Guidelines for Utilizing InCORS

INDIANA'S STATEWIDE GNSS-GPS REAL TIME NETWORK

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Land & Aerial Survey Office

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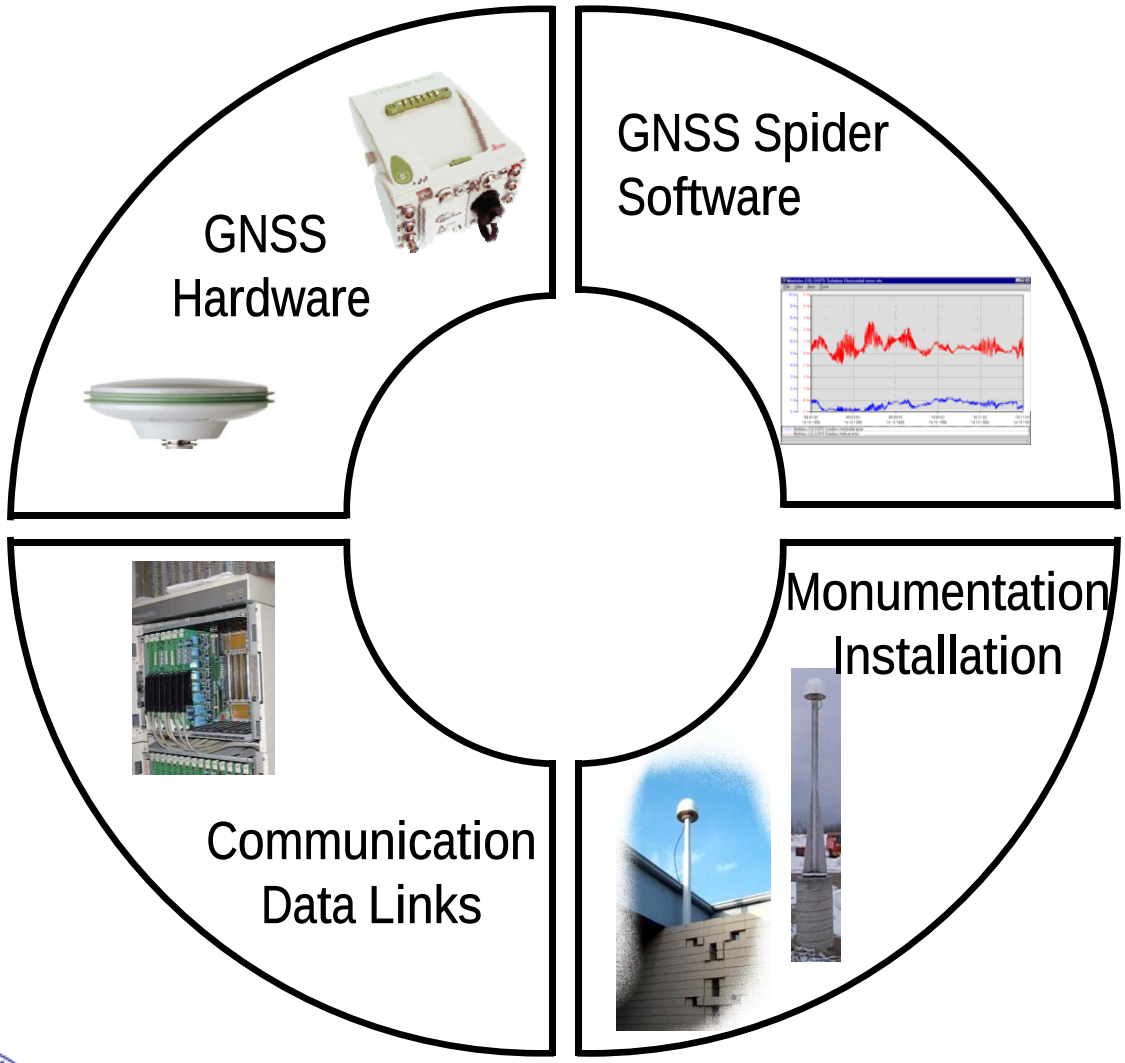
January 18, 2013

What is the **InCORS** Network?

Indiana **C**ontinuously **O**perating **R**eference **S**tation Network

- Network of 45 geodetic quality GPS (**GNSS**) receivers and antennas, permanently installed, located across the state – INDOT & ISP sites
- Partnering with KYTC, MDOT, ODOT, Noble Co. and KARA Co.
- Continuously collects GNSS data
- Transmits thru Internet to central servers
- Data archived for future use, available for download by users
- Data processed by server software to generate network corrections-available via internet in real-time

InCORS Components



4 main parts:

GNSS Hardware

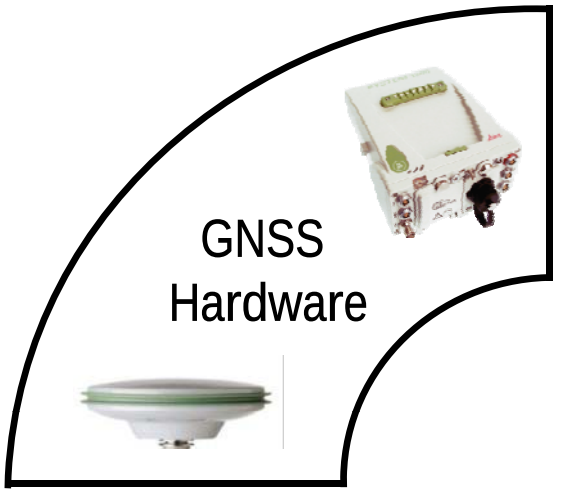
GNSS Software

Monumentation

Communication

InCORS Hardware

GNSS Hardware is the key component for functionality in communication, interface with Server Software, Satellite Constellation, Receiver Clock, and Flexibility for remote communications.

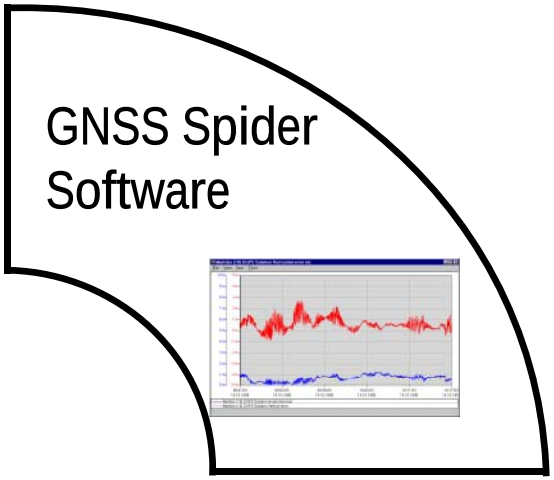


1202 GG Leica Antenna
Upgrading antennas
with AS10 Leica
Antenna (triple Freq.)

GRX1200GG PRO Leica Receiver

InCORS Software

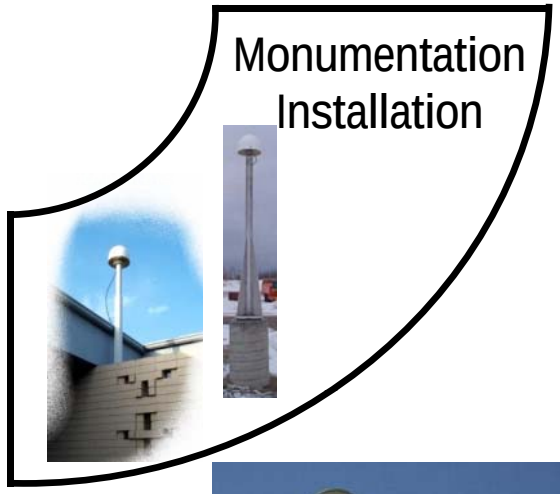
- Leica SpiderNet
- Modular and fully scalable
- For single and multiple stations
  - INDOT 45 stations
  - KYTC, MDOT, ODOT & Noble Co. 13 stations
  - Plans for using 2 in Illinois for total of 60 station licenses we currently have
- For small and large networks
- For Post-Processed and RTK Networks
- For all types of GPS receivers
  - Leica, Trimble, Ashtech, Topcon….
- For all communication methods



InCORS Monumentation

INDOT Operated Station Monuments

- 3 Concrete Monuments - permanent
- 42 Building Mounts – semi-permanent
- 37 stations have been accepted as National CORS thus far (NGS monitored)



InCORS Communication

Satellite Signals

GSM/GPRS Repeaters

MiFi Device

Cell Phones w/ data plan

GSM/GPRS & CDMA Modems

Communication Data Links

IOT Network

Cellular Network

Cellular Receiver

End User

Receiver Box

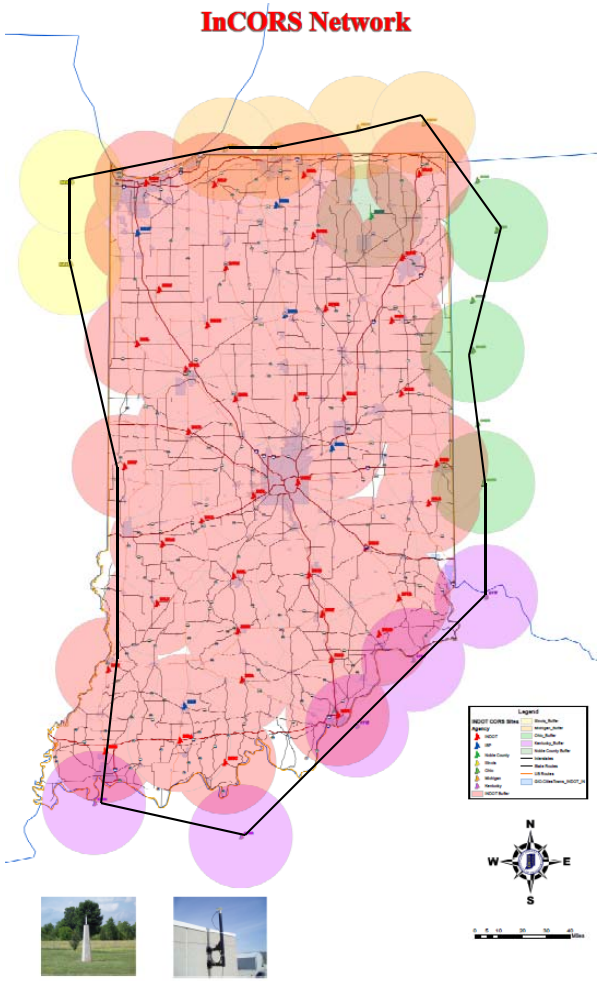
INDOT Servers

InCORS Network Details

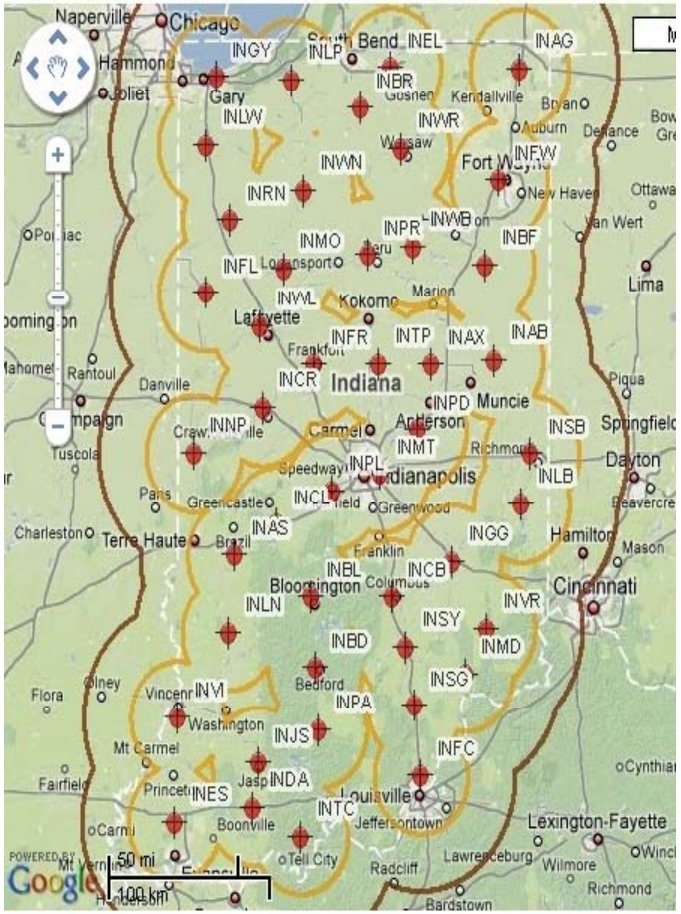
- DOT-Owned and Managed
  - Land & Aerial Survey Office (LASO)
- Utilizes state IOT Communications Network
- Utilizes state IOT Server Facility
- Free Access to Public & Private Sector
- Statewide Coverage
- Open Architecture
  - (RTCM 2.3,3.1,CMR,CMR+)
- Base Station Redundancy
- Public use started on February 1, 2010
- Currently have created over 1492 accounts

