Wisconsin Height Modernization Program

April 2012 Program Update

Diane Arendt, WisDOT

Northeast Chapter Meeting WSLS
Kewaunee, WI
April 12, 2012

Introduction - Overview

- ✓ Wisconsin Height Modernization Program is dedicated to a high level of quality and reliability for the positioning user group.
- ✓ High Precision Control Monuments – Passive control network
- ✓ Continuously Operating Reference Station Monuments – Active control network (WISCORS)
- ✓ Options for Long-term Maintenance of Passive & Active Network
- ✓ WisDOT staff currently working on WI-HMP: Leonard Perfetti, Elliot Smith, Jacob Rockweiler and John Ellingson – NGS State Advisor

Wisconsin Height Modernization

- ✓ One of the most successful programs of its kind
- ✓ Started in 1998 in a partnership with the NGS
- ✓ Established a network of high precision geodetic monuments
- ✓ In 2007 the WISCORS network was developed and constructed in the eastern half of the state.
- ✓ Working with border states and CO-OPS to develop consistent, accurate ties across state lines and to water gauges.

GPS Surveying at WisDOT

Wisconsin High Accuracy Network (WI-HARN)

- ✓ Second in nation to be developed and implemented (1991)
- ✓ National Geodetic Survey (NGS) interested in working with WisDOT because of the quality of the surveying program that existed here
- ✓ HARN cooperative effort of WisDOT and NGS
- ✓ Once system fine tuned by NGS, a second set of observations was carried out by NGS and WisDOT in 1997
- ✓ HARN gave us the very accurate horizontal foundation needed to support activities of WisDOT, and in addition to increased accuracy (compared to older, terrestrial methods), reduced costs substantially

Wisconsin Height Modernization Program

- ✓ Because of success of horizontal (WI-HARN) program in Wisconsin, WisDOT began pilot study to determine if GPS and related technology would provide similar benefits as to measuring elevations (heights)
- ✓ NGS began work on a national HMP about the same time (1998) and by 2001, at the specific direction of Congress, NGS worked with Wisconsin (and Louisiana) to determine what requirements of a HMP should be
- ✓ In 2002, NGS provided the first of several grants to WisDOT to assist in the development of the statewide WI-HMP
- ✓ *Objective is to provide 2 cm or better horizontal and vertical real-time positioning statewide*

Wisconsin Height Modernization Program

- Where does the Wisconsin Height Modernization Program fall within the Wisconsin DOT organizational structure?

- Wisconsin Department of Transportation
  - Division of Transportation Systems Development
  - Bureau of Technical Services
  - Surveying and Mapping Section
  - Geodetic Surveys Unit
  - Wisconsin Height Modernization Program
    - Since 2007, 3 FTE's work exclusively on WI-HMP
    - Other individuals work in various support capacities
    - Program Manager retired in May 2011

Wisconsin Height Modernization Program

- ✓ Funding of the Wisconsin Height Modernization Program:
- ✓ NOAA Grants (2002 – 2010):
  - ✓ $13.4 M total; No future NOAA grant opportunities anticipated
- ✓ State Planning and Research (2003 – 2012):
  - ✓ $2.7 M total (average $275,000 per year)
- ✓ State Improvement Dollars (2002 – 2012):
  - ✓ $3.7 M total (average $200,000 per year)
- ✓ Recently hired consultant to research alternative funding sources to complete and maintain the program.
  - ✓ Contacted numerous states with similar programs.
  - ✓ Estimated $4.0 M total required to complete initial program development efforts in Wisconsin

Wisconsin Height Modernization Program

- ✓ *Today, to meet our objective of better than 2 cm positioning in real time, we rely on two companion networks:*

- ✓ Passive network of GPS stations and bench marks that are surveyed by geographic regions (i.e. Phases)
  - Provides us the initial framework of latitude, longitude, and elevation – about 75% complete statewide
- ✓ Active network of Continuously Operating Reference Stations (CORS) that is developed by geographic regions (i.e. Zones)
  - Provides the cost effective tool to derive high accurate real-time (within seconds) latitude, longitude, and elevation – about 70% complete statewide
- ✓ Completion of both networks is a priority of the program

