

**PRAIRIE**  
PRECISION NETWORK INC.



## COMPLETE PPNI NETWORK RTK GUIDE

# Table of Contents

Table of Contents.....	2
Purpose of this Guide .....	3
Global Navigation Satellite System .....	4
Pass to Pass accuracy.....	5
Year to Year accuracy.....	5
Practical example of difference in accuracy .....	5
Challenges facing GNSS.....	5
Typical interference and delays: .....	6
Non-typical or dynamic interference and delays:.....	6
Satellite errors: .....	6
Tectonic Plate movement: .....	6
What reduces accuracy of GNSS .....	6
Why RTK is the most accurate signal.....	7
Operation of non-network RTK.....	8
Operation of network RTK .....	9
Farming techniques achievable with RTK.....	10
Inter-Row Seeding Benefits.....	10
Water Management.....	10
Pass to Pass Savings .....	10
Record Field Boundaries Once, Ready in 1 minute.....	11
Less Trampling .....	11
Harvest Shared Lines.....	11
Benefits of RTK with Starfire 3000 .....	12
Benefits of RTK with Starfire 6000 .....	13
Visual difference in accuracy .....	14
Calculate PPN coverage .....	15

# Purpose of this Guide

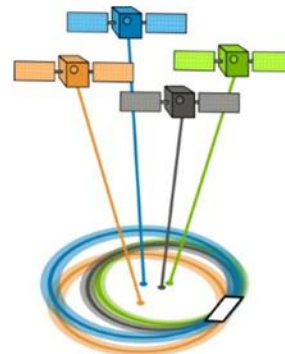
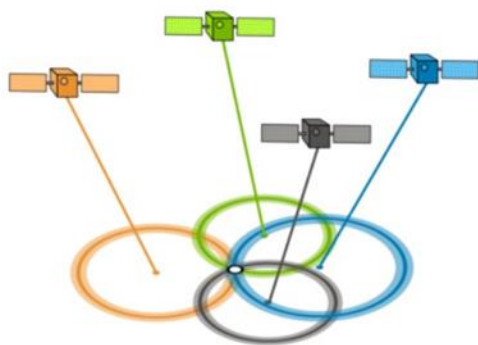
Goal of this guide is to educate a person about precision farming and how Prairie Precision Network (PPN) Real Time Kinematic (RTK) corrections enables the best farming practices. This guide covers:

- A basic technical description of how Global Navigation Satellite Systems (GNSS) work.
- Describes some the challenges and errors that occur with GNSS.
- How PPNI RTK best addresses these challenges in Canada.
- Visual representation of vertical and horizontal accuracy
- The best farming practices that farmers can only achieve with RTK and Deere products
- What it takes to get started with PPN
- The best way for installing PPN in farmers machinery to provide them with the best experience possible

# Global Navigation Satellite System

The details of whole system are complicated however there are 4 different GNSS. GPS (United States) and GLONASS (Russian) are currently operational and used by John Deere and PPNI. Galileo (European) and BeiDou (Chinese) will have global coverage by 2020 but are currently not used by John Deere. We will stick to the basics with no specifics on the differences between GNSS. All GNSS use trilateration, trilateration is just a fancy word for measuring distance. GNSS's accomplish trilateration by having each satellite's broadcast enough information that any receiver listening can know where each visible satellite is located and their approximate distance from it

Trilateration, how GNSS know your location



Spacing is really important for satellites. If they are too close together there is a large amount of uncertainty. Thus poor accuracy.

In the above diagrams the white shapes represent the possible area the receiver is located in. The rectangle to the right is much larger than the circle to the left. The rectangle situation occurs for horizontal accuracy in locations with trees or tall buildings where line of sight to satellites on one side is impeded. A similar situation to what is on the right always occurs for vertical accuracy as you can not receive GNSS signals from the other side of the planet thus is always one sided. Generally, your vertical confidence with most technology is 3x worse than your horizontal confidence in ideal conditions.