State Coverage

InCORS with Partnerships



InCORS Coverage



Network Adjustment Summary

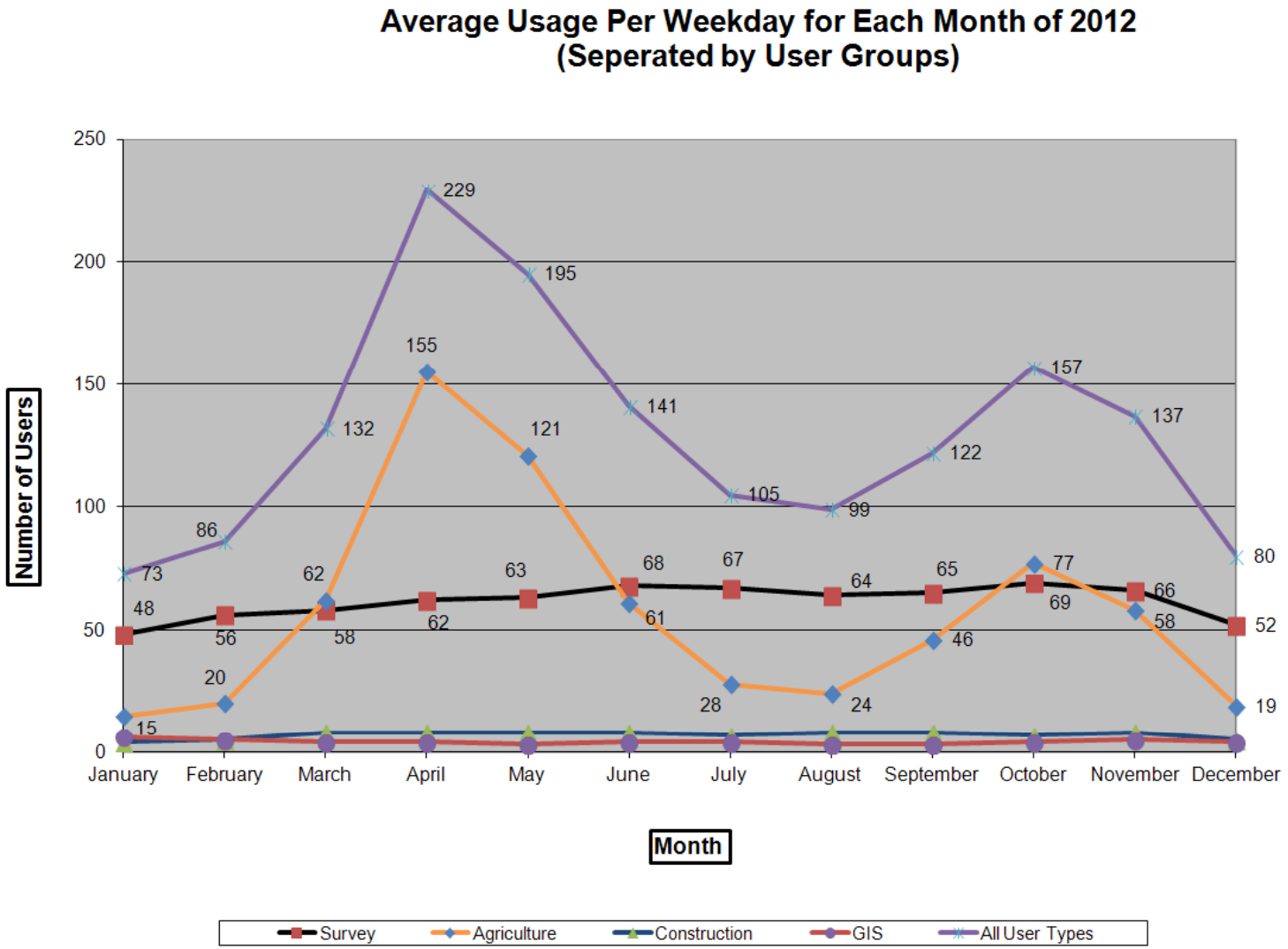
- Precision
  ± 0.5 cm Horiz. & ± 2.0 cm Vert. @ 95% (2-sigma)

- Adjusted vs. Published values
  ± 0.8 cm Horiz. & ± 2.0 cm Vert.

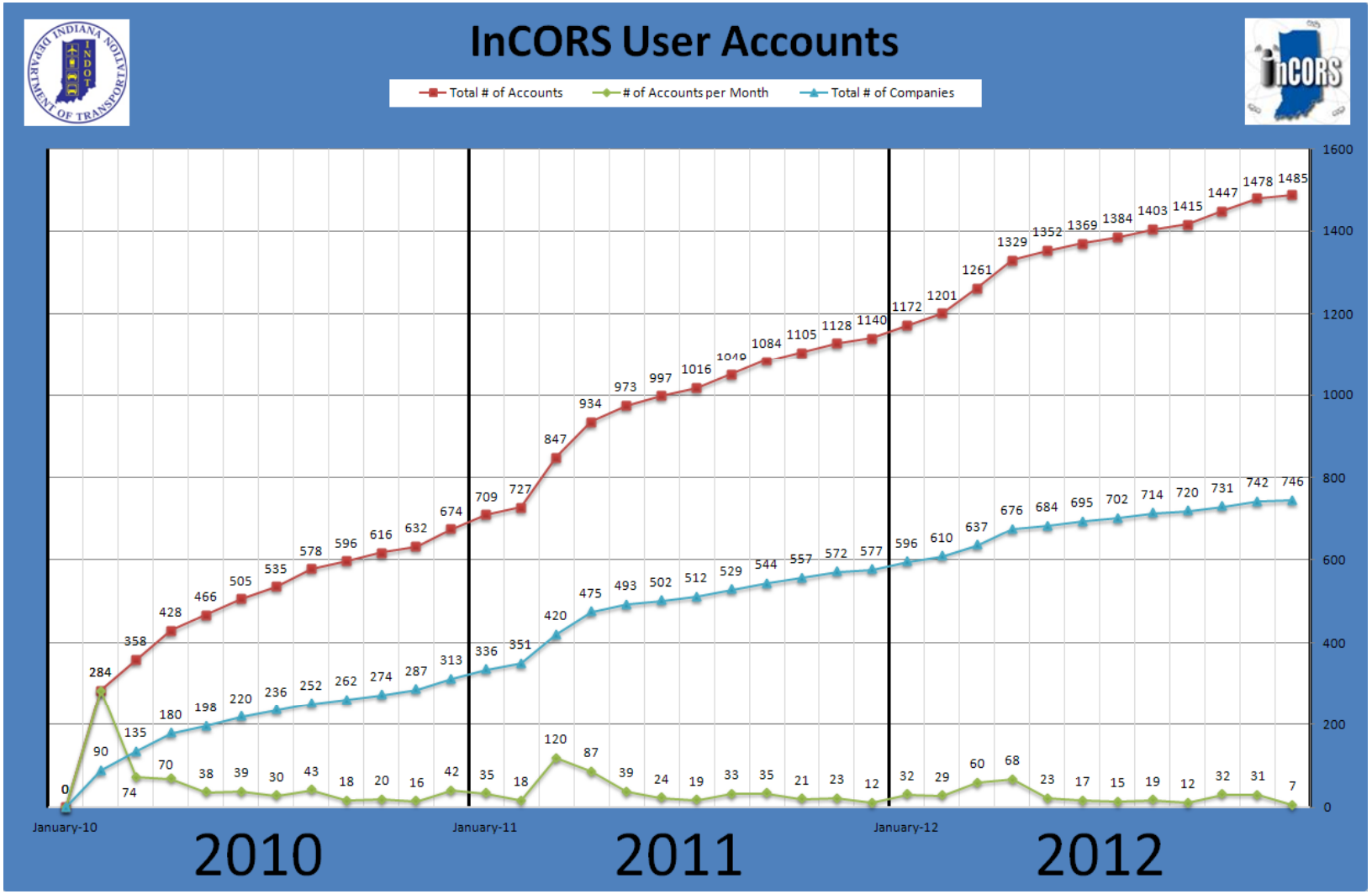
- Consistent w/ NAD83 (CORS96) (Reference Epoch 2002.0)
  ± 1 cm Horiz. & ± 2 cm Vert.

- Plans to update to our reference frame to
  NAD83 (2011) Epoch 2010.0 Coordinates

