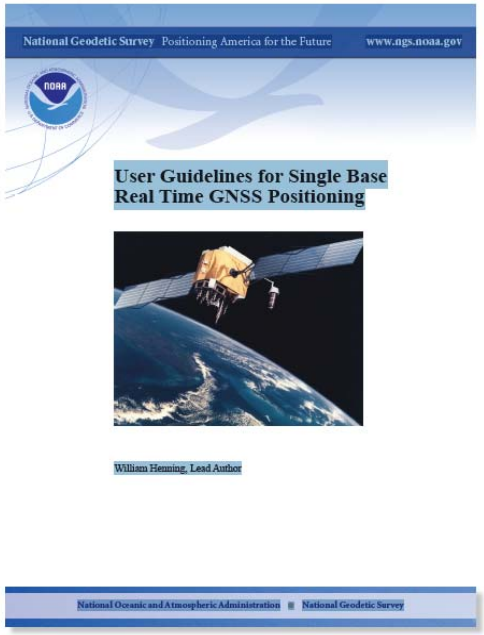
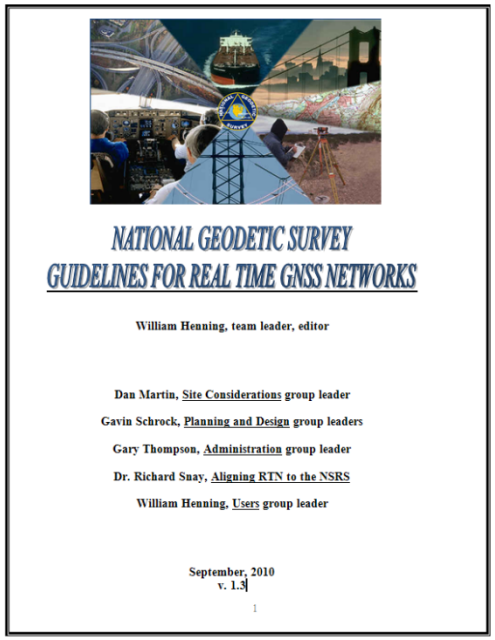
CURRENT NGS ACTIVITIES IN SUPPORT OF REAL TIME GNSS POSITIONING

NAVIGATION CENTER
The Navigation Center of Excellence

U.S. Department of Homeland Security
UNITED STATES COAST GUARD

CGSIC 50th Meeting - CORS User Forum
Oregon Convention Center • Portland, Oregon
September 20 & 21, 2010





