AtmOS HSRL Lidar Instrumentation

Solicitation Number: RFI-GSFC-AtmOS-HSRL Lidar
Agency: National Aeronautics and Space Administration
Office: Goddard Space Flight Center
Location: Office of Procurement

Notice Type:
Sources Sought

Posted Date:
7/22/2021

Response Date:
8/21/2021

SYNOPSIS

NASA Goddard Space Flight Center is hereby soliciting information from potential sources for flight High Spectral Resolution Lidars (HSRL) for potential future AtmOS acquisition.

The National Aeronautics and Space Administration (NASA) GSFC is seeking capability statements from all interested parties, including all socioeconomic categories of Small Businesses and Historically Black Colleges and Universities (HBCU)/Minority Institutions (MI), for the purposes of determining the appropriate level of competition and/or small business subcontracting goals for flight HSRL Lidars for potential future AtmOS acquisition. The Government reserves the right to consider a Small, 8(a), Women-owned (WOSB), Service Disabled Veteran (SD-VOSB), Economically Disadvantaged Women-owned Small Business (EDWOSB) or HUBZone business set-aside based on responses received.

No solicitation exists; therefore, do not request a copy of the solicitation. If a solicitation is released, it will be synopsized on SAM.gov. Interested firms are responsible for monitoring this website for the release of any solicitation or synopsis.

Interested firms having the required capabilities necessary to meet the requirements described herein should submit a capability statement of no more than 25 pages indicating the ability to perform all aspects of the effort.

Please advise if the requirement is considered to be a commercial or commercial-type product. A commercial item is defined in FAR 2.101.

This synopsis is for information and planning purposes only and is not to be construed as a commitment by the Government nor will the Government pay for information solicited. Respondents will not be notified of the results of the evaluation.

AtmOS BACKGROUND

The Atmosphere Observing System (AtmOS) was established by the NASA Science Mission Directorate Earth Science Division to fulfill the science needs proffered in the 2017 Earth Science Decadal Survey for the combined Designated Observables: Aerosols and Clouds, Convection and Precipitation (ACCP). The AtmOS Constellation Architecture is the result of a 2.5 year ACCP Architecture Study. The ACCP Architecture Study concluded in February 2021 and the mission was authorized to move into Pre-Phase A on May 23, 2021. The respondent may find information on the study results including the Science and Applications Traceability Matrix at the ACCP Architecture Study website: https://vac.gsfc.nasa.gov.

The AtmOS Constellation will make measurements of the aerosol and cloud microphysical properties as well as the measurements of the vertical velocity of convection, aerosol redistribution and precipitation to understand the processes that drive the Earth's atmosphere. By employing a multi-satellite architecture, AtmOS will be able to cover the relevant temporal and spatial scales, thereby transforming our understanding of this critical part of the Earth System. As part of pre-formulation and formulation activities, the AtmOS team is performing trade studies to determine options to make measurements and achieve sampling to meet as many of the AtmOS science objectives as possible within cost and schedule constraints. Through this RFI, the AtmOS team seeks information on HSRL Lidar approaches to further refine the payload assignments, spacecraft needs, and mission concept of operations necessary to meet the science objectives.

The selected AtmOS architecture is illustrated in Figure 1**Error! Reference source not found.**. This architecture encompasses flight assets in two orbit planes: (1) Polar: Sun-Synchronous Orbit, 450 km, and 1330 Ascending Node and (2) Inclined: Nominally 50 to 65 Degree Inclination, 407 km. Within the AtmOS Constellation, Inclined Plane assets will be launched first to achieve earliest possible science with instruments that will make advancements in the understanding aerosol and cloud properties and target the **dynamics** of the cloud processes and precipitation on sub-daily to sub-minute time scales. The Polar Plane will follow a year or two later with more advanced measurements targeting the seasonal, global scale microphysical properties of clouds and aerosol and their linkage to atmospheric radiation and longer-term climate **change**. The constellation targets understanding the dynamics of the Earth's Atmosphere and the processes that drive change over time.