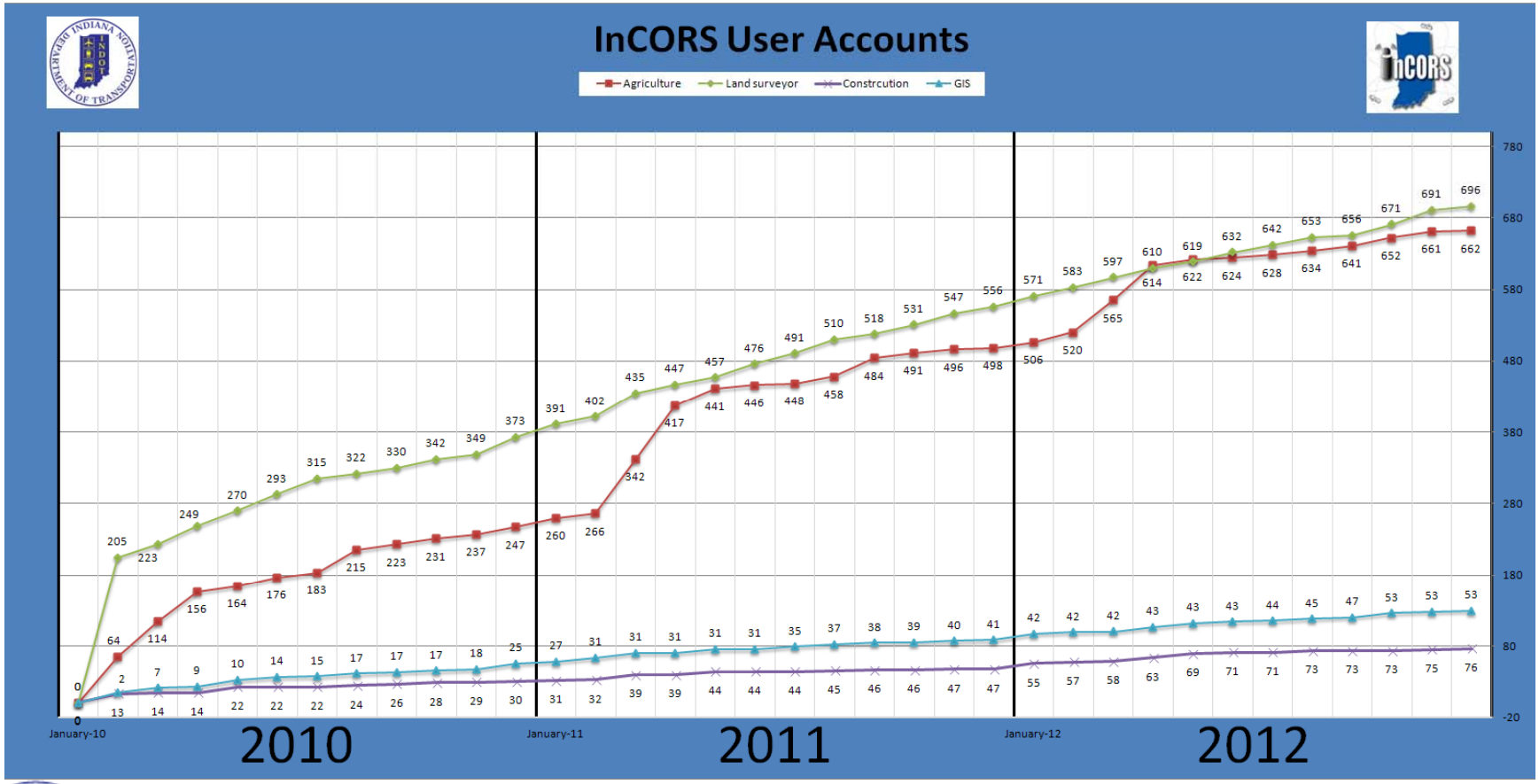
Average Usage



User Growth Over Time



User Growth by Type



Land and Aerial Survey Office Website

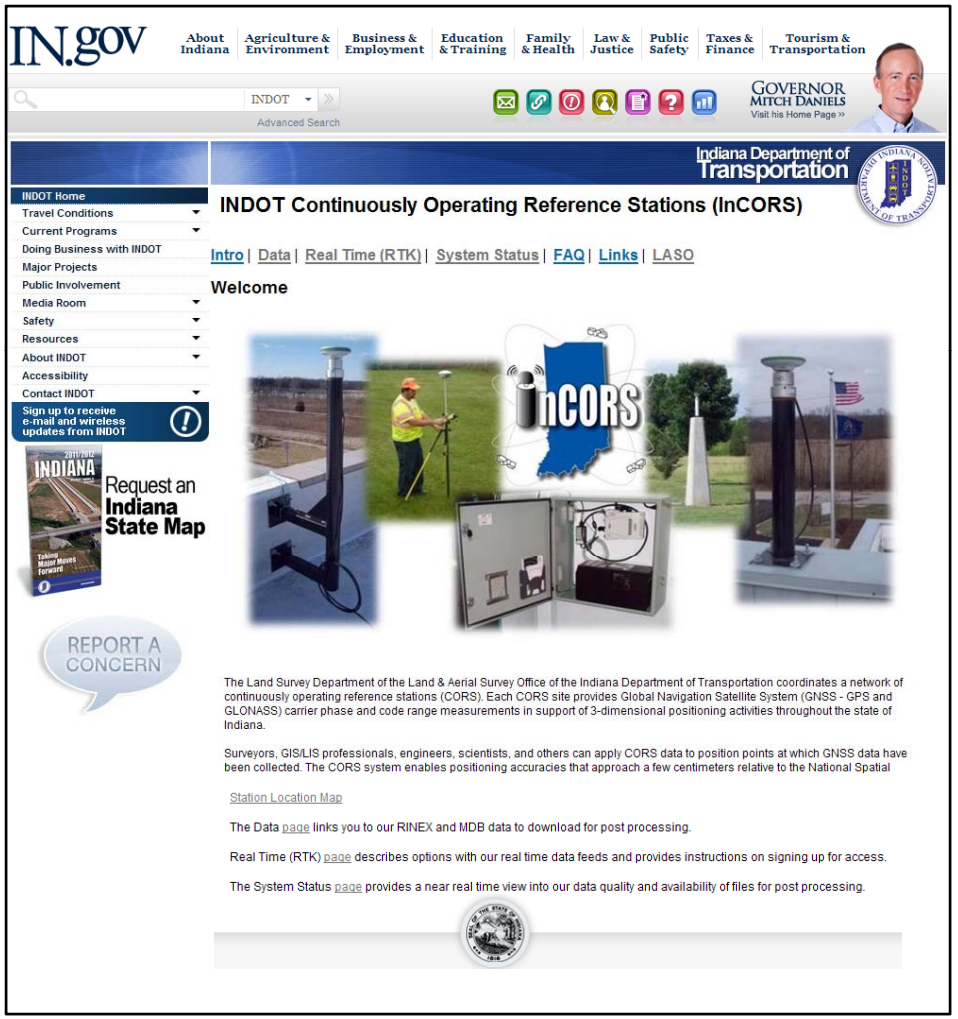
(http://www.laso.indot.in.gov)

InCORS Website

(http://incors.in.gov)

Welcome Page Contains:

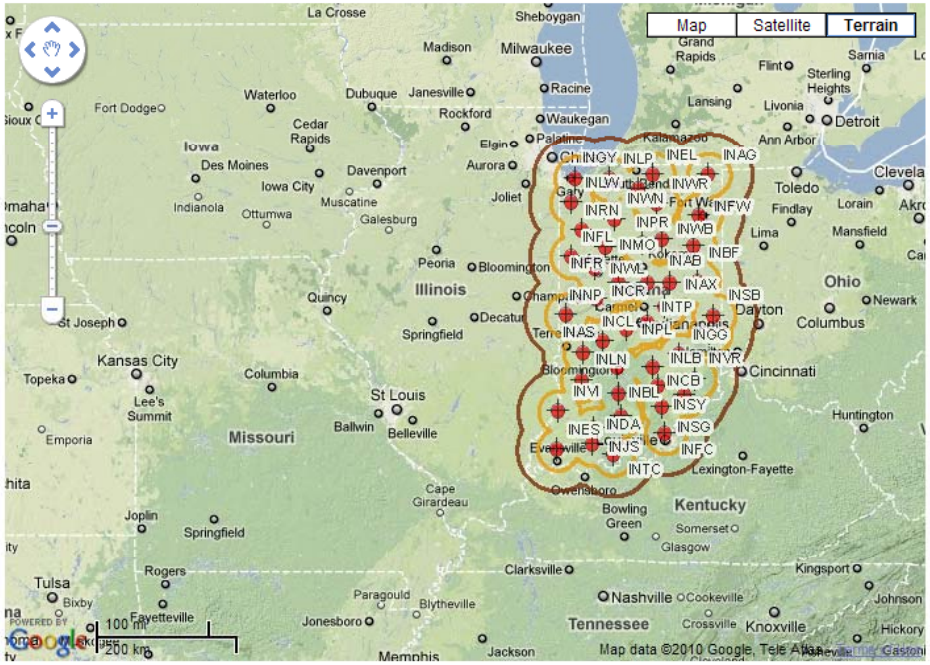
- Brief description
- Links to:
  - Station Location Map
  - Data Page
  - RTK info & instructions
  - System Status page



InCORS – Station Location Map

InCORS Station Locations

45 Sites across the state. Click on a site for more information.
Orange buffer is 30km from Stations and brown buffer is 60km from stations.
Mouse Click inside the sites for information and status of each location.



✓ Click on station icon to bring up metadata

InCORS Station Locations

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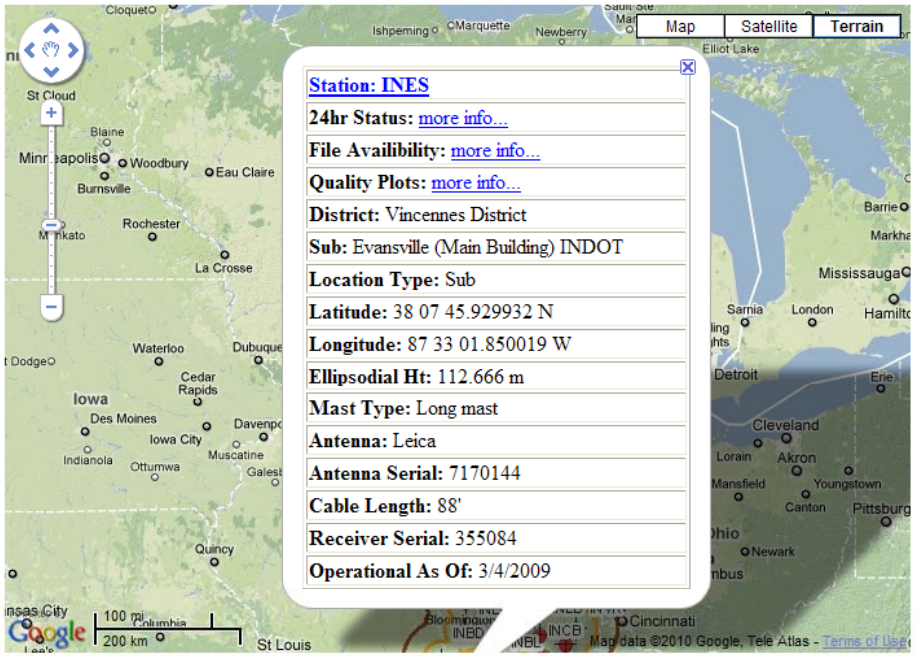
Orange buffer is 30km from Stations and brown buffer is 60km from stations.
Mouse Click inside the sites for information and status of each location.



InCORS – Data Page

Contains:

- Link to the ftp site for Rinex data
- Link to the Data and Website Disclaimer

InCORS – Real Time (RTK) Page

Contains:

- How to get access
- Link to the RTK User Agreement
- Links to RTK documents
- Submittal information for User Agreement
- User tech support note
  - Preferred method of contact: email to incors@indot.in.gov

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Governor Mitch Daniels — Visit his Home Page »

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Sign up to receive e-mail and text/phone updates from INDOT

Request an Indiana State Map

REPORT A CONCERN

INDOT Continuously Operating Reference Stations (InCORS)

Intro | Data | Real Time (RTK) | System Status | FAQ | Links | LASO

GNSS Reference Solutions

INDOT's GNSS Reference System delivers:

- cm level real-time kinematic corrections
- post-processing solutions
- sub-meter GIS corrections

Providing a real-time kinematic (RTK) correction service over the internet, and RINEX files for post-processing .You don't have to be a Leica user to enjoy the benefits of INDOT's GNSS. If your GPS or GNSS receiver can connect to the internet, INDOT can deliver the data you need.
With this service offered by INDOT using Leica's GNSS Technologies you don't need to invest in an extra base station to get accurate positions. You don't need to setup a base station first and worry about its safety. Just start your GNSS rover and connect. A few seconds later, you have the ability to survey with cm-accuracy.

IMPORTANT NOTIFICATION

As of Thursday July 12, 2012 the proxy server IP Address is 108.59.49.226.

You will need to change the IP Address on your data collector/controller to the new IP address (108.59.49.226).

The port numbers will remain the same.

RTK Access
To get access to our RTK Service you must first agree to our User Agreement and Data Disclaimers. Complete the [User Agreement], print, sign and return it to our office for processing by mail, fax or e-mail to:

Land & Aerial Survey Office
InCORS Network Administrator
120 South Shortridge Road
Indianapolis, IN 46219-6705
Phone: 317-610-7251, ext. 293
Fax: 317-356-9351
E-mail: incors@indot.in.gov

Currently the InCORS is providing Network RTK in RTCM (Real Time Correction Message) 2.3, and 3.1 in the MAX (R2K2 Full) and i-MAX (R2K2 LITE) formats via NTRIP (Networked Transport of RTCM via Internet) and TCP/IP, as well as CMR and CMR+ in the MAX (R2K2 Full) and i-MAX (R2K2 LITE) formats via NTRIP , and TCP/IP. The main difference between MAX and i-MAX is the processing is done at the ROVER for MAX and with i-MAX the processing is done at the servers.

In order to access these messages the user will need a wireless modem device that can access the wireless web. The modems come in all shapes and styles and through different wireless providers. INDOT does not recommend one provider over the other, the user must determine the coverage in his/her particular area to determine the best solution.

The users also need to complete the RTK Users Agreement which is available as a link on this page. Once the RTK User Agreement is signed and returned to INDOT, INDOT will provide the IP address, port number, account username and account password to the user.

