FGCS Update on NGS58_Rewrite

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by

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Executive Summary

- *The "NGS58_Rewrite" document sets forth the NGS' current standards and procedures for successful establishment of GNSS control using the OPUS PROJECTS service.*
- *The document prescribes Standards and Specifications for surveys which will become part of the NGS Integrated Database.*
- *This document is specifically limited to support OPUS Projects (version 5) and the current North American Datum of 1983 (NAD83) and the North American Vertical Datum of 1988 (NAVD88). Future versions of OPUS Projects and future datums will require revision of this publication.*

Minnesota Department of Transportation Bituminous Manual, 2019, page 16

Need for NGS58_Rewrite

- NGS58 was published in 1997, and GNSS technologies and survey methods have evolved and improved since then.
- NGS58 does not allow use of real-time kinematic (RTK) technology, which is highly popular.
- NGS has released freely available, web-based software **OPUS-Projects** to streamline the work:
  - Campaign-style GNSS surveys
  - Baseline processing and network adjustments
  - Prepares files in FGCS "Bluebook" format for uploading into IDB
  - Streamlines project data submissions to NGS for review and publication

Intent of NGS58_Rewrite

- This publication supplements "Standards and Specification for Geodetic Control Networks" issued September 1984, by Admiral John D. Bossler.
  - The 1984 publication will continue to provide supporting documentation for the classical survey techniques based on angle, distance, and leveling, as well as the less common inertial, photogrammetric, and gravity surveys as listed in Section 3 of the 1984 document.

Intent of NGS58_Rewrite

- This publication is intended to replace the Federal Geodetic Control Committee *preliminary publication* "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques." by Rear Admiral Wesley Hull, version 5.0 May 11, 1988, reprinted August 1, 1989 with corrections.

Recommendation

Intent of NGS58_Rewrite

- This publication replaces the NOAA Technical Memorandum NOS NGS 58 "Guidelines For Establishing GPS-Derived Ellipsoid Heights, (Standards: 2 cm and 5 cm), Version 4.3" November 1997 by David B. Zilkoski.

- This publication replaces the NOAA Technical Memorandum NOS NGS 59 "Guidelines for Establishing GPS-Derived Orthometric Heights" March 2008 by David B. Zilkoski.

Intent of NGS58_Rewrite

- This publication provides Classification, Standards, and Specifications for GNSS geodetic control surveys which use Global Navigation Satellite Systems (GNSS) and which will be submitted to NGS for review and publication. These types of surveys were not well-established at the date of the 1984, 1988, 1997, and 2008 publications. Considerable research [Citations?] into best practices and analysis of achievable results supports this publication.

Intent of NGS58_Rewrite

- This publication is specifically limited to support OPUS Projects (version 5) and the current North American Datum of 1983 (NAD83) and the North American Vertical Datum of 1988 (NAVD88). Future versions of OPUS Projects and future datums will require revision of this publication.

3 Classifications

3 CLASSIFICATIONS

NGS defines the following 3 ***Classifications of Intended Ellipsoid Height Network Accuracy*** for GNSS geodetic control surveys which will be submitted to NGS for review and publication.

Table 1 - Classifications of Intended Ellipsoid Height Network Accuracy

** Network Accuracy is stated as at the 95% confidence level*

	Description	PRIMARY	SECONDARY	LOCAL
1.1	Intended Ellipsoid Height Network Accuracy (cm) *	2 cm	3 cm	5 cm
1.2	Estimated Horizontal Network Accuracy (cm) *	1 cm	1.5 cm	2.5 cm
1.3	Estimated Orthometric Height Accuracy (cm) *	3 cm	4 cm	6 cm
1.4	Suggested Use	Primary control	Secondary control	Local control

Network Designs and Observation Methods

- The document explains in words and in examples
  - the NGS' recommended network designs.
  - the NGS' inclusion of GVX format, which enables the use of RTK methods.
- Sets observation methods for various mark types

Table 3 - Observation Method Requirements for Mark Types

	Mark Type	Observation Method Requirements for Mark Type
3.1	NCN CORS	NONE. OPUS Projects will automatically gather all needed information.
3.2	NRTK base	Follow Requirements for OPUS PP in Table 4.
3.3	SRTK base	Follow Requirements for OPUS PP in Table 4.
3.4	Passive	Follow Requirements for OPUS PP in Table 4 - or- Follow Requirements for GVX PP in Table 4 - or - Follow Requirements for GVX NRTK in Table 4 - or - Follow Requirements for GVX SRTK in Table 4.

