TECHNICAL ASSISTANCE AGREEMENT

Amendment No. 11 to TA 2780-11

This amendment is entered into among the following parties and is effective upon the date of signature of the last party to sign the agreement:

University Corporation for Atmospheric Research (UCAR), main office located at 3090 Center Green Drive, Boulder, CO 80301;

National Oceanic and Atmospheric Administration (NOAA), Office of Systems Development, and National Environmental Satellite, Data, and Information Service (NESDIS)/ Office of Satellite and Product Operations (OSPO), located at 1335 East-West Highway, E/OSC, Silver Spring, MD 20910;

California Institute of Technology, Jet Propulsion Laboratory (JPL), located at 4800 Oak Grove Drive, Pasadena, CA 91109;

Moog Inc., a corporation organized and existing under the laws of the state of New York, having offices at Seneca Street and Jamison Road, East Aurora, New York, 14052-0018, and all its domestic locations (hereinafter, collectively, referred to as "Moog USA")";

The Aerospace Corporation, located at 2310 E. El Segundo Blvd., El Segundo, CA 90245-4609;

SRI International (SRI), located at 333 Ravenswood Ave., Menlo Park, CA 94025-3493;

ATA-Aerospace (ATA), located at 1300 Britt Street SE, Albuquerque, NM 87123; ASRC

Federal Holding Company, LLC (ASRC), NOAA Fairbanks Command and Data Acquisition Stations (FCDAS), located at 7000 Muirkirk Meadows Drive, Suite 100, Beltsville, MD 20705;

Quantech, located at 91 Hartwell Ave., 3rd Floor, Lexington, MA 02421-3137;

Space Exploration Technologies Corp. (SpaceX), located at 1 Rocket Road, Hawthorne, California 90250;

Instar Engineering and Consulting, Inc. (Instar), located at 6901 S. Pierce St., Ste. #200, Littleton, CO 80128;

The University of Texas at Dallas (UTD), located at 800 West Campbell Rd., Richardson, Texas 75080;

The Analytic Sciences Corporation (TASC), an Engility Company, located at 4803 Stonecroft Blvd., Chantilly, VA 20151

Noblis, Inc., located at 2002 Edmund Halley Drive, Reston, VA 20191

Orbital Systems LLC., a fully owned subsidiary of Communications & Power Industries LLC (CPI), located at 3807 Carbon Rd, Irving, TX 75038;

Atlas Space Operations, Inc., located at 10850 E. Traverse Highway, Suite 3355, Traverse City, MI 49684

Technical Adventures, LLC, located at 639 Mandalay Grove Court, Merritt Island, FL 32953;

University of Maryland, a public agency and instrumentality of the State of Maryland, 1204 Marie Mount Hall, 7814 Regents Drive, College Park, MD 20742;

Science and Technology Corporation (STC), located at 21 Enterprise Parkway, Suite 150, Hampton, VA 23666.

National Space Organization (NSPO) of Taiwan, with offices located at 8F, No. 9 Prosperity Rd 1, Science-Based Industrial Park, Hsinchu 30078 Taiwan;

National Applied Research Laboratories (NARLabs) of Taiwan, with headquarters located at 3F, 106, Heping E. Road, Sec. 2, Taipei 106, Taiwan;

Ministry of Science and Technology (MOST) of Taiwan, with its principal place of business located at 19F, 106 Heping E. Rd., Sec. 2, Taipei, Taiwan 10622;

Central Weather Bureau (CWB) of Taiwan, with headquarters located at 64, Gongyuan Road, Taipei 10048, Taiwan;

National Central University (NCU) of Taiwan, located at No. 300 Jhongda Rd., Jhongli City, Taoyuan County 32001, Taiwan;

National Cheng Kung Univerisity (NCKU) of Taiwan, Department of Earth Sciences, Radio Occultation Ionosphere data post-processing group, Located at No. 1 University Road, Tainan City 701, Taiwan;

Taiwan Typhoon and Flood Research Institute (TTFRI), with offices located at 11F, 97, Roosevelt Road, Sec. 1, Taipei 10093, Taiwan;

Academia Sinica, Research Center for Environmental Changes, 128 Academia Road, Section 2, Nankang, Taipei 11529, Taiwan;

National Taiwan University (NTU), 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan ;

Kongsberg Satellite Services AS (KSAT), located at Prestvannveien 38 N-9291, Tromso, Norway;

Surrey Satellite Technology Limited (SSTL-UK), of the United Kingdom, located at Tycho House, 20 Stephenson Road, Surrey Research Park, Guildford, Surrey GU2 7YE;

Instituto Nacional de Pesquisas Espaciais (INPE) of Brazil, located at Av. Dos Astronautas, 1758 Jd. Granja – CEP: 12227-010, São José dos Campos, SP – Brazil;

Australian Bureau of Meteorology, Observing Systems and Operations Program, located at 700 Collins Street, Docklands VIC 3008; and

University of Energy and Natural Resources (UENR), Earth Observation Research and Innovation Centre, located at P. O. Box 214, Sunyani Ghana.

In-Space Missions Ltd., located at Whitmore View, Hammer Lane, Grayshott, Hampshire, GU26 6JD, UK

WHEREAS UCAR obtained authorization for this Technical Assistance Agreement on 08/03/2011 and is collaborating with NSPO and other parties named herein on a follow-on program to the Constellation Observing System for Meteorology, Ionosphere and Climate Program (COSMIC) – a science and satellite technology project called FORMOSAT-7/COSMIC-2, hereafter referred to and abbreviated as F-7/C-2. The F-7/C-2 mission will be a constellation of approximately twelve satellites carrying scientific payloads. The primary payloads are Global Navigation Satellite Sy stem (GNSS) radio occultation (RO) scientific payloads to collect atmospheric data for numerical weather and space weather prediction, atmospheric and ionospheric studies, and climate research. The secondary scientific payloads are a Radio Frequency (RF) beacon transmitter, and an Ion Velocity Meter (IVM) sensor to collect ionospheric data for space weather specification and prediction. UCAR is responsible for providing programmatic, technical, and scientific input for the planning and execution of the F-7/C-2 mission; and

WHEREAS, NOAA is responsible for providing Program Management, frequency coordination, development of the Remote Terminal Stations (RTS) and Groun"d Network Services (GNS) and Operation of RTS and GNS for FCDAS sites for the F-7/C-2 mission, and launch planning and development services to the project; and

