

# Technology Talk Bulletin

This Technology Talk Bulletin compares John Deere dealer's current Real Time Kinematic (RTK) base station approach to the different RTK technologies available.

## What is RTK?

RTK is a form of differential correction which utilizes satellite navigation and a local reference station to provide +/- 1 inch repeatable accuracy to a rover (e.g., a receiver on a vehicle) where nearly all drift is eliminated. The local reference stations can be standalone or networked, and there are a couple of common ways to deliver the RTK signal.

## Most Common RTK Delivery Methods

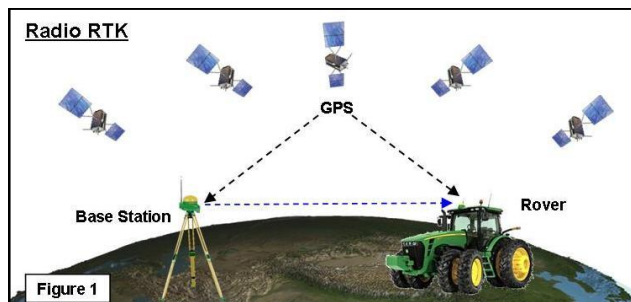
Today there are two primary approaches to deliver RTK signals to a rover/vehicle:

- A local base station that transmits a RTK correction signal to a rover via an RTK radio (e.g., 900MHz, 450MHz). This is the current approach utilized by Deere dealers.
- Through the internet via a cellular connection. This is often referred to as cellular RTK because the most common method of gaining internet access is by using a cellular modem on the vehicle. The modem must connect with a server to transmit an RTK signal.

## Types of RTK Base Stations

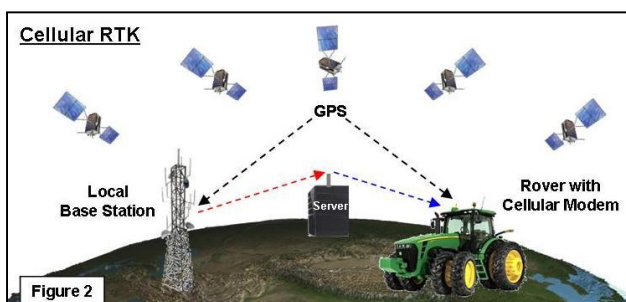
Base stations can be either standalone or networked.

Standalone base stations cover a very specific area (i.e., ~ 12 miles) and are not networked with other base stations. Standalone base stations can utilize radios or cellular to transmit an RTK correction.



### Radio Delivery (standalone)

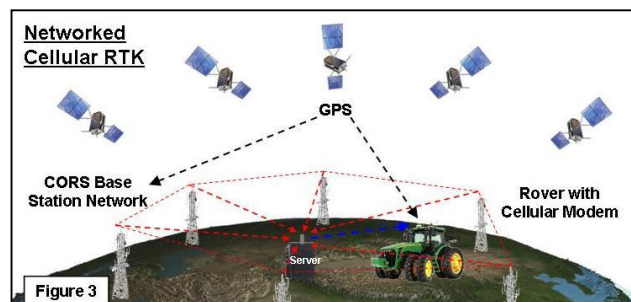
A base station receives signal from satellites and transmits the RTK corrections to the rover via radio. A direct line-of-sight is required and the accuracy at the rover depends on the distance from the base station. The base station in this example is not networked; therefore a customer would manually switch from one tower to another as they travel beyond the range of the base station. John Deere dealer base stations are standalone and utilize an RTK radios to transmit an RTK correction.



### Cellular Delivery (standalone)

A base station receives signal from satellites and transmits corrections to a server typically via the internet. The server transmits the signal from the reference station over the internet to the cellular modem on the rover. The accuracy of the rover depends on the distance from the local reference station. The base stations in this example are not networked together, therefore a customer would manually switch from one tower to another as they travel beyond the range of the base station.

The other type of base station approached is networked. Networked base stations have a variety of names; the most common is Continuously Operating Reference Station (CORS) Network.



### Networked Base Stations

Multiple base stations are connected to a central server. This server contains special software that connects/networks the base stations. These networks, through the server, create a large area in which a rover can move around without changing base stations. The server transmits the signal from the reference station over the internet to the cellular modem on the rover.

### **Additional Cellular RTK Details**

In order for a rover to utilize cellular RTK, it must have a cellular modem, a data plan, a server to connect to, and cellular coverage in the area where it operates. It is important to note that adding the modem and data plan adds cost to each rover even in situations where customers have access to a “free” CORS network. In areas with a CORS network that charges a subscription, this fee would be in addition to the data plan already required on each rover. As a benefit to these additional costs, a customer would no longer have line-of-sight requirements to receive the RTK signal, and if operating on a true network, the customer would also have the ability to “roam” between towers with no line jumps.

### **RTK Signal Range**

John Deere defines RTK accuracy +/- 1 inch repeatable accuracy and uses single non-networked base stations. In order to ensure Deere’s advertised accuracy, Deere limits the distance a rover can operate from the base station. Other RTK providers using a single base station may advertise longer accuracy range when using cellular, but they may not define what their level of RTK accuracy is. This is important because you can see a deterioration of repeatable accuracy the further away a rover is from a standalone base station. It is important to compare *both* pass-to-pass accuracy and repeatability of a signal when comparing the RTK signal range of different providers.