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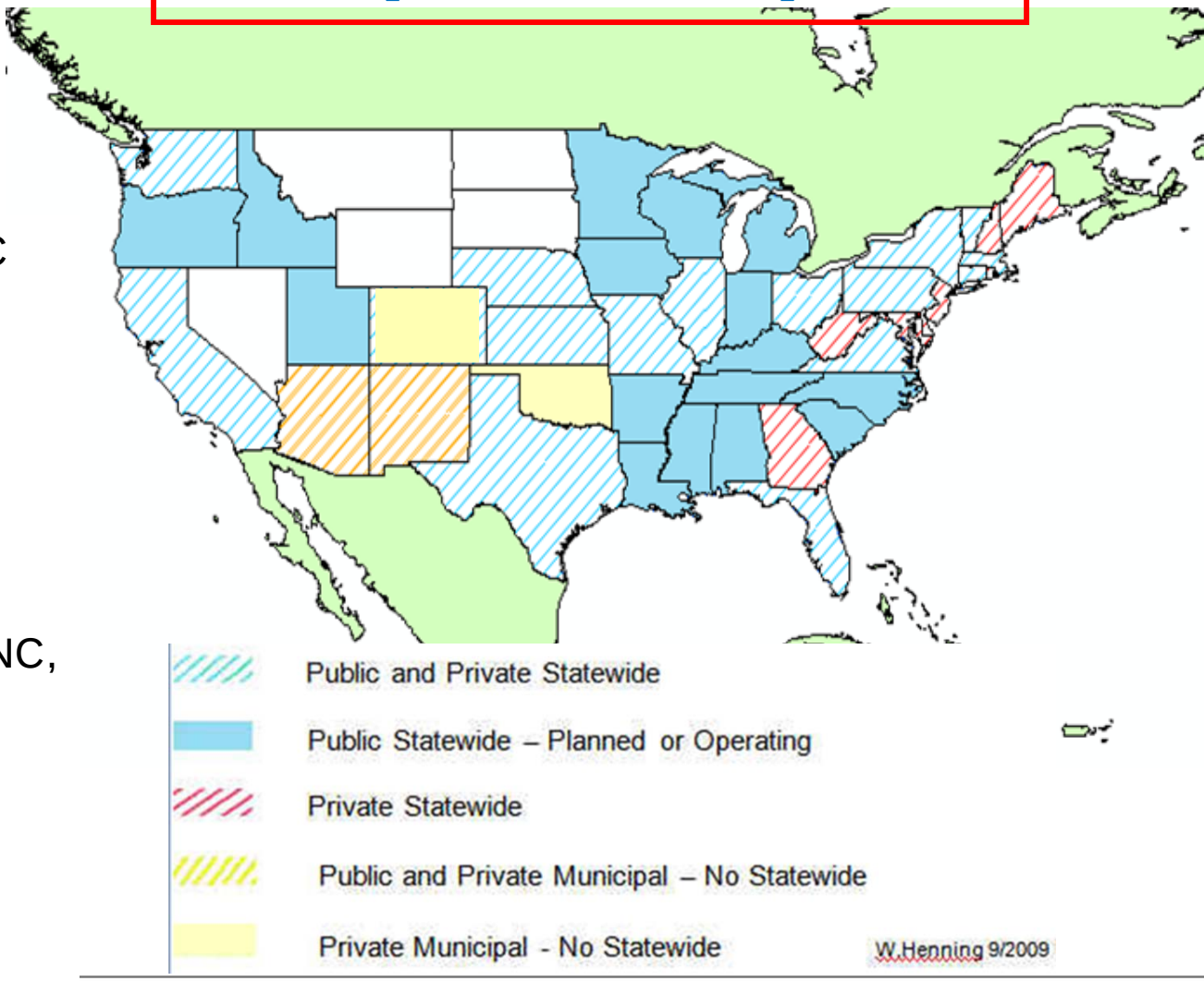
ACCOMPLISHING ACCURATE DATA COLLECTION 95% CONFIDENCE

- SBAS- 3 M H, 6 M V (UNSMOOTHED)
- COMMERCIAL DGPS – FEW DM, $$
- USCG BEACON – METER+
- CLASSICAL SURVEYING – 2-4 CM, LABOR/TIME INTENSIVE, $$$
- USER BASE RTK – 2-4 CM H, 3-5 CM V
- RTN – 3-4 CM H, 5-7 CM V
- AERIAL MAPPING - .15 M H, .25 M V, $$$
- SATELLITE IMAGERY – 0.5 METER H RESOLUTION, 3 M LOCATION, $$$
- LOW ALTITUDE AERIAL IMAGERY – 2-4 CM h, 3-5 CM V, $$
- TERRESTRIAL LASER SCANNING/MMS – PROJECT SITES ONLY, 0.015 H, 0.02 V

RTN IN THE USA (JAN 2010)

≥200 RTN WORLDWIDE
≥80 RTN USA
≥37 DOT

- ACADEMIC/SCIENTIFIC
- SPATIAL REFERENCE CENTERS
- VARIOUS DOTS + MACHINE GUIDANCE
- COUNTY
- CITY
- GEODETIC SURVEYS (NC, SC)
- MANUFACTURERS
- VENDOR NETWORKS
- AGRICULTURE
- MA & PA NETWORKS