WHEREAS, JPL is responsible for the design, development, documentation, and systems engineering and integration support of the GNSS radio occultation payloads for the F-7/C-2 mission; and

WHEREAS, Moog USA is responsible for the manufacture and integration support of the GNSS radio occultation payload flight units for the F-7/C-2 mission; and

WHEREAS, The Aerospace Corporation provides engineering support to the US Government for the development and integration of NOAA tracking capabilities into the COSMIC network, and overall systems engineering support and design, analysis, and manufacturing review support for the F-7/C-2 payloads, spacecraft, and launch vehicles; and

WHEREAS, UTD is responsible for design, development, systems engineering, interface control and integration support of the Ion Velocity Meter (IVM) for the F-7/C-2 mission; and

WHEREAS, SRI is responsible for design, development, systems engineering, interface control and integration support of the RF Beacon (SRI) sensor for the F-7/C-2 mission; and

WHEREAS, ATA-Aerospace will provide programmatic and technical input for the planning and execution of the F-7/C-2 payloads; and

WHEREAS, ASRC provides support for testing and operations at the Fairbanks, Alaska NOAA RTS downlink site (FCDAS); and

WHEREAS, Quantech will provide aerospace systems engineering/technical assistance (SETA) support to USAF for sensor development and ground systems development activities; and

WHEREAS, SpaceX is responsible for the manufacture, integration, and launch operations of the SpaceX Falcon launch vehicle for the F-7/C-2 mission; and

WHEREAS, Instar is responsible for supporting the F-7/C-2 launch program, providing analysis and engineering to assure proper integration of payloads on to the Space X launch vehicle; and

WHEREAS, TASC will provide system engineering and integration support to the SSAEM Program, including risk development/coordination, schedule tracking and development, and budget and funding analysis; and

WHEREAS, Noblis will provide systems engineering and program management support to NOAA; and

WHEREAS, Orbital Systems, LLC will provide development and operations support of the RTS and GNS for the Australian Bureau of Meteorology tracking site in Darwin, Australia; and

WHEREAS, Atlas Space Operations, Inc. is responsible for the development of the RTS and GNS and operation of RTS and GNS for Atlas Space Operations sites supporting the F-7/C-2 mission; and

WHEREAS, Technical Adventures, LLC will provide program management and engineering support to the US Government, specifically NOAA, for the development and operations of the integrated F-7/C-2 ground, launch, and space segments; and

WHEREAS, University of Maryland will provide support to NOAA related to the calibration, validation, and utilization of GNSS RO observations. This includes assessment of GNSS RO data quality and their utilization within numerical weather models.

WHEREAS, STC will provide programmatic, aerospace and systems engineering/technical assistance (SETA) support to NOAA in the planning and execution of the F-7/C-2 GNSS-RO Program. STC will provide technical liaison support to parties to the TAA, specifically NOAA, NSPO, and the USAF; and

WHEREAS, NSPO, the primary licensee, is one of the national laboratories organized under Taiwan's National Applied Research Laboratories (NARLabs). NARLabs is organized under Taiwan's Ministry of Science and Technology (MOST). NSPO is responsible for providing Program Management to the project for Spacecraft Development and Operation of the F-7/C-2 mission; and

WHEREAS, NSPO is responsible for contracting with a spacecraft vendor to build, integrate and test the satellites for the F-7/C-2 mission, carrying scientific payloads. Export of spacecraft hardware, excluding the scientific payloads, will not be managed under this TAA; and

WHEREAS, NSPO is responsible for developing and operating a Satellite Operations Control Center (SOCC) to operate the satellites of the F-7/C-2 mission. NSPO will command and control the satellites with tracking, telemetry, and commanding (TT&C) communication links provided by RTS; and

WHEREAS, NARLabs is the managing organization for NSPO. NARLabs provides direction and monitoring to the NSPO and will be involved in programmatic decisions; and

WHEREAS, MOST is the managing agency for NARLabs. MOST provides direction and monitoring to the NARLabs and will be involved in programmatic decisions; and

WHEREAS, CWB, which manages and operates the Taiwanese Analysis Center for COSMIC (TACC) for the COSMIC mission and will manage and operate the Taiwan Data Processing Center (TDPC) for F-7/C-2, is responsible for F-7/C-2 science data processing in Taiwan; and

WHEREAS, NCU will provide consulting services to NSPO for mission development, is responsible for developing the Taiwan data processing center with NSPO, and is a potential scientific payload provider; and

WHEREAS, NCKU is responsible for developing the Taiwan data processing center with NSPO, and is a potential scientific payload provider; and

WHEREAS, Academia Sinica will provide supervision of the execution of FORMOSAT-7/COSMIC-2 program as a member of the executive steering committee; and

WHEREAS, NTU will provide supervision of the execution of FORMOSAT-7/COSMIC-2 program as a member of the executive steering committee; and

WHEREAS, KSAT is responsible for the development of the RTS and GNS and Operation of RTS and GNS at KSAT downlink sites for the F-7/C-2 mission; and

WHEREAS, TTFRI is responsible for data utilization in Taiwan, and will provide consulting services to NSPO for mission development and will assist NSPO to develop the Taiwan Data Processing Center (TDPC) for the F-7/C-2 mission; and

WHEREAS, SSTL-UK is responsible for providing support for tasks related to satellite development and satellite-to-launch vehicle integration and test activities for the F-7/C-2 mission; and

WHEREAS, INPE is responsible for providing and operating a ground station for the reception of the F-7/C-2 data, and for providing the raw data back to NOAA/UCAR in real-time; and

WHEREAS, the Australian Bureau of Meteorology is responsible for providing and operating a ground station for the reception of the F-7/C-2 data, and for providing the raw data back to NOAA/UCAR in real-time; and

WHEREAS, UENR will host the F-7/C-2 RTS and GNS in Sunyani, Ghana, and support the tracking site's development, validation, and operations; and

WHEREAS, In-Space Missions Ltd. Will provide spacecraft systems engineering, integration & testing, and launch processing support.

WHEREAS, this is a re-baselined agreement of TA-0834-10 and all associated amendments, and UCAR, the licensor, did terminate TA-0834-10 within 30 days of execution of the re-baselined agreement per 22 CFR §124.6; and

WHEREAS, the parties now desire to modify the subject agreement.

