



HEXAGON



APN-087

# Application Note

## TerraStar on OEM7



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## Contents

TerraStar .....	4
Service Levels .....	5
TerraStar-L.....	5
TerraStar-C PRO.....	5
TerraStar-X Regional.....	5
L-band Coverage .....	6
Using TerraStar .....	6
Hardware Requirements.....	7
Firmware Requirements .....	7
Model Requirements .....	7
Configuration .....	8
Enable L-band Tracking .....	8
Subscriptions.....	9
Positioning with TerraStar .....	10
Subscription Managed Channel Configuration (SMCC).....	11
Operating in the Rapid Convergence Region .....	13
Additional Resources .....	14
Commands.....	14
Logs .....	14
Support.....	15
Documentation.....	15

## TerraStar

TerraStar is a global provider of precise satellite positioning services for land and near-shore applications. TerraStar owns, operates, maintains, and controls its global network of over 100 GNSS reference stations and the associated infrastructure to ensure maximum operational reliability of its augmentation services for land precise positioning. Corrections provided by the network are broadcast via five geostationary satellites or over the internet. For more information about TerraStar, visit [novatel.com](http://novatel.com).

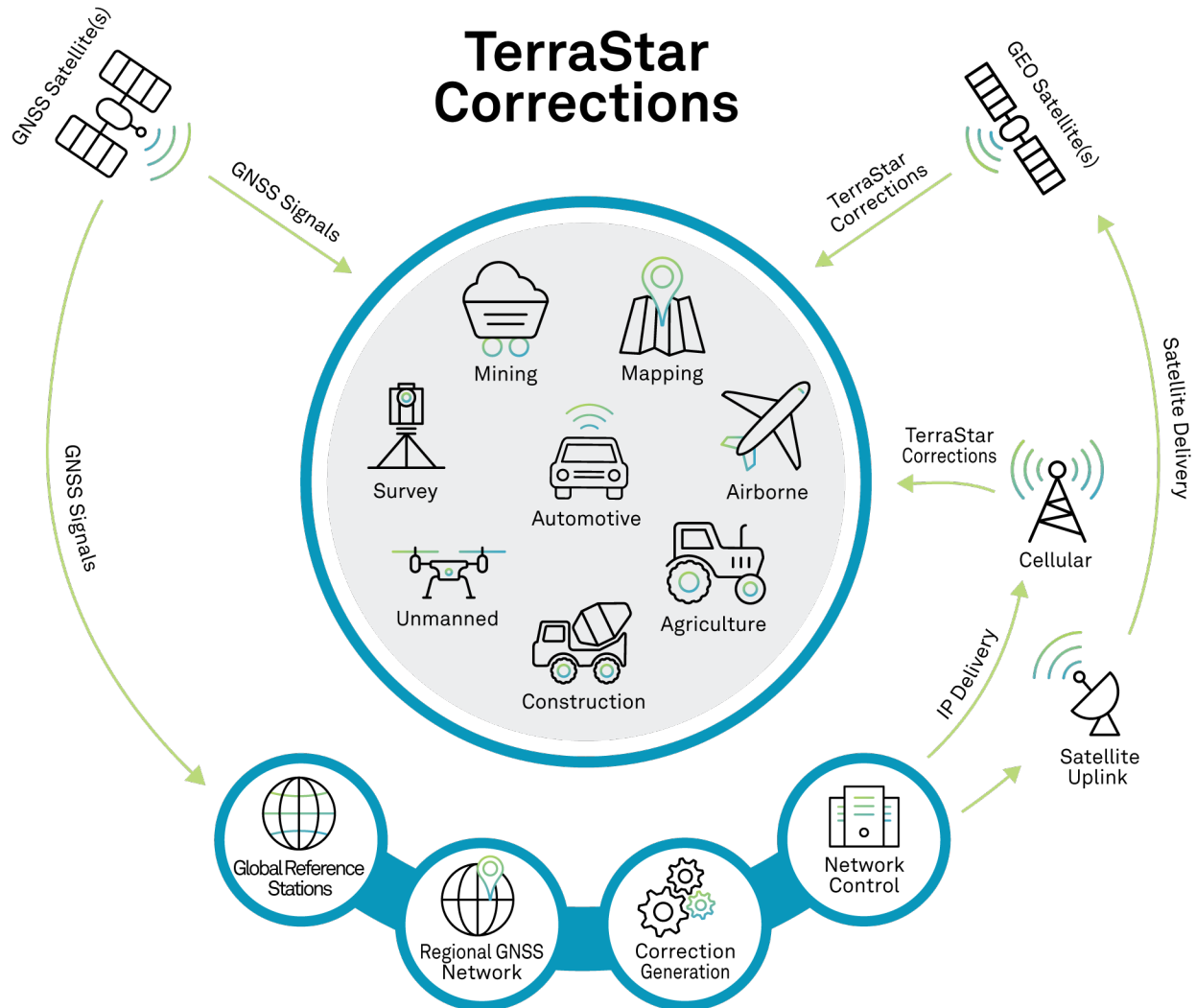


Figure 1: Global TerraStar corrections delivery



## Service Levels

### TerraStar-L

TerraStar-L is a real-time correction service that includes GPS and GLONASS satellite clock and orbit corrections derived from the TerraStar network of reference stations that can be used in applications requiring sub-metre accuracy.