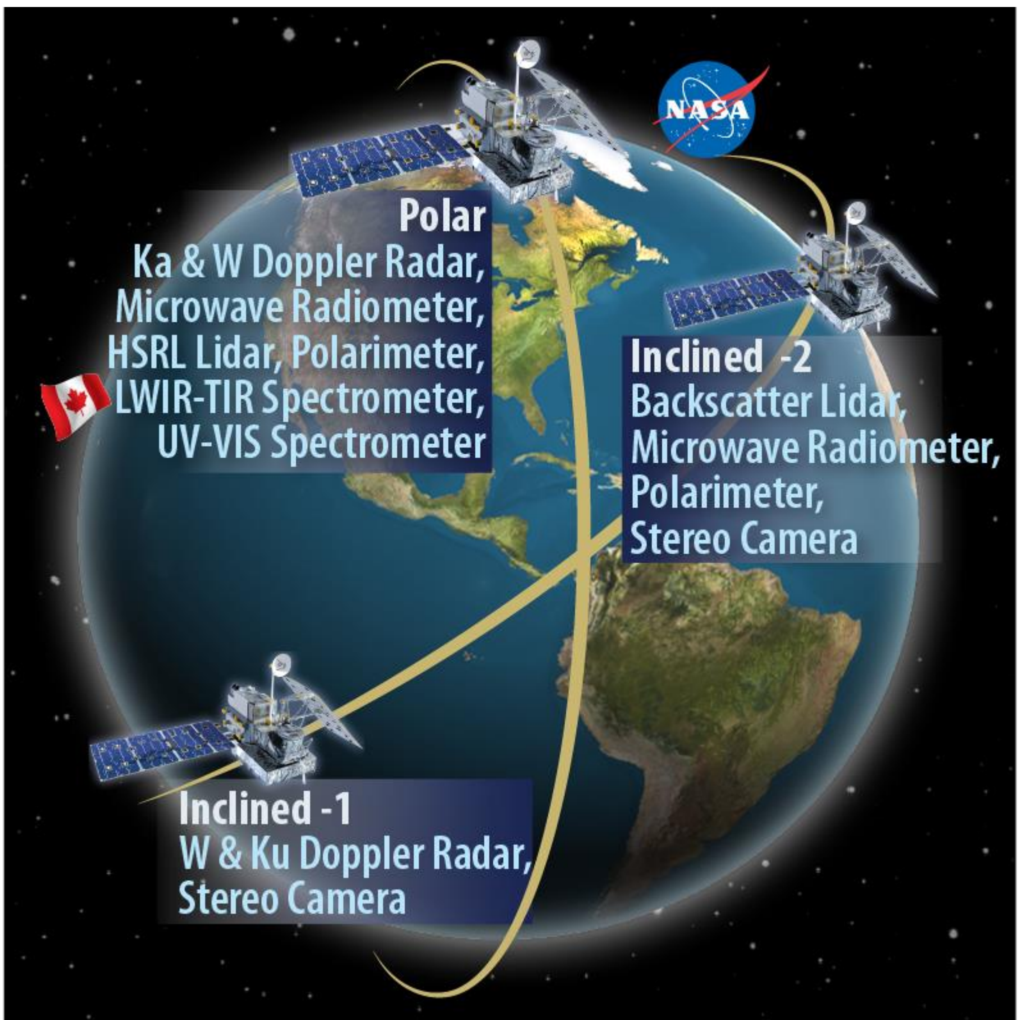

Figure 1 Preferred AtmOS Architecture Concept

While the concept illustrated in Figure 1**Error! Reference source not found.** accurately reflects the AtmOS intent, the number of spacecraft in the two orbit planes and the specific instrumentation assignment on the spacecraft remains under study during the pre-Phase A period.