NOW THEREFORE, the parties agree as follows:

REMOVE the following U.S. parties to the agreement:

1. **Riverside Technology, Inc.**

CHANGE the legal name of the following U.S. parties to the agreement:

1. **Orbital Systems, LLC**

NOW THEREFORE, the parties desire to enter into this Agreement as follows:

1. This Technical Assistance Agreement is intended to allow the implementation of the design, development, integration and test, launch vehicle planning and development support, operation, and follow-on support of a constellation of approximately twelve operational satellites with Global Navigation Satellite System (GNSS) radio occultation (RO) and other payloads applicable to weather and space weather prediction, atmospheric and ionospheric science, and climate research.

2. It is understood that this Technical Assistance Agreement is entered into as required under U.S. Government regulations and as such, it is an independent agreement between the parties, the terms of which will prevail, notwithstanding any conflict or inconsistency that may be contained in other arrangements between the parties on the subject matter.

3. The parties agree to comply with all applicable sections of the International Traffic in Arms Regulations (ITAR) of the U.S. Department of State and that more particularly in accordance with such regulations the following conditions apply to this agreement:

I.§124.7(a)

(1) The defense articles (hardware) to be exported in furtherance of this agreement are described in detail in the attached Exhibit A under Section 3.4. This includes the export of the F-7/C-2 primary GNSS RO scientific payload hardware (USML category XV(c)(2) and (c)(1)) of secondary scientific payloads as well as associated mass models and test equipment.

(2) The defense services and technical data to be furnished are described in the Exhibit A.

(3) The agreement is valid through September 30, 2020.

(4) Territory.

a. Subject to the terms and conditions of a Statement of Work and contract, the transfer of technical data, defense articles, and defense services is authorized between the United States and Taiwan, Norway, the United Kingdom**,** Brazil, Australia and Ghana for end-use by UCAR, NOAA, JPL, Moog, the Aerospace Corporation, UTD, SRI, ATA, ASRC, Quantech, SpaceX, Instar, **,** Engility, Noblis, Inc., Technical Adventures, LLC, **Orbital Systems, LLC**, Atlas Space Operations, Inc. University of Maryland, STC, and the foreign signatories NSPO, NARLabs, MOST, CWB, NCU, NCKU, AS, NTU, KSAT, TTFRI, SSTL-UK, INPE, the Australian Bureau of Meteorology, UENR and In-Space Missions Ltd.

b. Sublicensing rights are NOT granted to the foreign licensees.

c. Dual/Third Country National Employees are authorized as follows:

(1) Transfer of defense articles, to include technical data, to dual/third country nationals must be conducted in accordance with provisions of 124.8(a)(5).

d. The U.S. applicant (or U.S. Signatories) currently employs Foreign Person(s) of the following countries who will participate in this program: Malaysia, Ukraine.

e. Contract employees to any party to the agreement hired through a staffing agency or other contract employee provider shall be treated as employees of the party, and that party is legally responsible for the employees' actions with regard to transfer of ITAR controlled defensearticles to include technical data and defense services. Transfers to the parent company by any contract employees are not authorized. The party is further responsible for certifying that

each employee is individually aware of their responsibility with regard to the proper handling of ITAR controlled defense articles, technical data and defense services.

II. §124.8(a)

(1) This agreement shall not enter into force, and shall not be amended or extended without the prior written approval of the Department of State of the U.S. Government.

(2) This agreement is subject to all United States laws and regulations relating to exports and to all administrative acts of the U.S. Government pursuant to such laws and regulations.

(3) The parties to this agreement agree that the obligations contained in this agreement shall not affect the performance of any obligations created by prior contracts or subcontracts which the parties may have individually or collectively with the U.S. Government.

(4) No liability will be incurred by or attributed to the U.S. Government in connection with any possible infringement of privately owned patent or proprietary rights, either domestic or foreign, by reason of the U.S. Government's approval of this agreement.

(5) The technical data or defense service exported from the United States in furtherance of this agreement and any defense article which may be produced or manufactured from such technical data or defense service may not be transferred to a foreign person except pursuant to §126.18, as specifically authorized in this agreement or where prior written approval of the Department of State has been obtained.

(6) All provisions in this agreement, which refer to the United States Government and the Department of State, will remain binding on the parties after the termination of the agreement.

Cover Sheet for Signature Pages attached herewith for
UCAR-NSPO TAA #2780-11
Amendment Eleven
List of U.S. and Foreign Signatories

U.S. Signatories:

University Corporation for Atmospheric Research (UCAR)
National Oceanic and Atmospheric Administration/Office of Projects, Planning, and Analysis (NOAA/OPPA) and the National Environmental Satellite, Data, and Information Service/Office of Satellite and Product Operations (NOAA/NESDIS/OSPO)
California Institute of Technology, Jet Propulsion Laboratory (JPL)
Moog USA
The Aerospace Corporation
SRI International (SRI)
ATA-Aerospace (ATA)
ASRC Federal Holding Co. (ASRC)
Quantech Services, Inc.
Space Exploration Technologies Corp. (SpaceX)
Instar Engineering and Consulting, Inc. (Instar)
The University of Texas at Dallas (UTD)
The Analytic Sciences Corporation (TASC), an Engility Company
Noblis, Inc.
Orbital Systems, LLC
Atlas Space Operations, Inc.
Technical Adventures, LLC.
University of Maryland
Science and Technology Corporation (STC)

Foreign Signatories:

National Space Organization (NSPO) of Taiwan
National Applied Research Laboratories (NARLabs) of Taiwan
Ministry of Science and Technology (MOST) of Taiwan
Central Weather Bureau (CWB) of Taiwan
National Central University (NCU) of Taiwan
National Cheng Kung University (NCKU) of Taiwan
Taiwan Typhoon and Flood Research Institute (TTFRI) of Taiwan
Academia Sinica of Taiwan
National Taiwan University (NTU) of Taiwan
Kongsberg Satellite Services AS (KSAT) of Norway
Surrey Satellite Technology Limited (SSTL-UK) of the United Kingdom
Instituto Nacional de Pesquisas Espaciais (INPE) of Brazil
Australian Bureau of Meteorology
University of Energy and Natural Resources (UENR) of Ghana
In-Space Missions Ltd. of the United Kingdom

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement.

Except as modified above, in every other respect, the subject Agreement shall continue in force and effect unchanged.