### TerraStar-C PRO

TerraStar-C PRO is an advanced GNSS correction service that provides additional information, including higher rate clock and orbit corrections, and makes PPP ambiguity resolution possible.

TerraStar-C PRO corrections include centimetre-level accuracy, fast convergence, and fast re-convergence after GNSS outages.

### TerraStar-X Regional

TerraStar-X Regional GNSS correction technology leverages Hexagon's continuously operating global and regional reference networks for correction generation, data compression and delivery for precise, safe, reliable solutions at centimetre-level accuracy with less than one minute of convergence.

TerraStar-X Regional correction data generation takes place at Hexagon Autonomy & Positioning's processing centers where service reliability, redundancy and guaranteed service uptime ensure that corrections are available for users 24/7/365. TerraStar-X Regional's sub-minute convergence is available in select regions in North America, saving users time and money while delivering the precision and speed of traditional RTK networks without the need for base stations.

To use TerraStar services, a subscription must be purchased for each receiver. Depending on the specific needs of the application and end user, different types of subscriptions can be purchased with flexibility in length and region.



## L-band Coverage

There are five different L-band satellites that broadcast TerraStar corrections for specific regions, and the distribution of the L-band satellites allow for dual coverage in virtually any location. To provide additional coverage and redundancy, especially in large regions or countries, information for regional subscriptions is broadcast on the three beams best suited for that region.

