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Status report on the products and services of the upcoming modernized National Spatial Reference System

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Versions

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As the National Geodetic Survey (NGS) prepares to transition to a modernized National Spatial Reference System (NSRS) in 2022, it has become imperative to define and bound that modernized NSRS at its bare minimum level of success. In this way, NGS should not lose sight of important Products and Services (P/S) and can more easily track which components are on track and which require additional resources before 2022.

As a supplement to the below list of P/S of the modernized NSRS, NGS has set the goal of providing to the public an "alpha" version of each, if possible, sometime in calendar year 2019.

A word about the use of the terms "**alpha**", "**beta**" and "**live**" is worthwhile here. NGS currently embraces a three-stage product development strategy that begins with products in the developmental (or "alpha") stage. Such products are raw, often incomplete and only partially functional. They are used primarily for internal NGS testing. They are generally not ready for public testing. Only after substantial internal testing (including bug fixing, etc.) alpha products finally achieve "beta" status. Beta products tend to be fully functional and mostly bug free, though that is by no means a guarantee. These beta products are put on the NGS beta web page (*beta.ngs.noaa.gov*) for public scrutiny and testing. After enough testing is done, bugs fixed and stability appears to be reached, the products are released on the standard (or "LIVE") NGS web page (*www.ngs.noaa.gov*) and given a version number so that changes and updates can be tracked.

There are many purposes for generating a list of "alpha" P/S, and actually making them available in 2019. First, simply identifying an alpha version prevents things from falling through the cracks. Second, it allows NGS the opportunity to see how well (or if at all) such a P/S is functioning and integrating into NGS workflows. Third, it provides a check on the current status of each P/S at the time of this document's release. As the status of these various P/S will change frequently over the next few years, status updates will not cause a re-issuing of this document. Fourth, but probably most importantly, it provides users of the NSRS (both the geospatial public as well as industry partners) an introductory look at new file formats, functionality and terminology so that understanding of these P/S can occur years in advance of the 2022 deadline.

It is not out of the question that additions or subtractions to the P/S listed in this document will occur before 2022, necessitating an update to this document. Such updates will be announced through normal NGS communications channels.

The list is broken down into four tables. The first two are for definitional **constants** and **models** which must be codified before 2022. The third is for P/S that are currently scheduled to be released ***by*** 2022, the fourth for those P/S that are considered within the scope of the NSRS Modernization, but which, for time and resource reasons, are purposefully being scheduled for a ***post***-2022 release.

Alpha products, while generally incomplete and semi-functional do tend to provide a glimpse into the direction NGS is headed. As such, these products can be useful if shown publically with the proper caveats. At the 2018 Industry Days, NGS received feedback from our partners that early access to alpha products would be highly beneficial for the 2022 modernization effort, as it would allow industry time to begin making some changes to their own software. NGS agreed, and promised that during calendar year 2019 there would attempts to release alpha versions of every product or service which was expected to be at least in beta form by 2022. This report will therefore provide status of each product, specifically when in 2019 an alpha product might be available, if at all.

Table 1: Definitional Constants of the modernized NSRS – All must be released in final form by 2022.

