ATTACHMENT 1

STATEMENT OF WORK

Commercial Radio Occultation Data Purchase: 2020 - 2022

INTRODUCTION

In order to respond to an ever-growing demand for environmental information, NOAA continually strives for an observing enterprise that is flexible, responsive to evolving technologies and economically sustainable, while continuing to be a leader and member of the global meteorological community. To help meet these goals, NOAA is interested in purchasing commercially-available Earth observing data that satisfy observational requirements at a lower cost than government-provided alternatives. Having previously evaluated satellite-based radio occultation (RO) data from multiple sources for use in weather models and other systems, NOAA seeks to enter into one or more contracts to purchase near-real-time satellite-based RO data from commercial vendors.

SCOPE

NOAA intends to:

- Acquire near-real-time global navigation satellite system (GNSS) Level-0 RO and associated data from Commercial Providers, which will be delivered through a secure ingest portal to NOAA
- Derive neutral atmospheric and ionospheric products from the Level-0 data, including:
    - profiles of bending angle, refractivity, temperature and potentially water vapor from the mid-stratosphere to the lower troposphere, and
    - ionospheric absolute total electron content (TEC), electron density profiles (EDPs), amplitude and phase scintillation
- Ingest and integrate these derived parameters into NOAA's operational data systems, including weather and space weather prediction models, situational awareness products, and other operational applications.
- Share the near-real-time data and/or products with NOAA global meteorological partner agencies, and share the historical data and products with the community at large for climate monitoring and research efforts
- Archive the data for future access consistent with data rights specified in contract terms.

I. ELIGIBILITY FOR AWARD

In order to be eligible for award, vendors must have at least one operational RO instrument in low-Earth orbit, and a system capable of delivering data from that instrument, consistent with all latency and spatial distribution requirements detailed in this notice, as of the date of this request for proposals (RFP). Contingency awards will not be considered for this contract, and proposals received that do not meet this requirement will not be evaluated.

II. DATA SPECIFICATIONS

NOAA requires near-real-time delivery of on-orbit RO measurements, Precise Orbit Determination (POD) tracking data, and associated onboard measurements, per below, as Level 0 data. Level 0 data are defined as: reconstructed, unprocessed instrument POD and RO measurements as collected in real-time, at full resolution, with all communications artifacts removed (e.g., synchronization frames, communications headers). (Definition based on https://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products)

Unless otherwise specified below, data shall meet the following minimum requirements for all deliveries. [Note: these requirements may be revised upon award.]

1. RO Data Properties and Quality

1.1. RO soundings shall provide dual-frequency open-loop measurements as acquired on-orbit in real-time at either a 50 Hz or 100 Hz data rate.

1.2. RO data shall be provided with concurrent POD tracking data.

1.3. The contractor shall provide the signal-to-noise ratio (SNR) conversion factor from db-Hz to Volts/Volts, if applicable.

1.4. The top tangent point altitude of an occultation shall be at or above 90 km and the bottom tangent point altitude shall be below 10 km.

1.5. Level 1 SNR, averaged between 60-80 km, shall be greater than 200 Volts/Volt (V/V) in a 1 Hz band.

1.6. The maximum relative difference between the bending angle and the National Center for Atmospheric Research (NCAR) climate model between 25-40 km shall not exceed 0.25.

1.7. The standard deviation of the relative difference between the bending angle and the NCAR climate model between 25-40 km shall not exceed 3×10^{-5}

1.8. The maximum relative difference between the refractivity and the NCAR climate model between 10-60 km shall not exceed 0.5.

1.9. The maximum absolute difference of raw (unfiltered) L1 and L2 excess phase finite differences between 20-40 km shall not exceed 0.1 m/sample.

1.10. The mean difference between the bending angle and the NCAR climate model between 60-80 km shall not exceed 10^{-4} radians.

1.11. The median standard deviation over 30 days of the difference between the bending angle retrievals and the NCAR climate model between 60-80 km shall not exceed 3 microradians.

1.12. Not more than 20% of the bending angles beneath 60 km in a profile shall exceed the Numerical Weather Prediction (NWP) Quality Control (QC) model comparison threshold described in Appendix A.

2. POD Tracking Data Properties

2.1. POD tracking data as acquired on-orbit in real-time shall be provided, including dual-frequency pseudorange, carrier phase, and SNR.