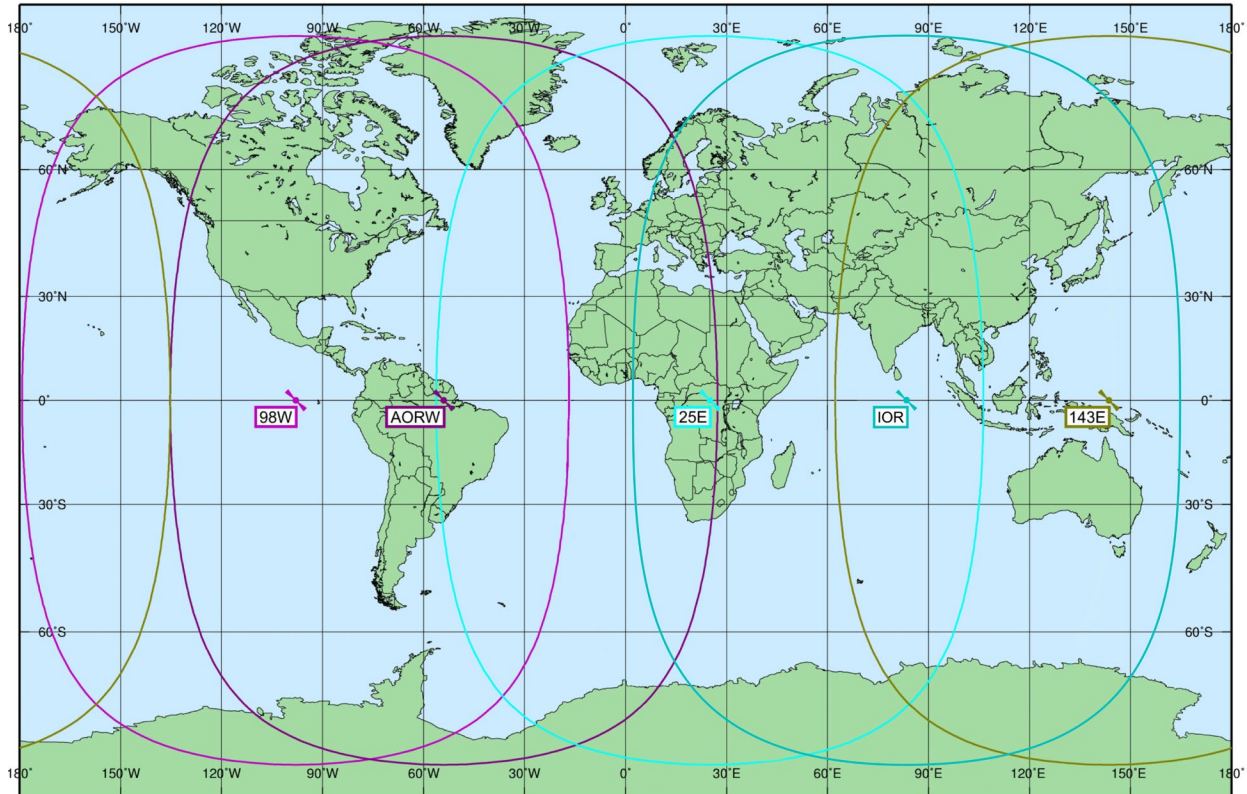


Figure 2: Global TerraStar coverage

More detail on coverage areas for specific beams can be viewed in the [interactive coverage map](#).

## Using TerraStar

In addition to a TerraStar subscription, there are specific hardware and software requirements that must be met to use TerraStar corrections and obtain a PPP solution.

## Hardware Requirements

To use TerraStar corrections and obtain the best performance, the following hardware is required:

- A NovAtel OEM7 receiver card, enclosure, or smart antenna.
- A GNSS antenna capable of receiving L-band signals (unless you are using [IP Delivery](#) for TerraStar Corrections).
- Best performance is achieved through an antenna with full GNSS signal support.

Table 1: Full GNSS signal support

GPS	L1	L2	L5	
GLO	L1	L2		
GAL	E1	E5b	E5a	E6
BDS	B1C	B2a	B2b	B3

## Firmware Requirements

- TerraStar-L is supported on all OEM7 firmware versions.
- TerraStar-C PRO requires firmware version 7.05.00 or later.
  - 7.08.10 or later is required for best TerraStar-C PRO convergence performance.
- TerraStar-X Regional requires firmware version 7.06.03 or later.
  - 7.08.10 or later is required for best convergence performance outside the TerraStar-X region.

## Model Requirements

- TerraStar-L subscriptions require the “L” designator in the char[4] position under the Positioning Options of the firmware model.
- TerraStar-C PRO subscriptions require the “P” designator in the char[4] position under the Positioning Options of the firmware model.
- TerraStar-X subscriptions require the “R” designator in the char[4] position under the Positioning Options of the firmware model.

Table 2: Letter designators for positioning option character [4]

Positioning Options	
L	Pseudorange Positioning ( <b>Basic Single Point Positioning, DGPS/DGNSS, GLIDE + TerraStar-L PPP</b> )
P	Pseudorange Positioning + TerraStar-C PRO
R	Pseudorange Positioning + RTK Rover + TerraStar-X
N	None

A receiver with an “R” model as in FDN-RNN-TBN can support subscriptions ranging from TerraStar-L to TerraStar-X.



## Configuration

### Enable L-band Tracking

Before a receiver can start using corrections through a TerraStar service, it first must be configured to track the L-band signal from a TerraStar geostationary satellites.