All values will be treated as *exact* in the modernized NSRS

Name	Description	Status	Source	Values (2019 Alpha versions in BLUE)
Reference Ellipsoid	• Converts XYZ↔ ϕλh • Provides Normal Gravity Field • Provides time-dependency to both of the above values	**Done**	GRS 80 will be used. Time dependency will be definitionally set to zero.	a= 6.378137×10^6 m GM= 3.986005×10^{14} m^3/s^2 J_2= 1.08263×10^{-3} ω= 7.292115×10^{-5} rad/s
Euler Pole Parameters for the North American Plate	Converts XYZ(ITRF2014,t)↔XYZ(NATRF2022,t) Part 1 of 4 of **EPP2022**	**Incomplete**	Alpha: ITRF2014 Plate Motion Model Final: IAG Working Group	ω_X : +0.024 ± 0.002 mas/year[1] ω_Y : -0.694 ± 0.005 mas/year[1] ω_Z : -0.063 ± 0.004 mas/year[1]
Euler Pole Parameters for the Pacific Plate	Converts XYZ(ITRF2014,t)↔XYZ(PATRF2022,t) Part 2 of 4 of **EPP2022**	**Incomplete**	Alpha: ITRF2014 Plate Motion Model Final: IAG Working Group	ω_X : -0.409 ± 0.003 mas/year[1] ω_Y : +1.047 ± 0.004 mas/year[1] ω_Z : -2.169 ± 0.004 mas/year[1]
Euler Pole Parameters for the Caribbean Plate	Converts XYZ(ITRF2014,t)↔XYZ(CATRF2022,t) Part 3 of 4 of **EPP2022**	**Incomplete**	Alpha: ITRF2008 Plate Motion Model Final: IAG Working Group	ω_X : +0.049 ± 0.201 mas/year[1] ω_Y : -1.088 ± 0.417 mas/year[1] ω_Z : +0.664 ± 0.146 mas/year[1]
Euler Pole Parameters for the Mariana Plate	Converts XYZ(ITRF2014,t)↔XYZ(MATRF2022,t) Part 4 of 4 of **EPP2022**	**Incomplete**	Alpha: computations at NGS from the 2017 survey (paper pending) Final: TBD	Withheld from public release until publication of paper
W_0	The gravity potential of the geoid at 2020.00	**Done**	By agreement with the Geodetic Survey of Canada, 16 April 2012.	62636856.0×10^7 m^2/s^2

[1] While these values show uncertainty estimates, NGS will treat the final EPP2022 values as exact when converting ITRF2014 coordinates and uncertainties into NATRF2022, PATRF2022, MATRF2022 and CATRF2022 coordinates and uncertainties.

Table 2: Definitional Models of the modernized NSRS – All must be released in final form by 2022.

Name	Description	Status	Status (2019 Alpha status in BLUE)
GM2022	• Model of Earth's time dependent external gravitational potential	**Incomplete**	2007: GRAV-D begun 2016: GeMS project begun 2018: NGS/NGA reach agreement for cooperative computation of annual geopotential models, with NGS providing GRAV-D data, and NGA producing the models. This will include NGA's planned "EGM2020" as well as continued work eventually leading to GM2022. 2018: GRACE data for GEMS acquired 2019: Alpha version will use PGM17 with time dependencies from GRACE

IFVM2022	• Model of time dependent 3-D crustal motion
	• Given ϕ,λ,h,t_1,t_2 => Provide:
	  • $\phi(t \in [t_1,t_2])$, $\Delta\phi(t_1,t_2)$
	  • $\lambda(t \in [t_1,t_2])$, $\Delta\lambda(t_1,t_2)$
	  • $h(t \in [t_1,t_2])$, $\Delta h(t_1,t_2)$
	• Uncertainty estimates of all of the above
	• In any of the four frames of the modernized NSRS
		Incomplete	6/2017: Scoping study approved. Attempts to get funding to fund University research have been mostly unsuccessful.
			3/2019: Use of NOAA Cooperative Institutes being pursued
			3/2019: Internal proof of concept using NGS employees to pursue SAR was discussed and abandoned
			3/2019: Repro2 ITRF2014 CORS coordinate functions available and being analyzed for CORS-only IFVM
			
			2019: Alpha version will consist of a series of drift/jump grids based on the NOAA CORS Network (NCN). Likely not available until end of 2019

GEOID2022	• Model of time dependent ellipsoid/geoid separation • Given ϕ,λ,t => Provide: • $N(\phi,\lambda,t)$ • Uncertainty estimates of the above • In NAPGD2022	**Incomplete**	2014: Annual xGEOID models computed. 2019: Alpha version will be xGEOID2019 with linear velocities derived from GRACE
DEFLEC2022	• Model of time dependent surface deflections of the vertical • Given ϕ,λ,t => Provide: • $\zeta(\phi,\lambda,t)$, $\eta(\phi,\lambda,t)$ • Uncertainty estimates of the above • In NAPGD2022	**Incomplete**	2018: Annual xDEFLEC models computed as companions to xGEOID models 2019: Alpha version will be xDEFLEC2019 with linear velocities derived from GRACE

