tbody>
</table>

**Absolute 01**

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

Press letter button next to Survey RTK Base Location.

![Survey RTK Base Location](image1)

![Survey RTK Base Location](image2)
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 information for the absolute base location, make sure to record 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 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.

<table>
<thead>
<tr>
<th>StarFire ITC - RTK</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTK Network</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio Channel 1 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network 1 - 4000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio Repeater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Station Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>Sat. Corrections</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Distance (ft)</td>
<td>2.28</td>
<td></td>
</tr>
<tr>
<td>Location #</td>
<td>341</td>
<td></td>
</tr>
<tr>
<td>Location #</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location #</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Battery (V)</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>Absolute 01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Once it is showing, push the button 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.

<table>
<thead>
<tr>
<th>StarFire ITC - RTK</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absolute Base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTK Network</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configuration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio Channel 1 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network 1 - 4000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio Repeater</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Configure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Station Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>Sat. Corrections</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Distance (ft)</td>
<td>2.26</td>
<td></td>
</tr>
<tr>
<td>Location #</td>
<td>341</td>
<td></td>
</tr>
<tr>
<td>Location #</td>
<td>13.6</td>
<td></td>
</tr>
<tr>
<td>Absolute 01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 (1 - 200). 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 the letter button next to RTK Network is currently to change it.

Configuring a Repeater

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

To begin, select SETUP>> StarFire iTC >> Diff Correction Setup >> RTK Setup
Make sure the RTK Operating Mode is set to Vehicle Repeater and the Radio Channel and Network ID are the same as the base you are configuring the repeater to. Then select the configure button.

Make sure the RTK Operating Mode is set to Vehicle Repeater and the Radio Channel and Network ID are the same as the base you are configuring the repeater to. Then select letter button E.

<table>
<thead>
<tr>
<th>Operating Mode</th>
<th>Vehicle Repeater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Channel Configuration</td>
<td>330</td>
</tr>
<tr>
<td>Network ID</td>
<td>1 - 4000</td>
</tr>
<tr>
<td>Location #</td>
<td>13.0</td>
</tr>
<tr>
<td>Configure</td>
<td></td>
</tr>
</tbody>
</table>

Select the Start button under Configure Repeater Radio.

Once it is showing select letter button E next to Configure Repeater Radio.
Once the configuration is complete (100%), the screen will revert back to the previous screen above. Hit the return button at the bottom to exit.

Once the configuration is complete, the screen will revert back to the previous screen above. Hit the return button at the bottom to exit.
John Deere RTK Radios operate in the 902 – 928 MHz band. This MHz range is an unlicensed and unregulated range. As of August 1, 2009, the FCC restricts Effective Isotropic Radiated Power (EIRP) in the 902 – 928 MHz band to 36 dBm or 4 Watts. The EIRP tells you the absolute strength of the signal that you are broadcasting in any direction. You can use the following formula to calculate the EIRP of your system.

Radio power (30 dB) – coax/connector loss (dB) + antenna gain (dB) = EIRP (36 dB)

**Example 1 Calculation with no Coax:**

Subtract the Radio power from the FCC Regulations.

\[ FCC \text{ Regulations (36 dB)} - \text{Radio power (30 dB)} = 6 \text{ dB} \]

A single antenna with 6 dB gain or less can be used. *Note: Most antenna suppliers advertise antenna gain in dB or dBi. Make sure to use the dB gain of the antenna for these calculations. To convert dBi to dB, subtract 2.15.*

**Example 2 Calculation with Coax:**

You have a 6 dB (8.15 dBi) antennae and 100 ft of Andrews 5/8” Heliax LDF5-50A Coax (1.25 dB loss per 100 ft.). First, subtract the signal loss due to coax cable. *Note: The manufacturer of the coax cable will be able to provide the signal loss (dB) of the cable you are using.*

\[ \text{Radio power (30 dB)} - \text{Coax Loss (1.25 dB)} = 28.75 \text{ dB} \]

Now you can subtract that number from 36 dB to get the maximum gain antenna that can be used and still maintain an EIRP of 36dB or less.

\[ FCC \text{ Regulations (36 dB)} - \text{Radio power and coax loss (28.75 dB)} = 7.25 \text{ dB} \]

A single antenna with 7.25 dB gain or less can be used.

*Note: It is your responsibility to follow all FCC rules and regulations for the 902 – 928 MHz band. You can find more information at [http://www.fcc.gov](http://www.fcc.gov)*
Troubleshooting Potential RTK Network Problems

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 set up 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 vehicle 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 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.

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 pictures above, 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 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
- 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 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 1ft. 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 6 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 (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 vehicle.

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 ITC 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 vehicle 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 vehicles 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 vehicle.

