

TECHNOLOGY AND INTEGRATED DISCIPLINE ENGINEERING SERVICES

Task Order Statement of Work (SOW)

Date: August 10, 2020

Task Name: Jitter and Dynamic Analysis Support

Task No.: 11

Task Modification: 17

Task Monitor (TM): Kuo-Chia (Alice) Liu

Contract number: NNG15CR65C

I. Scope

As the current and next generation space instruments and observatories aim to achieve tighter pointing and lower jitter requirements, there is an increasing need of jitter and dynamic analysis support. At the same time, many of the project support requests do not include full time support throughout the entire project/mission lifetime. In order to more efficiently coordinate the GSFC jitter support needs, this task is designed to allow several projects (instrument, payload, spacecraft, and/or observatory) to request for similar type of support under one task.

The jitter and dynamic analysis support typically includes predicting pointing performance from various disturbance sources, creating disturbance models from test data, providing expert consultation on mitigating jitter risks, and guiding designs for resolving jitter issues. This support will also require advanced algorithm and simulation development that incorporates both multiple rigid-bodies and/or flexible-body dynamics as appropriate.

The required support described in this statement of work (SOW) includes support of several flight Projects as described in each subtask in Section III. . The contractor shall provide a lead support engineer for this task who will work closely with the government Task Monitor (TM) to define specific tasks, schedule, and work priorities each week. The contractor shall attend relevant reviews, project meetings, and technical interchange meetings per request from the TM. The contractor shall be expected to provide timely support of unplanned high-priority actions as circumstances dictate

II. Period of Performance

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The performance period for this task shall be task award date through the following end dates for different subtasks:

- *Subtask 1 (ICESat-2) ended on September 30, 2017*
- *Subtask 3 (GEDI) ended on September 30, 2017*
- *Subtask 6 (ATLAST) ended on September 30, 2018*
- *Subtask 9 (PACS GDS) ended on September 30, 2018*
- *Subtask 10 (PACE OCI) ended on Dec. 31, 2019*
- *Subtask 11 (LUCY L' Ralph) ended on September 30, 2019*
- *Subtask 12 (Moon Express) ended on September 30, 2019*
- *Subtask 13 (WFIRST Spacecraft Jitter) ended on September 30, 2019*
- *Subtasks 2, 4, 5, and 7 are extended to April 14, 2021*
- *Subtask 8 (PACE ACS/Jitter) to end on Dec. 31, 2020*

III. Subtask Description

1. **Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) and Advanced Topographic Laser Altimeter System (ATLAS) Instrument Control and Jitter Analysis Support**

Task Completed in FY17

2. **Neutron Star Interior Composition Explorer (NICER) Pointing and Jitter Analysis Support**

- a. Contractor shall update the Attitude Ground System (AGS) software to improve observation efficiency.

3. **Global Ecosystem Dynamics Investigation (GEDI) Lidar Pointing and Jitter Analysis Support**

Task Completed in FY17

4. **Landsat-9 and Thermal Infrared Sensor-2 (TIRS-2) Control System and Jitter Analysis Support**

- a. In this subtask, the contractor shall perform disturbance data and jitter analyses for the TIRS-2 cryocooler. The contractor shall support TIRS-2 jitter characterization test and provide test analysis and predictions. (Completed in FY19)

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- b. The contractor shall provide jitter analysis and mitigation consultation for the Landsat-9 Project.
5. **Laser Communications Relay Demonstration (LCRD) Mission Pointing Algorithm and Test Support**
- a. The contractor shall provide support to mission level PAT tasks including requirement reviews, PAT pointing budget updates, and ground station work reviews.
 - b. The contractor shall provide support for planning for on-orbit checkout of PAT pointing and jitter performance.
 - c. The contractor shall review host spacecraft GN&C design, analysis, and test data in the areas that affect LCRD/PAT mission success.
6. **Advanced Technology Large-Aperture Space Telescope (ATLAST) Concept Study Task Completed**
7. **Wide-Field Infrared Survey Telescope (WFIRST) Integrated Modeling**
- a. In this subtask, the contractor shall support WFIRST Integrated Modeling (IM) efforts, including the following tasks
 - i. Provide Observatory distortion model development, integration, and checkout
 - ii. Perform structure-thermal-optical (STOP) analysis for the Wide Field Instrument components, Instrument Carrier Launch Lock stroke, High Gain Antenna boom distortion, Observatory flight configuration, and Payload and Observatory ground test configurations.
 - iii. Develop analysis process and perform analysis for moisture desorption
 - iv. Develop structural model for test chamber disturbance evaluation and provide mitigation recommendations
 - v. Provide test preparation analysis for model validation tests
 - vi. Provide jitter test assessments for SES test configurations, as well as supporting isolation system development
 - b. The contractor shall perform the following tasks to support IM jitter analysis efforts:
 - i. Prepare observatory structural model for jitter analysis
 - ii. Perform reaction wheel induced jitter analysis