To enable L-band tracking, the AUTO setting is recommended in most cases:

```
ASSIGNLBANDBEAM AUTO
```

The AUTO setting allows the receiver to automatically track the highest elevation TerraStar satellite for best performance. The receiver firmware includes a default list of TerraStar satellites beams (see [LBANDBEAMTABLE](#)).

The receiver uses its position to determine which TerraStar signal is the best to use in a particular location.

To verify the L-band tracking status, use the [LBANDTRACKSTAT](#) log. For example:

```
#LBANDTRACKSTAT,COM1,0,71.0,FINESTEERING,2045,331169.000,02004008,29e3,32768;
5,
"SP98W1",1545885000,1200,974c,00c2,0,-32.095,42.138,3.9499,2395.248,45504,0,0,
5824512,0,0.0000,
"98W",1545865000,1200,974c,00c2,0,-138.875,41.949,4.0328,2421.916,46080,0,0,
5898240,0,0.0000,
"AORW",1545845000,1200,974c,00c2,0,-190.871,45.021,4.5517,2417.987,45952,0,0,
5881856,0,0.0000,
",,0,0,0000,0003,0,0.000,0.000,0.0000,0.000,0,0,0,0,0,0.0000,
",,0,0,0000,0003,0,0.000,0.000,0.0000,0.000,0,0,0,0,0,0.0000
```

This log reports the L-band tracking status of the TerraStar beams. Some important fields are highlighted above for three beams that the receiver is tracking and are described below for beam "98W":

- **98W**: This is the name of the TerraStar beam or transmitting satellite being tracked. Additional details for the tracked beam can be output and viewed with the [LBANDBEAMTABLE](#) log.
- **00c2**: This is the "Tracking Status Word". A tracking status of "00c2" indicates that the receiver is tracking the TerraStar signal.
- **41.949**: This is the C/No or "Carrier to Noise Density Ratio" (in dB-Hz). The C/No is typically about 40-45 dB-Hz in ideal tracking conditions. A low C/No value (below 38 dB-Hz) can result in missed corrections and correspondingly degraded performance.
- **2421.916**: This is the "Lock Time" (in seconds). This field can be monitored to ensure that the L-band signal is being tracked continuously without any loss of lock.

While the actual tracking of the L-band beam does not require a subscription, the receiver will not decode and use the TerraStar corrections until a valid subscription is activated.



## Subscriptions

A valid subscription is required to use TerraStar services. To purchase a TerraStar subscription, users should contact their NovAtel dealer or sales office<sup>1</sup>. [NovAtel's eStore](#) also allows purchasing of TerraStar subscriptions.

Test subscriptions can be made available for test and demonstration purposes. Please contact NovAtel Customer Support<sup>2</sup> for more information.

For purchase or trial subscription purposes, the NovAtel receiver's Product Serial Number (PSN) is needed. Before contacting your NovAtel sales office, obtain the PSN for the receiver you wish to activate using the LOG VERSION command. In the example [VERSION](#) log below, the PSN is "**BMHR17300202B**":

```
[COM1]<VERSION COM1 0 76.0 FINESTEERING 2057 494698.848 02004000 3681 15526
< 9
< GPSCARD "FFNRNNTBN" "BMHR18210047D" "OEM7700-1.01" "OA7CR0603RN0000"
"OM7BR0100RB0000" "2019/Apr/10" "06:09:54"
< OEM7FPGA "" "" "" "OMV070001RN0000" "" "" ""
< APPLICATION "" "" "" "ES7AR0601RN0000" "" "2019/Apr/10" "06:10:12"
< DEFAULT_CONFIG "" "" "" "ES7CR0603RN0000" "" "2019/Apr/10" "06:10:31"
< PACKAGE "" "" "" "ES7PR0601RN0000" "" "2019/Apr/10" "06:10:23"
< DB_WWWISO "WWWISO" "0" "" "WMC020204RN0003" "" "2018/Dec/06" "12:51:56"
< ENCLOSURE "SMART7-W" "NMSR18270010E" "0.0.0.0" "" "" "" ""
< WIFI "RS9113" "" "" "1.7.0" "" "2019/Apr/10" "06:10:37"
< REGULATORY "US" "" "" "" "" "" ""
```

Once a subscription is purchased, the subscription activation signal can be broadcast at the time of the service activation (default), or at a specified start date and time (upon user request). The receiver must be [configured to track the TerraStar signal](#) prior to the subscription start time.