# Challenges facing GNSS

A system as complex as GNSS will have trouble being accurate. The logistics broadcasting radio waves through the earth's atmosphere from multiple satellites orbiting earth ~20 000 km away to any receiver willing to listen to achieve 1-inch accuracy is no small task. Consider that in 1 microsecond (a millionth of a second) a radio wave from the satellite travels ~300m. So, the information that GNSS satellites send need to be extremely accurate otherwise your location becomes a ballpark figure. If you ask one a GNSS satellites for the time it will tell you 10:31 AM... and 32.123456 seconds small errors in time can result in large errors in position without correction. With farming there are only 2 accuracy measures worth talking about.

## Pass to Pass accuracy

just means should be able to leave and return to the same spot with reasonable confidence within 15 minutes. However, there are no guarantees you can return to that spot within the +/- range if you are away from it longer than 15 minutes.

## Year to Year accuracy

Year to year accuracy is also called drift. this means you can confidently come back to the same spot +/- range your standing right now an entire year from now.

## Practical example of difference in accuracy

When a producer returns to a field they might notice discrepancy between what they know to be the crop row where an AB line was established, and where the guidance device is suggesting the AB line is currently located. WAAS and SF1 correction services may seem accurate during one field operation but be off-track when the operator returns to the field. This is because WAAS and SF1 do not correct for conditions that slowly change from year to year but in a 15-minute window these changes are unlikely to amount to a position difference beyond their pass to pass accuracy range

# What reduces accuracy of GNSS

There are several factors that daily disturb GNSS accuracy, I will go over a few common ones. GNSS satellites must broadcast radio waves through the earth's atmosphere. These waves experience interference and delays in the ionosphere and troposphere. Satellite clocks and orbits are not perfect and occasionally need to be adjusted as well as the land beneath our feet is slowly moving every year.

## Typical interference and delays:

These can mostly be accounted for now that satellites broadcast multiple GNSS frequency's and receivers can do complex math quickly (different frequency waves bend differently when they enter earth's atmosphere, similar idea to what causes a rainbow). Without any correction these can result in position errors of:

Ionospheric	+/- 5 meters	+/- 16.4 feet
Tropospheric	+/- 50 centimeters	+/- 1.64 feet

## Non-typical or dynamic interference and delays:

These cannot currently be accounted for in real time over a large area. Dynamic interference will result in a degradation of accuracy for any GNSS and in severe cases can result loss of a satellite lock (the discrepancies in the GNSS signal received becomes too high to account for). Examples of dynamic interference includes geomagnetic storms (if you see intense aurora in the night sky, you can assume your GNSS system will not be as accurate as you expect) and solar flares.

## Satellite errors:

These typically affect drift and include changes in satellite configuration, satellite orbit, and satellite clock errors. Technology has progressed, there are now very, very few reference stations on earth (7 for the GPS) that help correct satellite for their orbit, clock and configuration. Keep in mind GNSS satellites are in constant motion orbiting the earth twice a day. So, it's likely that within 15 minutes the conditions of the satellite constellation will not change thus your pass to pass accuracy is fine. However, over the span of one year likely some satellites will need alterations which will cause drift. Without any correction these can result in position variance of:

Clock Errors	+/- 2 meters	+/- 6.56 feet
Orbit Errors	+/- 2.5 meters	+/- 8.2 feet

## Tectonic Plate movement:

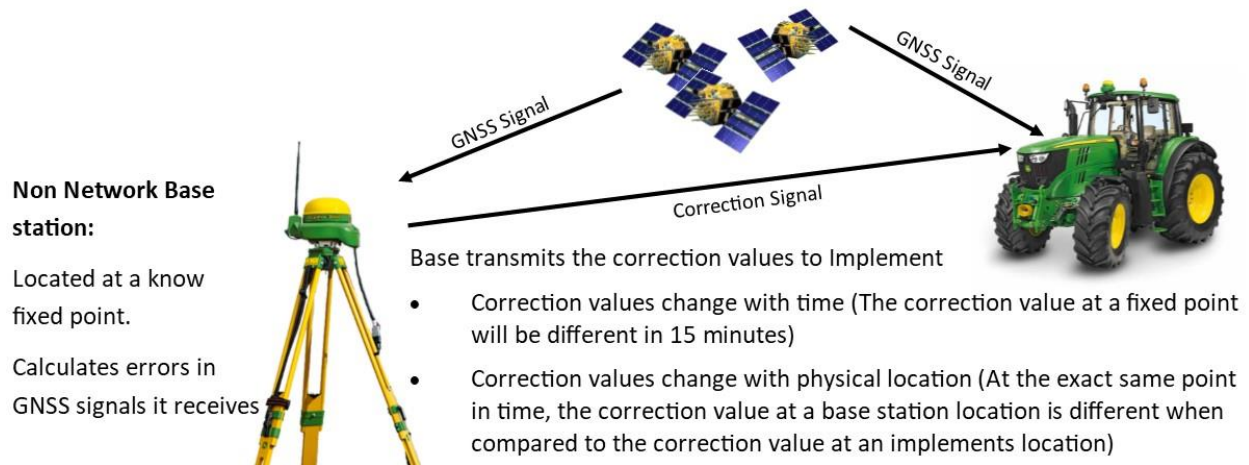
when the ground itself is moving across the entire planet in different directions this introduces small amounts of drift year over year.

Plate Movement	+/- up to 8 cm/year	+/- up to 3 inch/year
----------------	---------------------	-----------------------

# Why RTK is the most accurate signal

RTK uses reference stations with well known stationary locations. Since base stations have high confidence in their location they can calculate the difference between the satellite signals they receive and what those signals should be at their location. PPNI has approximately 100 reference stations which provide great coverage in the prairies and using a network RTK structure PPN maximizes our RTK coverage area.

# Operation of non-network RTK

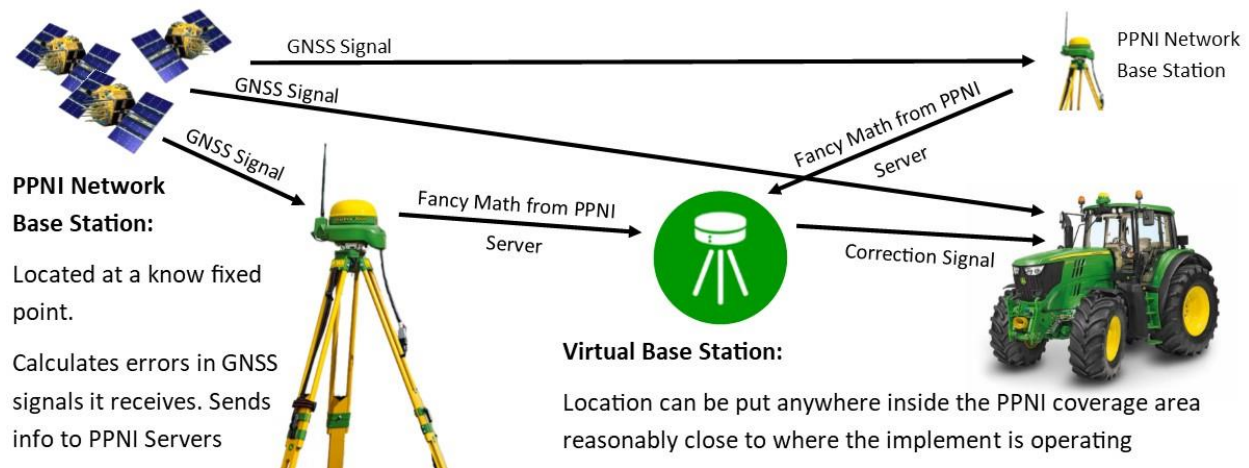


## NON-NETWORK RTK

a typical setup consists of a single base station from which differential corrections are collected and then sent to the implement. The implement then performs some data processing using the differential correction provided by a base station to improve the accuracy of it's location. However differential correction values will differ with both time and space. This means that the further the implement ventures from a base station the more inaccurate the correction signal will become, which is the reason non-network RTK is not feasible for wide area coverage.