2.2. POD tracking data shall include dual frequency measurements from a minimum of four GNSS satellites simultaneously for 95% of the POD data collection period.

2.3. POD tracking data shall be recorded at 1 Hz or faster.

2.4. Every other orbit of each satellite shall be covered by POD data at no less than 50% duty cycle with minimum continuous arc length of 50 minutes per orbit.

2.5. POD tracking data shall be collected using the following GNSS: GPS, GLONASS, or Galileo.

3. Onboard Navigation Solutions

3.1. Navigation solutions calculated onboard the spacecraft shall be provided, including at a minimum: receiver clock offsets, and time-tagged Earth-Centered-Earth-Fixed position and velocity.

3.2. Navigation solution data shall be provided at intervals of 30 seconds or less.

4. Onboard Receiver Clock

4.1. The contractor shall provide a description of the onboard receiver clock steering methods to enable NOAA to determine any needed processing adjustments on the ground.

4.2. If the POD and RO receiver clocks are not the same, the contractor shall provide a description of how to align them for single difference RO data processing.

5. Satellite Attitude Quaternion Data

5.1. Attitude quaternion data shall be collected concurrently with all POD and RO data.

5.2. Attitude quaternion data shall be collected every 30 seconds or more frequently.

6. Geographic Distribution

The geographic location of a sounding or occultation is defined as the latitude and longitude of the measurement at the 500 meter excess phase point.

6.1. The system shall provide neutral atmospheric soundings with near-uniform global coverage. The number of profiles provided each day shall not vary by more than a factor of three (3) between any 30 degree latitude band.

6.2. Within any 30 degree latitude band, the number of profiles provided each day within a 30 degree longitude section shall not vary by more than a factor of three (3) from any other 30 degree longitude section.

7. Temporal Distribution

The time of a sounding or occultation is defined as the Coordinated Universal Time (UTC) of the measurement at the 500 meter excess phase point.

7.1. Daily variability: The quantity of RO occultations delivered in any six-hour period of the day (0:00-6:00, 600-12:00, 12:00-18:00, or 18:00-24:00 UTC), when averaged over 30 consecutive days, shall vary by less than a factor of two from any other six-hour period.

8. Metadata

8.1. Metadata shall include, at a minimum, for each satellite/instrument configuration:

8.1.1. Satellite mass, center of mass, external dimensions including any protruding appendages (ex. solar array wings, antennae), satellite coordinate system geometry, POD and RO antenna reference vectors relative to the center of mass, antenna boresight vectors, and antenna fields of view, and

8.1.2. RO and POD antenna phase center offset and phase center variation measurements and corresponding uncertainty estimates, in ANTEX format (https://kb.igs.org/hc/en-us/articles/201096516-IGS-Formats).

9. Data Formats

9.1. The contractor shall deliver RO tracking data as high-rate occultation Level 0 files.

9.2. The contractor shall deliver all POD tracking data as Level 0 files.

9.3. The contractor shall deliver on-orbit computed navigation solution data as Level 0 files or in SP3 format (https://kb.igs.org/hc/en-us/articles/201096516-IGS-Formats).

9.4. The contractor shall deliver all attitude quaternion data as Level 0 files.

9.5. The data descriptor files shall conform to the International Organization for Standardization (ISO) 19115-1:2014 (content) and ISO 19139 (XML schema) standards, in accordance with the NOAA Environmental Data Management Framework.

III. DATA DELIVERY REQUIREMENTS

1. In order for NOAA to prepare for operational ingest, at least 30 days prior to the start of the first operational data delivery Period of Performance (POP), the contractor shall coordinate with NOAA to provide:

1.1. At least 24 hours of contiguous on-orbit data, representative of that to be provided during the data delivery period and compliant with the data requirements specified herein

1.2. Metadata (IV.8.1) necessary to prepare ground processing so NOAA may integrate the data into its operational data systems

1.3. A detailed Level 0 data decoding dictionary for each to-be-delivered Level 0 data type. If delivered in binary format, in addition to the dictionary, deliver binary decoder software as source code.

1.4. For any proposed non-mandatory data, at least 72 hours of representative data for the same time period as the representative on-orbit data sample

2. Data files shall be named according to the file naming conventions used by the University Corporation for Atmospheric Research (UCAR) COSMIC Data Analysis and Archive Center (CDAAC), as defined at https://cdaac-www.cosmic.ucar.edu/cdaac/doc/formats.html. Offerors who cannot comply with the file name convention used by the CDAAC shall propose an alternative naming convention. Acceptance of any alternative naming conventions is at the discretion of the Government.