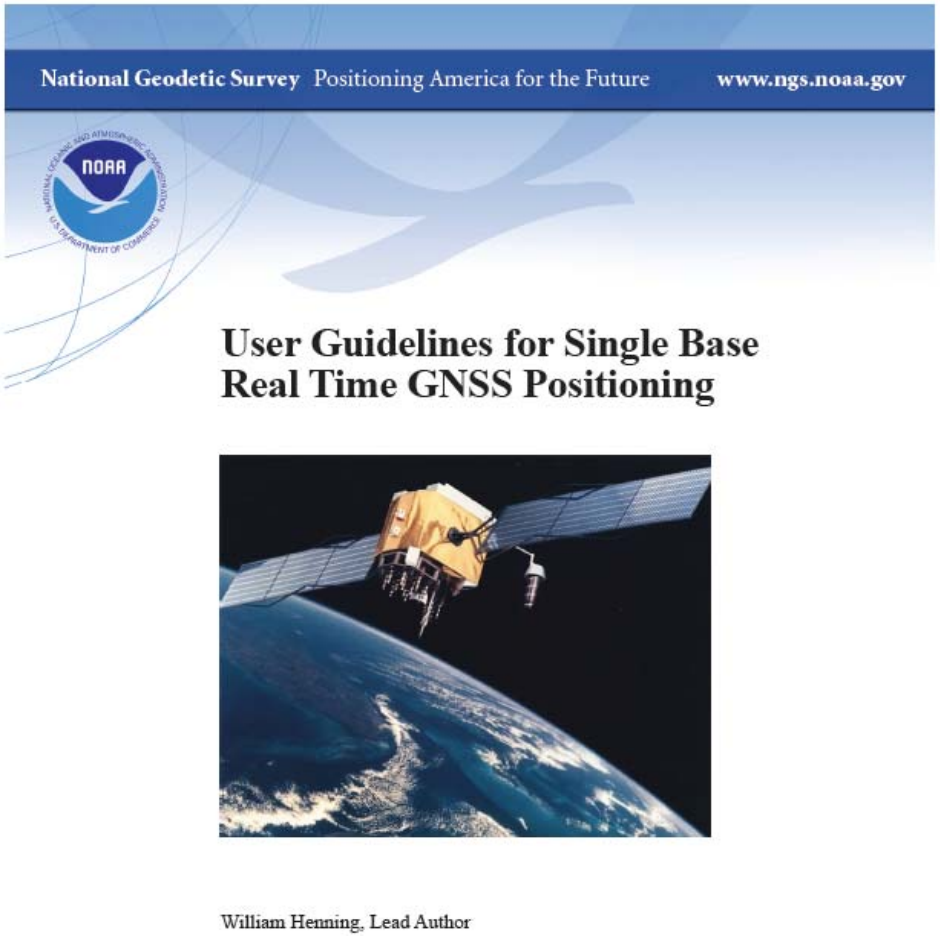
NGS GOALS FOR RTN's

- All real-time positioning services available in the U.S. provide coordinates that are consistent with the National Spatial Reference System, and hence, with each other
- User equipment can operate with services from different RTN's to the greatest extent possible
- Reference stations contained in each RTN meet prescribed criteria in terms of stability and data quality
- Best methods for RTN users may be advanced
- NGS will promote the use of RTCM 3.x messages via NTRIP software

NGS SINGLE BASE GUIDELINES Released Jan 2010

WHY?

