



# CORS USERS FORUM

Real Time GNSS Networks

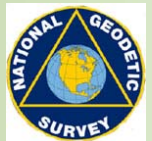
Tennessee DOT

Jim Waters, PE, RLS

Assistant Director TDOT Design Division



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Savannah, Georgia

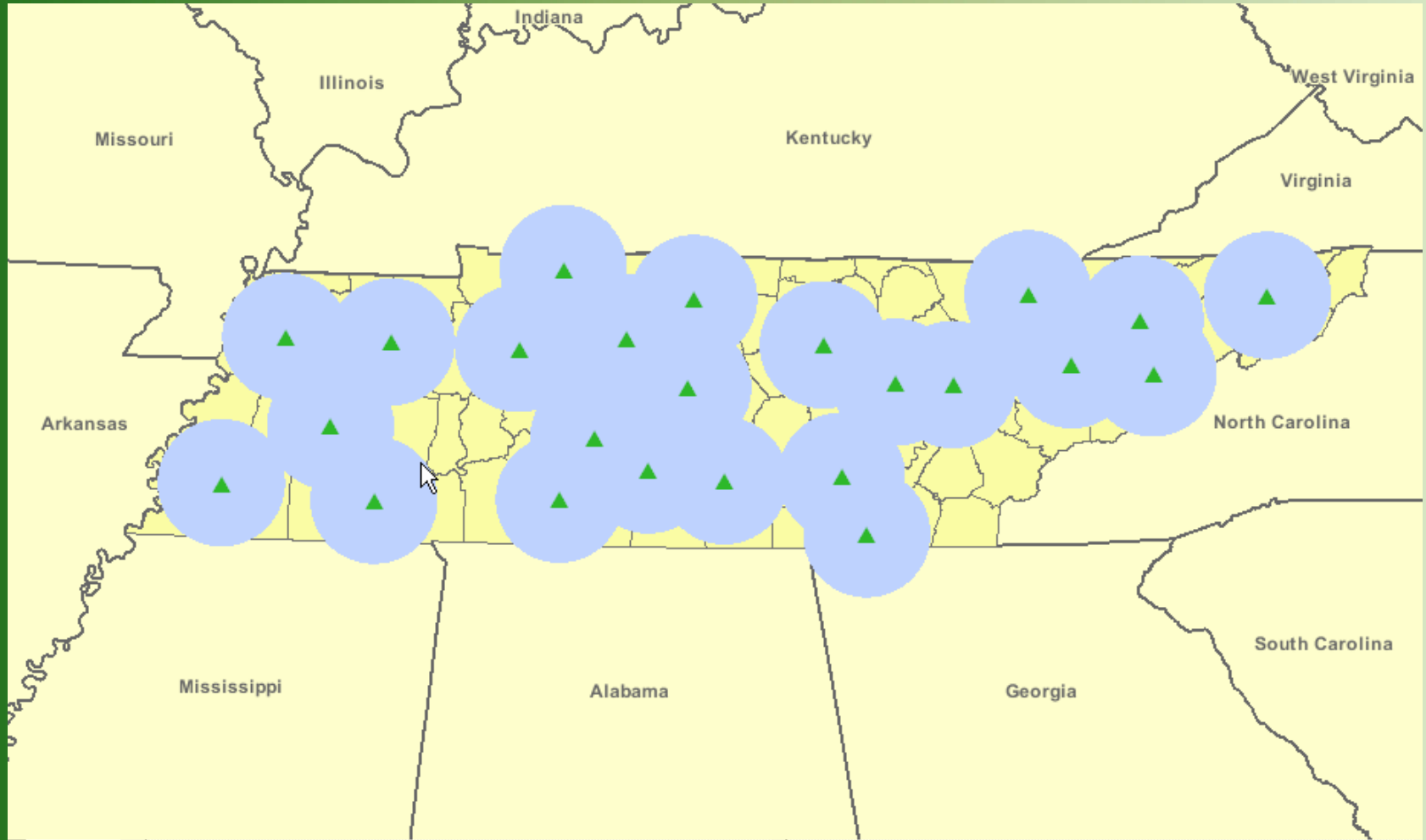