Wisconsin Height Modernization Program

- ✓ Passive Network Development

- ✓ All WI-HMP Projects are Bluebooked and published datasheets are available at: www.ngs.noaa.gov

- ✓ Bench Marks (BM's)

  FGCS 2nd Order - Class 1, Published on North American Vertical Datum of 1988 – NAVD 88(2007)

- ✓ GPS Stations

  Horizontal FGCS B-order or 1st Order accuracy, Published on North American Datum of 1983 (2007) – NAD83(NSRS2007)

Wisconsin Height Modernization Program

- ✓ Passive Network Development
- ✓ 100% of Monumentation activities performed by consultants
- ✓ 100% of Field Observations performed by consultants
- ✓ Technical support now also utilizes consultant services
- ✓ What do we do? Our primary role is planning, recon, and project oversight/management of all activities for the program

- ✓ HMP Statewide Status Map & Bench Mark Map
- ✓ Statewide Vertical Adjustment
  - Started Fall 2011 & Completed March 2012, resulting elevations to be published very soon for more than 5400+ BM's.
  - 221 NAVD88(2007) Elevations which were within 5 mm were constrained
  - Provided good agreement along state borders and Lake Michigan area
  - Everyone is happy!!!

Wisconsin Height Modernization Program

- ✓ Plans for Passive Network Development in 2012

- ✓ Phase 7C (Northwest WI)
  - 850 Double-Run KM's of leveling
  - 28 B-Order stations to observe
  - 102 First Order stations to observe
  - GPS Obs planned to start in May 2012
  - Leveling Obs planned to start in June 2012

- ✓ Phase 8B (North Central WI)
  - Recon on-going now
  - Anticipate constructing about 200 monuments starting in May
  - Communication with Michigan regarding border area
  - Survey obs planned for 2013

Wisconsin Continuously Operating Reference Stations (WISCORS)