3. Each data delivery shall include:

3.1. RO measurements and associated data (e.g., POD, spacecraft attitude)

3.2. Satellite identifier and the date and times of: acquisition of observation, receipt at ground station, and readiness of TAR files for submission to NOAA, using a known time reference system with specified epoch. GPS Reference Time epoch is preferred, but not required.

3.3. Data descriptor files in the XML format, providing a description of each batched delivery of related data files, enabling off-line archive users to search the descriptor to locate RO and POD instrument data files and their associated metadata files.

4. The data descriptor files shall conform to the ISO 19115-1:2014 (content) and ISO 19139 (XML schema) standards, in accordance with the NOAA Environmental Data Management Framework.

5. The contractor shall deliver data to NOAA batched per downlink as compressed TAR files, with each TAR file including concurrent POD, RO, and all related satellite data files, and with file names correlating file types.

6. The contractor shall deliver all files to the NOAA Operational Secure Ingest System (OSIS) in accordance with the OSIS Interface Control Document (latest version).

7. The contractor shall, upon receipt of OSIS alert or failure notification, resolve and (as needed) redeliver data files when data latency requirements can still be met.

8. Re-delivered file names shall include a date or identifier unique to that delivery.

9. Latency

9.1. Latency shall be defined per-observation as the time from onboard collection to the delivery of the data to the NOAA OSIS interface.

9.2. All delivered measurements shall have a latency of 140 minutes or less.

10. Data Quantity:

Delivery Orders under this contract will specify a quantity of quality controlled (QC'd) profiles required on a daily basis that can be assimilated by the National Centers for Environmental Prediction (NCEP) for NWP. A profile is defined as a time series of RO observations made during an occultation event that NOAA can process into a quasi-vertical series of bending angles.

10.1. Profiles shall pass the QC processes described herein. For reference, NOAA's combined data QC processes rejected an overall average of approximately 34% of the received observations during the Commercial Weather Data Pilot (CWDP) Round 2 Pilot Study.

IV. GENERAL REQUIREMENTS

1. The contractor shall participate in a post-award kick-off meeting.

2. The contractor shall be available to discuss deliveries, support initial data integration, discuss anomalies, and provide sustaining engineering information, if necessary, through the end of the contract Period of Performance.

3. For any sensor or system change that may affect data delivery or data quality in any way (e.g., spacecraft, instrument, software, configuration, or other processing change), the contractor shall provide written notification to NOAA of pending change no less than fourteen (14) days in advance of its implementation and shall include a description of the planned change as well as any impacts on the operations concept, configuration, delivery, or data content.

4. The contractor shall provide timely notification to NOAA designated points of contact of anomalies and

events that impact or have the potential to impact data deliveries or data volumes.

5. The contractor will only be paid for data delivered that meets the above Data Specifications and Data Delivery requirements.

6. The contractor shall provide a method of contact that is available 24x7 and will respond within 30 minutes of notification by NOAA to investigate and resolve data delivery or performance issues.

V. CONTRACTING OFFICER'S REPRESENTATIVE AND TASK MANAGER

1. In accordance with CAR Clause 1352.201-72, a Contracting Officer's Representative (COR) will be designated at award. The COR may provide technical direction and has the authority to accept delivery. The COR is not authorized to make any commitments or otherwise obligate the Government or authorize any changes which affect the contract price, terms, or conditions of the award. Any Contractor request for changes shall be referred to the Contracting Officer directly or through the COR. No such changes shall be made without the express written prior authorization of the Contracting Officer.

2. A Task Manager (TM) will be designated at award. The TM does not have delegated authority to represent the Contracting Officer or bind the Government. The TM cannot change, waive, add, or request any additional specifications or performance. The Contractor shall notify the COR and the Contracting Officer, in writing, of any contract administration issues, including, but not limited to, changes in anticipated data delivery timelines or data specifications, as soon as they become known.

VI. PERIOD OF PERFORMANCE

The Contract Period of Performance will be from September 30, 2020 through September 29, 2022. This Period of Performance will consist of one base year September 30, 2020 through September 29, 2021, and one option year September 30, 2021 through September 29, 2022.