# TDOT GNSS Reference Network

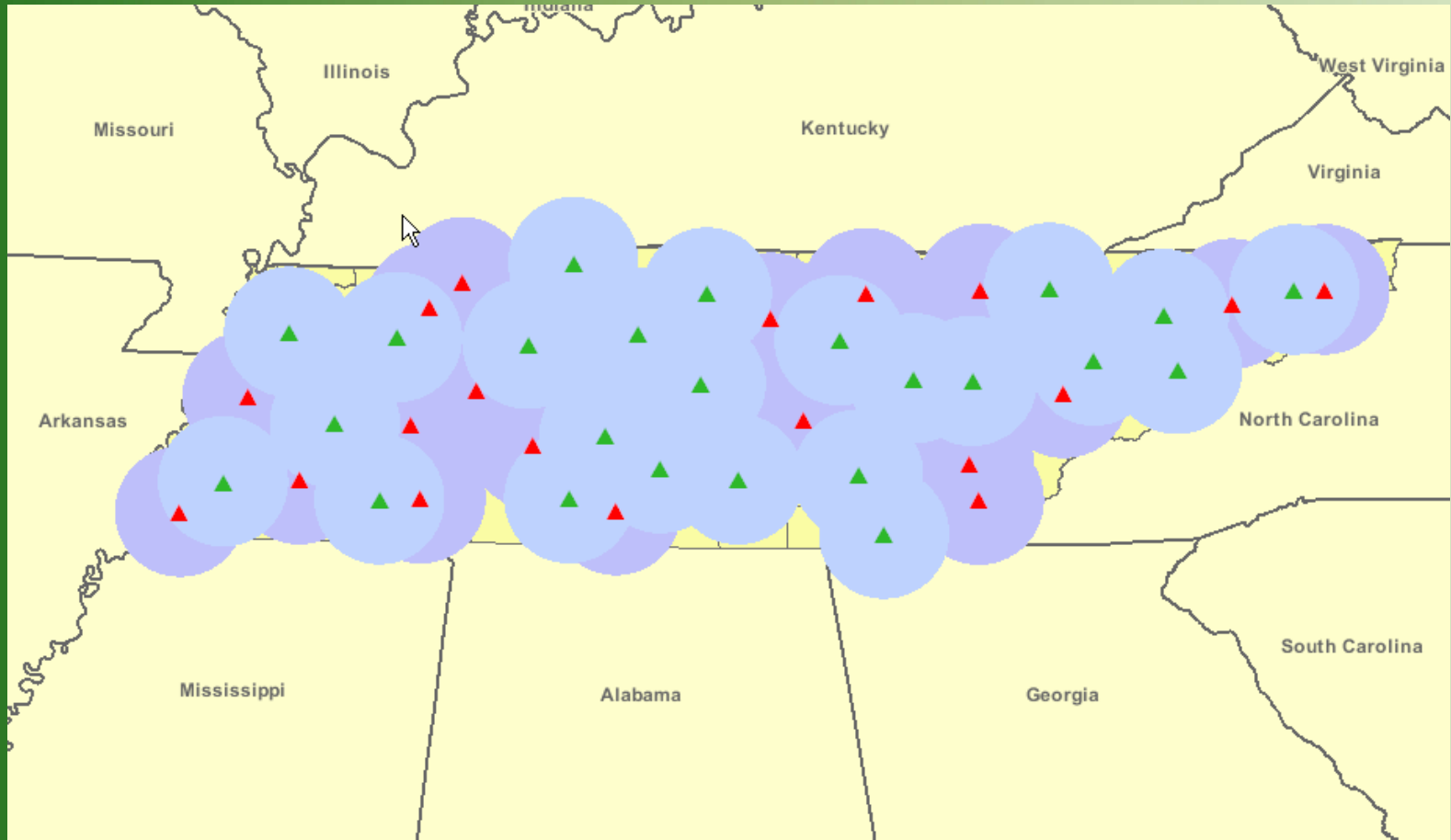
- 22 GNSS Reference Stations
  - All National CORS
  - Aligned to NSRS
- 2 GNSS Reference Stations
  - Submitted to NGS for National CORS Inclusion.
- 20 Proposed GNSS Stations
  - Planned National CORS Sites.
  - Possible Mount Change
- Additional GNSS Stations T.B.D.