Available RTK Corrections/Products

BROADCAST RTK CORRECTIONS FROM THE InCORS NETWORK

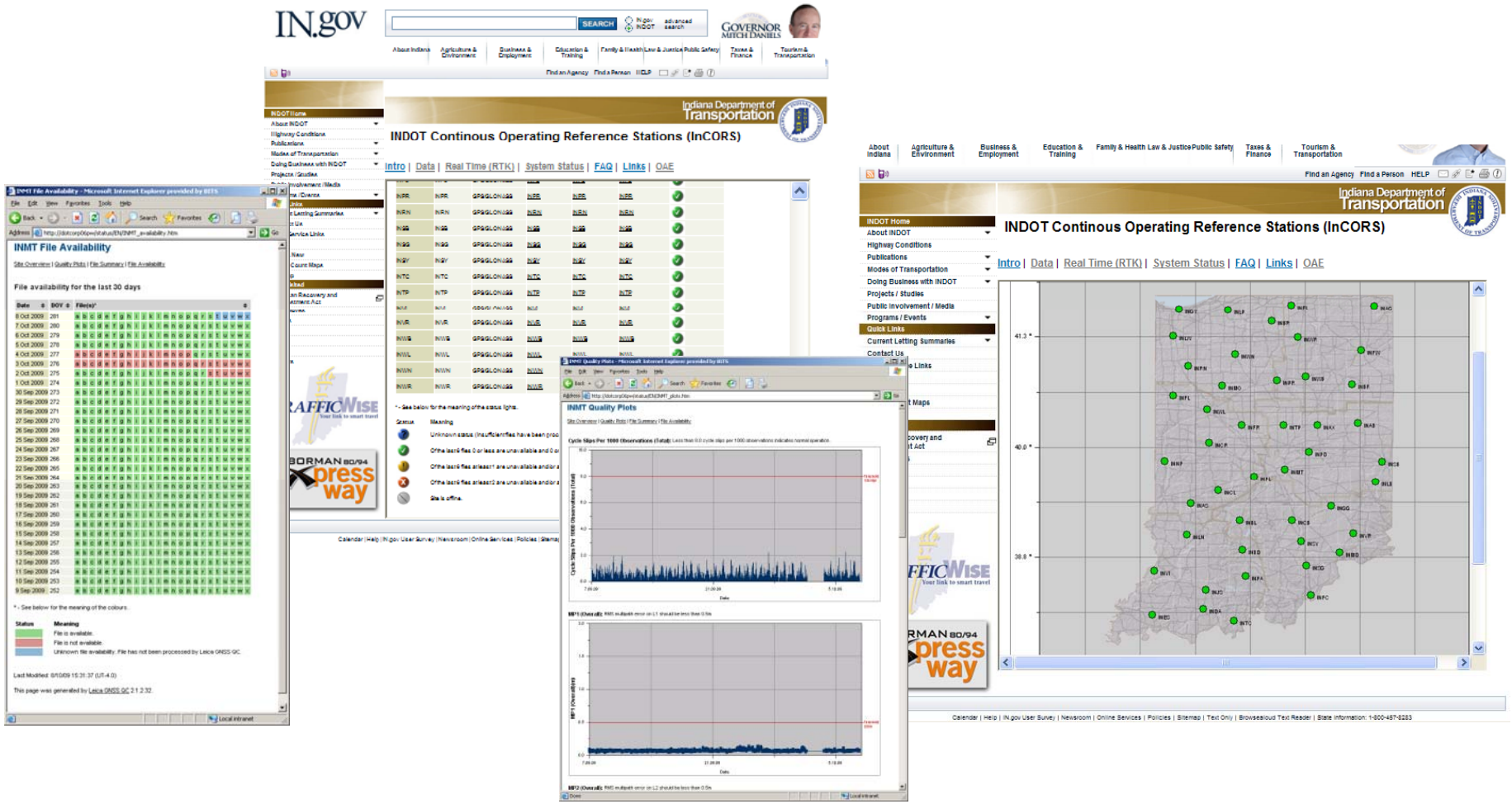
May 27, 2011

RT Product Name	RT Product Type	Message Type	Connection Type	Connection Port	Ntrip Mount Point	Network Correction	Glonass Capable
RTCM 3.1 MAX (GNSS)	Automatic cells	MAX RTCM 3.x (Extended;1015;1016)	NTRIP-Client	10000	RTCM3_MAX	Yes	Yes
RTCM 3.1 iMAX (GNSS)	Automatic cells	i-MAX RTCM 3.x (Extended)	NTRIP-Client	10000	RTCM3_IMAX	Yes	Yes
RTCM 2.3 iMAX (GPS)	Automatic cells	i-MAX RTCM 2.x (Type 18;19)	NTRIP-Client	10000	RTCM2_IMAX	Yes	No
RTCM 3.1 Nearest (GNSS)	Nearest site	RTCM 3.x (Extended)	NTRIP-Client	10000	RTCM3_NEAR	No	Yes
RTCM 2.3 Nearest (GPS)	Nearest site	RTCM 2.x (Type 1;2;18;19)	NTRIP-Client	10000	RTCM2_NEAR	No	No
CMR Nearest (GPS)	Nearest site	CMR	NTRIP-Client	10000	CMR_NEAR	No	No
CMR+ Nearest (GPS)	Nearest site	CMR+	NTRIP-Client	10000	CMRP_NEAR	No	No
CMR+ iMAX (GPS)	Automatic cells	i-MAX CMR+	NTRIP-Client	10000	CMRP_IMAX	Yes	No
CMR+ iMAX (GNSS)	Automatic cells	i-MAX CMR+	NTRIP-Client	10000	CMRP_IMAX(GNSS)	Yes	Yes
CMR+ Nearest (GNSS)	Nearest site	CMR+	NTRIP-Client	10000	CMRP_NEAR(GNSS)	No	Yes
INAG RTCM IMAX *	Single Cell	i-MAX RTCM 3.x (Extended)	NTRIP-Client	10000	INAG_RTCM_IMAX	Yes	Yes
INEL RTCM IMAX *	Single Cell	i-MAX RTCM 3.x (Extended)	NTRIP-Client	10000	INEL_RTCM_IMAX	Yes	Yes
INGY RTCM IMAX *	Single Cell	i-MAX RTCM 3.x (Extended)	NTRIP-Client	10000	INGY_RTCM_IMAX	Yes	Yes
INLP RTCM IMAX *	Single Cell	i-MAX RTCM 3.x (Extended)	NTRIP-Client	10000	INLP_RTCM_IMAX	Yes	Yes
RTCM 3.1 iMAX (GNSS)	Automatic cells	i-MAX RTCM 3.x (Extended)	TCP/IP	11000		Yes	Yes
RTCM 2.3 iMAX (GPS)	Automatic cells	i-MAX RTCM 2.x (Type 18;19)	TCP/IP	11001		Yes	No
RTCM 2.3 Nearest (GPS)	Nearest site	RTCM 2.x (Type 1;2;18;19)	TCP/IP	11002		No	No
CMR+ iMAX (GNSS)	Automatic cells	i-MAX CMR+	TCP/IP	11003		Yes	Yes
CMR Nearest (GPS)	Nearest site	CMR	TCP/IP	11005		No	No
CMR+ Nearest (GPS)	Nearest site	CMR+	TCP/IP	11006		No	No
RTCM 3.1 MAX (GNSS)	Automatic cells	MAX RTCM 3.x (Extended;1015;1016)	TCP/IP	11007		Yes	Yes
RTCM 3.1 Nearest(GNSS)	Nearest site	RTCM 3.x (Extended)	TCP/IP	11008		No	Yes
CMR+ iMAX (GPS)	Automatic cells	i-MAX CMR+	TCP/IP	11009		Yes	No
CMR+ iMAX (GNSS)	Automatic cells	i-MAX CMR+	TCP/IP	11010		Yes	Yes
RTCM3_INxx **	Single Site	RTCM 3.x (Extended)	NTRIP-Client	7071	RTCM3_INxx	No	Yes
CMR_INxx **	Single Site	CMR	NTRIP-Client	7072	CMR_INxx	No	No
CMRP_INxx **	Single Site	CMR+	NTRIP-Client	7073	CMRP_INxx	No	Yes

* = These products include only the InCORS stations around the Indiana/Michigan border. They were created because some of the Michigan stations are not Glonass capable which eliminates Glonass from the network solution when the Michigan sites are used.

** = These products are single base corrections. Since they are tied to one base and do not utilize the Nearest capability the user will have to manually switch to a new base product if the station they are using goes offline. (INxx stands for the site code for example Alexandria is INAX and the CMR+ mount point would be CMRP_INAX)

InCORS – System Status Page



What You Need

- Need a rover that at a minimum, can:
  - Connect to the internet via cell phone or cell modem
  - Network is independent of cell service provider, select the provider with best service in the area you work in!
  - Send a NMEA message with account username and password, or has NTRIP functionality
  - Can utilize RTCM 2.3, RTCM 3.x, CMR, CMR+ or Leica message formats
- Strongly encourage all users to run the most recent firmware for the rover they are using.
- For Construction/Ag machine control or project areas in cell service voids, solutions exist to provide on-site radio broadcast of baseline and network solutions.

InCORS – RTK User Agreement

INDIANA DEPARTMENT OF TRANSPORTATION

Indiana Continuously Operating Reference Station (InCORS) Network Real Time Correction Message User's Responsibility and Agreement for the Use and Access of Data

GENERAL

The Real Time Network Correction broadcasts in Radio Technical Commission for Maritime Services (RTCM) format and Compact Measurement Record (CMR) format for the stations which are a part of the InCORS system and are offered to you, the user ("User"), as a public service. You should read the following to understand the limitations regarding the information provided and the use to be made of these RTCM and CMR broadcasts.

Government personnel and the general public may use this system to retrieve RTCM and CMR Messages. A User may not:

1) knowingly and without authorization, alter, damage, or destroy the Indiana Department of Transportation ("INDOT") or another user's computer system, network, software, program, documentation or data contained therein;
2) use this service to conduct or attempt to conduct any business or activity or solicit the performance of any activity that is prohibited by law. In addition, taking action which results in blocking access to this IP address by other users, will be deemed an unauthorized use and may subject the User to law enforcement action.

This system uses administrative monitoring of Users accessing the system. System administrators may provide evidence of possible criminal activity identified during such monitoring to the appropriate law enforcement officials. If you (User) do not wish to consent to monitoring, exit this system now.

A User shall not hold himself or herself out as a representative, agent, or employee of INDOT and INDOT shall not be liable for any representation, act or omission of the User.

DISCLAIMER OF LIABILITY AND RELIABILITY

In preparation of this RTCM and CMR Broadcast Service, INDOT has endeavored to offer current, correct, and clearly expressed information. Nevertheless, errors may occur. INDOT expressly disclaims any liability, of any kind, or for any reason, that might otherwise arise out of any use of the RTCM and/or CMR information broadcast provided by this service. In particular but without limiting its disclaimer, INDOT disclaims any responsibility for typographical errors or inaccuracies of the information provided or contained within the broadcast message. INDOT makes no warranties or representations whatsoever regarding the quality, content, completeness, availability, suitability, adequacy, sequence, accuracy, or timeliness of the information and data provided by this service.

INDOT makes no representations or warranties of any kind regarding this service that may serve as the basis for holding INDOT liable, under any circumstances, for any consequence of the use of this information contained in the RTCM and/or CMR broadcast message. INDOT makes no representations or warranties regarding the condition or functionality of this Broadcast Service, its suitability for use, or that this Broadcast Service will be uninterrupted or error-free.

If misleading, inaccurate or otherwise inappropriate information is discovered, INDOT asks that it be brought to INDOT's attention so that efforts may be made to correct or remove it.

Reference in this document/service/website to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by INDOT.

It is the responsibility of the user to determine the quality, accuracy, and suitability of the service provided.

The user shall agree not to disclose any information regarding IP addresses, account usernames and account passwords to any other entity without the express written consent of INDOT.