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 vehicles 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 vehicles 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. Vehicle Setup and any possible obstructions

RTK vehicle operation is directly affected by the quality of the base station location and setup, not just vehicle GPS receiver interferences. The base station is feeding satellite correction information to the vehicle (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 vehicle (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 vehicle operation, the PDOP can be viewed under the StarFire information pages in both the Original Greenstar Display and GS2 Display.

**Pictures from GS2 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.

<table>
<thead>
<tr>
<th>900 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>Radio Temp (°C)</td>
<td>-40 °C to 75 °C</td>
<td>-40 °C to 75 °C</td>
</tr>
<tr>
<td>Antenna Reflected Power</td>
<td>0 to 10 = Good</td>
<td>0 to 10 = Good</td>
</tr>
<tr>
<td></td>
<td>11-30 = Marginal</td>
<td>11-30 = Marginal</td>
</tr>
<tr>
<td></td>
<td>30+ = Antenna issue</td>
<td>30+ = Antenna issue</td>
</tr>
<tr>
<td>Transmit Current</td>
<td>500-700 ma</td>
<td>500-700 ma</td>
</tr>
<tr>
<td>Avg Signal Level</td>
<td>60-100 = Good</td>
<td>60-100 = Good</td>
</tr>
<tr>
<td></td>
<td>100-up = Marginal to no radio link</td>
<td>100-up = Marginal to no radio link</td>
</tr>
<tr>
<td>Avg Noise Level</td>
<td>Will vary</td>
<td>Will vary</td>
</tr>
<tr>
<td>Difference between signal and noise</td>
<td>Signal Level Minus Average Noise Level</td>
<td>Signal Level Minus Average Noise Level</td>
</tr>
<tr>
<td></td>
<td>30 - Greater = Good</td>
<td>30 - Greater = Good</td>
</tr>
<tr>
<td></td>
<td>20 - 30 = Marginal</td>
<td>20 - 30 = Marginal</td>
</tr>
<tr>
<td></td>
<td>0 - 20 = Unreliable output</td>
<td>0 - 20 = Unreliable output</td>
</tr>
<tr>
<td>Overall Receive Rate</td>
<td>Invalid Reading on Base</td>
<td>90-100 % = Good Signal</td>
</tr>
</tbody>
</table>
DTAC SOLUTIONS FOR REFERENCE

Base Station Solutions
- **71356** - RTK base station setup
- **67345** - Requirements needed to operate a base station with a power converter
- **69595** - New Features added to RTK base station
- **71370** - Absolute survey on a base station never completes

RTK Radio Solutions
- **53909** - 2-way radio interference with StarFire
- **77048** – Diagnosing RTK radios
- **79639** – RTK radio self test

Satellite Availability and Repeatability Solutions
- **69162** - RTK repeatability Issues
- **65142** - Inadequate GPS signal strength with RTK
- **84045** – GPS satellite availability issues
- **83227** – Troubleshooting AutoTrac accuracy
- **83339** – AutoTrac accuracy affected by AB line drift or line jumps with RTK
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
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 vehicles.

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 vehicles 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 vehicles 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>LMR-400 (3/8&quot;)</th>
<th>LMR-500 (1/2&quot;)</th>
<th>LMR-600 (1/2&quot;)</th>
<th>LMR-900DB (5/8&quot;)</th>
<th>LMR-1200DB (7/8&quot;)</th>
</tr>
</thead>
<tbody>
<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!*
Overview:

NorthernTool.com offers over 15,000 products on their website. Their product line offers everything from air compressors to welding equipment. All of the products listed below are good examples of what you need to use on your shared base station.

Products:

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
Overview:
Aubuchon Hardware is a website that offers a variety of tools and electrical products. Below are two examples of the weatherproof electrical boxes. These boxes can be found at most electrical stores.

Products:

Indoor/Outdoor Pull Box Enclosure
- Part # 609628
- Features
  - Hubbell Electrical Products Model # RSC060604RC
    - INDOOR/OUTDOOR - SURFACE MOUNT
      - "RAINPRO"
      - Inside W x H x D 6 x 6 x 4
      - Unit Weight: 3.4000 lbs
- Description - made of 16 gauge pre-galvanized sheet steel. For run of conduit for power or communication conductors. Service box for wiring devices or switch box for controlling wet location equipment. Drip shield top and smooth seamless sides, front and back. Knockouts are standard in bottom.

Indoor/Outdoor Pull Box Enclosure
- Part # 609373
- Features
  - Hubbell Electrical Products Model # RSC060604RC
    - INDOOR/OUTDOOR - SURFACE MOUNT
      - "RAINPRO"
      - Inside W x H x D 8 x 8 x 4
      - Unit Weight: 3.4000 lbs
- Description - made of 16 gauge pre-galvanized sheet steel. For run of conduit for power or communication conductors. Service box for wiring devices or switch box for controlling wet location equipment. Drip shield top and smooth seamless sides, front and back. Knockouts are standard in bottom.