Name	Description	Status	Status (2019 Alpha status in BLUE)
GRAV2022	• Model of time dependent surface gravity • Given ϕ,λ,t => Provide: • $g(\phi,\lambda,t)$ • Uncertainty estimates of the above • In NAPGD2022	**Incomplete**	2017: Project to finalized all gravity/DEM files begun 2019: Project near completion 2019: Alpha version (xGRAV2019) of will be put out as an experimental product with xGEOID2019 and xDEFLEC2019. No time dependencies.
DEM2022	• Model of time dependent crust of the Earth[2]	**Incomplete**	2017: Project to finalized all gravity/DEM files begun 2019: Project near completion 2019: Alpha version (xDEM2019) of will be put out as an experimental product with xGEOID2019 and xDEFLEC2019. No time dependencies.
IGLD2020	• The International Great Lakes Datum of 2020 • Replaces IGLD85 • Cooperative project with NGS, CO-OPS and Canada • Specific portions under NGS's "NSRS Modernization" include: • Software to compute dynamic heights based upon latitude, longitude, ellipsoid height, geoid undulation and surface gravity	**Incomplete**	2016: Project to compute dynamic heights from GNSS begun 2017: Research. Various issues at GL water level stations investigated and resolved 2018: Equations/data provided to NGS SDD for incorporation into NSRS database, ready for new versions of OPUS 2019: Alpha version, relying upon xGRAV2019 will be put into alpha versions of OPUS

[2] In a perfect world, a Digital Elevation Model would perfectly reflect the Earth at all resolutions and with all time-dependencies. Thus the IFVM2022 model should perfectly align with the time-dependent component of DEM2022. Such consistencies are being slowly implemented, but will not be fully implemented by 2022. As such, the primary use of DEM2022 is as an input data set to the GEOID2022 model, and not as an actual geodetically accurate model of the Earth for any sort of validation of heights.

Table 3: The products and services of the modernized NSRS – Planned for release in 2022.

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

NSRS Database	• Repository for ***all*** data in the NSRS
	  • The NOAA CORS Network
	  • Orbits
	  • Raw data
	  • Computed data
	  • Definitional data
	  • Metadata
	  • Versioning
	• Geospatial
	• Temporal
	• Data Delivery System for Points/Marks, Stations and Sites, Projects, Data and more
	  • Capable of geospatial queries
	  • Capable of generating time dependent plots
	  • Capable of pulling data by project
	  • CORS metadata / selection tool
		Incomplete	2019: Alpha version exists with basic information and data models

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

"The NOAA CORS Network"[3] : Modernized	• Maintain NGS position as an IGS Analysis Center
	• Continue to compute orbits daily/weekly
	• ITRF2014[4] coordinate functions on all CORSs
	• All coordinate functions can, with 100% certainty, be attached to an identified GRP at each CORS
	• Non-linear functions as applicable
	• Colored noise as applicable
	• Daily processing methodology updated to be scalable to significantly more CORSs than NGS currently processes to allow for these possibilities:
	  • Fast re-processing upon release of new ITRFs
	  • Ingestion of all RTN base stations in the USA
	  • Ingestion of other CGNSS networks
	  • Ingestion of all CGNSS at all USA tide/water stations
	  • To increase the density of input data to the Intra-frame velocity model (IFVM2022)
	• Definition of "Persistent Disagreement"[5] between daily Final Discrete Coordinates and Final Running Coordinates ("coordinate function") exists
	• Policies and procedures exist for when a CORS has "Persistent Disagreement" as above:
	  • Remove a CORS from OPUS
	  • Update its Final Running Coordinates ("coordinate function")
	  • Return the CORS to OPUS
		Incomplete	2017: NGS began reprocessing all data in the NOAA CORS Network to arrive at piecewise linear ITRF2014 coordinate functions good through 2017. In 2019, those coordinate functions are available in BETA form. No other components listed under the "Description" are part of this computation
			
			2019: Alpha version using only piecewise linear ITRF2014 coordinate functions will be available by Summit (May)

[3] "The NOAA CORS Network" or NCN is the recently adopted name of the network of all CORSs which are managed at NGS. This was adopted as a solution to the problem that "CORS" was being used both to mean one station as well as to mean "the network of all stations". See *Blueprint for 2022, Part 3: Working in the Modernized NSRS* for more details.

[4] As of 2019, NGS policy is that the definition of NATRF2022, PATRF2022, MATRF2022 and CATRF2022 will be tied to ITRF2014. A release, and subsequent adoption at NGS, of a new ITRF prior to 2022 will likely necessitate an update to that policy.

[5] See *Blueprint for 2022, Part 3: Working in the Modernized NSRS* for more details.