The anticipated instrumentation suite for the AtmOS Constellation as assigned to the Inclined Orbit and the Polar Orbit is shown in Table 1. Note that some passive instrumentation/sensors (i.e. Polarimeter, Microwave Radiometer) are found in both orbit planes but their performance and spacecraft allocation needs may differ depending upon the assigned orbit plane. The High Spectral Resolution Lidar, subject of this RFI, is expected to fly on the Polar Orbit Plane.

Table 1 Anticipated AtmOS Science Instrumentation

Polar Orbit Plane Instrumentation	**Inclined Orbit Plane Instrumentation**	**Acquisition Comment for Passive Instruments**
---	W/Ku Band Doppler Radar	Subject of a separate AtmOS RFI
W/Ka Band Doppler Radar	---	Subject of a separate AtmOS RFI
---	Backscatter Lidar	Subject of a separate AtmOS RFI
High Spectral Resolution Lidar	**---**	**Subject of this AtmOS RFI**
LWIR-TIR Spectrometer	---	Proposed CSA Contribution
Microwave Radiometer	Microwave Radiometer	Subject of a separate AtmOS RFI
Polarimeter	Polarimeter	Subject of a separate AtmOS RFI
UV-VIS Spectrometer	---	Subject of a separate AtmOS RFI
---	Stereo Camera (Tandem Stereographic Cameras)	Subject of a separate AtmOS RFI

HSRL LIDAR PERFORMANCE

Lidar Introduction

Lidar measurements of backscatter, depolarization, and extinction, acquired during both daytime and nighttime, provide critical profile information for studying aerosol and cloud impacts on climate, weather, and air quality. Spaceborne lidar provides high vertical resolution profiles of aerosol and cloud distributions that complement both active (radar) retrievals of cloud properties and passive (polarimeter) retrievals of aerosol properties. Satellite lidars have provided essential measurements of aerosol and cloud vertical distributions (Winker et al. 2010, McGill et al. 2015). The continued need for lidar observations was recognized in the 2017 Decadal Survey (DS) which recommend lidar and multi-angle polarimeter observations to achieve the science goals of the Aerosols Designated Observable. Following the publication of the DS, NASA conducted a combined Mission Concept Study for the 1) Aerosols and 2) Clouds, Convection, and Precipitation (ACCP) Designated Observables. The ACCP Study confirmed that lidar observations were critical to provide many of the aerosol and cloud geophysical variables necessary to meet ACCP mission objectives, particularly when combined with polarimeter observations. Additionally, lidar observations of optically thin clouds and near-cloud top observations in optically thick clouds contribute significantly to the success of ACCP's cloud-related objectives.

HSRL Lidar Definition

Table 2 provides a set of target performance/capability values. Respondents are encouraged to provide information on reduced instrument performance if it can provide significant size, weight, and power (SWaP) or cost savings, or improved performance if it can be achieved without significant increase in SWaP or cost increase. The AtmOS objectives require a lidar that emits light at both 532 nm and 1064 nm and measures the subsequent light backscattered at these wavelengths. The laser transmitter output at both wavelengths should be linearly polarized to allow for measurements of the volume depolarization ratio, which is used to identify non-spherical particles such as dust and ice (Sassen and Cho 1992, Murayama et al. 2001). Depolarization measurements also provide a measure of the multiple scattering in water clouds (Hu et al. 2006). Additionally, lidar measurements at multiple wavelengths have sensitivity to particulate size (Oo and Holz 2011). For aerosol geophysical variables (GVs) to be retrieved with sufficient accuracy to allow the AtmOS objectives to be met, the use of the HSRL technique at 532 nm is required to isolate the attenuated molecular backscatter signal (i.e., product of the molecular backscatter and two-way transmission). This provides significantly more accurate GVs, including the aerosol optical depth and extinction profiles, particularly near the surface compared to a standard backscatter lidar. The HSRL technique also enables observations of additional aerosol intensive properties (e.g., the extinction-to-backscatter ratio, wavelength dependence of backscatter, particulate depolarization ratio) needed to advance the inference of aerosol type (Burton et al. 2012, Groß et al. 2012) that is crucial to multiple AtmOS objectives. It is also desirable to have a daytime SNR substantially better than the CALIPSO (Winker et al. 2010) for detecting tenuous aerosols (Thorsen et al. 2017) and a detector dynamic range large enough to accommodate the backscatter from liquid water clouds.