# TDOT GNSS Reference Network



# TDOT GNSS Reference Network (With Proposed Stations)



# TDOT GNSS Reference Network

- Hardware Components
  - GNSS Receiver
    - Topcon Net G3 Receivers
  - GNSS Antenna
    - Topcon G3 A1 Antennae
  - Mounting Bracket
    - Custom Steel Brackets
  - Cables
    - Times Microwave LMR 400 (<50 meters) and LMR 600 (>50 meters).



# TDOT GNSS Reference Network

- Hardware Components
  - Servers
    - One data storage server
    - One network access server
  - IT Network
    - All receivers connected behind firewall to TDOT IT Infrastructure.
    - Connected to 100 mbps switches.
  - Uninterrupted Power Supply
  - In-Line Lightning Protection



# TDOT GNSS Reference Network

- Software Components
  - Topcon TopNET Software
    - **TopNET-S** is the server component which manages reference stations.
    - **TopNET-V** is the network correction software for both single base line solutions and modeled network solution.
    - **TopNET-R** is the remote user component for monitoring receivers and changing receiver configurations.
    - **TopNET Web** is the web interface for network information.
    - **Download Center** is responsible for downloading all raw data files.



# TDOT GNSS Reference Network

TopNET-5 0.0.0.0:8000

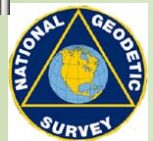
File Setup View Help

Date Start	Send	Receiver	User	Task	Address	Interface	Messages
9/15/2008 10:3...	23053...	TN43	jjvp210	TopNET-V	12.189.231.51...	TCP 10.165.1...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23579...	TN35	jjvp210	TopNET-V	12.189.231.51...	TCP 10.173.8...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23183...	TN25	jjvp210	TopNET-V	12.189.231.51...	TCP 10.185.2...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23635...	TN33	jjvp210	TopNET-V	12.189.231.51...	TCP 10.174.9...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	21067...	TN23	jjvp210	TopNET-V	12.189.231.51...	TCP 10.182.2...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23453...	TN15	jjvp210	TopNET-V	12.189.231.51...	TCP 10.190.1...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23346...	TN24	jjvp210	TopNET-V	12.189.231.51...	TCP 10.181.2...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23742...	TN37	jjvp210	TopNET-V	12.189.231.51...	TCP 10.177.2...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	22418...	TN14	jjvp210	TopNET-V	12.189.231.51...	TCP 10.195.1...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	22191...	TN36	jjvp210	TopNET-V	12.189.231.51...	TCP 10.176.8...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	18274...	TN11	jjvp210	TopNET-V	12.189.231.51...	TCP 10.198.1...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 6:50:53	1893...	TN23	jj01307	TopNET-R	10.170.144.54...	TCP 10.182.2...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:53	1920...	T338	jj01307	TopNET-R	10.170.144.54...	TCP 10.174.9...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:53	1936...	TN37	jj01307	TopNET-R	10.170.144.54...	TCP 10.177.2...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:53	1944...	TN31	jj01307	TopNET-R	10.170.144.54...	TCP 10.171.5...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:53	1867...	TN32	jj01307	TopNET-R	10.170.144.54...	TCP 10.180.6...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 10:3...	22785...	TN38	jjvp210	TopNET-V	12.189.231.51...	TCP 10.183.6...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 11:4...	16823...	TN32	jj01307	TopNET-V	10.170.145.31...	TCP 10.180.6...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	22407...	TN34	jjvp210	TopNET-V	12.189.231.51...	TCP 10.178.1...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	23856...	TN31	jjvp210	TopNET-V	12.189.231.51...	TCP 10.171.5...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 10:3...	22626...	TN22	jjvp210	TopNET-V	12.189.231.51...	TCP 10.187.1...	jps/RD:10,UO:1.0,SI:10,PO:10,GE:1.0,NE:1.0,rM:1....
9/15/2008 6:50:51	1916...	TN12	jj01307	TopNET-R	10.170.144.54...	TCP 10.196.6...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1849...	TN11	jj01307	TopNET-R	10.170.144.54...	TCP 10.198.1...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1916...	TN44	jj01307	TopNET-R	10.170.144.54...	TCP 10.167.6...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1912...	TN36	jj01307	TopNET-R	10.170.144.54...	TCP 10.176.8...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1916...	TN14	jj01307	TopNET-R	10.170.144.54...	TCP 10.195.1...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1919...	TN22	jj01307	TopNET-R	10.170.144.54...	TCP 10.187.1...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1934...	TN35	jj01307	TopNET-R	10.170.144.54...	TCP 10.173.8...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1936...	TN33	jj01307	TopNET-R	10.170.144.54...	TCP 10.174.9...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1932...	TN15	jj01307	TopNET-R	10.170.144.54...	TCP 10.190.1...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1922...	TN38	jj01307	TopNET-R	10.170.144.54...	TCP 10.183.6...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1930...	TN25	jj01307	TopNET-R	10.170.144.54...	TCP 10.185.2...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1932...	TN24	jj01307	TopNET-R	10.170.144.54...	TCP 10.181.2...	jps/UO:1.0,SI:2,PV:2,rE:2,
9/15/2008 6:50:51	1924...	TN41	jj01307	TopNET-R	10.170.144.54...	TCP 10.168.5...	jps/UO:1.0,SI:2,PV:2,rE:2,