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- iii. Coordinate with the Spacecraft team on performing harness testing and correlate harness model to test data
- iv. Provide WFIRST isolation system transmissibility specifications
- c. The contractor shall provide IM lead analyst support, and organize weekly team meetings and splinter meetings to ensure the IM products can be delivered in a timely fashion. The contractor shall determine and document appropriate IM process and guidelines (e.g. math model specs and usage of model uncertainty factors). The contractor shall work with IM lead and teams to develop the WFIRST System Analysis and Model Validation Plan.
- d. The contractor shall perform the following tasks to support IM structural-thermal-optical-performance (STOP) analysis efforts:
 - i. Provide a general code to automate performance load cases interface to Sigfit and generate optical input files for Zemax and further raytracing. Upon request, provide interface cod to Code V
 - ii. Perform optical analysis via the linear optical model (LOM) feature in Sigfit to generate the final rms wavefront (WFE) results, using compensation value as obtained either from the single Wide Field Channel (WFC) Zemax models or from the combined WFE and Coronagraph Instrument (CGI)
 - iii. Process distortion cases and provide outputs to optical analysis lead
 - iv. Perform optical analysis and design support for the auto-collimating flat
- e. The contractor shall perform the following tasks to support IM High Gain Antenna System (HGAS) mechanism and instrument filter wheel mechanism jitter analysis:
 - i. Perform HGAS jitter analysis to support actuator design trades and flight predictions for each IM analysis cycle
 - ii. Perform sensitivity and uncertainty analysis in order to determine error bounds on the nominal results
 - iii. Perform instrument mechanism jitter analysis
 - iv. Provide jitter consultation and perform independent and/or cross-checks on other analyses per request from IM lead
- f. The contractor shall provide consultation on multi-body rigid-body and flexible-body dynamics upon request from IM lead

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- g. The contractor shall provide performance assessment on the Instrument Carrier pulse-width-modulation heater control design, as well as software code for automating IM process and improving IM analysis efficiency
- h. The contractor shall participate in weekly team meetings, provide weekly and monthly status updates,, and document analysis results in PowerPoint presentations

8. Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Jitter Consultation

In this subtask, the contractor shall provide PACE Spacecraft jitter analysis consultation which include reaction wheel, solar array drive, and tip/tilt platform analyses.

The contractor shall set up the jitter analysis model and checkout the jitter model in preparation for jitter analysis. The contractor shall also perform preliminary jitter analysis to identify any analysis issues.

9. PACE – Goddard Dynamic Simulator (GDS) Analysis Support

Task Completed

10. PACE – Ocean Color Instrument (OCI)

Task Completed

11. Lucy – Ralph Instrument (L’Ralph)

Task completed in FY19

12. Lunar Cargo Transportation and Landing by Soft Touchdown (CATALYST)

Task completed in FY19

13. Wide-Field Infrared Survey Telescope (WFIRST) Spacecraft Analysis

Task 13 combined with Task 7 starting FY20

IV. Deliverables/Schedules/Milestones

At a minimum, the contractor shall deliver the items specified below:

<i>Ref#</i>	<i>Deliverables</i>	<i>Due Date</i>
1	<i>IceSat2/ATLAS Final Analysis Report (in PowerPoint format)</i>	<i>End of contract</i>

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2a	<i>Provide NICER Pointing Control Flight Software (PCFS) ICD updates and selected sections in the PCFS Algorithm Description Document</i>	<i>March , 2016</i>
2b	<i>Provide final NICER jitter analysis and TMD stroke results</i>	<i>March 2016</i>
2c	<i>Provide updates to PCFS ICD and contribute to algorithm document</i>	<i>December, 2016</i>
2d	<i>Deliver NICER AGS final updates</i>	<i>End of contract</i>
3b	<i>Provide GEDI stepper jitter analysis slides for the GEDI Pointing System PDR Engineering Peer Review</i>	<i>December 2016</i>
3c	<i>Provide MDA model updates for GEDI Pointing Simulation</i>	<i>September 2016</i>
3d	<i>Provide GEDI stepper jitter analysis slides for the GEDI Pointing System CDR Engineering Peer Review</i>	<i>November 2016</i>
4a	<i>Provide TIRS-2 Cryocooler disturbance data analysis results (PowerPoint slides or spreadsheets are acceptable)</i>	<i>September 2016</i>
4b	<i>TIRS-2 SSM test data analysis report</i>	<i>March 2018</i>
4c	<i>Provide TIRS flight cryocooler data analysis report</i>	<i>September 2018</i>
4d	<i>Provide TIRS-2 jitter characterization report</i>	<i>December 2018</i>
4e	<i>Provide Landsat-9 spacecraft jitter analysis report</i>	<i>End of contract</i>
5a	<i>Provide monthly report to LCRD PAT team</i>	<i>Monthly</i>
5b	<i>Provide on-orbit pointing system calibration plan</i>	<i>September 2018</i>
7a	<i>Provide weekly status updates during team meetings</i>	<i>Weekly</i>
7b	<i>Provide IM analysis reports as assigned</i>	<i>Each WFIRST IM Analysis Cycle</i>
7c	<i>Provide IM review support as requested</i>	<i>2 reviews in FY21</i>
7d	<i>Provide Math Model Guideline updates</i>	<i>1 update in FY21</i>
7e	<i>Provide thermal control analysis results in PowerPoint presentation</i>	<i>Yearly</i>
7f	<i>Provide System Analysis and Model Validation Plan</i>	<i>2 updates in FY21</i>
8a	<i>Provide auto-code workflow for PACE ACS team</i>	<i>May 2018</i>
8b	<i>Provide jitter analysis model</i>	<i>March 2019</i>
9	<i>Provide PACE ACS hardware/interface models build 1</i>	<i>September 2018</i>
12	<i>Provide a list of recommendations for tools that can be used to</i>	<i>September 2018</i>