Table 2 HSRL Target Performance/Capabilities

Description	**Target Value**	**Rationale / Notes**
Laser wavelengths	532 & 1064 nm	Cloud-aerosol discrimination and aerosol size capabilities, consistency for climate record
Depolarization wavelengths	532 & 1064 nm	Aerosol typing and cloud phase capabilities
HSRL wavelength	532 nm	Isolating the attenuated molecular signal from the total/particulate signal
Range bin length[a]	<=30m	Near-surface retrievals
Laser pulse repetition frequency	As needed	Chosen so that the footprint spacing is continuous along track
Duty Cycle	>90%	Provide measurements in day and night conditions
Gain ratio uncertainty (knowledge): molecular to particulate channel	<3%	Daytime aerosol retrievals
Cross-talk between molecular and total/particulate channels[b]	<6%	Daytime aerosol retrievals
Cross-talk uncertainty (knowledge)	<15%	Daytime aerosol retrievals
532 nm backscatter calibration uncertainty	<3%	Daytime aerosol retrievals, 1064 nm calibration transfer
Polarization gain ratio uncertainty (knowledge)	<0.5%	Daytime aerosol retrievals
Calibration Methods	Responder to describe	Methods that enable the stated accuracies in the gain ratios, cross-talk, and calibration uncertainty targets above
Total/particulate attenuated backscatter SNR (532 nm)[c]	>9	Daytime aerosol retrievals
Molecular attenuated backscatter SNR (532 nm)[c]	>5	Daytime aerosol retrievals
Total attenuated backscatter SNR (1064nm)[c]	>7	Daytime aerosol retrievals
Maximum total attenuated backscatter (532 & 1064 nm)[d]	2.5 km^{-1} sr^{-1}	Detector dynamic range sufficient for bright liquid clouds
TRL	6	Required by PDR

[a] Desirable to have <=10m range bin length in the 532nm channel for retrievals in opaque clouds

[b] e.g., contrast ratio / particulate transmission ratio, impact of laser spectral purity, etc…

[c] Target SNRs for a 5-km horizontal and 30-m vertical resolution under daytime conditions (viewing zenith angle = 0^o, solar zenith angle = 30^o, surface reflectance = 0.05) for an aerosol target (single range bin of aerosol with backscatter

coefficients of $\beta(532\text{nm}) = 1\text{x}10^{-3}\ km^{-1}sr^{-1}$, $\beta(1064\text{nm}) = 8\text{x}10^{-4}\ km^{-1}sr^{-1}$) at 2 km altitude (no overlying particulate attenuation and molecular attenuation as determined from the US standard atmosphere).

[d] Desirable to have larger dynamic range than this target to accommodate ocean surface backscatter (to enable ocean-surface constrained retrievals) and the larger maximum cloud backscatter from a possible smaller range bin length[a]

HSRL LIDAR RESOURCE ALLOCATION TARGETS

The AtmOS team has developed target spacecraft resource allocations for the HSRL Lidar based on information gathered during the ACCP Mission Concept Study Phase, including information gathered from an instrumentation Request for Information submitted during that period. From this information the mission systems team developed spacecraft concepts commensurate with allocations as found in

Table 3. The Respondent should provide both their Current Best Estimate and Maximum Expected Value resource needs in the attached spreadsheet under tab labeled ‘Spacecraft Accommodation.’ Note: The values in the table below are not requirements but rather for informational purposes to provide the respondent with the notional resources needs currently envisioned by the AtmOS team. Exceedance of these values are acceptable and expected, especially in the event of enhanced performance capability.