The subscription activation message is broadcast for a period of 30 days from the specified date/time (UTC) of the activation. The subscription activation is re-sent every hour for the first 24 hours. For the following 29 days (or the remaining days of the subscription if <30 days) the subscription activation message is sent approximately every 3-6 hours.

When an active but expiring subscription is renewed, the updated subscription information gets broadcast during the last seven days of the active, expiring subscription. If the receiver tracks the TerraStar signal during that time, there will be no disruption in service when the renewal subscription begins. The activation information for the renewal subscription continues to be broadcast periodically for the subsequent 30 days.

To verify the TerraStar subscription and status, use the [TERRASTARSTATUS](#) log, for example:

```
<TERRASTARSTATUS COM1 0 72.5 FINESTEERING 1835 140874.036 00000020 fdc1 13306
< ENABLE LOCKED 0 DISABLED ONSHORE
```

In this example, the access status **ENABLE** indicates that the subscription is valid.

<sup>1</sup> [www.novatel.com/where-to-buy/sales-offices/](http://www.novatel.com/where-to-buy/sales-offices/)

<sup>2</sup> Contact [support.novatel@hexagon.com](mailto:support.novatel@hexagon.com) for more details. Maximum of 3 test subscriptions allowed per receiver.

The [TERRASTARINFO](#) log reports the subscription type:

```
[COM1]<TERRASTARINFO COM1 0 76.0 UNKNOWN 0 0.224 02000020 91ea 15437
< "QU243:3775:7727" TERM 00007f00 167 2019 0 GEOGATED 0.00000 0.00000 0
```

The subscription mask field “00007f00” indicates a TerraStar-X subscription.

## Positioning with TerraStar

When the receiver is configured to track the TerraStar signal and has downloaded a valid subscription, it will then begin decoding the correction data coming from the TerraStar beams to compute a PPP position.

To verify the availability of a PPP position solution, the following logs can be used:

- PPPPOS
- BESTPOS
- GPGGA

Here is an example command that will request the PPPPOS log on the COM1 port every second:

```
LOG COM1 PPPPOS ONTIME 1
```

The PPPPOS log will always output the PPP solution when available, whereas the BESTPOS and GPGGA logs will output the “best available” solution. When using BESTPOS or GPGGA logs, another solution will be output in some cases, typically an autonomous (SINGLE) or SBAS (WAAS) position type, until the accuracy of the PPP solution becomes the best available.

At first, the PPP solution will be flagged as converging. After the convergence completes, the position type will change to indicate a converged solution with the position types as shown in the table below:

Table 3: PPP Position Status by Log and GPS Quality

PPP Solution Status	BESTPOS/PPPPOS	GPGGA (Quality Indicator)
TerraStar-L Converging	PPP_BASIC_CONVERGING	1
TerraStar-L Converged	PPP_BASIC	2
TerraStar-C PRO / TerraStar-X Converging	PPP_CONVERGING	2
TerraStar-C PRO / TerraStar-X Converged	PPP	5

For example, the TerraStar-C PRO solution below transitions from “**PPP\_CONVERGING**” to “**PPP**” based on the [PPPCONVERGEDCRITERIA](#) command setting. By default, the solution is flagged as converged when the estimated horizontal (2D) standard deviation of the solution is under 0.32 metres:

```
[COM1]<PPPPOS COM1 0 71.0 FINESTEERING 2057 414472.000 02040020 ec34 14968
< SOL_COMPUTED PPP_CONVERGING 51.15044107608 -114.03068004318 1097.1153 -
17.0000
WGS84 0.8505 1.3157 2.0220 "TSTR" 12.000 0.000 31 31 31 27 00 00 3f 37

[COM1]<PPPPOS COM1 0 76.0 FINESTEERING 2057 414928.000 02000020 ec34 14968
< SOL_COMPUTED PPP 51.15043714755 -114.03067696242 1097.6564 -17.0000 WGS84
0.0799 0.2168 0.1836 "TSTR" 18.000 0.000 33 33 33 29 00 00 3f 37
```