University Corporation for Atmospheric Research (UCAR) By: John J. Braun Name: John Braun Title: UCAR Empowered Official Date: 21 /Feb/2019	**National Oceanic and Atmospheric Administration (NOAA) / Office of Projects, Planning, and Analysis (OPPA)** By: _____ Name: Margaret Caulfield Title: Acting Director Date:
National Oceanic and Atmospheric Administration (NOAA) / Office of Satellite and Products Operations (OSPO) By: _____ Name: Vanessa Griffin Title: Director Date:	**California Institute of Technology, Jet Propulsion Laboratory (JPL)** By: _____ Name: Reed Wilcox Title: Empowered Official Date:
Moog USA By: _____ Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date:	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date:
SRI International By: _____ Name: Jocelyn To Title: Assistant General Counsel Date:	**ATA-Aerospace** By: _____ Name: Anthony R. Tenorio Title: Managing Partner Date:

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University Corporation for Atmospheric Research (UCAR) By: _____ Name: John Braun Title: UCAR Empowered Official Date:	**National Oceanic and Atmospheric Administration (NOAA) / Office of Projects, Planning, and Analysis (OPPA)** By: _____ Name: Elsayed Talaat Title: Director Date: 3/5/2019
National Oceanic and Atmospheric Administration (NOAA) / Office of Satellite and Products Operations (OSPO) By: _____ Name: Vanessa Griffin Title: Director Date:	**California Institute of Technology, Jet Propulsion Laboratory (JPL)** By: _____ Name: Reed Wilcox Title: Empowered Official Date:
Moog USA By: _____ Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date:	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date:
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National Oceanic and Atmospheric Administration (NOAA) / Office of Satellite and Products Operations (OSPO) By: _____ Name: Vanessa Griffin Title: Director Date:	**California Institute of Technology, Jet Propulsion Laboratory (JPL)** Reed E Wilcox Digitally signed by Reed E Wilcox DN: c=US, o=CALIFORNIA INSTITUTE OF TECHNOLOGY-JET PROPULSION LABORATORY, ou=CALIFORNIA INSTITUTE OF TECHNOLOGY-JET PROPULSION LABORATORY, cn=Reed E Wilcox, 0.9.2342.19200300.100.1.1=A01096900001375B8ACBEF00001895 Date: 2019.03.11 10:15:25 -07'00' By: _____ Name: Reed Wilcox Title: Empowered Official Date:
Moog USA By: _____ Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date:	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date:
SRI International By: _____ Name: Jocelyn To Title: Assistant General Counsel Date:	**ATA-Aerospace** By: _____ Name: Anthony R. Tenorio Title: Managing Partner Date:

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Moog USA By: FranMarie Mulla Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date: 28 FEBRUARY 2019	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date:
SRI International By: _____ Name: Jocelyn To Title: Assistant General Counsel Date:	**ATA-Aerospace** By: _____ Name: Anthony R. Tenorio Title: Managing Partner Date:

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Moog USA By: _____ Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date:	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date: 2/25/19
SRI International By: _____ Name: Jocelyn To Title: Assistant General Counsel Date:	**ATA-Aerospace** By: _____ Name: Anthony R. Tenorio Title: Managing Partner Date:

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Moog USA By: _____ Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date:	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date:
SRI International By: _____ Name: Jocelyn To Title: Assistant General Counsel Date: 2/21/2019	**ATA-Aerospace** By: _____ Name: Anthony R. Tenorio Title: Managing Partner Date:

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Moog USA By: _____ Name: FranMarie Mulla Title: Trade Compliance Manager/EO Date:	**The Aerospace Corporation** By: _____ Name: Donna L. Avila Title: Alternate Empowered Official; Associate Principal Director,Security & Safety Directorate Date:
SRI International By: _____ Name: Jocelyn To Title: Assistant General Counsel Date:	**ATA-Aerospace** By: Anthony R. Tenorio Name: Anthony R. Tenorio Title: Managing Partner Date: February 21, 2019

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement. (*continued from previous page*)

ASRC Federal Holding Company, LLC By: _____ Name: Clifford Greenblatt Title: Empowered Official Date:	**Quantech Services, Inc.** By: _____ Name: James V. Monopoli Title: President/CEO Date:
Space Exploration Technologies Corp. (SpaceX) By: _____ Name: Kent Harris Title: Export Compliance Officer Date:President/CEO Date:	**Instar Engineering and Consulting Inc. (Instar)** By: _____ Name: Poti G. Doukas Title: Vice President, Instar Date:
The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

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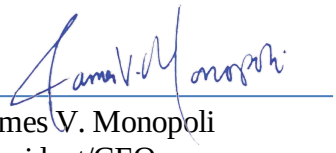
ASRC Federal Holding Company, LLC By: _____ Name: Clifford Greenblatt Title: Empowered Official Date:	**Quantech Services, Inc.** By:  Name: James V. Monopoli Title: President/CEO Date: 22Feb19
Space Exploration Technologies Corp. (SpaceX) By: _____ Name: Kent Harris Title: Export Compliance Officer Date:President/CEO Date:	**Instar Engineering and Consulting Inc. (Instar)** By: _____ Name: Poti G. Doukas Title: Vice President, Instar Date:
The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement. *(continued from previous page)*

ASRC Federal Holding Company, LLC By: _____ Name: Clifford Greenblatt Title: Empowered Official Date:	**Quantech Services, Inc.** By: _____ Name: James V. Monopoli Title: President/CEO Date:
Space Exploration Technologies Corp. (SpaceX) By: _____ Name: ~~Kent Harris~~ Sarah Banco Title: Export Compliance Officer Date: ~~President/CEO~~ March 14, 2019 Date:	**Instar Engineering and Consulting Inc. (Instar)** By: _____ Name: Poti G. Doukas Title: Vice President, Instar Date:
The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

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ASRC Federal Holding Company, LLC By: _____ Name: Clifford Greenblatt Title: Empowered Official Date:	**Quantech Services, Inc.** By: _____ Name: James V. Monopoli Title: President/CEO Date:
Space Exploration Technologies Corp. (SpaceX) By: _____ Name: Kent Harris Title: Export Compliance Officer Date:President/CEO Date:	**Instar Engineering and Consulting Inc. (Instar)** By: _____ Name: Poti G. Doukas Title: Vice President, Instar Date:
The University of Texas at Dallas (UTD) Emily Lacy Digitally signed by Emily Lacy Date: 2019.02.22 12:07:06 -06'00' By: _____ Name: Emily Lacy Title: Assoc Dir, OSP Date: 2/22/19	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

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The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: Lauren McGinley Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