Table 3 HSRL Lidar Target Resource Allocations (with Scan Type and Swath Coverage)

Resource	Units	Target Allocation (Current Best Estimate)**
Mass	kg	350
Operational Power (Orbit Average)	W	575
Envelope Dimensions in Operational Configuration (L x W x H). See Figure 2.	cm	150 x 150 x 150
Data Rate (Peak*)	bits/second	5.0×10^7
*Peak data rate is the nominal rate while the instrument is in its acquisition mode.		**Please provide both the Current Best Estimate (CBE) and the Maximum Expected Value (MEV) for these resources. MEV = [(100 + XX)/100] CBE where XX is contingency in percent.

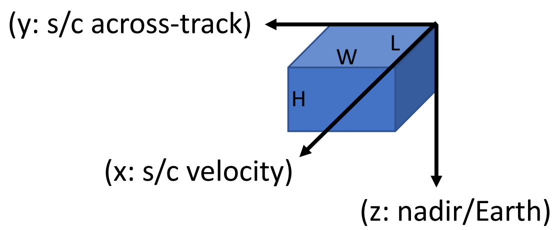

Figure 2 Instrument reference coordinate system.

INSTRUMENT MATURITY

The respondent is encouraged to use the narrative section of the response to describe the technical maturity and supporting basis for the instrument use in spaceflight. In addition to the narrative, the respondent should address the itemized requests within the spreadsheet on technology readiness assessment.

Suitable instrument candidates must be no less than Technology Readiness Level (TRL) 6 by the HSRL Lidar Preliminary Design Review (PDR), see Table 4. TRL definitions can be found in the NASA Systems Engineering Handbook, and they apply to the relevant, intended environment (e.g. airborne instrument demonstrated in that environment would be considered TRL 6, but would not be considered TRL 6 if they were intended for a spaceflight environment for AtmOS).

If the candidate instrument is not currently at TRL 6 for the intended environment, the response should include the following:

a) An estimate of current TRL, using the TRL definitions in Appendix G of the NASA Systems Engineering Handbook (NASA SP-2016-6105 Rev. 2, 2016).
b) A technology maturation plan that outlines the approach and timeline to achieve TRL 6
c) Identification of the external funding source(s) supporting the effort to achieve TRL 6 and qualify the hardware for the intended environment

COST ESTIMATE

The AtmOS Constellation is cost-constrained. The AtmOS team requests a rough-order-of-magnitude estimate on the total cost in 2021 dollars for the HSRL Lidar. For purposes of cost estimation and planning, the respondent should consider award of the instrument Phase A contract NET March 2022. Award of an instrument delivery contract should occur sometime in Phase B for Phase C-E. Phase B is expected to start NET March 2023. The respondent should assume that the instrument is delivered to a spacecraft provider for integration and testing at observatory-level and for delivery to the launch site for launch and a follow-on period of on-orbit checkout. For purposes of developing the Cost Estimate, the respondent should assume the following draft AtmOS milestone schedule found in Table 4.

Table 4 Draft AtmOS Milestone Schedule

Milestone	Date
Mission Concept Review	2/1/22
HSRL Lidar System Requirements Review	10/1/22
Mission Systems Requirements Review	12/1/22
HSRL Lidar Preliminary Design Review	4/1/24
Mission Preliminary Design Review	6/1/24
HSRL Lidar Critical Design Review	4/1/25
Mission Critical Design Review	6/1/25
Inclined Orbit Plane Systems Integration Review	6/1/26
Polar Orbit Plane Integration Review	6/1/27
Inclined Systems Integration Review	6/1/26
Polar Systems Integration Review	6/1/27
Inclined Launch	3/1/28
Inclined On-Obit Checkout Complete/Operations Commence	6/1/28
Polar Launch	3/1/29
Polar On-Obit Checkout Complete/Operations Commence	6/1/29

MISSION ASSUMPTIONS AND SPACECRAFT INTERFACE ASSUMPTIONS

When developing their response, the respondent should consider the following Mission and Spacecraft Interface assumptions detailed in Table 5. Note: Since the HSRL Lidar is intended for the Polar Orbit Plane, assumptions for the Inclined Orbit Plane are not applicable. The respondent should elaborate in the narrative if there are any issues with any of these assumptions.