VII. SECURITY REQUIREMENTS

1. The contractor shall comply with CAR 1352.239-72, section (i). The contractor may request COR approval of alternate security accreditation methodologies for compliance with section (i) including: information security assessment methodology promulgated by the U.S Federal Government (specifically, National Institute of Standards and Technology (NIST) Special Publication (SP) 800-37 and NIST SP 800- 53), or internationally recognized private industry information technology (IT) security frameworks (such as International Standards Organization (ISO)/International Electrotechnical Commission (IEC) 27033, 27001, 27006 and 27002, or Control Objectives for Information and Related Technology (COBIT)).

2. The contractor shall deliver files to NOAA ingest using either Hypertext Transfer Protocol Secure (HTTPS) (preferred) or Secure File Transfer Protocol (SFTP).

3. Data integrity method shall be approved by NOAA. Examples include SHA256 or Digital certification.

4. Certificate shall be approved by NOAA. Examples include GNUpg/OpenSSL Self-Signed, Trusted CA, Federal Bridge CA, or Department of Defense.

VIII. DATA RIGHTS

NOAA shall have unlimited rights (as defined at FAR 52.227-14) to all data delivered by the Contractor pursuant to this contract. Furthermore, the Contractor waives potential copyright and related rights in all data delivered to NOAA pursuant to this contract worldwide through the Creative Commons 1.0 Universal Public Domain Dedication (https://creativecommons.org/publicdomain/zero/1.0/).

At their discretion, the contractor may propose additional, different data rights at different data price levels. However they must, at a minimum, propose delivery with unlimited rights as specified above for their proposal to be acceptable.

IX. NONCONFORMANCE

This contract is subject to FAR 52.212-4, Contract Terms and Conditions, Commercial Items. Pursuant to 52.212-4(o), Warranty, the Contractor warrants and implies that data delivered complies with the requirements and is fit for the particular purpose of this contract. In accordance with FAR 52.212-4(a), the Government may require replacement of nonconforming data at no increased cost or exercise its right to terminate in part or in full in accordance with FAR 52.212-4(l) or (m).

ADDITIONAL CAPABILITIES THAT MAY BE SOUGHT UNDER A DELIVERY ORDER

The following list represents examples of additional specifications which the government may consider under a Delivery Order. These are not requirements.

- Lower-latency Level 0 data. The usefulness and NWP impact of observations falls off continuously with time after collection, even before the maximum allowable latency time expires. This is especially true for ionospheric data. For example, ionospheric data delivered to NOAA within approximately 22 minutes of observation will have additional uses in space weather nowcasting and other applications.

- Mid- to high-latitude data. NOAA ingests RO observations from numerous missions to fulfill its RO requirement. With the launch of Constellation Observing System for Meteorology, Ionosphere, and Climate-2 (COSMIC-2), NOAA has adequate RO coverage in the equatorial region. In order to provide more homogeneous RO coverage for the weather models, NOAA may desire to solely purchase data outside of the equatorial region.

- Higher signal-to-noise ratio data. Data with superior SNR (measured as V/V) are of increased value to NOAA for both neutral atmosphere and space weather applications, as they provide higher-fidelity products for modeling and prediction. For example, data yielding bending angle STDV of less than 2 microradians will be of greater use to NOAA.

- Local time sampling. A set of measurements that samples all local times in as uniform a pattern as possible will help capture information related to the diurnal cycle and are therefore desired.

- Space Weather Observations. Ionospheric measurements collected from negative elevation angle to zenith would be beneficial. Specifically, observations that enable the retrieval of electron density profiles in the 60 - 800 km height range, S4 indices, and sigma-phi would be useful, as would data that enable derivation of in situ electron and/or total mass density.

APPENDIX A: Numerical Weather Prediction Quality Control Process

NWP QC Test for Commercial RO

Definitions:

O = Bending angle from the RO observation.

z = Impact height of bending angle observation
(Only bending angles beneath 60 km are considered.)

B = Background bending angle at z, assuming GFS analysis
ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod
https://rda.ucar.edu/datasets/ds084.1/#!description

Threshold Process:

For $z < 10$ km: Reject if $\left(\frac{|O-B|}{O} > 1 - 0.9375\frac{z}{10\text{ km}}\right)$

For $z \geq 10$ km: Reject if $\left(\frac{|O-B|}{O} > \max\left(0.0625, \frac{15\ \mu rad}{O}\right)\right)$