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	<i>handle data interfaces with Simulink.</i>	
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Note 1: each reference number corresponds to the subtask number in Section III. Note 2: Since subtasks 10 and 11 are solely on providing consultation, no deliverables are required for those 2 subtasks.

V. Management Approach

a. Staff Allocation, Expertise, and Skill Mix

The contractor shall staff this work item with at least one senior engineer who has had more than 15 years of experience in jitter consultation and analysis support. The contractor shall provide the appropriate skill mix and staffing level for the requested work.

b. Configuration Management

Systems and documents will be covered under the appropriate Project Configuration Management Plan.

c. Facilities

Appropriate IT devices to support the analyses, specification development, and report development are required. It shall be the contractor's responsibility to provide and set up local workstations and network connections at the contractor's off-site facilities as required, and to install any required tools and utilities on the contractor's equipment.

d. Risk Management and Best Practices

The contractor shall manage schedule, cost, and technical risk through monitoring and reporting of progress and performance metrics, identifying issues well in advance of negative consequences, recommending corrective action to the TM, and implementing corrective actions with the compliance of the TM.

e. Performance Metrics

The work performed for this task will be evaluated by the TM based on the technical merit. The TM shall develop detailed performance metrics that shall reflect the contractor's performance in meeting research analysis, specific mission requirements, deliverables and delivery schedule, and the contractor's cost. Technical evaluation of the task performance is a subjective combination of performance metrics, technical quality of deliverables, cost control, significant events, innovations and meeting requirements set forth in the SOW.

The following performance metrics apply to this SOW:

- 1. Timely delivery of high priority products.*
- 2. Work coordination among supporting contractors to deliver needed products.*

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3. *Appropriate cost control and minimization of work duplication.*

f. Government Furnished Facilities, Equipment, Software and Other Resources

The Government shall provide equipment (computer etc.) as needed.

VI. ODC (Travel and Procurement)

Travel may be proposed for engineering support task activities as directed by the Project.

All travel requests are for subtask 7 (WFIRST)

<u>From</u>	<u>To</u>	<u>Duration</u>	<u>Number of Trips</u>	<u>Number of Travelers</u>	<u>Dates</u>
<u>GSFC</u>	<u>Pasadena, CA</u>	<u>3 days</u>	<u>1</u>	<u>1</u>	<u>FY21</u>
<u>GSFC</u>	<u>Rochester, NY</u>	<u>2 days per trip</u>	<u>0</u>	<u>2</u>	<u>FY21</u>
<u>GSFC</u>	<u>Phoenix, AZ</u>	<u>2 days per trip</u>	<u>1</u>	<u>1</u>	<u>FY21</u>
<u>GSFC</u>	<u>Denver, CO</u>	<u>4 days</u>	<u>0</u>	<u>1</u>	<u>FY21</u>
<u>Rochester, NY</u>	<u>GSFC</u>	<u>4 days</u>	<u>1</u>	<u>1</u>	<u>FY21</u>

VII. Work Location

The work location shall be determined between the TM and contractor. In some cases, the contractor's work shall be performed primarily at the contractor's location, with support for team meetings and other activities as appropriate at the Goddard Space Flight Center. In other cases, the TM may request the contractor to co-locate with the Flight Project office.

VIII. Reporting Requirements

a. Weekly status report

The contractor shall participate in a weekly status meeting with the TM. No written weekly status report would be required.

b. Financial 533 report

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The contractor shall provide 533 reporting and CTR broken down by each subtask as described in Section III. The parent task will conquer all the sum numbers rolling up from all the subtasks as described in Section III.

IX. Security Requirements

The contractor shall comply with Information Technology Security procedures and requirements as defined by NPG 2810.1A in the performance of this task. In addition, the contractor shall comply with all applicable federal rules and regulations and agency directives. NOTE: There will not be any handling of classified data.

X. Training Requirements

N/A

XI. References

N/A

XII. Summary of Changes in this Task Modification

In this task mod, period of performance for all subtasks have been updated. The subtask task descriptions have also been modified to indicate if the subtask has been completed or will be extended through FY21. The ODC section has also been updated to reflect travel needs for subtask 7 in FY21.