-LEGACY USERS
-CLOSEST BASE NETWORKS
- AREAS WITHOUT CELL COVERAGE
-APPLICATIONS OPERATING WITH SINGLE BASE, E.G., MACHINE GUIDANCE, PRECISION AGRICULTURE, DEFORMATION MODELING, PROJECT BASE STATIONS



http://www.ngs.noaa.gov/PUBS_LIB/NGSRealTimeUserGuidelines.v1.0.pdf

DRAFT GUIDELINES- 95% CONFIDENCE

ACCURACY CLASS SUMMARY TABLE

	CLASS RT1	CLASS RT2	CLASS RT3	CLASS RT4
ACCURACY (TO BASE)	0.015 HORIZONTAL., 0.025 VERTICAL	0.025 HORIZONTAL., 0.04 VERTICAL	0.05 HORIZONTAL., 0.06 VERTICAL	0.15 HORIZONTAL., 0.25 VERTICAL
REDUNDANCY	≥ 2 LOCATIONS, 4-HOUR DIFFERENTIAL	≥ 2 LOCATIONS, 4-HOUR DIFFERENTIAL	NONE	NONE
BASE STATIONS	≥ 2 , IN CALIBRATION PROJECT CONTROL	RECOMMEND 2 IN CALIBRATION	≥ 1 , IN CALIBRATION	≥ 1 , IN CALIBRATION RECOMMENDED
PDOP	≤ 2.0	≤ 3.0	≤ 4.0	≤ 6.0
RMS	≤ 0.01 M	≤ 0.015 M	≤ 0.03 M	≤ 0.05 M
COLLECTION INTERVAL	1 SECOND FOR 3-MINUTES	5 SECONDS FOR 1-MINUTE	1 SECOND FOR 15 SECONDS	1 SECOND FOR 10 SECONDS
SATELLITES	≥ 7	≥ 6	≥5	≥ 5
BASELINE DISTANCE	≤ 10 KM	≤ 15 KM	≤ 20 KM	ANY WITH FIXED SOLUTION
TYPICAL APPLICATIONS	PROJECT CONTROL CONSTRUCTION CONTROL POINTS CHECK ON TRAVERSE, LEVELS SCIENTIFIC STUDIES PAVING STAKE OUT	DENSIFICATION CONTROL TOPOGRAPHIC CONTROL PHOTOPOINTS UTILITY STAKE OUT	TOPOGRAPHY CROSS SECTIONS AGRICULTURE ROAD GRADING SITE GRADING	SITE GRADING VETLANDS GIS POPULATION MAPPING ENVIRONMENTAL

NATIONAL GEODETIC SURVEY

GUIDELINES FOR REAL TIME GNSS NETWORKS

William Henning, team leader, editor

Dan Martin, Site Considerations group leader

Gavin Schrock, Planning and Design group leaders

Gary Thompson, Administration group leader

Dr. Richard Snay, Aligning RTN to the NSRS

William Henning, Users group leader

September, 2010
v. 1.3

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RTN GUIDELINES FOR GNSS POSITIONING–

WILL NOT SPECIFY OR DEFINE A STANDARD, BUT WILL HELP ADMINISTRATORS AND USERS TO BE AWARE OF ALL THE ISSUES INVOLVED WITH THIS NEW TECHNOLOGY

60+ CONTRIBUTORS:

- NGS ADVISORS
- DOT
- STATE GEODETIC SURVEYS
- GNSS MANUFACTURERS
- SRCs
- BLM, NPS

"WHAT IS TRUTH?"

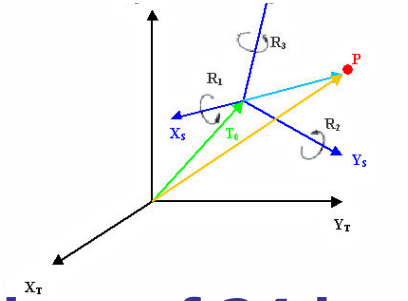
- HOW ARE STATION COORDINATES COMPUTED? WHEN SHOULD RTN BE READJUSTED?
- ARE THE RTN REFERENCE STATIONS MAINTAINED WITH VELOCITIES? IF SO, HOW ARE VELOCITIES COMPUTED?
- DO OVERLAPPING RTN PRODUCE COMPARABLE COORDINATES?
- IS THERE SUFFICIENT METADATA TO KNOW THE *PRECISION* AND/OR *ACCURACY* OF POSITIONS OBTAINED?
- ★IS LOCAL PASSIVE MONUMENTATION WITHIN ACCEPTABLE TOLERANCE OF THE RTN STATIONS? IF THERE IS SUBSTANTIAL DIFFERENCES, WHAT WILL BE HELD AS TRUTH?
- THE NATIONAL CORS NETWORK IS THE BASIS OF OUR HORIZONTAL + ELLIPSOID HEIGHT TRUTH AND REPRESENTS THE REALIZATION OF THE NSRS- AT WHAT ACCURACY ARE THE RTN ALIGNED TO IT?