If the user agrees to all the provisions of this document, the entity capable of executing documents on behalf of the firm or company utilizing this service must sign, date, and return this document together with the following:

1.) The name of the Individual or Firm.
2.) Name and signature of the officer of the firm or representative authorized to execute documents on the firms' behalf.
3.) Contact information for the individual or firm (name, address, e-mail).*
4.) Equipment manufacturer make and model of equipment.

Once INDOT processes the completed agreement you will be provided with a username and password that will allow you access to the Broadcast Service. At this time this service is provided free of charge, however INDOT reserves the right to assess fees in the future if it becomes necessary in order to defray network maintenance and upgrade costs.

JURISDICTION

Use of this service is governed by the laws of the State of Indiana.

SEVERABILITY

If any part of this Disclaimer is determined to be invalid or unenforceable pursuant to applicable law including, but not limited to, the warranty disclaimers and liability limitation set forth above, then the invalid or unenforceable provision will be deemed superseded by a valid, enforceable provision that most closely matches the intent of the original provision and the remainder of the Disclaimer shall continue in effect.

Any rights not expressly granted herein are reserved.

Fill out information neatly and sign below:

Contact Information:
Company Name:
Name of Contact Person:
Address:
Phone:
Fax:
* E-mail:

*** NOTE: The e-mail address you provide is used to communicate information to the user regarding network status updates, scheduled maintenance, and software/firmware upgrades which may affect network availability. It is the users' responsibility to ensure all contact information, including e-mail address, is correct and updated when necessary.**

Primary Application (Check One):
- ☐ Survey
- ☐ Construction
- ☐ Agriculture
- ☐ Geographic Information Systems
- ☐ Other, please Specify

Number of accounts requested:

Equipment Make & Model:

I agree to all the provisions of this agreement:

Signature of Firm Officer or Authorized Representative

Date:

Printed Name and Title

Mail, Fax or E-mail completed form to:

Land & Aerial Survey Office
Attn: Network Administrator
120 South Shortridge Road
Indianapolis, IN 46219-6705
Fax: (317) 356-9351
E-mail: incors@indot.in.gov

(Please allow ample time for processing, incomplete forms will delay processing)

This section for office use only:

Rover User Name: _____ User Name: _____ Password: _____

RTK User Accounts

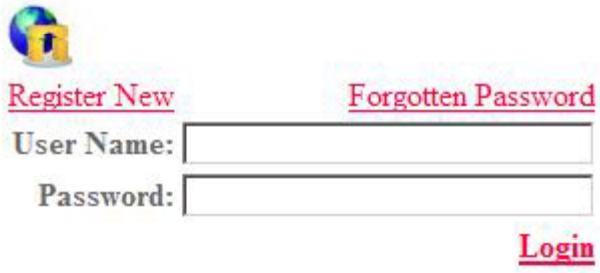
- After we receive your signed agreement
  - We will register you into SpiderNet
  - Username & password assigned
  - Email sent out w/ info

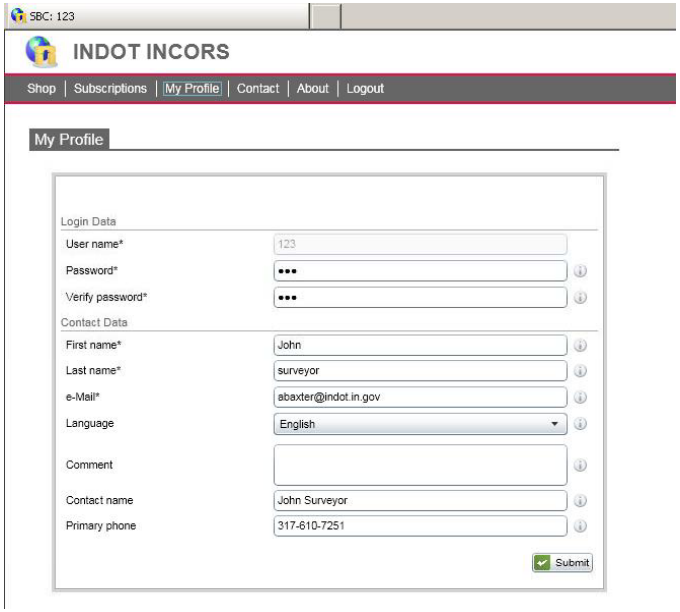
Typical email information:
The IP address is: xx.xxx.xx.xxx
The port is: 10000 for NTRIP which includes: RTCM 2.3, 3.0, etc
User Name: xxxxxxx Password: xxxxxxxx
If you need TCP/IP connection please send email request…
Tech support document attached

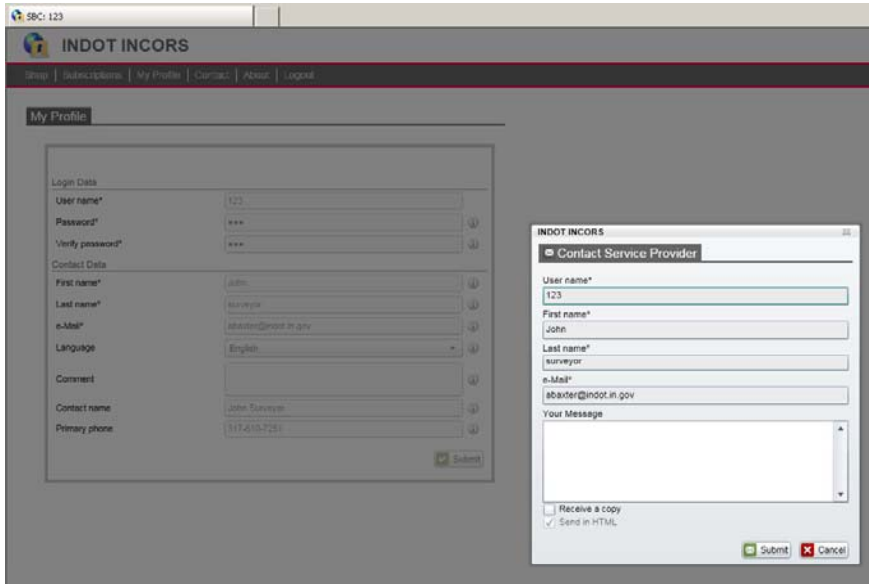
Spider Website for Users

- Login to Spider at *http://10.114.30.153/sbc/*

- Within Spider you will be able:
  - Change your password
  - Update contact information
  - Contact us for information and questions