Networked cellular RTK, or CORS networks operate differently from non-networked base stations. These networked base stations can be further apart than standalone base stations and still maintain *both* pass-to-pass and repeatable accuracy. The range is possible because of the software on the server that connects together all of the base stations. This software allows rovers to move around inside of the network without changing base stations and without line jumps. It is important to know whether cellular RTK base stations are truly networked or just standalone when comparing them to a traditional John Deere Dealer network.

### **What are the applications CORS networks?**

CORS networks have been implemented by private and governmental agencies in certain regions of the world. Businesses use these networks for surveying, monitoring movement of the Earth’s crust, monitoring movement of man-made structures (such as dams and bridges) and, more recently, machine control in construction and agriculture. These systems are gaining in popularity for two reasons. The base station maintenance costs are handled through the agencies and there are no line-of-sight requirements for optimal system performance. However, the annual cost of ownership for this type of system can be more expensive than an RTK radio solution.

### **What does cellular RTK cost?**

You may have seen advertisements claiming that cellular RTK is less expensive than radio RTK. It is critical to compare complete system requirements to develop an accurate cost comparison. The following identifies factors that contribute to RTK investment costs. Please refer to attachment at the end of this document to better understand how customer costs vary between John Deere’s radio RTK and cellular RTK.

#### **Hardware Costs**

Radio RTK and cellular RTK require a vehicle GPS receiver, display, activations, and appropriate harnesses and brackets. Cellular RTK systems require additional components such as a cellular modem and in some cases an additional radio at each rover.

#### **Service Costs**

Since cellular RTK requires an internet connection with a data modem, a customer will usually need an unlimited data plan which typically costs \$40-\$100 per month per rover. All private networks and some public networks also charge a fee to access the network which can cost up to \$3,000 per rover per year. Some public networks such as state DOTs are offering access to the server for free, but this practice could change over time and should be confirmed with the local provider if a customer considers this service. Remember, free access to a server does not equate to “free RTK system.” The customer will still incur the additional reoccurring rover expenses listed above.

#### **Other Costs**

Expenses associated with cellular RTK can also be higher due to customer support issues and potential downtime associated with someone other than the John Deere dealer operating the network.

### **Where is cellular RTK available?**

Cellular RTK coverage areas are constantly evolving and there is no single resource to find where cellular RTK is available. Use an internet search tool, talk with your local wireless carrier, or contact the state DOT to find out if cellular RTK is available in your area.

### **What are the customer's advantages/disadvantages of radio RTK?**

#### **Advantages**

- Dedicated service and support from your dealership
- More consistent performance
- Lower initial investment costs
- Customers using an entry level GreenStar system can easily upgrade to a RTK Network for much lower costs. (Please refer to the John Deere price pages for upgrade options.)
- RTK Extend that allows 15 minutes of RTK performance without satellite access
- Coverage in areas not covered by a cellular signal

#### **Disadvantages**

- Requires line-of-sight
- Limited to 12 mile range from base station
- No "Roaming" between base stations

### **What are the customer's advantages/disadvantages of cellular RTK?**

#### **Advantages**

- No line-of-sight requirements
- Potential base station roaming (if using a network)
- Potential internet connection at the rover

#### **Disadvantages**

- Connection cost even in areas with "free" corrections available
- Cellular coverage is needed at the rover
- Potentially multiple points of contact for support

### **What is John Deere doing?**

We are currently investigating the feasibility and performance of using RTK corrections via cellular delivery for StarFire receivers. It is critical to John Deere that cellular RTK provides not only a reliable signal, but also aligns with Deere dealers' investment in shared base station networks.

John Deere remains committed to the John Deere Dealer Base Station strategy. We continue to investigate enhancements to traditional RTK to increase the value proposition of your dealership's shared base station network.

### **Summary**

Cellular RTK is an evolving technology that is an option for parts of North America where traditional RTK coverage is not adequate. Cellular reception, data latency, third party maintenance of a network, and additional investment costs through hardware and subscription fees, are factors customers need to consider when determining what solution best fits their needs. John Deere will continue to test the feasibility of cellular RTK technology in North America and around the World. We must be confident that it will fit into your dealership's business model, meet the high demands of our customers and is a solution we can stand behind together.

Our experience has been that dealer owned shared base station network delivers the highest differentiating value proposition to customers. Now is the time to invest in a network if you have not made the commitment. The support and service you provide to customers is second to none, making a John Deere Dealer base station the best RTK solution for you and your customers. Resources are available from John Deere to help plan your shared base station network. Visit the Dealer Corner on StellarSupport.com today to get started.