9/15/2008 19:00:44 TN11 > RE004%em%  
 Client=10.170.144.54:58373 < Rcv=1 RE:OK. Send=2250085  
 Client=10.170.144.54:58373 < Rcv=0 CloseUsr  
 Client=10.170.144.54:58373 < Rcv=0 RE:OK.  
 Client=jj01307/10.170.144.54:58373 (Download\_Center) thread terminated

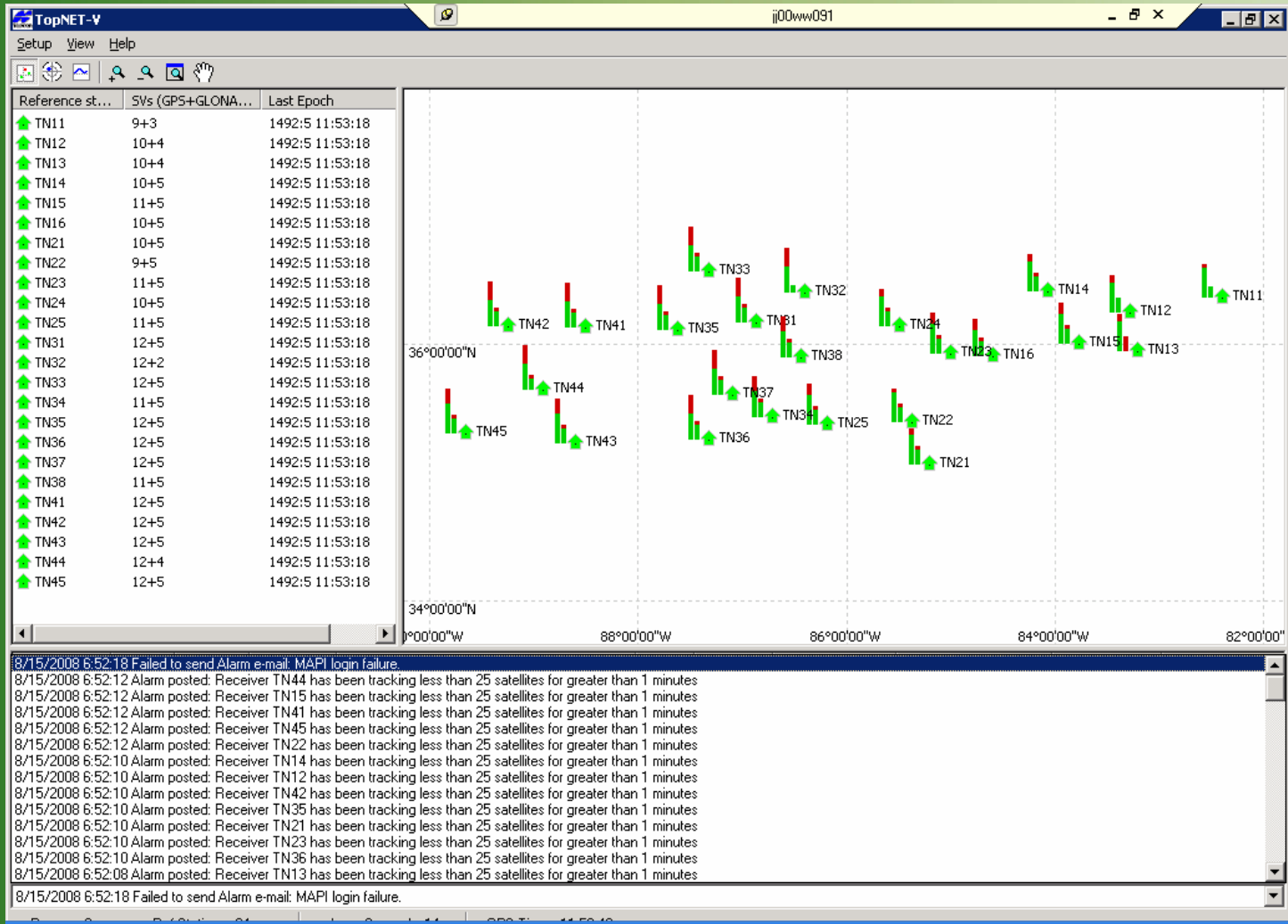


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# TDOT GNSS Reference Network



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# TDOT GNSS Reference Network

TopNET-R @ 10.170.145.31

Connection Tools View PC Clock Sync Setup Help

Name	SVs (GPS+GLONASS)	Latitude	Longitude	Elev. Ht. (m)	Last Epoch (GPS)	Latency (ms)
T338	9+6	36°33'31.39749"N	87°19'09.99959"W	135.4221	1497:2 00:14:18	1522
TN11	8+2	36°21'42.04840"N	82°23'33.93635"W	449.0145	1497:2 00:14:18	1912
TN12	8+6	36°14'53.02986"N	83°17'11.08060"W	336.1011	1497:2 00:14:18	1896
TN13	8+7	35°56'37.12277"N	83°12'26.42406"W	359.4972	1497:2 00:14:18	1912
TN14	7+6	36°24'27.39746"N	84°03'54.63992"W	328.4646	1497:2 00:14:18	1896
TN15	8+7	36°00'08.32504"N	83°46'13.95961"W	270.3026	1497:2 00:14:18	1912
TN16	8+6	35°54'09.89101"N	84°36'04.37101"W	216.7291	1497:2 00:14:18	1928
TN21	8+6	35°03'51.82818"N	85°12'25.93956"W	195.8962	1497:2 00:14:18	1896
TN22	9+6	35°23'25.81626"N	85°22'40.98104"W	205.7647	1497:2 00:14:18	1912
TN23	8+5	35°55'10.77690"N	84°59'57.56995"W	526.2795	1497:2 00:14:18	1896