Standards for each Observation Method

Table 4 - Standards for Observation Requirements by Method

Table 4 - Standards for Observation Requirements by Method

	Requirement	PRIMARY	SECONDARY	LOCAL
4.1	Requirements for ALL METHODS - Repeat occupations and offset time	Offset sessions/occupations by 3 to 21 hours. See Specifications for detailed explanation.		
4.2	Requirements for OPUS PP - Required TOTAL Static GNSS Observation Time (T)	T = 20 hours (for 0 to 200 km)	T = 4 hours (for 0 to 100 km) T = 6 hours (for 0 to 150 km) T = 8 hours (for 0 to 200 km)	T = 4 hours (for 0 to 200 km)
	- Recommended GNSS Session Durations	(2) 10 hour sessions or (3) 7 hour sessions or (4) 5 hour sessions Requires at least 1 session on a different day.	(2) 2 hour sessions (2) 3 hour sessions (2) 4 hour sessions	(2) 2 hour sessions
4.3	Requirements for GVX PP - Number and duration of sessions	3 sessions 60 minutes each (for 0 to 25 km) 90 minutes each (for 25 to 50 km) Requires at least 1 session on a different day.	3 sessions 30 minutes each (for 0 to 25 km) 60 minutes each (for 25 to 50 km)	3 sessions 15 minutes each (for 0 to 25 km) 30 minutes each (for 25 to 50 km)
4.4	Requirements for GVX NRTK - Number and duration of occupations	(6) 5 minutes Requires at least 3 occupations on a different day.	(3) 5 minutes	(3) 5 minutes
4.5	Requirements for GVX SRTK - Number and duration of occupations	Not allowed	(5) 5 minutes Requires at least 2 occupations on a different day.	(4) 5 minutes Requires at least 1 occupation on a different day.

Standards for Network Design

Table 5 - Standards for Network Design

	Requirement	PRIMARY	SECONDARY	LOCAL
5.1	**All HUBS are NCN CORS** Unless pre-approved in Project Proposal	Yes.		
5.2	**Distance between HUBS** Unless pre-approved in Project Proposal	100 km minimum, 400 km maximum.		
5.3	**Project includes 3 or more CORS, arranged as follows:** Unless pre-approved in Project Proposal	1 local CORS used as HUB (0 to 200 km) plus 1 or more nearby CORS (0 to 300 KM) plus 1 or more distant CORS (375-800 km) Measured from the project center. See Specifications for detailed explanation		
5.4	**Project includes 1 or more OPUS PP verified passive marks as checkpoints**	Yes, if GVX vectors are uploaded to the Project.. See Specifications for detailed explanation.		
5.5	**Longest OPUS PP Vector from HUB to mark *(excluding from HUB to NCN CORS)*** Unless pre-approved in Project Proposal	200 km (for T = 20 hrs)	100 km (for T = 4 hrs) 150 km (for T = 6 hrs) 200 km (for T = 8 hrs)	200 km (for T = 4 hr)
5.6	**Longest *GVX* Vector** GVX PP GVX NRTK GVX SRTK	 50 km 40 km Not allowed	 50 km 40 km 10 km	 50 km 40 km 20 km
5.7	**Maximum Number Of Vector Steps In A Vector Chain**	2 vector steps, consisting of: 1 OPUS derived vector, plus 1 GVX vector.		
5.8	**Minimum Spacing Distance Between Adjacent Marks** Unless pre-approved in Project Proposal	1000 meters	500 meters	100 meters
5.9	**Timeliness of Projects** Unless pre-approved in Project Proposal	Start to end of observations = 12 months End of observations to date of submission = 6 months		

Standards for Monumentation

Table 6 - Standards for Monumentation

	Requirement	PRIMARY	SECONDARY	LOCAL
6.1	**General Requirement**	Stable, publicly-accessible, identifiable, and permanent monuments. Include a "typical monument" diagram in Project Proposal.		
6.2	**Stamping/Designation**	Prefer unique stampings (see Annex D). Avoid offensive designations.		
6.3	**Stability Code** Unless pre-approved in Project Proposal	A or B (See Annex P)	A, B, or C (See Annex P)	A, B, C, or D (See Annex P)