Table 5 Mission and Spacecraft (MSC) Interface Assumptions

Identifier	Category	Polar, Inclined, or Common	Mission Parameters and Spacecraft Interface: Driving/Key Assumptions
MSC1	Orbit	Polar	450 km +/-10 km altitude, Sun Synchronous Polar Orbit, Ascending Node: 1330
MSC2	Orbit	Inclined	407 km +/- 10 km altitude, 50 to 65 degree inclination
MSC3	Orbit and Thermal Interface	Inclined	For thermal purposes, the Inclined Spacecraft will perform approximately 9 to 12 180-degree yaw maneuvers per year to maintain a consistent 'cold side' to the spacecraft. The responder should note any instrument performance or functional concerns with this inclined ConOps assumption.
MSC4	Launch Date	Inclined	See Table 5
MSC5	Launch Date	Polar	See Table 5

Identifier	Category	Polar, Inclined, or Common	Mission Parameters and Spacecraft Interface: Driving/Key Assumptions
MSC6	Instrument Design Life	Polar	Minimum 3 Years, accommodate 5 years for any consumable.
MSC7	Instrument Design Life	Inclined	Minimum 3 Years, accommodate 5 years for any consumable.
MSC8	Instrument Risk Classification	Common	Risk Class C per NASA 8705.4A
MSC9	Launch Vehicle	Common	Assume environment envelope of the following launch vehicles: Falcon 9, Blue Origin New Glenn, and ULA Vulcan Centaur.
MSC10	Launch Orientation	Common	The instrument design and mounting to the spacecraft will allow for launch in any orientation with respect to the launch velocity direction.
MSC11	Deployments	Common	Deployments for initial instrument configuration are acceptable. and should be noted by the vendor. For example, this might include protective aperture covers or release mechanisms for a system locked during launch.
MSC12	Orbital Debris Reduction	Common	The instrument should retain with the instrument any deployed hardware. No hardware is to be released into orbit.
MSC13	Thermal Interface	Common	Instrument is responsible for its own thermal management, including any cryocoolers, operational heaters, thermal radiators, thermal straps, and heat pipes. Assume that spacecraft will accommodate field of view for instrument radiators with view to a 'cold side' of the spacecraft. Conductive heat transfer between instrument and mounting interface will be restricted.
MSC14	Survival Power	Common	Spacecraft will provide dedicated power feed for survival heaters from nominal 28 V DC power service. Instrument is responsible for its own survival heaters and control (e.g. thermostats).
MSC15	Operational Power Service	Common	Assume nominal 28 V DC power service from spacecraft battery system, notionally 23 V to 32 V DC range of variation.
MSC16	Spacecraft Attitude Control System	Common	The spacecraft will maintain a fixed nadir-pointing attitude during operations.
MSC17	Science Data Management	Common	Instrument need not provide its own data storage system. Assume spacecraft will provide adequately sized data recorder to store instrument science, telemetry, housekeeping for periodic spacecraft downlinking.
MSC18	Science Data Management	Common	Data Rate values provided in the targeted resource allocation are for uncompressed data. Assume that the spacecraft will not implement any data compression on the instrument science data. The instruments may wish to implement data compression (lossy or lossless) algorithms prior to transfer to the spacecraft.

SOLICITATION

The AtmOS team will conduct a Pre-Acquisition Strategy Meeting with NASA Headquarters and Earth Science Division (ESD) in late Summer 2021 and a final Acquisition Strategy Meeting during Phase A. The purpose of this solicitation is to help inform the AtmOS team in preparation for those Acquisition Strategy meetings. NASA Headquarters Earth Science Division (ESD) will make the final determination as to the acquisition approach including a determination if the HSRL Lidar will be commercially competed.

The Key Decision Point (KDP) A for AtmOS is expected to be no earlier than 3/2022. If solicited, the HSRL Lidar solicitation will be posted no earlier than first quarter CY 2022.