TN24	9+7	36°08'03.78873"N	85°29'57.82572"W	308.3926	1497:2 00:14:18	1928
TN25	9+6	35°22'01.53677"N	86°11'20.78467"W	301.2888	1497:2 00:14:18	1912
TN31	9+7	36°10'13.14790"N	86°52'14.39281"W	111.9193	1497:2 00:14:18	1912
TN32	9+2	36°23'48.64576"N	86°24'19.68720"W	173.0222	1497:2 00:14:18	1896
TN33	9+7	36°33'31.40115"N	87°19'09.99306"W	135.2627	1497:2 00:14:18	1912
TN34	8+5	35°25'34.80805"N	86°42'43.88582"W	228.8560	1497:2 00:14:18	1912
TN35	9+7	36°06'14.24117"N	87°37'21.52898"W	229.8376	1497:2 00:14:18	1912
TN36	9+5	35°15'20.83087"N	87°19'33.74935"W	259.0308	1497:2 00:14:18	1912
TN37	9+7	35°36'13.84636"N	87°05'37.70310"W	192.1899	1497:2 00:14:18	1896
TN38	8+7	35°53'46.06182"N	86°26'37.29318"W	140.1434	1497:2 00:14:18	1896
TN41	8+7	36°07'34.97224"N	88°30'45.87347"W	114.9765	1497:2 00:14:18	1912
TN42	9+7	36°08'12.63905"N	89°14'53.31841"W	94.1230	1497:2 00:14:18	1928
TN43	9+7	35°13'42.94056"N	88°36'14.11240"W	120.7901	1497:2 00:14:18	1928
TN44	9+5	35°38'25.59297"N	88°55'08.63532"W	90.7943	1497:2 00:14:18	1912
TN45	8+7	35°17'57.46322"N	89°39'34.60751"W	62.3950	1497:2 00:14:18	1928

9/15/2008 19:14:02 TN45 online

UTC: 00:14:07 Local: 19:14:07

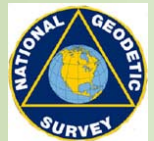
start

Novell GroupWise - Ji... Microsoft PowerPoint ... 3J00WW091 - jj00ww... C:\Documents and Se... Ps Adobe Photoshop CS... TopNET-R @ 10.170....