# Operation of network RTK



## PRAIRIE PRECISION NETWORK RTK

In contrast to every other RTK technology available in western Canada which act as single independent entities that only broadcast the correction of their specific base location, PPNI's base stations are networked together which allow PPNI to know the corrections at any location in our coverage area and provide this to our customers.

How our Network operates.

PPNI sends the differential corrections from all our base stations to our server (The towers located on dealerships, and other strategic points). With all this information PPNI servers can model what the proper correction signal should be with reasonable confidence at any location within the PPNI network coverage area. However, the model is useless unless we know the location of the implement, so our Modems send the implements location to PPNI Servers (this is the reason for the GPS antenna attached to our modems). Now that PPNI's server has all the information it needs; the server creates a virtual base station reasonably close to the implement. PPNI sends the RTK corrections of the virtual base station location to the customers implement. Using our network customers are no longer limited by line of sight, can travel anywhere in our coverage area and receive RTK corrections of a location reasonably close to them.

# Farming techniques achievable with RTK

## Pass to Pass Savings



When farming with RTK every pass down the field can save 6-12" compared to less accurate signal levels. This is because there is no need for overlap (or fudge factor) using RTK compared to SF1 or SF2. You can set to your tracking width to the full implement size at start up and adjust from there. This translates to significant savings in time and money

## Inter-Row Seeding Benefits



Studies have shown up to a 12% yield increase when inter-row seeding. This is a result of getting the seed into the warmer black dirt, which causes a better plant start and stand. As well the stubble shades the dirt when heat occurs, allowing the plant to fill fully during what would otherwise stress it.

Less trash builds up is a benefit when pulling a drill directly between rows. This is only achieved with the repeatability of RTK from year to year.

## Water Management



For any of the John Deere Water Management products, RTK signal accuracy is required. Surface Water Pro Plus and iGrade both require a valid RTK receiver above the scraper cutting edge.

This is because vertical accuracy can be 3x worse than horizontal accuracy (see GNSS operation). So to achieve proper results with Surface Water Pro Plus or iGrade, RTK is needed. These programs can save a significant amount of time, reduce dirt moved and get the job done right the first time.

## Less Trampling



With the repeatable accuracy of RTK corrections, you can come back to the same tracks during the year, every year. This results in trampling less crop when applying product.

And if your interested in the precision of ExactApply why not also use the highest precision RTK correction signal to compliment this system.

## Harvest Shared Lines



When Harvesting with RTK and multiple machines, we can eliminate the small uncut rows in the middle of the field caused by GPS drift. With all your machines using RTK you can save your AB lines before hand or send right away when using shared guidance lines.

We do not fix the overlap that might exist at either end of the field but rather where machines meet in the middle or anywhere else in the field.

## Record Field Boundaries Once, Ready in 1 minute



With the repeatable accuracy of RTK corrections, you can return to a field at any time and not have to record the field boundary again. Couple RTK with the precision of section control to save time and money in every field.

With RTK you benefit from faster pull in time reaching full accuracy in 1 minute so your unit is ready to go when you are.

# Benefits of RTK with Starfire 3000

When upgrading a Starfire 3000 Receiver to RTK a farmer will experience substantial technical benefits when using the latest software update that will save them time every year.

- RTK extend for 15 minutes. Basically, this means the receiver now maintains RTK accuracy for 15 minutes when RTK signal is lost due to bad cell coverage.
- SF2 fall back for 14 days without disengaging AutoTrac and no need for an SF2 subscription. Say your cell network fails so you can no longer receive correction signals from PPNI. You can continue to operate on SF2 for free
- Achieve confident accuracy in 1 minute, so your farmers implement is ready to go right when they are. Unlike SF2 which requires nearly 90 minutes to reach accuracy confidence.
- Long term repeatability. They only need to record a field boundary once.