DATA SECURITY

The information provided will be maintained on GSFC-maintained secure servers, and accessed only by civil servants, or contractors that have signed Non-Disclosure Agreements (NDAs) that preserve vendor proprietary and competition sensitive data.

It is not NASA's intent to publicly disclose vendor proprietary information obtained during this solicitation, including any cost estimates provided. To the full extent that it is protected pursuant to the Freedom of Information Act and other laws and regulations, information identified by a respondent as "Proprietary or Confidential" will be kept confidential.

The North American Industry Classification System (NAICS) code for this procurement is 336419, Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing, with a size standard of 1,000 employees.

RESPONSE CONTENT REQUIREMENTS

This RFI is to solicit specific capability information from any experienced source and promote collaboration and competition. The RFI seeks responses that provide the technical resource footprint, science performance, and vendor capability statements for the HSRL Lidar. The description of the HSRL Lidar should include any relevant laboratory, sub-orbital, or spaceflight information regarding the hardware configuration as previously demonstrated and the science returned, as well as the instrument calibration and data validation methods.

Interested offerors/vendors having the required specialized capabilities to meet the intended application should submit a capability statement indicating the ability to perform all aspects of the effort described herein. Responders are invited to submit a narrative and to fill out the attached. HSRL Lidar spreadsheet. The narrative should not exceed 25 pages. Science publications and other relevant information can be referenced in the narrative to provide examples of the source's expertise, facilities, and prior work, especially regarding hardware and/or test results for the HSRL Lidar. The respondent should include within the narrative a description of the HSRL Lidar operating principles within the larger AtmOS operational concept including any measurement synergies enabled by the instrument. The respondent is encouraged to use the narrative to include an instrument functional block diagram, technology readiness assessment basis, identification of any long-lead components or subsystems, and any potential risks (cost, technology, or schedule) envisioned for the HSRL Lidar based on the AtmOS schedule and flight architecture.

The attached AtmOS HSRL Lidar spreadsheet offers a convenient and concise means of addressing the anticipated HSRL Lidar performance, spacecraft resource, and mission operational concept needs. The spreadsheet includes the technical information necessary to support Mission Concept development/pre-formulation. The spreadsheet includes separate tabs for General Information, HSRL Lidar Performance, Supplemental Information, Spacecraft Accommodation, Orbit and Attitude, and TRL. Please complete one spreadsheet for each candidate instrument submitted.

Responses must also include the following: name and address of firm, size of business; average annual revenue for past 3 years and number of employees; ownership; whether they are large, small, small disadvantaged, 8(a), Woman-owned, Veteran Owned, Service-Disabled Veteran Owned, Historically Underutilized Business Zone and Historically Black Colleges and Universities/Minority Institutions and number of years in business. Also include affiliate information: parent company, joint venture partners, potential teaming partners, prime contractor (if potential sub) or subcontractors (if potential prime), list of customers covering the past five years (highlight relevant work performed, contract numbers, contract type, dollar value of each procurement; and point of contact - address and phone number).

This synopsis is for information and planning purposes and is not to be construed as a commitment by the Government nor will the Government pay for information solicited. Respondents will not be notified of the results of the evaluation.

Technical questions should be directed to: Vickie Moran at Vickie.E.Moran@nasa.gov.

Procurement related questions should be directed to: Jonathon D. Wingerberg at jonathon.d.wingerberg@nasa.gov .

Interested offerors shall address the requirements of this RFI in written format as described in the previous paragraphs by electronic mail to: Vickie Moran at Vickie.E.Moran@nasa.gov by August 21,2021. Responses can be submitted via email. The subject line of the submission should be "RFI for AtmOS HSRL Lidar," and attachments should be in Microsoft WORD, POWERPOINT, EXCEL or PDF format. The email text must give a point-of-contact and provide his/her name, address, telephone/fax numbers, and email address.

Contracting Office Address:
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

Primary Point of Contact:
Jonathon D. Wingerberg
jonathon.d.wingerberg@nasa.gov