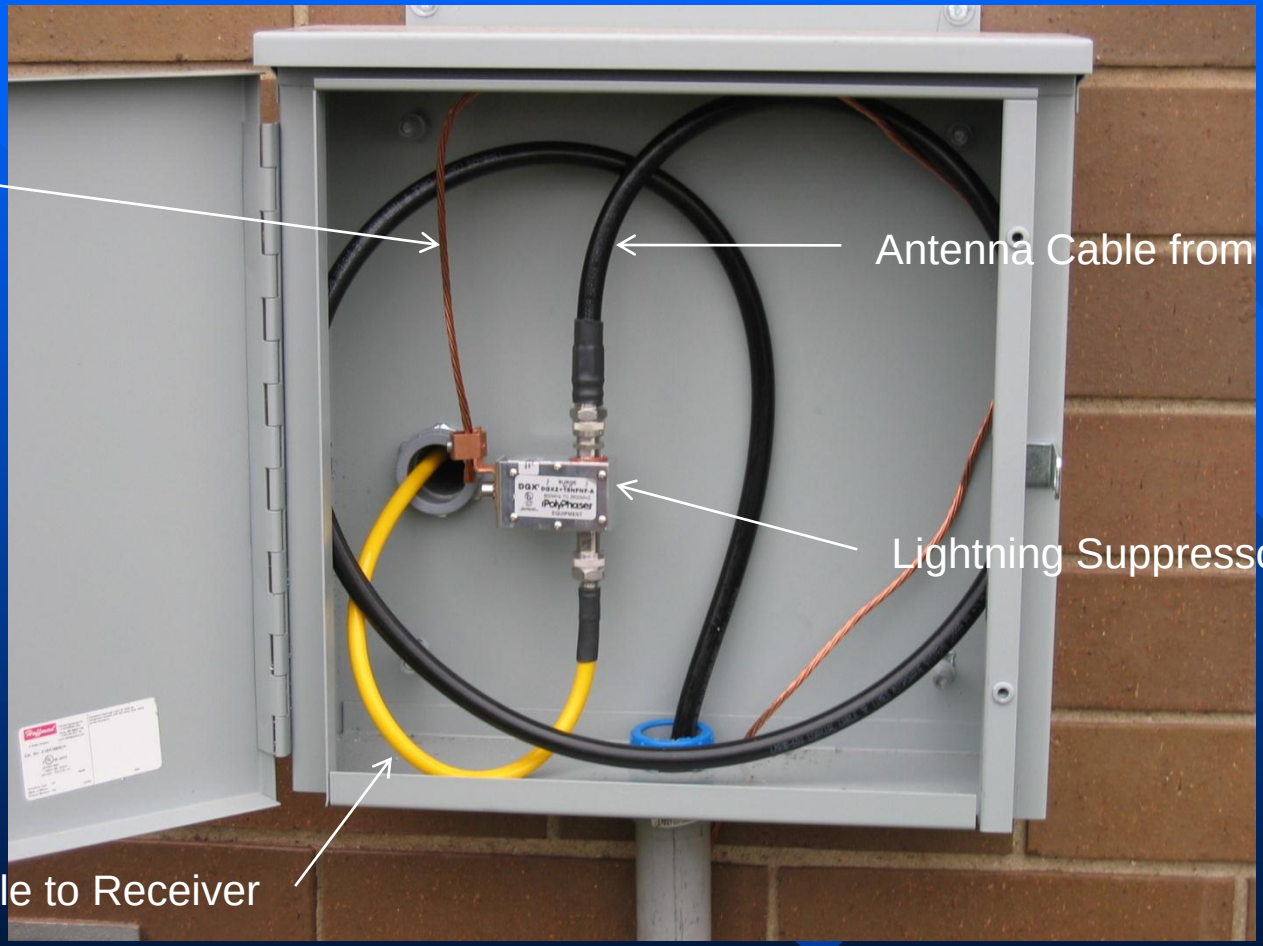
- ✓ *Provides the user the ability to perform 2 cm real-time positioning (horizontal and vertical) when using the passive network*
- ✓ Continuous Operating Reference Stations (CORS) are established at approximate 50 km (~31 mi) spacing
- ✓ Site conditions dictated if concrete pillar or building mount monument was used; Now only concrete pillars are used
- ✓ CORS sites include public educational buildings, county facilities, municipal facilities, and a park
- ✓ System utilizes Trimble GPS hardware (NetR5) and software
- ✓ System operational in July 2008
- ✓ As of 21 March 2012, 1095 users signed up since WISCORS became operational.

CORS Site Considerations

- ✓ Clear view of horizon above 10°
- ✓ Distance from GPS antenna to GPS receiver has to be less than 250 ft
- ✓ Distance from GPS receiver to Ethernet hub has to be less than 300 ft
- ✓ Security of site
- ✓ High speed internet on-site or can be installed
- ✓ Prefer concrete pillar monument over building mount
- ✓ Location to other CORS within 50 km

CORS Concrete Pillar Monument

CORS Service Enclosure



Electrical (Data) Enclosure

Status of WISCORS – Quick Review

- ✓ Forty-four(44) CORS Sites in the Eastern Half of Wisconsin are operational
- ✓ Twenty (20) CORS Sites have been constructed and will be brought into production with VRS3Net
- ✓ Fifteen (15) CORS Sites remain to be constructed in the state
- ✓ Partner Agreements have been signed with all partner agencies
- ✓ Cooperation planned with neighboring states and government agencies (CO-OPS, USACE)
- ✓ Work continues on transitioning to VRS3Net Environment
  - ✓ New blades have been ordered from IBM
  - ✓ Accuracy Testing of the new base station coordinates continues
  - ✓ New Web Application is nearing completion

WISCORS – Plans for 2012

- ✓ Cooperation with MnDOT to establish a station near LaCrosse
  - ✓ MnDOT to provide the GPS Hardware
  - ✓ WisDOT to provide the site, monument, and required infrastructure
  - ✓ Initial proposed location at Weigh Station along I-90
- ✓ At least 10 CORS will be constructed in 2012, with construction to start after the completion of passive monumentation campaign – likely August 2012
- ✓ Monuments will be constructed to enable data sharing with MnDOT.
  - ✓ Met with MnDOT in January to discuss preliminary plans
  - ✓ Sites will be evaluated on a case-by-case basis, starting with Roberts and Siren.
  - ✓ Additional base station software licensing from Trimble will be required

Can CORS Networks Be Used For Anything Other Than Surveying?