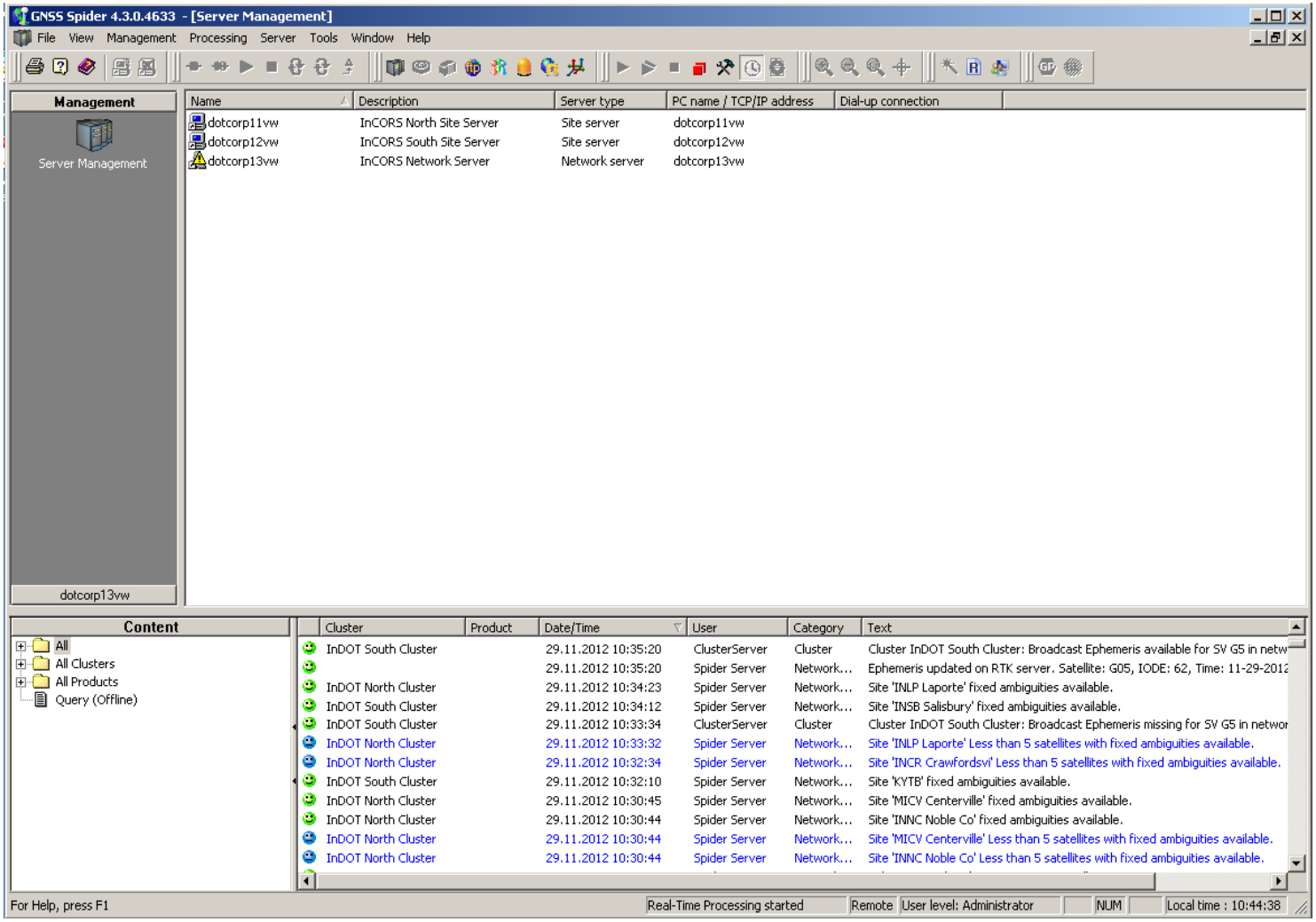




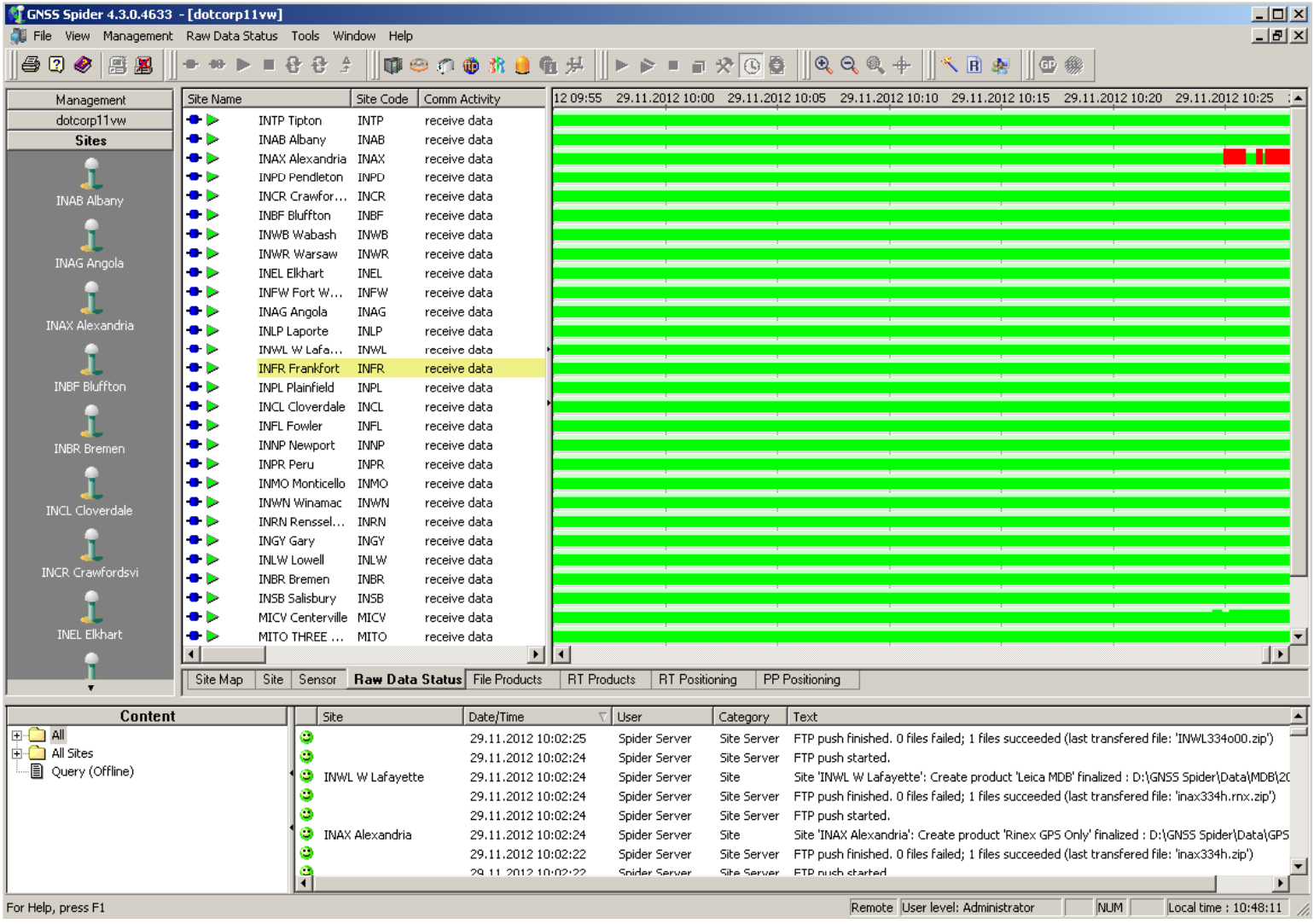


InCORS Network Administration (Behind the Scenes)

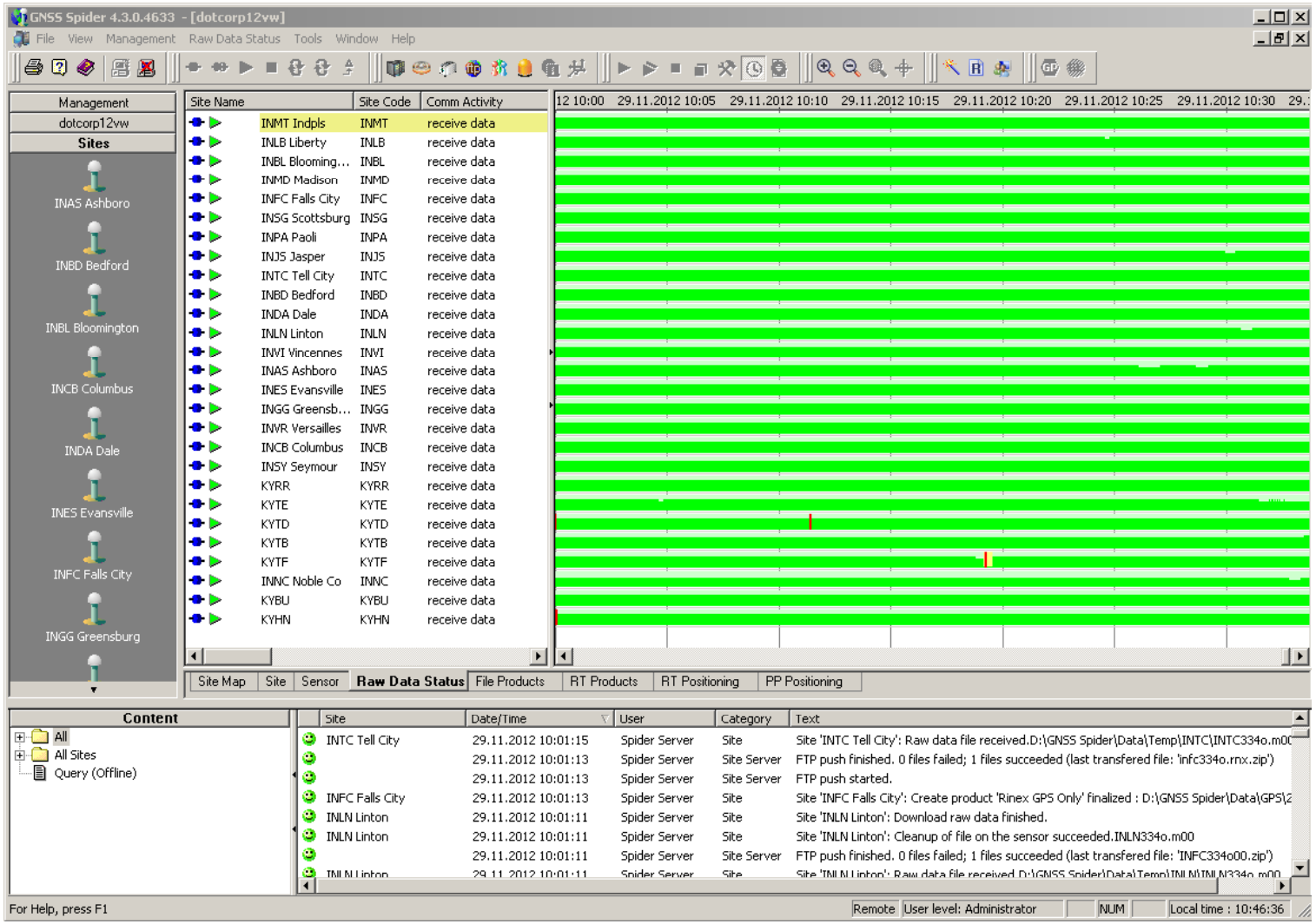
Network Admin Software (GNSS Spider)



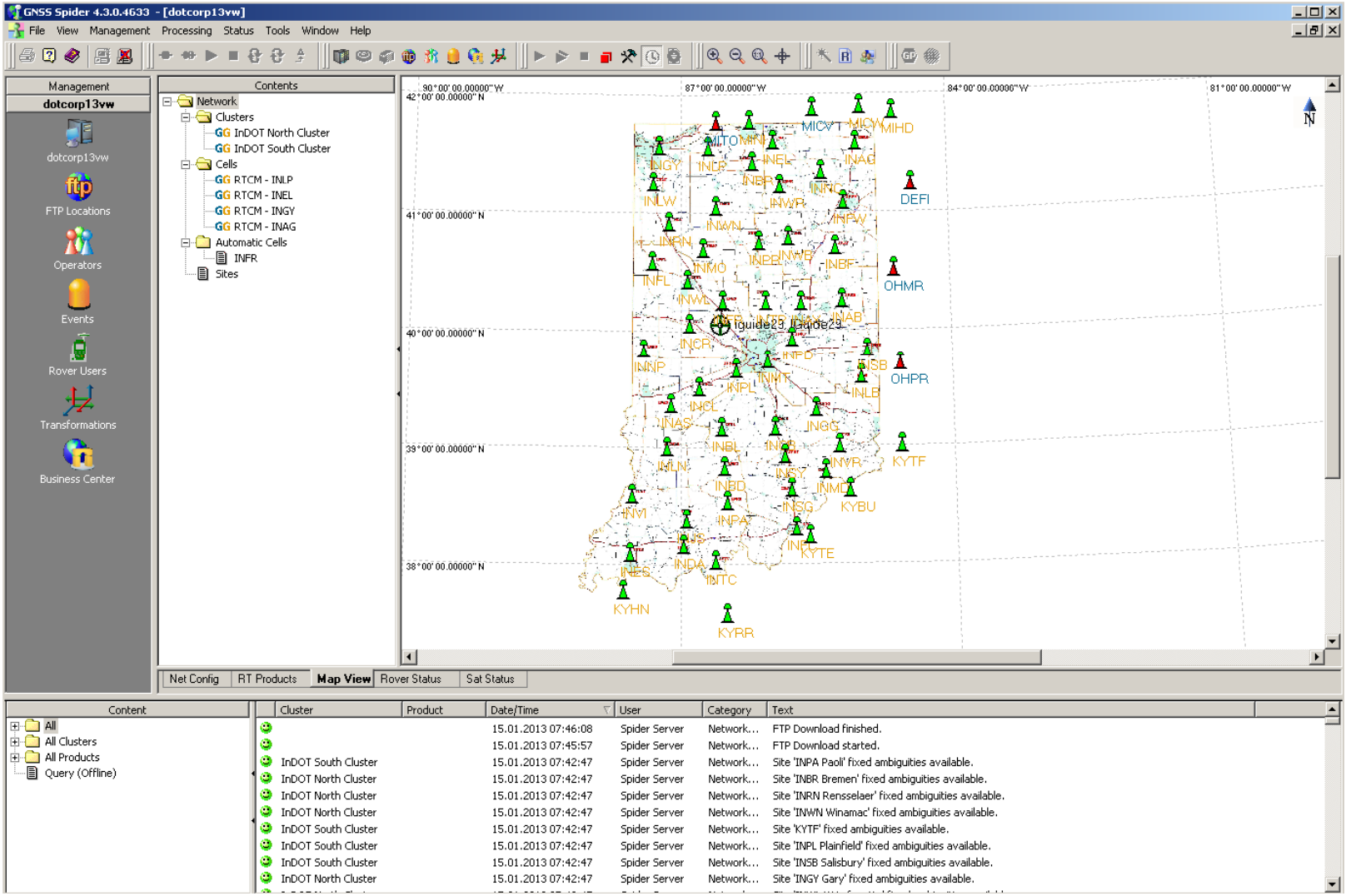
North Site Server (dotcorp11vw)



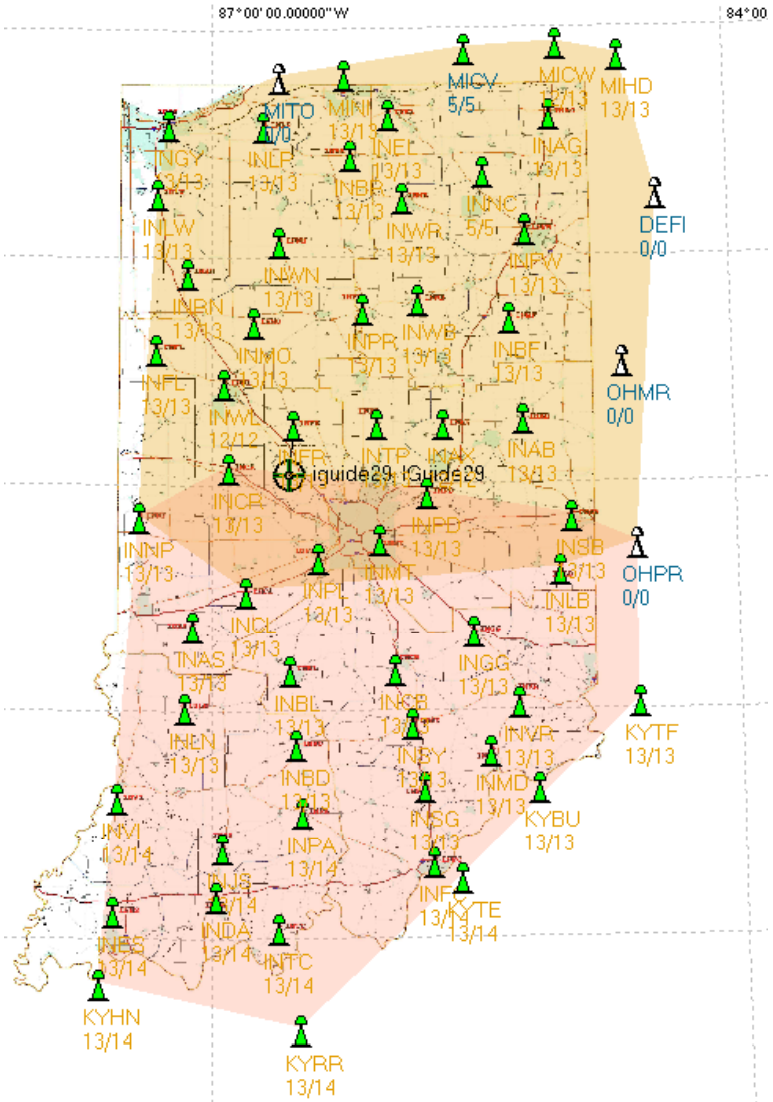
South Site Server (dotcorp12vw)