Standards for Session Processing and Adjustment Results

Table 7 - Standards for Session Processing and Adjustment Results

	Requirement	PRIMARY	SECONDARY	LOCAL
7.1	**Achieved Network Accuracy,** less than or equal to, from HOR Constrained .SUM file, (see Figure 4) **HORIZ (cm)** **UP (cm)**	 1.0 2.0	 1.5 3.0	 2.5 5.0
7.2	**Achieved Local Accuracy,** less than or equal to, from HOR Constrained .SUM file, (see Figure 5) **HORIZ (cm)** **UP (cm)**	 1.0 2.0	 1.5 3.0	 2.5 5.0
7.3	**Peak-to-peak Coordinate Comparison,** less than or equal to, from OP Table, (see Figure 6) **NORTH (cm)** **EAST (cm)** **UP (cm)**	 3.0 3.0 6.0	 4.0 4.0 8.0	 5.0 5.0 10.0
7.4	**Maximum Residuals per Vector,** less than or equal to, from .TXT PREPLT2, (in any adjustment) (see Figure 8) **DN (cm)** **DE (cm)** **DU (cm)**	 1.5 absolute value 1.5 absolute value 3.0 cm absolute value	 2.0 absolute value 2.0 absolute value 4.0 cm absolute value	 2.5 absolute value 2.5 absolute value 5.0 cm absolute value
7.5	**Statistical Checks** - Horizontal Constrained Adjustment (.TXT) file (see Figure 9) and - Vertical Constrained Adjustment (.TXT) file (see Figure 9) **F-Statistic Test** **Maximum Allowable Mark Constraint Ratio**			 PASS 3.5, unless explained in the Project Report.
7.6	**WinDesc**			Error-free output. (see Windesc .ERR file) WinDesc file excludes the NCN CORS, but Includes all non-NCN marks.

Standards for Achieving Valid Orthometric Heights

Table 8 - Standards for Achieving Valid Orthometric Heights

	Requirement	PRIMARY	SECONDARY	LOCAL
8.1	**Minimum Number Of Benchmarks**	2		
8.2	**Order/Class Of Benchmarks**	3rd Order or better, and K-heights, (see Specification 8.2 for detail.)		
8.3	**Maximum Allowable Distance From Newly Established Benchmarks to 2 Existing Valid Benchmarks** Unless pre-approved in Project Proposal	Varies. 30 km to 50 km, see Specification 8.3 for detail.		

Standards for Equipment Used in Field Observations and Office Procedures

Table 9 - Standards for Equipment Used in Field Observations and Office Procedures

	Requirement	PRIMARY	SECONDARY	LOCAL
9.1	**Tripod Type** Include a "typical tripod" photo or description in Project Proposal.	Fixed height	Fixed height	Adjustable
9.2	**Receiver - dual frequency, GPS/GNSS capable**	Yes, receiver is listed in RCVR_ANT.TAB file		
9.3	**Antenna - calibrated by NGS**	Yes, antenna is listed in ANTCAL file		
9.4	**RINEX version**	2.11 or newer		
9.5	**Ephemeris**	for OPUS PP or GVX PP Final For NRTK or STRK Broadcast	for OPUS PP or GVX PP Rapid For NRTK or STRK Broadcast	for OPUS PP or GVX PP Rapid For NRTK or STRK Broadcast
9.6	**Field Observation Logs**	Required for each occupation. See: *https://www.ngs.noaa.gov/surveys/forms/*		

Specifications

- The Specifications explain each standard and/or describe how to meet the standard.
- The Specifications section is arranged by Table and then each standard is discussed separately in the order found in the Table.

Project Proposals

- It is the surveyor's responsibility to plan the survey project carefully, then submit a Project Proposal to NGS for approval.
- NGS provides a web page and Sample Project Proposal template for this purpose.
- The Standards make several mentions of "unless pre-approved in the Project Proposal". The project proposal must address the need for such pre-approvals and discuss the justification for the requested pre-approvals.

Project Reports

- The surveyor must analyze the survey project carefully to verify adherence to the Standards as listed in these Tables.
- Upon completion of the project analysis, the surveyor must write a Project Report which summarizes and discusses the results of the project.
- The Project Report must contain a tabulation of the various Tables' requirements which the surveyor will use to support a provisional classification. NGS provides a Sample Project Report template for this purpose.

Project Reports

- The project report must discuss any pre-approvals that were requested in advance, what final impact these had on the project, and also discuss unexpected circumstances which may justify post-approval of additional variances from the Standards.

- The Project Report will be used by the NGS acceptance personnel to efficiently determine whether the requirements for the intended classification have been achieved.

Status

- The NGS58_Rewrite is incomplete and is in Draft Status.
- Awaiting several final decisions by the OPUS Projects Team regarding certain Recommendations to facilitate easier analysis by the surveyor and by NGS acceptance personnel.

- In the short term, write for the status quo.
- In the medium term, make revisions to reflect the Recommendations as they become effective.

Vision

- In the long term,
- OPUS Projects should be able to look at itself in the mirror and determine whether the Intended Classification of Ellipsoid Height Network Accuracy has been met in the submitted project.
- Each line in each Table can be envisioned as a question by which OPUS Projects can gauge achievement and conformity with the Standards.


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