- ✓ The WISCORS Network was developed by WisDOT for WisDOT's survey needs. Other users have adopted the system for their respective positioning needs
- ✓ Survey / Engineering is still the largest user group by percentage, but Precision Ag is probably the fastest growing user group
- ✓ Maritime, utilities, geologists, meteorologists, road building, GIS, emergency response, and navigation
- ✓ 24/7 Reliability?
- ✓ Implementation of a User Fee?

WISCORS Test Results

Control Point	Delta North (m)	Delta East (m)	Cut/Fill (m)
BURNETT S GPS	0.011	-0.003	-0.009
BURNETT S GPS	0.007	-0.011	-0.007
Average Difference =	**0.009**	**-0.007**	**-0.008**
HUBBARD C GPS	0.011	0.003	0.012
HUBBARD C GPS	0.017	-0.008	0.012
Average Difference =	**0.014**	**-0.003**	**0.012**
2J64			0.024
2J64			0.031
Average Difference =			**0.028**
OAK GROVE E GPS	0.007	-0.002	-0.004
OAK GROVE E GPS	0.001	-0.006	-0.010
Average Difference =	**0.004**	**-0.004**	**-0.007**
2J62			0.013
2J62			0.008
Average Difference =			**0.011**
Dodge Co. Ave. Diff. =	**0.009**	**-0.005**	**0.007**

Average Difference = 0.02 ft with Passive Network in place!!!

NOTE!!! Sample results from tests conducted in Dodge County

Test Results (GPS Stations – Checks)

Control Point	Northing	Easting	Elevation
BLACK WOLF W GPS	214620.934	717050.104	247.517
BLACK WOLF W GPS	214620.939	717050.112	247.516
BLACK WOLF W GPS	214620.939	717050.118	247.521
BLACK WOLF W GPS	214620.938	717050.113	247.527
BLACK WOLF W GPS	214620.940	717050.116	247.532
BLACK WOLF W GPS	214620.946	717050.123	247.525
BLACK WOLF W GPS	214620.944	717050.120	247.525
BLACK WOLF W GPS	214620.938	717050.120	247.525
BLACK WOLF W GPS	214620.944	717050.116	247.516
BLACK WOLF W GPS - Averaged	214620.940	717050.116	247.523
BLACK WOLF W GPS - Published	214620.939	717050.109	247.529
Day 1 Difference	**-0.001**	**-0.007**	**0.006**
NEKIMI S GPS	214236.562	711950.821	277.320
NEKIMI S GPS	214236.557	711950.819	277.307
NEKIMI S GPS	214236.561	711950.813	277.320
NEKIMI S GPS	214236.558	711950.827	277.310
NEKIMI S GPS	214236.562	711950.833	277.317
NEKIMI S GPS	214236.561	711950.809	277.320
NEKIMI S GPS	214236.564	711950.820	277.318
NEKIMI S GPS	214236.548	711950.823	277.320
NEKIMI S GPS	214236.554	711950.829	277.329
NEKIMI S GPS	214236.562	711950.822	277.319
NEKIMI S GPS – Averaged	214236.559	711950.822	277.318
NEKIMI S GPS – Published	214236.558	711950.820	277.330
Day 1 Difference	**-0.001**	**-0.002**	**0.012**

Measurements in meters

Test Results (Bench Marks – Checks)

Control Point	Northing	Easting	Elevation
3W92	209701.932	717015.333	252.628
3W92	209701.933	717015.339	252.633
3W92	209701.925	717015.333	252.635
3W92	209701.935	717015.337	252.629
3W92 - Averaged	209701.931	717015.336	252.631
3W92 - Published			252.643
Difference			**0.012**
3W94	213020.846	717044.064	252.003
3W94	213020.849	717044.066	252.001
3W94	213020.850	717044.061	251.999
3W94	213020.842	717044.068	252.006
3W94 - Averaged	213020.847	717044.065	252.002
3W94 - Published			252.007
Difference			**0.005**
3W95	215968.369	716927.473	243.947
3W95	215968.357	716927.481	243.942
3W95	215968.358	716927.472	243.938
3W95	215968.373	716927.486	243.939
3W95 - Averaged	215968.364	716927.478	243.942
3W95 - Published			243.945
Difference			**0.004**
3W96	217349.567	716914.694	241.581
3W96	217349.554	716914.707	241.576
3W96	217349.563	716914.705	241.578
3W96	217349.563	716914.691	241.588
3W96 - Averaged	217349.562	716914.699	241.581
3W96 – Published			241.592
Difference			**0.011**