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

OPUS: "For Everything" (for customers)	• Framework for ingesting/processing all survey data
	• One project name, regardless of how many types of data are in that project
	• Allow each data type in a project to be processed independently "in tabs" and data to "flow" between the tabs
	• Project planning assistance from NGS, if needed
	• Project tracking
	• Three related tasks :
	  • *Mark Recovery/New Mark Reporting*
	  • *Single occupation processing*:
	  • GNSS
	  • Relative Gravimetry for vertical gradients
	  • Absolute Gravimetry
	  • *Project processing*
		Incomplete	2018: Began build
			
			2019: Alpha version being developed for end of 2019

OPUS: Mark Recovery (for customers)	• Platform-independent[6] mark reporting page • Searches database based on position of user • Photo comparison software for validation • Feeds database • Simple: Photo + Position = "Submit" • Complex: Descriptive information; add to project	**Incomplete**	2018: Began build 2019: Alpha version available circa 2019: https://beta.ngs.noaa.gov/cgi-bin/recvy_entry_www.prl

[6] Should work in any browser, whether on a smartphone, tablet or computer.

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

OPUS: GNSS <u>single-occupation</u> processing (for customers)	• Stand-alone occupation processing
	• Any/all GNSS constellations
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Provide Preliminary[7] coordinates at midpoint epoch of file:
	  • XYZ in ITRF2014, and all four *TRF2022
	  • $\phi\lambda h$ in ITRF2014, and all four *TRF2022
	  • H, ζ, η, N, g, H^{dyn} in NAPGD2022
	  • SPC, USNG and UTM
	• Uncertainty estimates for all coordinates
	• "Trust my metadata" button
	• Automated harvesting by NGS, of files with "trusted metadata"
	• Occupations between 15 min and 48 hours
	• RINEX 3 supported
		Incomplete	2017: PAGES re-write began. New employees hired. Basic pseudo-range positioning software written for each constellation. RINEX 3 read/write code running.
			
			2019: Alpha version is effectively "OPUS-S" running on ITRF2014 coordinates in the NOAA CORS Network, though with alpha versions of EPP2022 and GEOID2022 available, an addendum to OPUS-S output could easily add alpha versions of NATRF2022, PATRF2022, MATRF2022, CATRF2022 and NAPGD2022 coordinates.

OPUS: GNSS <u>project</u> processing (for customers)	• Input of either raw receiver files, pre-processed vectors or OPUS: Stand Alone GNSS runs
	• Project processing / adjustments
	  • Adjust to any epoch of choice
	  • Any control (passive/active) allowed
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Cooperate with other technique "tabs" in same project
	• Any GNSS constellation
	• CORS assessment/selection tool
	• "Submit" button
	• "NGS can harvest my data as I go" button
	• "Submit a correction" button
	• New terminology
	• GPS month-based warnings
		Incomplete	2018: RTK module begun
			2019: Development of final Least Squares Adjustment module began.
			
			2019: Alpha version allowing for RTK/vector input planned for Summer 2019 release. Will rely upon ADJUST in alpha.

[7] "Preliminary" coordinates are one of the five defined types of coordinates in the modernized NSRS. See *Blueprint for 2022, Part 3: Working in the NSRS* for more information.

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

OPUS: Leveling project processing (for customers)	• Require GNSS under specific rules[8]
	• Cooperate with other technique "tabs" in same project
	• Project processing / adjustments
	  • Adjust to any epoch of choice
	  • Any control (passive/active) allowed
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• "Submit" button
	• "NGS can harvest my data as I go" button
	• "Submit a correction" button
	• New terminology
	• Break over-long projects into 1 year sub-projects
		Incomplete	2017: Project began, but was put on hold to divert resources to completing the "OPUS: GNSS Project processing" project.
			
			2019: Alpha version will likely not be available this calendar year

[8] See *Blueprint for 2022, Part 3: Working in the modernized NSRS* for more details.