With TerraStar-X Regional, a PPP solution is reported similarly to the above PPPPOS logs, however the base station ID field will report “**TSX**” for TerraStar-X Regional:

```
[COM1]<PPPPOS COM1 0 71.5 FINESTEERING 2057 415640.000 02000000 ec34 15437
< SOL_COMPUTED PPP 51.15043856926 -114.03068169619 1097.4570 -17.0000 WGS84
0.0250 0.0237 0.0536 "TSX" 14.000 0.000 17 17 17 16 00 00 00 33
```

### Subscription Managed Channel Configuration (SMCC)

For the receiver to maximise the benefit of all constellations and frequencies available, it will enable additional channels upon receipt of a TerraStar subscription and a subsequent power cycle or reset. SMCC automatically configures the subscribed device to the best channel configuration. Changing the configuration allows the receiver to use the entirety of the applicable correction messages for the given receiver hardware and subscription combination without user intervention or configuration.

SMCC was first introduced with firmware version 7.08.10 and our product support for this feature has increased with subsequent firmware releases, as detailed below:

- 7.08.10: OEM7700, OEM719, OEM729, PwrPak7 and CPT7700.
- 7.08.12: SMART7 (select variants).
- 7.08.14: OEM7720, OEM7500, CPT7 and PwrPak7D.
- 7.08.15: SMART7 (all variants), SMART2 and remaining agriculture products.

*Note: If the channel configuration is changed using **SELECTCHANGONFIG**, it must be removed using the **FRESET** command for SMCC to function properly. The **FRESET** command will remove all configuration and set the receiver to a factory reset mode.*

Table 4: TerraStar-C PRO SMCC behavior and model requirements

	<b>TerraStar-C PRO</b>	
	OEM7700, OEM719, OEM729, PwrPak7, SMART7 <sup>3</sup> , CPT7700	OEM7720 <sup>4</sup> , OEM7500 <sup>4</sup> , CPT7 <sup>4</sup> , PwrPak7D <sup>4</sup> , SMART2 <sup>5</sup>
Minimum model required to purchase a subscription	DDN-P	DDN-P
Model that supports full subscription functionality	FFN-P	MFN-P
Once active subscription is received, receiver automatically applies SMCC	FFN FF config (7)	MFN MF config (6) MFD MF config (6)

Table 5: TerraStar-X SMCC behavior and model requirements

	<b>TerraStar-X</b>
	OEM7700, OEM719, OEM729, PwrPak7, SMART7 <sup>3</sup> , CPT7700
Minimum model required to purchase a subscription	DDN-R
Model that supports full subscription functionality	FFN-R
Once active subscription is received, receiver automatically applies SMCC	FFN FF config (7)

The CHANCONFIGLIST log will show the new channel configuration number, as per the tables above.

SMCC is enabled by default, however it can be disabled if it is not your preferred configuration, as RTK may have different channel configuration requirements to match the RTK source. It can be changed using the [TERRASTARAUTOCHANCONFIG](#) command.

If a FRESET is sent after SMCC has changed the channel configuration, a power cycle or RESET must be done once the receiver boots for SMCC to re-enable and change the channel configuration as described above.

<sup>3</sup> FW 7.08.12 and newer only

<sup>4</sup> FW 7.08.14 and newer only

<sup>5</sup> FW 7.08.15 and newer only



## Operating in the Rapid Convergence Region

A receiver with a TerraStar-X Regional subscription has access to the regional rapid convergence and global TerraStar-C PRO corrections. The receiver will use the corrections that provide the fastest convergence and the best accuracy possible and will seamlessly manage the transition between the global and regional correction sources.