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The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: ~~Creighton Chin~~ Title: **Empowered Official** Date: 04 MAR 2019 CARL SCHOENEBERGER
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement. (*continued from previous page*)

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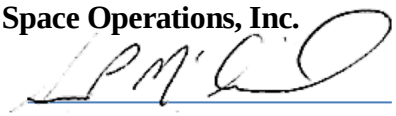
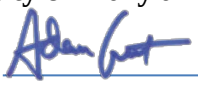
Space Exploration Technologies Corp. (SpaceX) By: _____ Name: Kent Harris Title: Export Compliance Officer Date:President/CEO Date:	**Instar Engineering and Consulting Inc. (Instar)** By: _____ Name: Poti G. Doukas Title: Vice President, Instar Date:
The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By:  Name: Sean McDaniel Title: CEO Date: February 20, 2019	**Technical Adventures, LLC** By: _____ Name: Jonathan Fulford Title: President Date:

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement. (*continued from previous page*)

ASRC Federal Holding Company, LLC By: _____ Name: Clifford Greenblatt Title: Empowered Official Date:	**Quantech Services, Inc.** By: _____ Name: James V. Monopoli Title: President/CEO Date:
Space Exploration Technologies Corp. (SpaceX) By: _____ Name: Kent Harris Title: Export Compliance Officer Date:President/CEO Date:	**Instar Engineering and Consulting Inc. (Instar)** By: _____ Name: Poti G. Doukas Title: Vice President, Instar Date:
The University of Texas at Dallas (UTD) By: _____ Name: Rafael Martin Title: Interim VP for Research Date:	**The Analytic Sciences Corporation (TASC), an Engility Company** By: _____ Name: Alicia Banks Title: Manager, Empowered Official Date:
Noblis, Inc. By: _____ Name: Lauren McGinley Title: VP, Gen. Counsel, and Secretary Date:	**Orbital Systems, LLC** By: _____ Name: **Creighton Chin** Title: **Empowered Official** Date:
Atlas Space Operations, Inc. By: _____ Name: Sean McDaniel Title: CEO Date:	**Technical Adventures, LLC** By: 2/26/2019 Name: Jonathan Fulford Title: President Date:

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement. (*continued from previous page*)

University of Maryland By:  Name: Adam Grant Title: Empowered Official Date: 3/1/2019	**Science and Technology Corporation (STC)** By: _____ Name: Hal J. Bloom Title: Empowered Official Date:
National Space Organization (NSPO) By: _____ Name: Title: Date:	**National Applied Research Laboratories (NARL)** By: _____ Name: Dr. Kuang-Chong Wu Title: Vice President Date:
Ministry of Science and Technology (MOST) By: _____ Name: Dr. Fong-Chin Su Title: Political Deputy Minister Date:	**Central Weather Bureau (CWB)** By: _____ Name: Chia-Ping Cheng Title: Director of MIC, CWB Date:
National Central University (NCU) By: _____ Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date:	**National Cheng Kung University (NCKU)** By: _____ Name: Dr. Chien-Hung Lin Title: Professor Date:
Taiwan Typhoon & Flood Research Institute (TTFRI) By: _____ Name: Dr. Ching-Yuang Huang Title: Director General Date:	**Academia Sinica** By: _____ Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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University of Maryland By: _____ Name: Adam Grant Title: Empowered Official Date:	**Science and Technology Corporation (STC)** By: Hal J Bloom Name: Hal J. Bloom Title: Empowered Official Date: 2.22.19
National Space Organization (NSPO) By: _____ Name: Title: Date:	**National Applied Research Laboratories (NARL)** By: _____ Name: Dr. Kuang-Chong Wu Title: Vice President Date:
Ministry of Science and Technology (MOST) By: _____ Name: Dr. Fong-Chin Su Title: Political Deputy Minister Date:	**Central Weather Bureau (CWB)** By: _____ Name: Chia-Ping Cheng Title: Director of MIC, CWB Date:
National Central University (NCU) By: _____ Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date:	**National Cheng Kung University (NCKU)** By: _____ Name: Dr. Chien-Hung Lin Title: Professor Date:
Taiwan Typhoon & Flood Research Institute (TTFRI) By: _____ Name: Dr. Ching-Yuang Huang Title: Director General Date:	**Academia Sinica** By: _____ Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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University of Maryland By: _____ Name: Adam Grant Title: Empowered Official Date:	**Science and Technology Corporation (STC)** By: _____ Name: Hal J. Bloom Title: Empowered Official Date:
National Space Organization (NSPO) By: Chun-Liang Lin Name: Dr. Chun-Liang Lin Title: Director General Date: Mar. 4, 2019	**National Applied Research Laboratories (NARLabs)** By: Kuang-Chong Wu Name: Dr. Kuang-Chong Wu Title: Vice President Date: Mar. 11, 2019
Ministry of Science and Technology (MOST) By: _____ Name: Dar-Bin Shieh Title: Deputy Minister Date: Mar. 19. 2019	**Central Weather Bureau (CWB)** By: _____ Name: Chia-Ping Cheng Title: Deputy Director General Date:
National Central University (NCU) By: _____ Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date:	**National Cheng Kung University (NCKU)** By: _____ Name: Dr. Chien-Hung Lin Title: Professor Date:
Taiwan Typhoon & Flood Research Institute (TTFRI) By: _____ Name: Title: Date:	**Academia Sinica** By: _____ Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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National Space Organization (NSPO) By: _____ Name: Dr. Chun-Liang Lin Title: Director General Date:	**National Applied Research Laboratories (NARLabs)** By: _____ Name: Dr. Kuang-Chong Wu Title: Vice President Date:
Ministry of Science and Technology (MOST) By: _____ Name: Dar-Bin Shieh Title: Deputy Minister Date:	**Central Weather Bureau (CWB)** By: Chia-Ping Cheng Name: Chia-Ping Cheng Title: Deputy Director General Date: 3/5, 2019
National Central University (NCU) By: _____ Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date:	**National Cheng Kung University (NCKU)** By: _____ Name: Dr. Chien-Hung Lin Title: Professor Date:
Taiwan Typhoon & Flood Research Institute (TTFRI) By: _____ Name: Title: Date:	**Academia Sinica** By: _____ Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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National Space Organization (NSPO) By: ..... Name: Dr. Chun-Liang Lin Title: Director General Date:	**National Applied Research Laboratories (NARLabs)** By: ..... Name: Dr. Kuang-Chong Wu Title: Vice President Date:
Ministry of Science and Technology (MOST) By: ..... Name: Dar-Bin Shieh Title: Deputy Minister Date:	**Central Weather Bureau (CWB)** By: ..... Name: Chia-Ping Cheng Title: Deputy Director General Date:
National Central University (NCU) By: Lung-C. Tsai Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date: March. 4, 2019.	**National Cheng Kung University (NCKU)** By: ..... Name: Dr. Chien-Hung Lin Title: Professor Date:
Taiwan Typhoon & Flood Research Institute (TTFRI) By: ..... Name: Title: Date:	**Academia Sinica** By: ..... Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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University of Maryland By: _____ Name: Adam Grant Title: Empowered Official Date:	**Science and Technology Corporation (STC)** By: _____ Name: Hal J. Bloom Title: Empowered Official Date:
National Space Organization (NSPO) By: _____ Name: Dr. Chun-Liang Lin Title: Director General Date:	**National Applied Research Laboratories (NARLabs)** By: _____ Name: Dr. Kuang-Chong Wu Title: Vice President Date:
Ministry of Science and Technology (MOST) By: _____ Name: Dar-Bin Shieh Title: Deputy Minister Date:	**Central Weather Bureau (CWB)** By: _____ Name: Chia-Ping Cheng Title: Deputy Director General Date:
National Central University (NCU) By: _____ Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date:	**National Cheng Kung University (NCKU)** By: Chien Hung Lin Name: Dr. Chien-Hung Lin Title: Professor Date: 4 March 2019
Taiwan Typhoon & Flood Research Institute (TTFRI) By: _____ Name: Title: Date:	**Academia Sinica** By: _____ Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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National Space Organization (NSPO) By: _____ Name: Dr. Chun-Liang Lin Title: Director General Date:	**National Applied Research Laboratories (NARLabs)** By: _____ Name: Dr. Kuang-Chong Wu Title: Vice President Date:
Ministry of Science and Technology (MOST) By: _____ Name: Dar-Bin Shieh Title: Deputy Minister Date:	**Central Weather Bureau (CWB)** By: _____ Name: Chia-Ping Cheng Title: Deputy Director General Date:
National Central University (NCU) By: _____ Name: Dr. Lung-Chih Tsai Title: Director of GPSARC, NCU Date:	**National Cheng Kung University (NCKU)** By: _____ Name: Dr. Chien-Hung Lin Title: Professor Date:
Taiwan Typhoon & Flood Research Institute (TTFRI) By: _____ Name: Title: Date:	**Academia Sinica** By:  Name: Dr. Huang-Hsiung Hsu Title: Deputy Director & Research Fellow of Research Center for Environmental Changes, Academia Sinica Date:

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National Taiwan University By: _____ Name: Dr. Cheng-Ku Yu Title: Professor Date: 2019 6 March	**Kongsberg Satellite Services AS (KSAT)** By: _____ Name: Kathrine Sandvoll Title: Contracts Officer Date:
Surrey Satellite Technology Limited (SSTL-UK) By: _____ Name: Sarah Parker Title: Finance Director Date:	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: Mr Bryan Hodge Title: General Manager Observing Systems and Operations Date:	**University of Energy and Natural Resources (UENR)** By: _____ Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date:
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date:	

IN WITNESS WHEREOF, the parties hereto have caused this Amendment Eleven to Agreement No. 2780-11 to be executed effective as of the day and year of the last signature of this agreement. (*continued from previous page*)

National Taiwan University By: _____ Name: Dr. Cheng-Ku Yu Title: Professor Date:	**Kongsberg Satellite Services AS (KSAT)** By: _____ Name: Kathrine Sandvoll Title: Contracts Officer Date: February 21, 2019
Surrey Satellite Technology Limited (SSTL-UK) By: _____ Name: Sarah Parker Title: Finance Director Date:	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: Mr Bryan Hodge Title: General Manager Observing Systems and Operations Date:	**University of Energy and Natural Resources (UENR)** By: _____ Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date:
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date:	

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National Taiwan University By: _____ Name: Dr. Cheng-Ku Yu Title: Professor Date:	**Kongsberg Satellite Services AS (KSAT)** By: _____ Name: Kathrine Sandvoll Title: Contracts Officer Date:
Surrey Satellite Technology Limited (SSTL-UK) By: SParker Name: Sarah Parker Title: ~~Finance~~ Managing Director Date: 4th March 2019	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: Mr Bryan Hodge Title: General Manager Observing Systems and Operations Date:	**University of Energy and Natural Resources (UENR)** By: _____ Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date:
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date:	

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Surrey Satellite Technology Limited (SSTL-UK) By: _____ Name: Sarah Parker Title: Finance Director Date:	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: Mr Bryan Hodge Title: General Manager Observing Systems and Operations Date:	**University of Energy and Natural Resources (UENR)** By: _____ Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date:
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date:	

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National Taiwan University By: _____ Name: Dr. Cheng-Ku Yu Title: Professor Date:	**Kongsberg Satellite Services AS (KSAT)** By: _____ Name: Kathrine Sandvoll Title: Contracts Officer Date:
Surrey Satellite Technology Limited (SSTL-UK) By: _____ Name: Sarah Parker Title: Finance Director Date:	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: ~~Mr Bryan Hodge~~ Mr Terry Stiles Title: General Manager Observing Systems and Operations Date: 6/3/2019	**University of Energy and Natural Resources (UENR)** By: _____ Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date:
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date:	

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Surrey Satellite Technology Limited (SSTL-UK) By: _____ Name: Sarah Parker Title: Finance Director Date:	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: Mr Bryan Hodge Title: General Manager Observing Systems and Operations Date:	**University of Energy and Natural Resources (UENR)** By: HKDapaah Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date: 26-02-2019
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date:	

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National Taiwan University By: _____ Name: Dr. Cheng-Ku Yu Title: Professor Date:	**Kongsberg Satellite Services AS (KSAT)** By: _____ Name: Kathrine Sandvoll Title: Contracts Officer Date:
Surrey Satellite Technology Limited (SSTL-UK) By: _____ Name: Sarah Parker Title: Finance Director Date:	**Instituto Nacional de Pesquisas Espaciais (INPE)** By: _____ Name: Dr. Ricardo M. O. Galvão Title: Director Date:
Australian Bureau of Meteorology (BoM) By: _____ Name: Mr Bryan Hodge Title: General Manager Observing Systems and Operations Date:	**University of Energy and Natural Resources (UENR)** By: _____ Name: Prof. Harrison Kwame Dapaah Title: Vice Chancellor of UENR Date:
In-Space Missions Ltd. By: _____ Name: Doug Liddle, CEO Title: CEO Date: 4/3/19	

EXHIBIT A: APPROVED TECHNOLOGY
Amendment Eleven to TA-2780-11

Between

University Corporation for Atmospheric Research

And

National Oceanic and Atmospheric Association

And

California Institute of Technology, Jet Propulsion Laboratory

And

Moog USA

And

The Aerospace Corporation

And

SRI International

And

ATA-Aerospace

And

ASRC Federal Holding Company, LLC

And

Quantech Services, Inc.