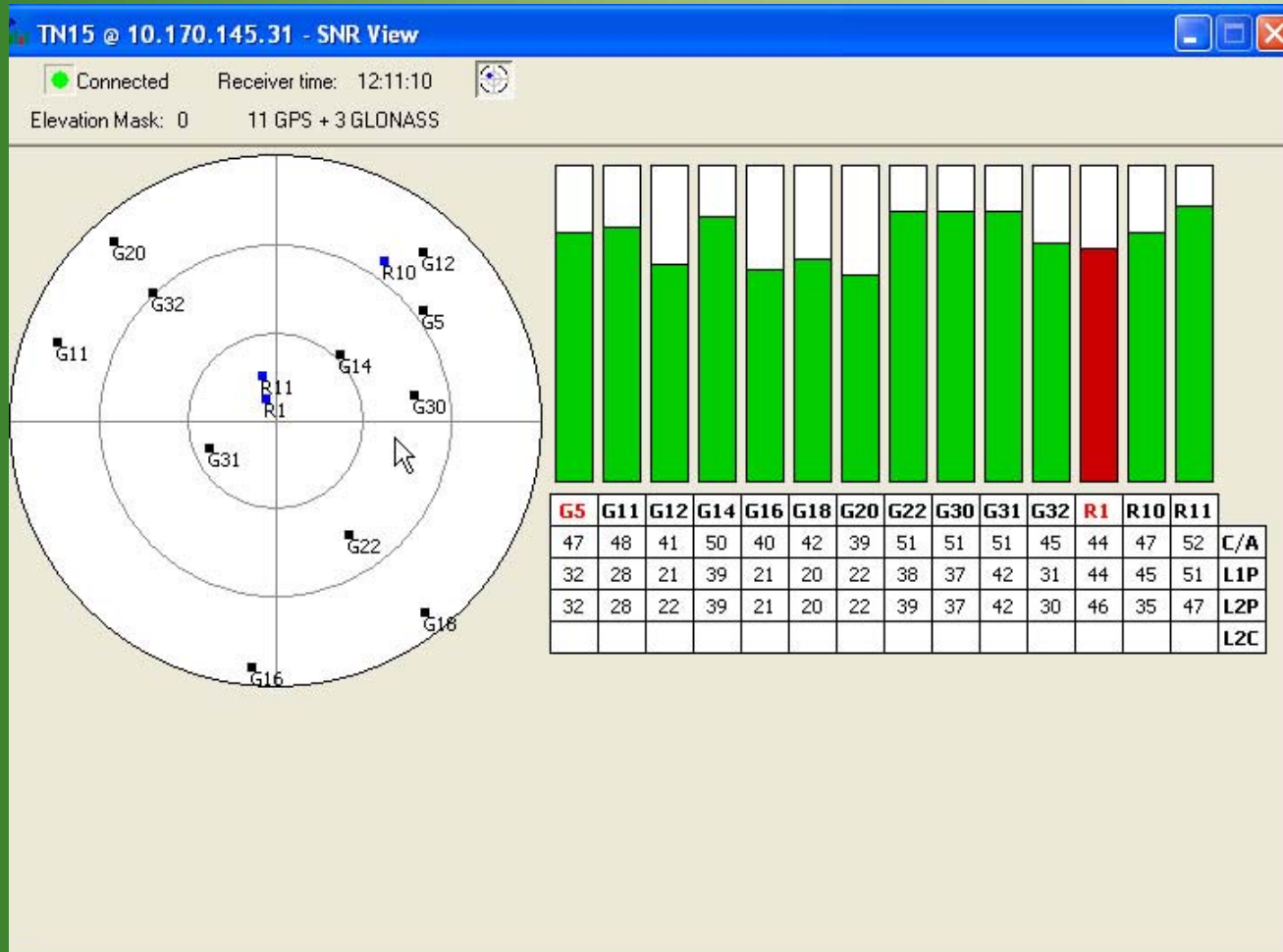
7:14 PM Monday 9/15/2008



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# TDOT GNSS Reference Network