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

OPUS: RTN Alignment Service (for customers)	• Two level service
	• Level 1:
	  • NGS ingests ALL base station data and operator-provided coordinates of base stations for 24 hours, and computes the station-by-station, and network-average alignment to the NSRS on any given day
	  • NGS provides a mechanism for this to happen automatically. (If the complete modernization of The NOAA CORS Network happens, these stations will come in to NGS daily and NGS will do the processing an issue the daily alignment. If not, this processing should occur after NGS performs its daily processing of The NOAA CORS Network).
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Level 2:
	  • NGS provides a manual on geographic spacing and minimum revisit schedule necessary to achieve Level 2 service.
	  • RTN operator, or their designated representative, occupies passive control using the above-mentioned manual, operating two different types of equipment and software: (1) a GNSS rover using only the RTN data and RTN software itself and (2) GNSS equipment capable of using NGS software and The NOAA CORS Network only.
	  • NGS processes all of these occupations, comparing derived coordinates and computes the mark-by-mark, and network-average alignment to the NSRS based on these passive mark occupations.
	  • Using a least-squares adjustment scheme developed explicitly for this process
			2013: Commitment by NGS to have service operational by 2015 is codified in NGS Ten Year Plan
			
			2013-2019: Project fails to make significant progress for a variety of reasons
			
			2019: No alpha version will be available

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

Comprehensive Coordinate Conversion and Transformation Engine (in two tools: NCAT and VDatum)	• One do-it all tool
	• Point by point
	• File Upload
	• Web services
	• Downloadable
	• Common code between all NGS tools
	  • NADCON
	  • VERTCON
	  • All hybrid geoid models
	  • All gravimetric geoid models
	  • All hybrid DoV models
	  • All gravimetric DoV models
	  • All 14 parameter transformations (including EPP2022)
	  • EPP2022
	  • IFVM2022
	  • XYZWIN
	  • UTMS
	  • USNG
	  • GGPCGP
	  • SPC83
	  • DYNAMIC_HT
	  • IGLD85
	  • SPCS2022
	  • GEOID2022
	• GRAV2022
		Incomplete	2019: Alpha version will be current versions of NCAT and VDatum. The current NCAT functionality is shown in blue in the list to the left.

The NGS Toolkit: Modernized	• *Integration* of CALIBRATE, Translev, WinDESC, LOCUS, LOOP and MTEN4 into OPUS as necessary • *Deprecation* of old, outdated code (GEOCON, ADJUST, LVL_DH, etc) • *Replacement* of old code with new (GRAV2022, IFVM2022) • *Creation* of exo-NGS software distribution center • *Creation* of other integrated code (INVERSE, FORWARD, INVERS3D and FORWRD3D could be 1 piece of code)	**Incomplete**	*2019: No alpha versions of the components of this project will be released, as the project has no PM, and much of this work is of lower priority than other ongoing work*

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)
Manual: GNSS	• Built on information since 1997 • Stand alone occupations • Short/long occupations • Networks • RTK/N	**Incomplete**	2019: The manual will be complete before the end of the calendar year.
Manual: Leveling	• Update to existing manual, incorporating new information and requirements • River Crossings with total station • GNSS requirements for NSRS incorporation	**Incomplete**	*2019: Project at an impasse due to personnel limitations. No alpha version expected.*
OPUS: **GNSS GPS Month-based processing (internal)**	• Every GPS month, create a GPS month-based project from 3 GPS months ago, internal to NGS • Harvest all GNSS data submitted in that older GPS month (whether as independent occupations or in projects) • Run raw data through OPUS, using hub-and-spoke method • Analyze the results of these solutions against those which yielded "Preliminary" results for users. Issue warnings for severe cases of disagreement. • Take all solutions, all submitted vectors, and the IFVM and perform an adjustment yielding FD coordinates in all 5 frames (XYZ, lat/lon/eht, plus oht, and including all uncertainties). Load all of this into the NSRS db. • Using a least-squares adjustment scheme developed explicitly for this process	**Incomplete**	2018: Project to scope out the resources needed to organize all bluebooked project data into raw data for re-processing yielded 40 person-year estimate. Investigation to prioritize which data needed to be reprocessed versus using existing vectors begun. No software yet established, nor LSA scheme formalized. *2019: No alpha version expected*

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

OPUS: Leveling project and/or multi-project processing (internal)	• Analyze submitted Leveling projects for compliance with NGS requirements
	• Analyze submitted Leveling projects for the possibility (albeit slim) that they overlap with another Leveling project, and combine all overlapping leveling projects into a single adjustment
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Create an internal project to NGS to process one (or more, if overlapping) leveling projects
	• Cooperate with GNSS "tab" in same project
	• Project processing / adjustments
	  o Process GNSS data into FD coordinates at survey epoch, and determine the "leveling adjustment epoch"
	  o Adjust leveling data to the "leveling adjustment epoch"
	• Load all FD information into the NSRS DB
		Incomplete	2019: No significant effort has yet been put toward this project, due to the overwhelming need to get GPS data processed first. Without GPS based NAPGD2022 heights, historic leveling has nothing to be re-adjusted to.
			