And

Space Exploration Technologies Corp. (SpaceX)

And
Instar Engineering and Consulting, Inc. (Instar)

And

The University of Texas at Dallas

And

The Analytic Sciences Corporation (TASC), an Engility Company

And

Noblis, Inc.

And

Orbital Systems, LLC

And

Atlas Space Operations, Inc.

And

Technical Adventures, LLC

And

University of Maryland

And

Science and Technology Corporation

National Space Organization

And

National Applied Research Laboratories

And

Ministry of Science and Technology

And

Central Weather Bureau

And

National Central University

And

National Cheng Kung University

And

Taiwan Typhoon and Flood Research Institute

And

Academica Sinica

And

National Taiwan University

And

Kongsberg Satellite Services AS

And

Surrey Satellite Technology Limited UK

And

Instituto Nacional de Pesquisas Espaciais (INPE) of Brazil

And

Australian Bureau of Meteorology

And

University of Energy and Natural Resources (UENR)

And

In-Space Missions Ltd.

EXHIBIT A: APPROVED TECHNOLOGY
Amendment Eleven to TA-2780-11

1 Purpose

FORMOSAT-7/COSMIC-2 (F-7/C-2) is a joint U.S.-Taiwan satellite program that will provide atmospheric data for the benefit of the operational weather and research communities. The purpose of this ***Exhibit A*** is to describe the technology required for the F-7/C-2 Program, and within the scope of this technology, the extent to which the U.S. signatories to this TAA will provide defense services and disclose technical data to NSPO and the other foreign signatories. Designated scientific satellite payloads and associated mass models and test equipment for export in furtherance of this agreement are also described in this *Exhibit A*. This TAA only includes planning and development of the Launch Vehicle (LV) services, not actual SC/LV integration or launch services. Actual SC/LV integration, launch, and early orbit activity will be the subject of a separate TAA or an amendment to this TAA.

2 Roles and Responsibilities

The F-7/C-2 Program is an international collaborative project primarily between the U.S.'s NOAA/NESDIS Office of Systems Development and Taiwan's NSPO with a primary goal to launch and operate a constellation of approximately twelve operational satellites with Global Navigation Satellite System (GNSS) radio occultation (RO) scientific payloads, as well as secondary space weather scientific payloads, to collect atmospheric data for numerical weather and space weather prediction, atmospheric and ionospheric studies, and climate research. Two main objectives of this collaboration are: 1) provide technical and scientific assistance to maximize the capabilities of GNSS RO technology in a real-time operational environment and 2) demonstrate the advantages and effectiveness of a satellite constellation in terms of risk management, operational flexibility, cost and compatibility with existing observational weather platforms. The F-7/C-2 system architecture is illustrated in Figure 1.

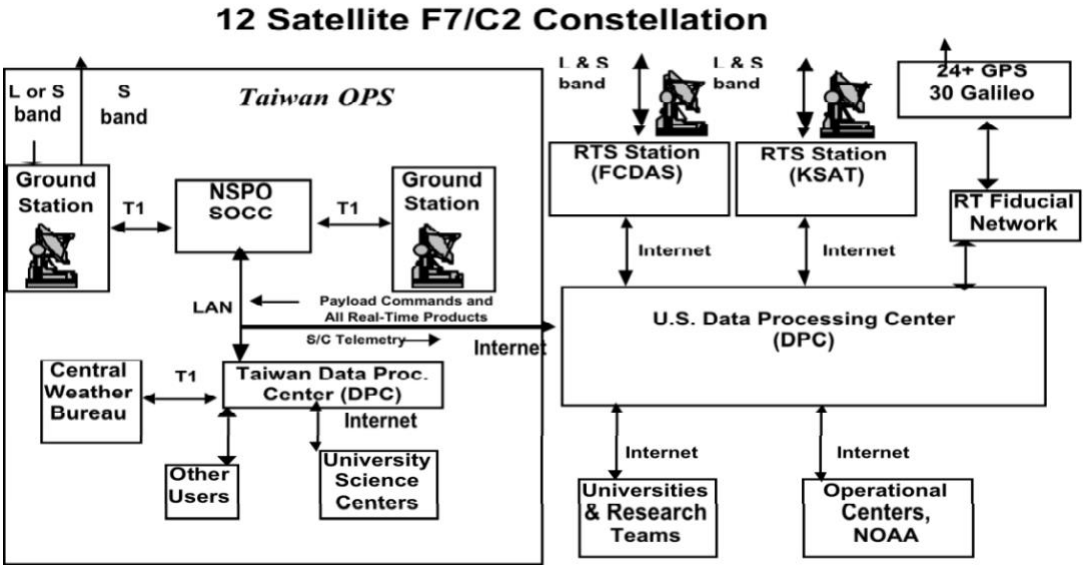

Figure 1 FORMOSAT-7/COSMIC-2 System Architecture

The American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Representative Office in the United States (TECRO) signed an Agreement for Technical Cooperation Associated with the Design, Development, Integration, Test, Launch and Operation of the F-2/C-2 Follow-On Mission, dated 27 May 2010. This Agreement provides a framework within which AIT, through its designated representative, NOAA, can provide technical expertise, training, and scientific exchange activities to TECRO, through its designated representative, NSPO. U.S. agencies and Taiwan's NSPO are expected to equally fund this project through in-kind contributions and activities that will be undertaken as specified in the Implementing Arrangements to the AIT-TECRO Agreement.

The USAF is providing significant support to NOAA for the F-7/C-2 mission. The USAF is responsible for sensor payload acquisition, sensor interface design, supporting development of the Remote Terminal Stations (RTS) and Ground Network Services (GNS), operation of RTS and GNS for the F-7/C-2 mission, supporting development of the US Data Processing Center, and shares responsibility for program management, systems engineering, interface control, and integration activities pertaining to the F-7/C-2 system. All payload hardware is owned by the USAF. With regard to launch vehicle services, the USAF is also responsible for launch planning and development services, launch vehicle acquisition, launch mission planning, launch mission design, systems engineering, interface control and integration activities pertaining to the F-7/C-2 launch vehicle.

