REAL TIME POSITIONING- BEST METHODS FOR HIGH ACCURACY RTN DATA COLLECTION

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ACCOMPLISHING ACCURATE DATA COLLECTION 95% CONFIDENCE

- SBAS- 3 M H, 6 M V
- 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 – PROJECT SITES ONLY, 0.015 H, 0.02 V

A CONFLUENCE OF TECHNOLOGY- USE OF RTK

- INTERNET DATA VIA CELL TECHNOLOGY
- SOFTWARE/FIRMWARE ALGORITHMS
- GNSS HARDWARE
- SATELLITE CONSTELLATIONS
- SATELLITE CODES/FREQUENCIES

III. OUTREACH, COOPERATIVE EFFORTS AND LEADERSHIP

FIG

AMERICAN CONGRESS ON SURVEYING & MAPPING 1941

AAGS

FGCS

RTCM

CSRC

TSRC

SRCW SPATIAL REFERENCE CENTER OF WASHINGTON

ESRI GIS and Mapping Software

LSRC Center for GeoInformatics - Louisiana State University

NORTH CAROLINA Geodetic Survey

BLM

Caltrans

MARYLAND SOCIETY of SURVEYORS

NEW JERSEY SOCIETY OF PROFESSIONAL LAND SURVEYORS

CLSA CALIFORNIA LAND SURVEYORS ASSOCIATION

FLORIDA SURVEYING AND MAPPING SOCIETY

FEMA

SOUTH CAROLINA GEODETIC SURVEY

GEOMATICS ENGINEERING

PROFESSIONAL LAND SURVEYORS OF COLORADO, INC.

KENTUCKY ASSOCIATION OF PROFESSIONAL SURVEYORS

WISCONSIN SOCIETY OF LAND SURVEYORS

NEW MEXICO PROFESSIONAL SURVEYORS

The Delaware Association of Surveyors

NEW YORK STATE ASSOCIATION OF PROFESSIONAL LAND SURVEYORS

+ PUBLIC & PRIVATE *RTN ADMINISTRATORS* SPANNING MORE THAN 35 STATES

GOAL OF RTN USER GUIDELINES: TO HELP PRODUCE PRECISE, REPEATABLE POSITION COORDINATES AT THE ROVER

SOME ISSUES:

- ACCURACY / PRECISION
- ORTHO HEIGHTS: CALIBRATION – 2 MONUMENTS, 4+ MONUMENTS / HYBRID GEOID MODEL
- COORDINATE DELTAS: PASSIVE MONUMENTS / ACTIVE STATIONS
- DATUMS / ADJUSTMENTS / EPOCHS FROM THE RTN
- METADATA
- PLANNING – SATELLITE AVAILABILITY, SPACE WEATHER, STORM FRONTS, MULTIPATH, ETC.

SINGLE-BASE USERS GUIDELINES

NATIONAL GEODETIC SURVEY
USER GUIDELINES
FOR CLASSICAL
REAL TIME GNSS POSITIONING

DRAFT

http://www.ngs.noaa.gov/PUBS_LIB/NGSRealTimeUserGuidelines.v2.0.2.pdf

v. 2.0.3 September 2008

William Henning, lead author

NATIONAL GEODETIC SURVEY
GUIDELINES FOR REAL TIME GNSS NETWORKS

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September 2009
v. 1.0

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BEST METHODS FROM THE GUIDELINES:

THE 7 "C'S"

- CHECK EQUIPMENT
- COMMUNICATION
- CONDITIONS
- CALIBRATION (OR NOT)
- COORDINATES
- COLLECTION
- CONFIDENCE

THE CONTROL IS AT THE POLE

ACHIEVING ACCURATE, RELIABLE POSITIONS USING GNSS REAL TIME TECHNIQUES

(AUGMENTED FROM NGS SINGLE BASE DRAFT GUIDELINES CHAPTER 5: FIELD PROCEDURES)

RT = single base, either active or passive

B = Both Single base and RTN

CHECK EQUIPMENT

- B BUBBLE- ADJUSTED?
- RT BATTERY- BASE FULLY CHARGED 12V?
- B BATTERY – ROVER SPARES?
- RT USE PROPER RADIO CABLE (REDUCE SIGNAL LOSS)
- RT RADIO MAST HIGH AS POSSIBLE? (5′ = 5 MILES, 20′ = 11 MILES, DOUBLE HEIGHT=40% RANGE INCREASE). LOW LOSS CABLE FOR >25′.
- RT DIPOLE (DIRECTIONAL) ANTENNA NEEDED?
- RT REPEATER?
- RT CABLE CONNECTIONS SEATED AND TIGHT?
- B"FIXED HEIGHT" CHECKED?
- RT BASE SECURE?

COMMUNICATION

- RT UHF FREQUECY CLEAR?
- B CDMA/CELL - STATIC IP FOR COMMS?
- B CONSTANT COMMS WHILE LOCATING
- RT BATTERY STRENGTH OK?
- B CELL COVERAGE?

CONDITIONS

- RT WEATHER CONSISTENT?
- B CHECK SPACE WEATHER?
- B CHECK PDOP/SATS FOR THE DAY?
- RT OPEN SKY AT BASE?
- RT MULTIPATH AT BASE?
- B MULTIPATH AT ROVER?
- B USE BIPOD?