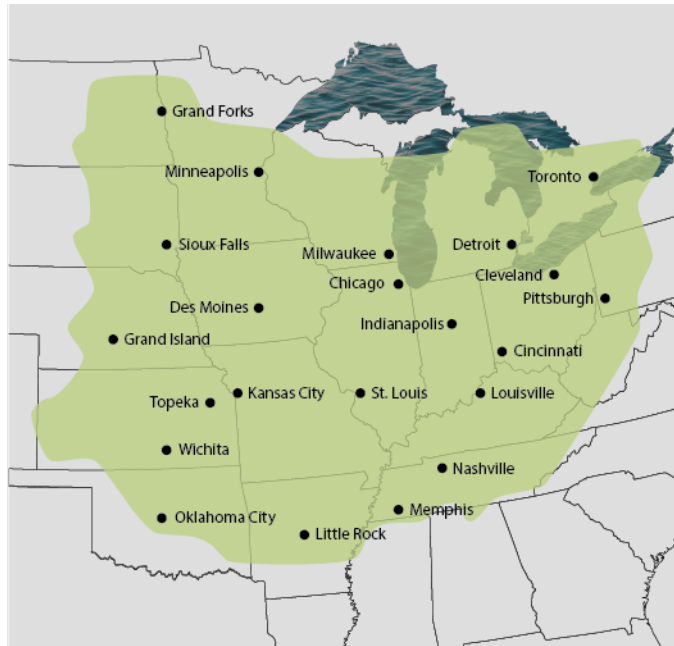


Figure 3: TerraStar-X regional rapid convergence region

When a receiver with TerraStar-X subscription is fully converged in the rapid convergence region, there will be no change to accuracy if the receiver exits the rapid convergence region. If a converged PPP solution is lost outside the zone, for example due to intermittent or complete loss of GNSS or L-band tracking, the receiver will re-converge. Re-convergence for a brief outage outside the rapid convergence region may still be under a minute.

If a receiver starts up in the rapid convergence region and moves out of it before convergence is complete, the system will continue operating with TerraStar-C PRO performance until the receiver is reset or power cycled. Any total reconvergence outside the rapid convergence region will follow TerraStar-C PRO convergence performance despite the receiver having a TerraStar-X subscription.

Both inside and outside the rapid convergence region, TerraStar-C PRO is a fallback service level for TerraStar-X Regional.



## Additional Resources

### Commands

For general information about issuing commands to a NovAtel receiver, please visit our online documentation for [Commands](#).

- [ASSIGNLBANDBEAM](#)
- [PPPCONVERGEDCRITERIA](#)
- [PPPDYNAMICS](#)
- [PPPRESET](#)
- [PPPSEED](#)
- [PPPSOURCE](#)
- [PPPTIMEOUT](#)
- [TERRASTARAUTOCHANCONFIG](#)

### Logs

Any of the logs described below can be output using the LOG command. For general information about requesting logs from a NovAtel receiver, please visit our online documentation for [Logs](#).

- [CHANCONFIGLIST](#)
- [LBANDBEAMTABLE](#)
- [LBANDTRACKSTAT](#)
- [PPPPOS](#)
- [PPPSATS](#)
- [TERRASTARINFO](#)
- [TERRASTARSTATUS](#)



## Support

To help answer questions and/or diagnose any technical issues that may occur, the [NovAtel Support website](#) is a first resource.

Remaining questions or issues, including requests for test subscriptions or activation resends, can be directed to [NovAtel Support](#).

Before contacting Support, it is helpful to collect data from the receiver to help investigate and diagnose any performance-related issues. A list of appropriate troubleshooting logs can be found on the [OEM7 Documentation Portal](#) (the LOG command with the recommended trigger and data rate is included with each log).

The data can also be collected using [NovAtel Application Suite](#).

## Documentation

For any questions on logs and commands, please visit the [OEM7 Documentation Portal](#).

## Contact Hexagon | NovAtel

[support.novatel@hexagon.com](mailto:support.novatel@hexagon.com) 1-800-NOVATEL (U.S. and Canada) or 1-403-295-4900

For more contact information, please visit [novatel.com/contact-us](https://novatel.com/contact-us)