			2019: No alpha version expected

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)

OPUS: <u>Reference-Epoch</u> processing for lat/lon/eht/oht (internal)	• Every five years, beginning in 2022, create a reference epoch computation project internal to NGS for the reference epoch of 2 years past (2020.0 in 2022, 2025.0 in 2027, etc)
	• Harvest all Final Discrete lat/lon/eht/oht/gravity/DoV coordinates (and uncertainty estimates) in the NSRS Database and add to the project
	• Using FD **lat/lon/eht/oht** coordinates (and uncertainty estimates), IFVM2022 (and uncertainty estimates) and GEOID2022 (and uncertainty estimates) as input, estimate lat/lon/eht/oht Reference Epoch coordinates at all input points
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Using GRS-80, compute **XYZ** Reference Epoch coordinates (and uncertainty estimates)
	• Using FD **gravity** coordinates (and uncertainty estimates), IFVM2022 (and uncertainty estimates) and GRAV022 (and uncertainty estimates) as input, estimate gravity Reference Epoch coordinates at all input points
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Using FD **DoV** coordinates (and uncertainty estimates), IFVM2022 (and uncertainty estimates), GRAV022 (and uncertainty estimates) and GEOID2022 (and uncertainty estimates) as input, estimate DoV Reference Epoch coordinates at all input points
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Load all of this into the NSRS db.
		Incomplete	2019: The decision to process on five year bases is codified in Blueprint for 2022, Part 3. The general methodology remains under investigation.
			
			2019: No alpha version expected

NADCON: Connecting NAD 83(11) epoch 2010.00 to **TRF2022 epoch 2020.00 (internal)**	• The final stand-alone NADCON • Computed in 2022 using the 2020.0 RE coordinates computed in that same year	**Incomplete**	2017: NADCON 5 completed, with a complete re-build of the software which will be used 2019: CORS data will be used to compute a simple alpha version

Name	Description (Already available portions in blue)	Status	Status (2019 Alpha status in BLUE)
VERTCON: Connecting NAVD 88 and other vertical datums to NAPGD2022 epoch 2020.00 (internal)	• The final stand-alone VERTCON • Computed in 2022 using the 2020.0 RE coordinates computed in that same year	**Incomplete**	2017: NADCON 5 completed, with a complete re-build of the software which will be used 2019: GPSBM data (from GEOID18 etc.) used to generate an alpha version
SPCS2022	• State Plane Coordinate System of 2022 • Based on user feedback	**Incomplete**	*2019: Alpha versions available at: https://www.ngs.noaa.gov/SPCS/download.shtml*

Table 4: The products and services of the modernized NSRS – Planned for release *after* 2022

Name	Description	Status	Status description

OPUS: Absolute Gravity single-occupation processing (for customers)	• Stand-alone occupation processing
	• Using "g" or other software
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Provide Preliminary[9] coordinates at midpoint epoch of file:
	  • g in NAPGD2022
	• Uncertainty estimates for all coordinates
	• "Trust my metadata" button
	• Automated harvesting by NGS, of files with "trusted metadata"
	• All equipment supported
		Incomplete	2019: Most work of this sort is processed in existing software outside of OPUS. Thus no engine need be created, but an interaction with "g", interactions with other data types, and an NSRS DB feed mechanism still need to be built.
			
			2019: No alpha version expected

OPUS: Vertical Gravity Gradient single-occupation processing (for customers)	• Stand-alone occupation processing
	• Relative-gravimeter based g-pod occupations
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• Provide Preliminary[10] coordinates at midpoint epoch of file:
	  • dg/dh in NAPGD2022
	• Uncertainty estimates for all coordinates
	• "Trust my metadata" button
	• Automated harvesting by NGS, of files with "trusted metadata"
	• All equipment supported
		Incomplete	2019: Most work of this sort is processed in existing NGS software outside of OPUS, however it is currently in MATLAB. Thus the engine needs to be (a) checked for LSA consistency with the rest of OPUS and (b) converted to a language used inside OPUS. Then, interactions with other data types, and an NSRS DB feed mechanism still need to be built.
			