**To be able to receive PPN RTK on a Starfire 3000 the customer needs to purchase:**

- **SF2 activation for their Starfire 3000**
- **RTK activation for their Starfire 3000**
- **PPN Modem/Booster install kit**
- **PPN Subscription**
- **SIM card and plan from cell provider (1 GB)**

# Benefits of RTK with Starfire 6000

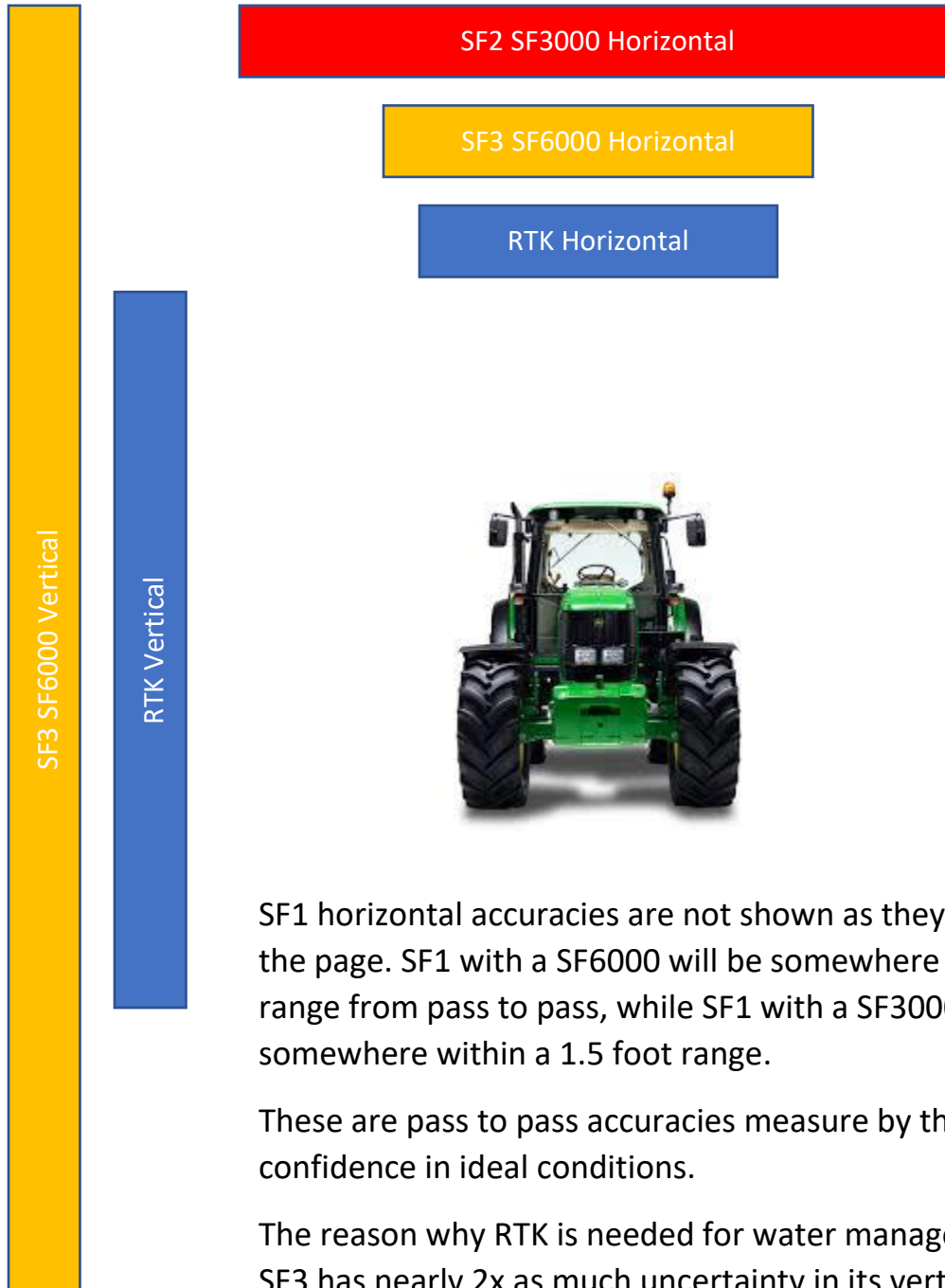
When upgrading a Starfire 6000 Receiver to RTK a farmer will experience several technical benefits when using the latest software update that will save them time every year. SF3 is designed to work with RTK allowing for remarkably quick pull in times and extended coverage.