OVERLAPPING RTN-NSRS?, HOMOGENEOUS?, USES ALL GNSS GEAR?

REFERENCE STATION COORDINATE DERIVATION:

ALL CORS FIXED

ALL CORS WEIGHTED



OPUS (Average of 10 days of 24 hour data sets)

OPUS + HARN

BEST FIT TO ONE MASTER STATION

<u>THE NGS RECOMMENDATION</u>: Process at least 10 days of GPS data from all RTN stations using a simultaneous network adjustment while "constraining" several CORS coordinates with weights of 1 cm in each horizontal dimension and 2 cm in the vertical dimension.

SUGGESTIONS FOR DETERMINING VELOCITIES FOR RTN STATIONS

- **Use the "HTDP" (Horizontal Time-Dependent Positioning) software to predict velocities for new RTN stations. (The predicted vertical velocity will be zero.) Adopt "TDP" when available (which will be a 3D velocity model).**

- **After 3 years, use GPS data from the RTN station to produce a time series of the station's coordinates, then use this time series to estimate a velocity for the RTN station.**

HOW WILL NGS VALIDATE RTN?

"Develop guidelines for both the administration and use of real-time GNSS networks and especially for ensuring that these networks are compatible with the NSRS."

1. TOP DOWN: OPUS POSITIONS ON RTN REFERENCE STATIONS AT APPROPRIATE INTERVALS COULD PRODUCE GRAPHICS THAT WOULD SHOW BIASES AT A GLANCE.

2. USER UP: PHYSICAL MONUMENTATION, ESTABLISHED WITH BEST TECHNOLOGY, COULD BE USED AS FIDUCIAL STATIONS TO HELP THE USER VERIFY THAT RTN ARE PRODUCING ACCURATE COORDINATES,

VALIDATING RTN REFERENCE STATIONS:

#1 Include a subnetwork of the RTN into the NGS **CORS** network. This would be three stations If RTN has less than 30 stations, 10% of RTN with greater than 30 stations.

#2 Align all RTN reference stations coordinates to the CORS network at 2-cm horizontal and 4-cm vertical

#3 For each reference station in the RTN, use the a version of Online Positioning User Service (OPUS) at http://www.ngs.noaa.gov/OPUS/ to test for the continued consistency of its adopted positional coordinatesand velocity on a daily basis, and revise the station's adopted coordinates and/or velocity if the tests reveal a need to do so. OPUS-PROJECTS looks promising

PROPOSED RTN CASE STUDY PROJECTS: 2010/2011

1. OREGON: MARK ARMSTRONG, KEN BAYS, RON SINGH, OREGON ACADEMIA

2. LOUISIANA: DENIS RIORDAN, LSU C4G = GULFNET INSIDE A NEW HEIGHT MODERNIZATION PROJECT

THESE COULD SHOW:

- **COMPARISON OF RTN ORTHOS TO GEODETIC LEVELING**
- **COMPARISON OF GNSS STATIC CAMPAIGN VALUES TO RTN**
- **REPEATABILITY OVER TIME, SEASONS AND DISPARATE CONDITIONS**
- **COMPARISON OF LEGACY GEAR TO NEWER GEAR**
- **EVALUATE INTERPOLATIONS VIS A VIS DISTANCE AND IONO CONDITIONS (NOTE IMPENDING SOLAR MAX)**
- **MANY OTHER STATISTICS AND EVALUATIONS**