Network Server (dotcorp13vw)



InCORS Clusters

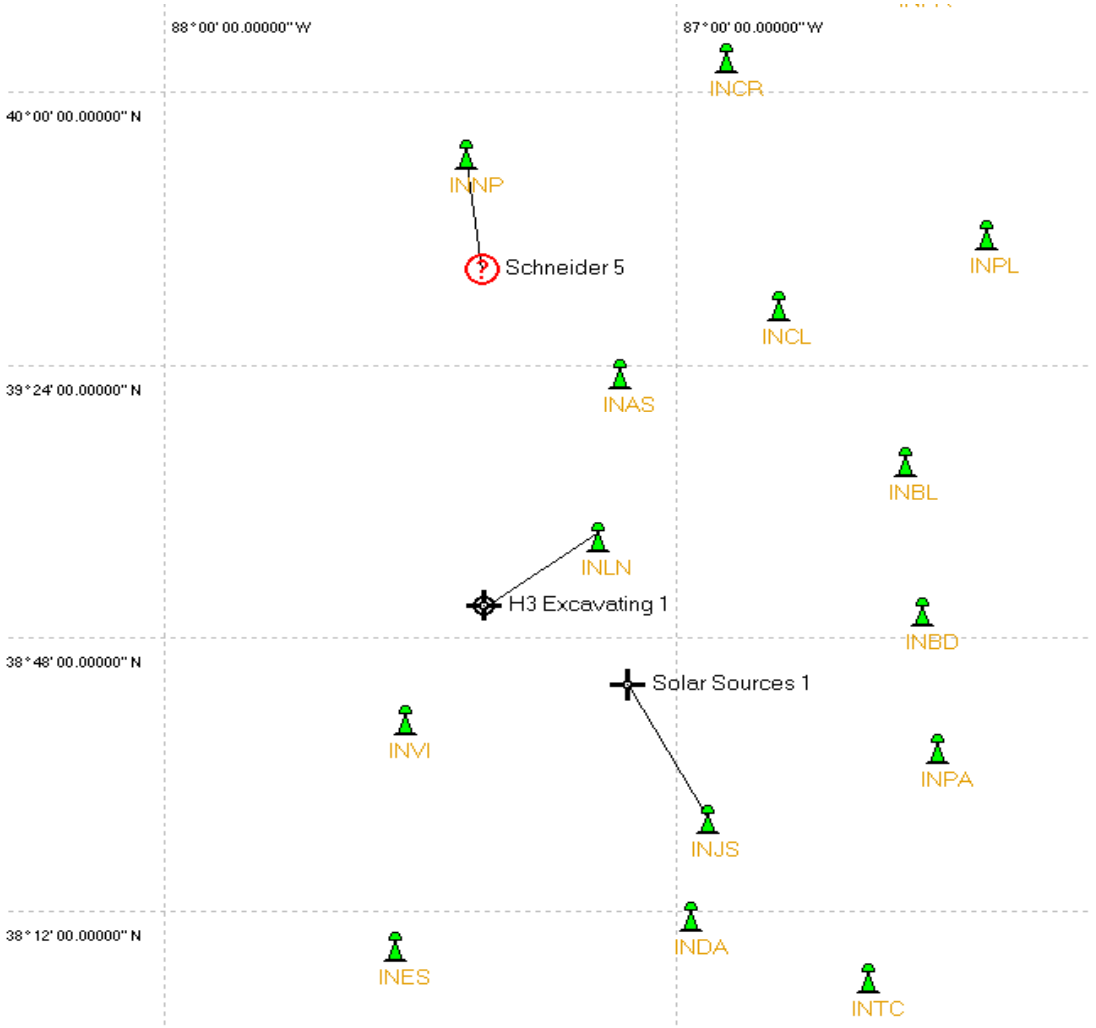


InCORS Network Broadcast Corrections

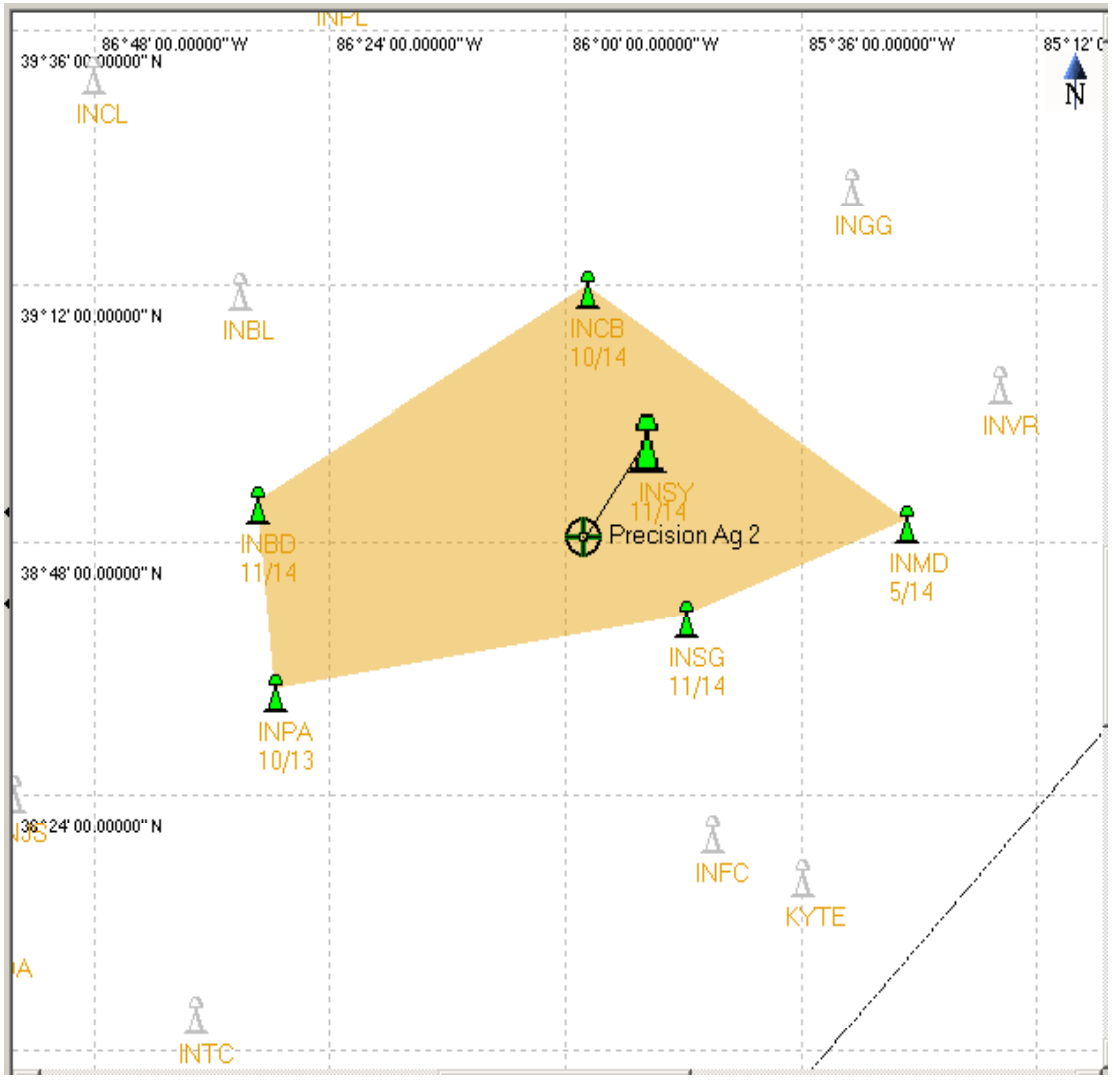
Broadcast Corrections

- Two types of corrections
  - Nearest Site
  - Automatic Cell
- Nearest Site Correction
  - Single Baseline Solution
  - CMR, CMR+, RTCM 2.3, RTCM 3.1 available
  - PPM errors increase with rover distance from base
  - Network software automatically selects the closest reference station to the rover based on the submitted NMEA message
- Automatic Cell
  - Network Solution
  - CMR+, RTCM 2.3, RTCM 3.1 available with MAX and iMAX
  - Network software automatically selects the closest reference station and then uses it and next five nearest stations to model corrections
  - Helps to minimize PPM errors due to rover distance from base

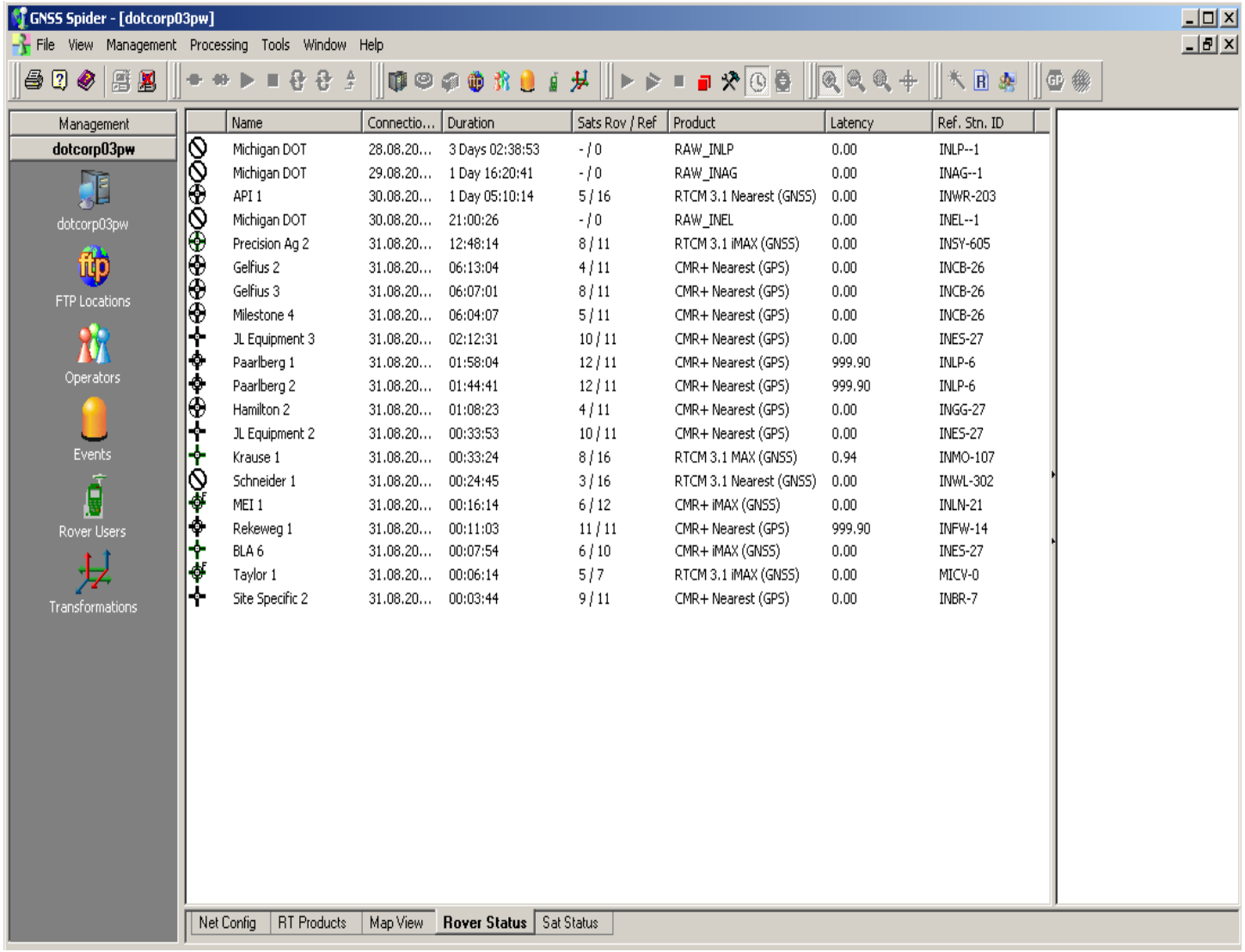
Nearest Solution (Single Baseline)