- RTK extend now lasts for 14 days. The Starfire 6000 does this by using real time self learning on the last RTK signal and cross checks with SF3 to improve reliability. Pretty amazing.
- The receiver achieves confident accuracy in 1 minute instead of 30 minutes on start up with SF3, this way the implement is ready when you are.

**To be able to receive RTK on a Starfire 6000 receiver the customer needs to purchase:**

- **SF3 activation for their Starfire 6000**
- **RTK activation for their Starfire 6000**
- **PPN Modem/Booster install kit**
- **PPN Subscription**
- **SIM card and plan from cell provider (1 GB)**

# Visual difference in accuracy



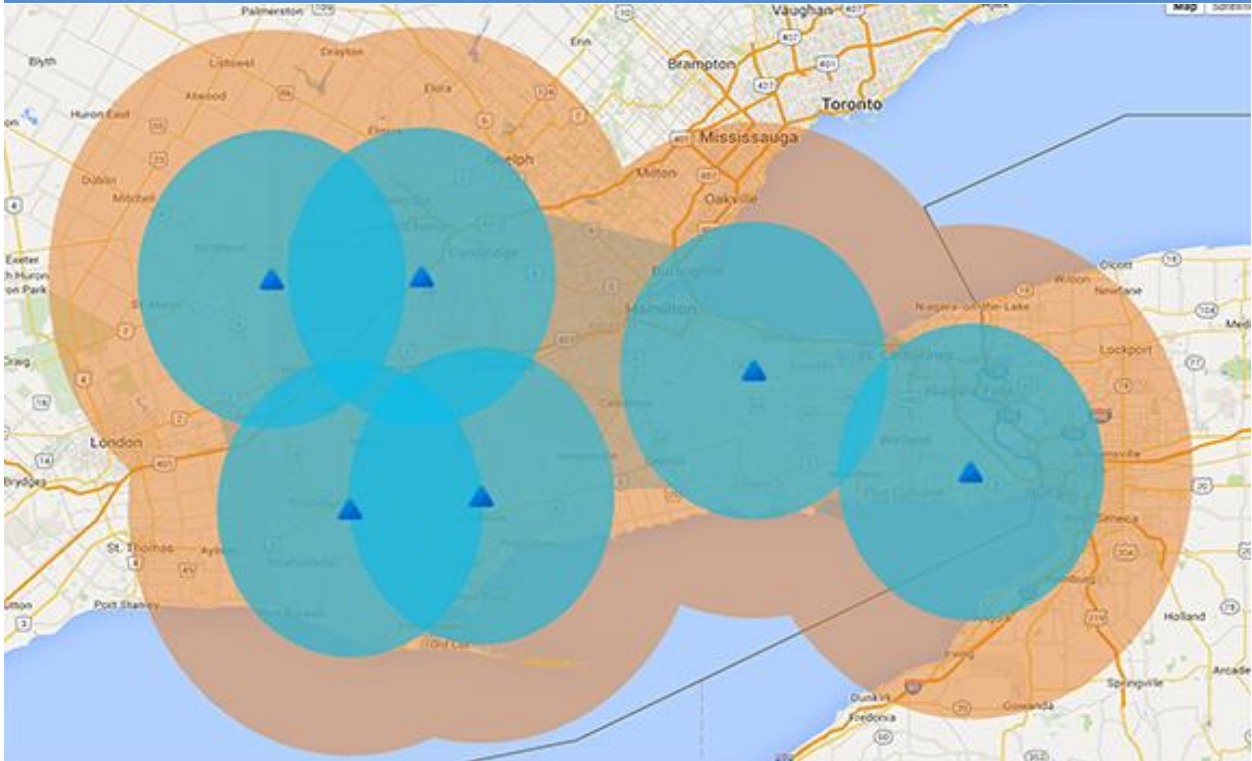
SF1 horizontal accuracies are not shown as they will not fit on the page. SF1 with a SF6000 will be somewhere within a 1 foot range from pass to pass, while SF1 with a SF3000 will be somewhere within a 1.5 foot range.