			2019: No alpha version expected

[9] "Preliminary" coordinates are one of the five defined types of coordinates in the modernized NSRS. See *Blueprint for 2022, Part 3: Working in the NSRS* for more information.
[10] "Preliminary" coordinates are one of the five defined types of coordinates in the modernized NSRS. See *Blueprint for 2022, Part 3: Working in the NSRS* for more information.

Name	Description	Status	Status description

OPUS: Classical <u>project</u> processing (for customers)	• Follow specific rules for classical surveys in the modernized NSRS (such as requiring GNSS)[11]
	• Input of angles and distances
	• Cooperate with other technique "tabs" in same project
	• Project processing / adjustments
	  • Adjust to any epoch of choice
	  • Any passive control allowed
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• "Submit" button
	• "NGS can harvest my data as I go" button
	• "Submit a correction" button
	• New terminology
	• Break over-long projects into 1 year sub-projects
		Incomplete	2019: Most work of this sort is processed in existing software outside of OPUS (StarNET). Thus the engine needs to be created from scratch inside NGS to have LSA consistency with the rest of OPUS. Then, interactions with other data types, and an NSRS DB feed mechanism still need to be built.
			
			2019: No alpha version expected

OPUS: Relative gravity <u>project</u> processing (for customers)	• Follow specific rules for relative gravity surveys in the modernized NSRS (such as requiring GNSS)[12]
	• Input of relative gravimeter data
	• Cooperate with other technique "tabs" in same project
	• Project processing / adjustments
	  • Adjust to any epoch of choice
	  • Any passive control allowed
	  • Using a least-squares adjustment scheme developed explicitly for this process
	• "Submit" button
	• "NGS can harvest my data as I go" button
	• "Submit a correction" button
	• New terminology
	• Break over-long projects into 1 year sub-projects
		Incomplete	2019: Most work of this sort is processed in existing NGS software outside of OPUS, however it is currently in MATLAB. Thus the engine needs to be (a) checked for LSA consistency with the rest of OPUS and (b) converted to a language used inside OPUS. Then, interactions with other data types, and an NSRS DB feed mechanism still need to be built.
			
			2019: No alpha version expected

[11] See *Blueprint for 2022, Part 3: Working in the modernized NSRS* for more details. However, the rules for requiring GNSS for Classical surveys has not yet been detailed.
[12] See *Blueprint for 2022, Part 3: Working in the modernized NSRS* for more details. However, the rules for requiring GNSS for Classical surveys has not yet been detailed.

Name	Description	Status	Status description
OPUS: Special Support for Calibration Baselines (for customers)	• To establish, correct or simply use a CBL • Relies upon other OPUS tools (GNSS and/or leveling and/or classical) • Loads the NSRS Database	**Incomplete**	2019: Most work of this sort is processed in existing NGS software outside of OPUS (CALIBRATE), however it is currently in Visual BASIC. Thus the engine needs to be (a) checked for LSA consistency with the rest of OPUS and (b) converted to a language used inside OPUS and (c) coded with rules specific for calibration baselines. Then, interactions with other data types, and an NSRS DB feed mechanism still need to be built. *2019: No alpha version expected*
OPUS: Special Support for Airport Surveys (for customers)	• To support the airport survey program of NGS • Relies upon other OPUS tools (GNSS and/or leveling and/or classical) • Loads the NSRS Database	**Incomplete**	2019: Most work of this sort is processed in existing NGS software. Thus the engine needs to be (a) checked for LSA consistency with the rest of OPUS and (b) converted to a language used inside OPUS and (c) coded with rules specific for airport surveys. Then, interactions with other data types, and an NSRS DB feed mechanism still need to be built. *2019: No alpha version expected*
OPUS: Special Support for new CORS installation (for customers)	• To provide owner's of new CORSs with the tools and path necessary to become part of the NOAA CORS Network • Relies upon other OPUS tools (GNSS) • Loads the NSRS Database	**Incomplete**	2019: Applications for a station to join the NOAA CORS Network are not currently done in OPUS. However it is envisioned that this would be the process, with requests handled digitally, and a data stream set up to feed into NGS for testing. Eventually this would then allow the already-tested station to slide effortlessly into official membership in The NOAA CORS Network. *2019: No alpha version expected*