<b>John Deere Radio RTK</b>	
<b>Pros</b>	
Local Service and Support	From the RTK Base Station to the rover, the customer is supported by a single supplier, aligned with the interests of agricultural customers.
RTK Extend	If the rover loses sight of the base station, the patented "RTK Extend" feature will remain active for 15 minutes to keep the vehicle on track. When the RTK signal is available again, the rover will automatically switch back.
RTK Network Expansion	As producers grow larger and cover more ground, the local John Deere dealer is able to expand their RTK Network as needed to sustain this partnership.
<b>Cons</b>	
Line-of-sight required	Line-of-sight visibility is required from the base station to the rover to obtain full correction signal. If line-of-sight is interrupted due to terrain or other structures, the rover may lose signal and switch to RTK Extend. Line-of-sight can be enhanced by using the new StarFire 450 RTK radio if there is foliage interference or repeaters.
No Roaming Between Base Stations	Similar to CORS, customers must manually change base stations as they move throughout the network.
Network Fee	There is typically a recurring fee to access a dealer owned RTK network to ensure network maintenance and uptime.
Accuracy	Similar to CORS, John Deere RTK accuracy depends upon the distance from the base station. Operating within 12 miles = 1 inch repeatable accuracy.

<b>Cellular RTK</b>	
<b>Pros</b>	
Line-of-sight	The correction data is transferred over a cellular network, so it may be available in areas limited by line-of-sight with traditional RTK radios. Cellular signals operate at different frequencies and power levels than traditional RTK.
Accuracy	With virtual reference stations, accuracy is not directly related to the distance from the nearest base station. In contrast, CORS accuracy degrades with distance from the nearest base station. Accuracy is generally better with static surveys than with moving machinery.
Network roaming	There is no need to switch base stations with virtual reference stations as long as you are inside the network. Customers using a single reference station which is not networked will have to change base stations manually.
<b>Cons</b>	
Continuous Cellular Coverage	Cellular RTK requires a <u>continuous</u> data connection via cell modem. If the cellular connection is lost, the rover loses corrections. Cellular signal availability is affected by the local cell coverage, peak cell network usage (voice typically has priority over data), and many other factors. How dependable is the cellular coverage in your area? Furthermore, how reliable is the CORS/ virtual reference station infrastructure in your area? These questions are critical to cellular RTK performance. Also, "RTK-Extend" is not possible for cellular RTK to compensate for a lost connection.
Data Plan Fees	Each rover will usually need an unlimited data (phone) plan with a cellular provider. These fees can range from \$40 - \$100 per month.
Network Access Fees	All private networks and some public networks also charge a fee to access the network which can cost up to \$3,000 per rover per year. Make sure you are aware of how these additional fees will impact your overall investment.
Necessary Hardware	A cellular modem and other necessary harnesses/brackets are necessary to provide corrections to the rover.
Reliant on Third Party for Signal, Support and Maintenance	Cellular RTK networks are managed by different providers depending on the area. It could be the Dept. of Transportation or a private business. Customers would be dependent on the service provider to maintain and support the network as well as depend on their cellular provider for a continuous data connection. It is important for the customer to understand who is responsible for support if a problem arises.
Not Available in all Areas	A cellular signal along with a virtual reference stations or CORS network is required for this technology to work. There are many areas in North America that do not have either.

**John Deere Radio RTK solution vs. Cellular RTK solutions**

	<b>John Deere</b>	<b>eGPS</b>	<b>Trimble</b>	<b>Raven</b>	<b>Leica</b>	<b>AutoFarm / Ag Leader</b>
<b>Rover Components</b>	StarFire iTC	Intuicom Bridge	Ag3000	Slingshot	MojoRTK	ParaDyme
Display Activation	\$6,500	\$6,500	\$4,000	---	---	\$2,695
Display	\$4,895	\$4,895	\$5,000	\$5,210	\$3,300	\$4,795
Receiver	\$4,295	\$4,295	\$4,995	\$7,870	\$11,990	\$8,885
Vehicle Guidance Kit **	\$0	\$0	\$1,495	\$2,200	\$2,800	\$4,200
RTK Activation	\$3,000	\$3,000	\$2,000	included	---	\$5,000
RTK Radio Bundle	\$1,345	\$1,345	---	---	---	---
Cellular Modem	---	\$4,035	\$1,500	\$1,650	---	---
CORS Ready- one-time	---	---	---	---	---	---
Additional components	\$100	\$295	\$100	\$350	---	---
<b>TOTAL LIST PRICE</b>	<b>\$20,135</b>	<b>\$24,365</b>	<b>\$19,090</b>	<b>\$17,280</b>	<b>\$18,090</b>	<b>\$25,575</b>
Subscription - reoccurring *	\$1,000	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200
Data Plan - reoccurring *	---	\$800	\$800	\$800	\$800	\$1,500
<b>Total Reoccurring Fee/yr</b>	<b>\$1,000</b>	<b>\$2,000</b>	<b>\$2,000</b>	<b>\$2,000</b>	<b>\$2,000</b>	<b>\$2,700</b>

\* The Subscription and Data Plan fees listed in this document are estimates and may be different depending on geographic areas, service providers, or additional options.

\*\* Assumes the customer has a AutoTrac Ready John Deere tractor. The extra fees in this row account for the additional hardware to make the system compatible with the Deere machine.

**The prices listed in this table for non-John Deere components have been obtained from public sources and are believed to be accurate as of April 13, 2010. All prices in the table are subject to change at any time.**