Measurements in meters

Long-term Maintenance of Passive Network

- ✓ Through Phase 7 over 7500 marks will have been published since the inception of the program
- ✓ Establishment of a GIS Database to assist in the management of the Passive Network Mark Maintenance Program
- ✓ Beginning in 2012 the Wisconsin County Surveyor Association members will be enlisted to help perform routine maintenance of HMP marks in their county
- ✓ In the past, a Limited Term Employee was hired to perform these duties and on average visited about 40 marks each week
- ✓ WisDOT Improvement projects have caused the destruction of the majority of over 100 marks lost to date. A system will be implemented in 2012 which will use Transportation Improvement Projects funds to replace the station(s)

Long-term Maintenance of Active Network (WISCORS)

- ✓ WisDOT's Office of Policy, Budget, and Finance is currently developing 2 'white sheet' papers to guide the process
  - Request for funding to complete development of the Passive and Active networks (approx. $1.25 M / year for 3 years)
  - Explore the feasibility of establishing a User Fee to sustain the WISCORS Network
- ✓ Any user fee would not be placed into a segregated fund, however WisDOT would "provide the support necessary to sustain the WISCORS Network"
- ✓ Other states which are operating CORS Networks have been contacted and interviewed by a consultant we hired to acquire information to aid WisDOT's OPBF in the decision making process

Long-term Maintenance of Active Network (WISCORS)

Proposed User Fee would cover the following expenses:

- ✓ GPS Receivers (anticipated replacement cycle 7 years)
- ✓ GPS Hardware and Firmware Warranties
- ✓ Application Software Maintenance through vendor
- ✓ Application Software Upgrades
- ✓ Server Hardware Expansion/Replacement
- ✓ Miscellaneous Equipment and Supplies
- ✓ Replacement of CORS
- ✓ Catastrophic Destruction of CORS
- ✓ Supplies for Passive Mark Maintenance (witness & guard posts)
- ✓ Replacement of Passive Network Marks

Long-term Maintenance of Active Network (WISCORS)

- ✓ Staff will need to be available to perform the following:
  - Resolve receiver, internet, and power issues at CORS sites to ensure day-to-day operations and availability of the system
  - Maintenance of system software
  - Coordinate security and user access to the system
  - Respond to user inquiries
  - Monitor and update coordinate values of CORS
- ✓ Yearly replacement cost of hardware and software estimated at $300,000 (includes receivers, software upgrades, and warranties)

Contact Information

Leonard Perfetti
Wisconsin Height Modernization Program
Program Coordinator
Wisconsin Department of Transportation
Truax Center
Surveying & Mapping
3502 Kinsman Blvd.
Madison, WI 53704

E-Mail: *leonard.perfetti@dot.state.wi.us*
Phone: *608.246.5373*
Cell: *608.516.6365*
Fax: *608.245.8959*

Elliot P. Smith
WISCORS Network Administrator
Geodetic Specialist
Wisconsin Department of Transportation
Truax Center
Surveying & Mapping
3502 Kinsman Blvd.
Madison, WI 53704

E-Mail: *elliot.smith@dot.state.wi.us*
Phone: *608.243.5986*
Cell: *608.516.6364*
Fax: *608.245.8959*

Diane Arendt, RLS
Geodetic Specialist
Wisconsin Department of Transportation
Truax Center
Surveying & Mapping
3502 Kinsman Blvd.
Madison, WI 53704

E-Mail: *diane.arendt@dot.state.wi.us*
Phone: *608.243.5988*
Cell: *608.516.6368*
Fax: *608.245.8959*