These are pass to pass accuracies measure by the typical 95% confidence in ideal conditions.

The reason why RTK is needed for water management is clear. SF3 has nearly 2x as much uncertainty in its vertical position when compared to RTK.



# Calculate PPN coverage



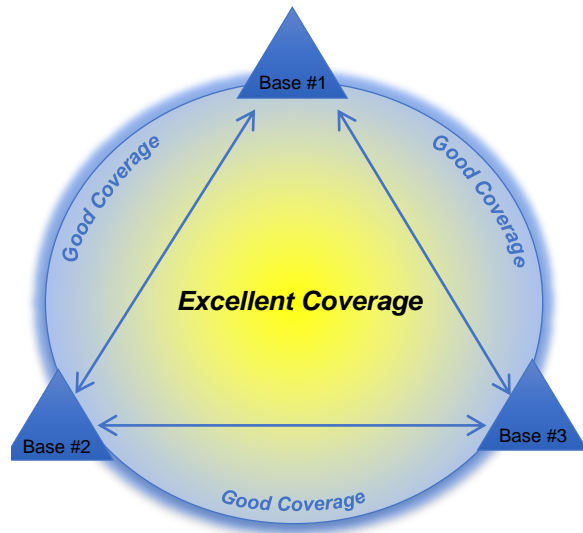
## HOW TO CALCULATE PPN COVERAGE

As previously discussed in the operation section, it is not the same as traditional or sightline RTK when calculating coverage in a VRS network.

How we determine coverage is to check which base stations surround the working area and determine the distance between those base stations.

So as you see on the figure to the right, if we wanted to see coverage for the middle of the circle we would have to measure the distance between base #1, #2 and #3. If the distances are less than our assumed coverage guidelines than you will have excellent VRS coverage.

In the above map of Southern Ontario you can see that we have excellent coverage, as all our bases are close enough to each other to create the proper corrections for a rover.



### ASSUMED COVERAGE GUIDELINES

Northern Prairies	50-60Kms
Central/Southern Prairies	60-70Kms
Southern Ontario	70-80Kms

# What you need to get started with PPN

1. You need to purchase an SF2 or SF3 activation for your Starfire Receiver
2. You need to purchase an RTK activation for your Starfire Receiver
3. "GX-450" Cell Modem and Installation Kit
4. A sim card and data plan, (1- 2 GB / Month is plenty)



# How to install PPN correctly

Basically, here are the most important things to do, to ensure your farmer has the best PPN RTK experience.

- **Make sure the Cell antenna and PPN GPS antenna are installed on OPPOSITE SIDES OF THE CAB.** (this is because the GPS antenna is not shielded well thus if the two antennas are installed close together PPN GPS receiver will not be able to identify its location. The modem needs to send its location to the PPN server, so it can send the proper RTK correction signals for the area it's in to the Starfire Receiver. Your customer will experience degraded service if the modem is having trouble getting a location fix.
- **Make sure not to pinch wires and all connections are secure and in good condition.** (having unreliable connections is a serious problem especially with real time applications like RTK. If the GPS antenna line is damaged to you will experience similar problems to what is seen above. Slower Startup times, degraded service etc. If the power cable is not secured properly the modem will power cycle and cause issues. Generally, just make sure connections are free from corrosion and their clips are secure when installing PPN.
- **Cell Boosters should be installed with all modems.** This helps stop lots of potential problems before they start, if a customer is spending the money for the highest precision install the booster to improve PPN reliability

Click the following link to see a quick install Manual with pictures

[Quick Install Manual](#)

Click the following link to see a full manual with more detail and explanation

[Full Install Manual](#)