CALIBRATION (OR NOT)

- B ≥ 4 H & V, KNOWN & TRUSTED POINTS?
- B CALIBRATION RESIDUALS-OUTLIERS?
- B DO ANY PASSIVE MARKS NEED TO BE HELD?
- RT BASE WITHIN CALIBRATION?

$$x' = s \cos \alpha x + s \sin \alpha y + t_x$$
$$y' = s \sin \alpha x + s \cos \alpha y + t_y$$

Where s is scale factor
x and y are coordinates from original system
x′ and y′ are coordinates of point in transformed system
α is rotation angle from original to transformed system
t_x and t_y are components of translation from original to transformed system

COORDINATES

- B TRUSTED SOURCE?
- B WHAT DATUM/EPOCH ARE NEEDED?
- RT GIGO
- B ALWAYS CHECK KNOWN POINTS.
- B PRECISION VS. ACCURACY
- B GROUND/PROJECT VS. GRID/GEODETIC
- B GEOID MODEL QUALITY
- B LOG METADATA

COLLECTION

- B CHECK ON KNOWN POINTS!
- B SET ELEVATION MASK
- B ANTENNA TYPES ENTERED OK?
- B SET COVARIANCE MATRICES ON (IF NECESSARY).
- B RMS SHOWN IS TYPICALLY 68% CONFIDENCE (BRAND DEPENDENT)
- B H & V PRECISION SHOWN IS TYPICALLY 68% CONFIDENCE
- B TIME ON POINT? QA/QC OF INTEGER FIX
- B MULTIPATH? DISCRETE/DIFFUSE
- B BUBBLE LEVELED?
- B PDOP?
- B FIXED SOLUTION?
- B USE BIPOD?
- B COMMS CONTINUOUS DURING LOCATION?
- B BLUNDER CHECK LOCATION ON IMPORTANT POINTS.

MULTIPATH = NOISE
SPECULAR(DISCRETE) & DIFFUSE

SOURCES:

TOWERS

BUILDINGS

WATER

VEHICLES

TREE CANOPY

STRUCTURES

CONFIDENCE

- B CHECK KNOWN BEFORE, DURING, AFTER SESSION.
- B NECESSARY REDUNDANCY?
- B WHAT ACCURACY IS NEEDED?
- RT REMEMBER PPM
- RT BASE PRECISION TO NEAREST CALIBRATION POINT
- B AVERAGE REDUNDANT SHOTS – PRECISION DIFFERENCE WITHIN NEEDS OF SURVEY
- B BE AWARE OF POTENTIAL INTERFERENCE (E.G., HIGH TENSION TOWER LINES)

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

FURTHER WORK IN THE OFFICE

CHECK:

- Antenna heights (height blunders are unacceptable and can even produce horizontal error - Meyer, et.al, 2005).
- Antenna types
- RMS values
- Redundant observations
- Horizontal & vertical precision
- PDOP
- Base station coordinates
- Number of satellites
- Calibration (if any) residuals

METADATA !

BESIDES ATTRIBUTE FIELDS, THE RT PRACTICIONER MUST KEEP RECORDS OF ITEMS NOT RECORDED IN THE FIELD,
FOR INSTANCE:

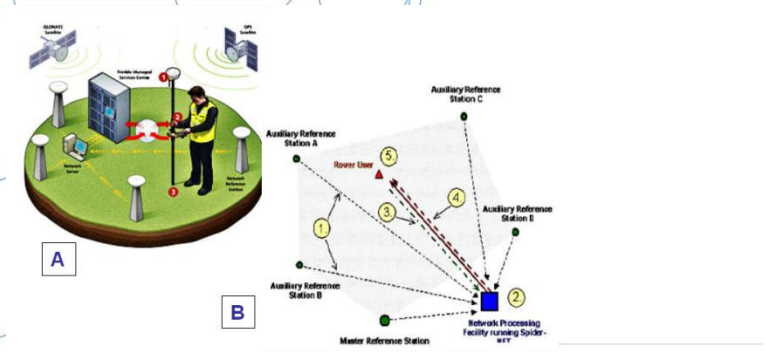
- ✓ **WHAT IS THE SOURCE OF THE DATA?**
- ✓ **WHAT IS THE DATUM/ADJUSTMENT/EPOCH?**
- ✓ **WHAT ARE THE FIELD CONDITIONS?**
- ✓ **WHAT EQUIPMENT WAS USED, ESPECIALLY- WHAT ANTENNA?**
- ✓ **WHAT FIRMWARE WAS IN THE RECEIVER & COLLECTOR?**
- ✓ **WHAT REDUNDANCY, IF ANY, WAS USED?**

QUICK FIELD SUMMARY:

- Set the base at a wide open site
- Set rover elevation mask between 12° & 15°
- The more satellites the better
- The lower the PDOP the better
- The more redundancy the better
- Beware multipath
- Beware long initialization times
- Beware antenna height blunders
- Survey with "fixed" solutions only
- Always check known points before, during and after new location sessions
- Keep equipment adjusted for highest accuracy
- Communication should be continuous while locating a point
- Precision displayed in the data collector can be at the 68 percent level (or 1σ), which is only about half the error spread to get 95 percent confidence
- Have back up batteries & cables
- RT doesn't like tree canopy or tall buildings

THE QUICK SUMMARY BOILED DOWN:

- **COMMUNICATIONS: THE KEY TO SUCCESS**
- **CHECK SHOT: FIRST BEFORE NEW WORK**
- **REDUNDANCY: FOR CONFIDENCE**

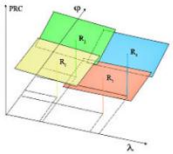


Three types of RTN:

A. VRS – Duplex Communication

B. MAC – Duplex or Broadcast

C. FKP – Broadcast Only



≥200 RTN WORLDWIDE
≥80 RTN IN THE USA
≥35 DOT WITH STATEWIDE NETWORKS PLANNED OR OPERATING