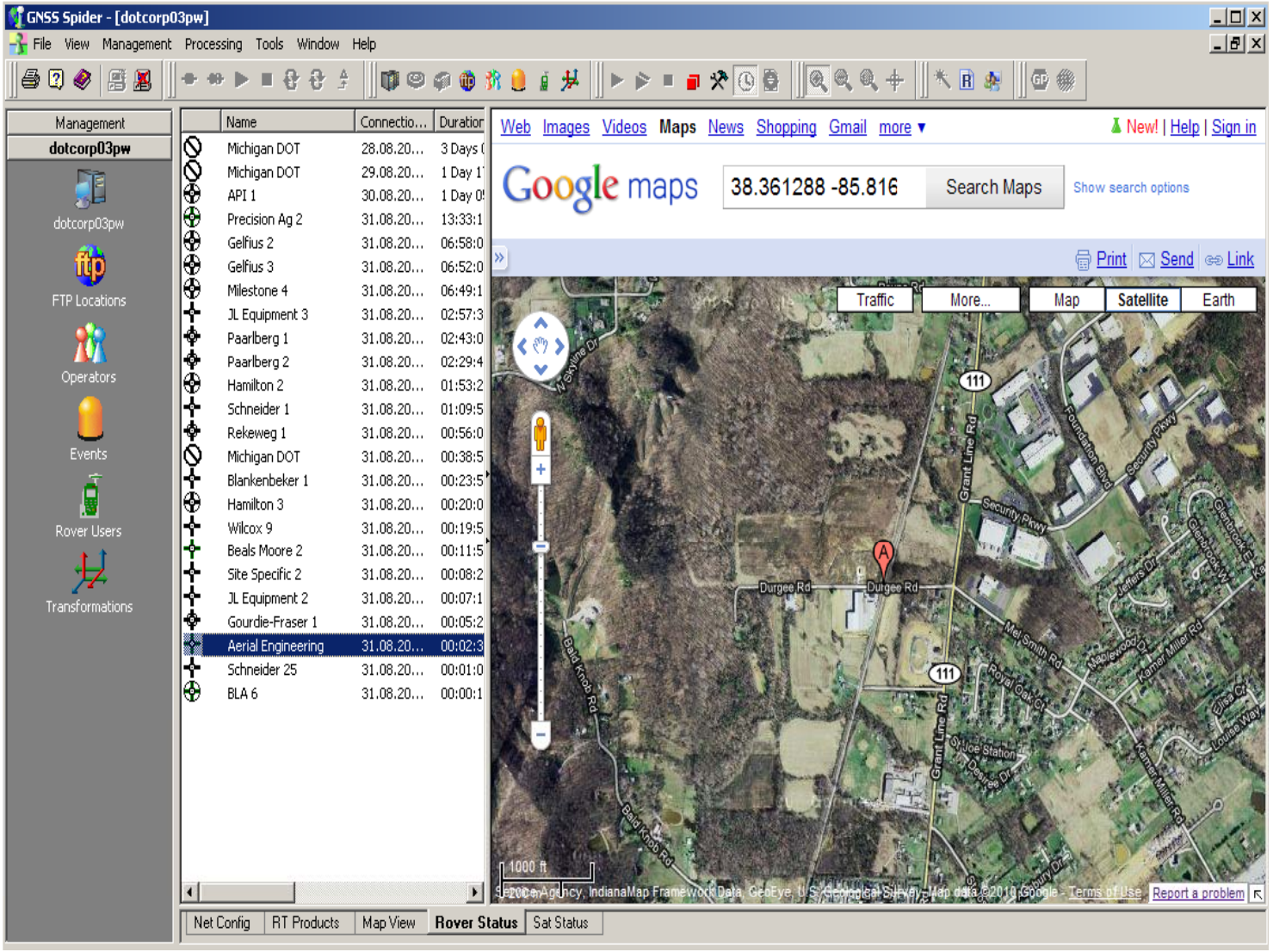
Automatic Cell



Rover Status



Rover Location Map



Leica Geosystem's Focus on Network Solution Concepts for the Indiana RTN

National Geodetic Survey
Guidelines for Real Time GNSS Networks

March 2011
v. 2.0

The "Seven C's"

1. **C**heck Equipment, Data Collector Parameters & Site information
2. **C**onditions
3. **C**oordinates
4. **C**ommunication
5. **C**onstraining to passive monuments (a.k.a. Calibrations or Localizations)
6. **C**ollection
7. **C**onfidence

Check Equipment, Data Collector Parameters & Site information

- Measure the actual height of the antenna reference point (ARP)
- Ensure that all necessary and correct projection parameters are in the collector
- Test your wireless data communications
- Make sure all your devices are fully charged

Conditions

- Use mission planning

  Allowing one GLONASS (shortened to GLN in the following) satellite for the GLN/GPS system time parameter resolution, a minimum combination of these two constellations for RT positioning is given as:
  GPS ≥ 5, GLN = 0
  GPS = 4, GLN = 2
  GPS = 3, GLN = 3
  GPS = 2, GLN = 4 (Can't initialize with only GLN sats.)
  (Gakstatter, 2009)

- Be aware of multipath conditions
- Check NOAA's Space Weather Prediction Center (SWPC)

Coordinates

- Most RTN in the U.S. maintain their reference station ARP coordinates in the NAD 83 datum, albeit with varying adjustments and epochs. Recall that our national "horizontal" datum of NAD 83 has had several adjustments:

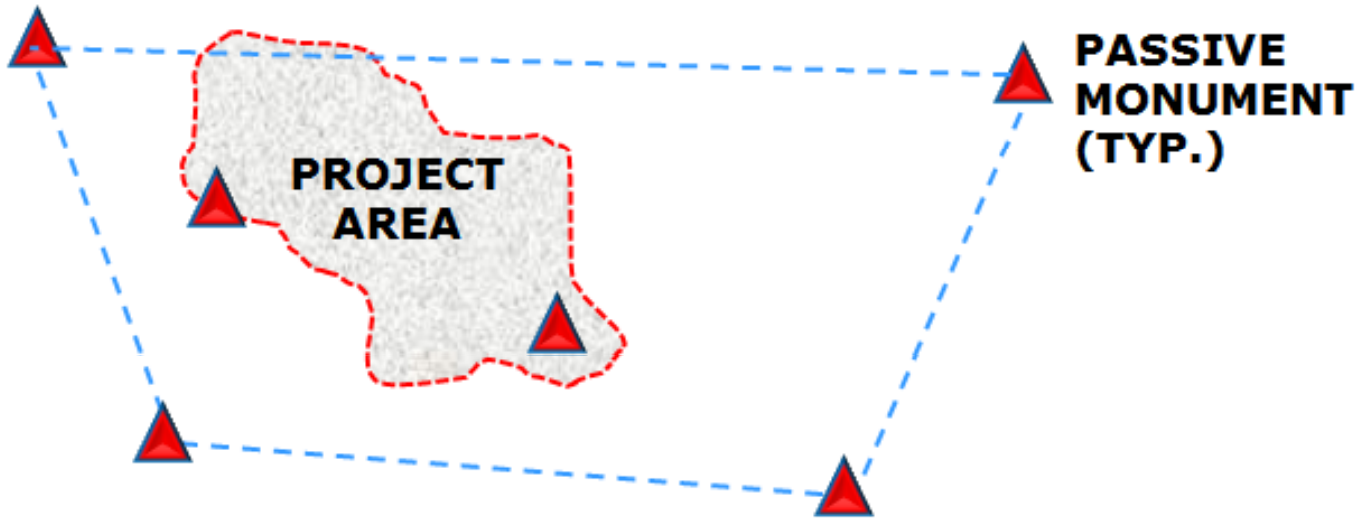
NAD 83 (1986) – the original adjustment
NAD 83 (HARN)
NAD 83 (FBN-CBN)

NAD 83 (CORS 96)\ epoch 2002.0 (current InCORS)

NAD 83 (NSRS 2007)\ epoch 2007.0

NAD 83 (2011)\ epoch 2010.0 (future InCORS)

Constraining to passive monuments



Collection

- Check a known coordinate point before, during and at the end of data collection.

- Set an elevation cut-off or mask of between 10° and 15°.

Confidence

- Redundancy is the king of RT GNSS positioning
- Checks on known points
- Obvious Multipath

metadata

Example of Surveying and Mapping Documentation (M*etadata)*
Basis of Bearings and Coordinates
Linear unit: International foot (ift)
Geodetic datum: North American Datum of 1983 (2007)
Vertical datum: North American Vertical Datum of 1988 (see below)
System: Arizona LDP
Zone: Cochise County
Projection: Transverse Mercator
Latitude of grid origin: 31° 19’ 00” N
Longitude of central meridian: 109° 45’ 00” W
Northing at grid origin: 0.000 ft
Easting at central meridian: 240,000.000 ift
Scale factor on central meridian: 1.000195 (exact)
All distances and bearings shown hereon are projected (grid) values based on the preceding projection definition. The projection was defined such that projected (grid) distances are equivalent to “ground” distances in the project area. The basis of bearings is geodetic north. Note that the grid bearings shown hereon (or implied by grid coordinates) do not equal geodetic bearings due to meridian convergence.

Rule 12

865 IAC 1-12-22 Measurements for route surveys
Authority: IC 25-21.5-2-14
Affected: IC 25-21.5

Sec. 22. (a) When conducting a route survey, the land surveyor shall be responsible to use the minimum standards of measurement for urban surveys provided for in section 7 of this rule, except that relative positional accuracy may not exceed five tenths (0.5) feet for a route survey.

(b) Measurements generally shall be shown on the route survey plat with a number of significant figures representative of the precision of the work.

(c) The measurements specifications outlined in this section will apply to all of the following items shown on a route survey:

(1) The control survey points.

(2) Survey ties to either of the following:

(A) The nearest United States Public Land Survey subdivision corners that are reasonably accessible on both sides of the controlling survey line.

(B) Monuments with established state plane coordinates.

(3) All monuments and reference monuments, and any ties thereto, that are set relative to the controlling survey line.

(d) If the route survey references or is based on state plane coordinates or utilizes the Global Positioning System (GPS), the written surveyor's report shall identify the following:

(1) The datum and projection.

(2) The year of applicable datum adjustment.

(3) The originating or controlling monuments.

(4) The GPS base stations or positioning software used, for example, the Online Positioning User Service (OPUS).

(5) The source and format of the corrections if real time kinematic GPS was used.

(6) The Geoid model used, if applicable.

(7) The scale, elevation, and combination factors used in the coordinate calculations.

(8) Information on any translation to or from a local system.

(9) The collection processes and methodology of final positioning.

(10) Whether the distances shown are grid or ground.

(State Board of Registration for Land Surveyors; 865 IAC 1-12-22; filed Jul 17, 1991, 4:30 p.m.: 14 IR 2250; filed Oct 13, 1992, 5:00 p.m.: 16 IR 893; errata, 21 IR 4537; readopted filed May 22, 2001, 9:55 a.m.: 24 IR 3237; filed May 4, 2006, 1:25 p.m.: 29 IR 3016; readopted filed Nov 9, 2012, 11:26 a.m.: 20121205-IR-865120390RFA)
NOTE: 864 IAC 1.1-13-37 was renumbered by Legislative Services Agency as 865 IAC 1-12-22.

INDOT Mission & Values

- INDOT Mission:
  - INDOT will plan, build, maintain and operate a superior transportation system enhancing safety, mobility and economic growth

- INDOT Values:
  - Respect
  - Teamwork
  - Accountability
  - Excellence

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