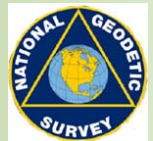


# TDOT GNSS Reference Network

The screenshot shows a Windows 'Download Center' window for the IP address 10.170.145.31. The window is divided into three main sections:

- Receiver List:** A table with two columns: 'Receiver' and 'State'. It lists receivers TN11 through TN44, all with a state of 'Wait until' followed by a specific time.
- File List:** A table with columns: 'Original File', 'Current File', 'FTP Server', 'FTP Directory', and 'State'. It shows several entries for files being downloaded from various receivers (TN41, TN34, TN23, TN12) to local drives (D:\TN...).
- Log:** A scrollable area containing a series of status messages with timestamps, such as '8/15/2008 8:02:52 Service started', '8/15/2008 8:05:00 Time has come for T33B', and '8/15/2008 8:10:02 New file TN120815m found on TN12'. It details the successful download of files from receivers T33B, TN34, TN23, TN12, and TN34.

The taskbar at the bottom shows the Start button, several open applications including 'Download Center - 10...' and 'TopNET-R @ 10.170.145...', and the system clock showing 19:19:38 on 8/15/2008.



# TDOT GNSS Reference Network

TopNET web interface - Microsoft Internet Explorer

Address: <http://tdotcors.state.tn.us:8080/TopNETweb/>

Map Google Sky Plot Log File... About...

Reference st...	SVs (G...	Last Epoch	Status
TN11	8+2	1497:2 00:11:30	OK
TN12	8+5	1497:2 00:11:30	OK
TN13	8+7	1497:2 00:11:30	OK
TN14	7+6	1497:2 00:11:30	OK
TN15	8+7	1497:2 00:11:30	OK
TN16	8+6	1497:2 00:11:30	OK
TN21	8+6	1497:2 00:11:30	OK
TN22	8+6	1497:2 00:11:30	OK
TN23	8+4	1497:2 00:11:30	OK
TN24	8+7	1497:2 00:11:30	OK
TN25	8+6	1497:2 00:11:30	OK
TN31	8+7	1497:2 00:11:30	OK
TN32	9+2	1497:2 00:11:30	OK
TN33	9+7	1497:2 00:11:30	OK
TN34	8+5	1497:2 00:11:30	OK
TN35	8+7	1497:2 00:11:30	OK
TN36	8+5	1497:2 00:11:30	OK
TN37	8+7	1497:2 00:11:30	OK
TN38	8+7	1497:2 00:11:30	OK
TN41	8+6	1497:2 00:11:30	OK
TN42	8+7	1497:2 00:11:30	OK
TN43	8+7	1497:2 00:11:30	OK
TN44	8+5	1497:2 00:11:30	OK
TN45	8+7	1497:2 00:11:30	OK

Rover ID	Port #	Service	Quality	Position	SVs Sent	Bytes Sent	IP Address	Ntrip User	Duration

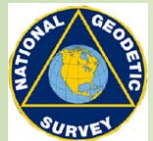
start

Novell Group-Wise - Ji... Microsoft PowerPoint ... J300WW091 - jj00ww... C:\Documents and Se... Ps Adobe Photoshop CS... TopNET web interfac...

7:10 PM Monday 9/15/2008



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# TDOT GNSS Reference Network



- Current Phase?
  - TDOT Staff Using Network Daily for Survey Applications
  - Manufacturers have been testing with TDOT Network:
    - Topcon
    - Trimble
    - Leica
    - Eagle Point
    - Carlson

# TDOT GNSS Reference Network



- Future Plans
  - Agreements with other State of TN Agencies for supplemental reference stations.
  - Public Sector User Agreement under development, planned public access scheduled for December 2008.
  - User fees will be charged to cover TDOT costs in support of public sector access.

# TDOT, Topcon, & Hayes Instrument Installation Team





# TDOT GNSS Reference Station

- Website:
  - <http://tdotcors.state.tn.us:8080/TopNETweb/>
- Contact Information:
  - Jim Waters, PE, RLS
  - TDOT Design Division
  - Suite 1300, James K. Polk Building
  - Nashville, TN 37243
  - (615) 741-0450
  - [Jim.Waters@state.tn.us](mailto:Jim.Waters@state.tn.us)