The primary responsibilities of UCAR to the F-7/C-2 Program are:

- Manage and execute the transfer of defense services and technical data to NSPO as described in this TAA.
- Maintain a library and document release log of all released ITAR data subject to U.S. Government Inspection and Audit.
- Provide for protection/storage/backup of all program documents.
- Provide programmatic, technical, and scientific input for the planning and execution of the F-7/C-2 mission.
- Provide Data Processing Center (DPC) to retrieve, process, disseminate, and archive F-7/C-2 data products in near real-time.
- Control access to technical data at their facilities, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.
- Provide payload data to the USAF, NOAA, and other government agencies and private partners for use in weather forecasting.

The primary responsibilities of NOAA to the F-7/C-2 Program are:

- Provide COSMIC-2 System Program Management coordination
- Develop Remote Terminal Stations (RTSs) ground tracking stations and Ground Network Services (GNS) used for tracking, telemetry, and commanding (TT&C) of the F-7/C-2 spacecraft. NOAA will subcontract with a contractor, ASRC for support for operations services at NOAA Fairbanks Command and Data

Acquisition Stations (FCDAS). NOAA will subcontract with Kongsberg Satellite Services (KSAT) for services at KSAT downlink sites.
- Operate RTSs and associated GNS for the duration of the F-7/C-2 mission.
- Provide Frequency Coordination for the F-7/C-2 mission.
- Control access to technical data at their facilities, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of the California Institute of Technology, Jet Propulsion Laboratory (JPL) to the F-7/C-2 Program are:
- Design and develop the GNSS RO scientific payloads.
- Provide hardware and software interface and control information to successfully integrate and operate the GNSS RO payloads for the F-7/C-2 RO mission.
- Provide support to integrate and test the GNSS RO payloads onto the spacecraft.
- Provide payload operations and troubleshooting support.
- Provide technical and scientific input for the planning and execution of the F-7/C-2 mission.
- Based on the approved TAA, create a Rules of Engagement Technology Transfer Control Plan. The document will convey how JPL will approve and mark technical data prior to export, manage/monitor technical interchange meetings and teleconferences and control access to technical data at their facility. The JPL Office of Export control will train the COSMIC-2 personnel regarding the Rules of Engagement and what technical data and defense services are authorized under the Agreement, and any Modifications.
- Control access to technical data at their facilities, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Moog USA to the F-7/C-2 Program are:
- Manufacture and test the GNSS RO payload engineering and flight models.
- Provide support to integrate and test the GNSS RO payloads onto the spacecraft.
- Provide hardware and software interface and control information to successfully integrate and operate the GNSS RO payloads for the F-7/C-2 RO mission.
- Provide payload operations and troubleshooting support.
- Control access to technical data at their facility, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of The Aerospace Corporation to the F-7/C-2 Program are:
- Provide engineering support to the US Government for the development and integration of NOAA tracking capabilities into the F-7/C-2 network.
- Provide technical and scientific input for the planning and execution of the F-7/C-2 mission.
- Provide technical, scientific, and systems engineering input for the integration and testing of the sensor payloads on the F-7/C-2 spacecraft.

- Provide technical and systems engineering input for the development, deployment, integration, and testing of the F-7/C-2 data reception, data dissemination, and data processing activities.
- Provide technical review of the F-7/C-2 spacecraft design, design analyses, manufacturing processes, and testing to ensure mission success.
- Provide technical and systems engineering support for definition and verification of the spacecraft-to-launch vehicle interfaces, test requirements, and integrated payload stack.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of the University of Texas at Dallas (UTD) to the F-7/C-2 Program are:

- Design and develop the IVM scientific payloads.
- Provide hardware and software interface and control information to successfully integrate and operate the IVM payloads for the F-7/C-2 mission.
- Provide support to integrate and test the IVM payloads onto the spacecraft.
- Provide payload operations and troubleshooting support.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of SRI International (SRI) to the F-7/C-2 Program are:

- Design and develop the RF Beacon (SRI) payload.
- Provide hardware and software interface and control information to successfully integrate and operate the RF Beacon (SRI) payloads for the F-7/C-2 mission.
- Provide support to integrate and test the RF Beacon (SRI) payloads onto the spacecraft.
- Provide payload operations and troubleshooting support.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of ATA-Aerospace to the F-7/C-2 Program are:

- Provide programmatic and technical input for the planning and execution of the F-7/C-2 science payloads.
- Support the execution of the science payload acquisition activities.
- Support the development of the science payload interface control documents.
- Control access to technical data at their facility, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of ASRC Federal Holding Company, LLC NOAA Fairbanks Command and Data Acquisition Stations (FCDAS) to this effort include:

- Provide services and personnel support to NOAA at the Fairbanks Command and Data Acquisition Station as required for NOAA to integrate, test, and operate the associated Ground Network Services (GNS) at the Alaska NOAA RTS downlink site.
- Control access to technical data at their facility, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Quantech to the F-7/C-2 Program are:

- Provide systems engineering input for the planning and execution of the F-7/C-2 sensor payloads.
- Support the sensor payload acquisition activities.
- Support the development of the sensor payload interface control documents.
- Support the development of the COSMIC-2 ground system and ground integration activities.
- Control access to technical data at their facilities, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Space Exploration Technologies Corp. (SpaceX) to the F-7/C-2 Program are:

- Produce a launch vehicle for the F-7/C-2 first 6 satellites
- Provide for analysis of the F-7/C-2 satellite in support of launch vehicle integration
- Manage and support the launch vehicle/satellite integration and test activities at the F-7/C-2 launch site
- Integrate the F-7/C-2 first 6 satellites on to the launch vehicle along with additional primary and secondary payloads
- Perform launch and orbit insertion of the first 6 F-7/C-2 satellites
- Control access to technical data at their facilities, train their personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services

The primary responsibilities of Instar to the F-7/C-2 Program are:

- Support the COSMIC-2 launch program.
- Provide analysis and engineering to assure proper integration of payloads on to the Space X launch vehicle.

The primary responsibilities of TASC to the F-7/C-2 Program are:

- Provide system engineering and integration support to the SSAEM Program, including:
    - Risk development/coordination;
    - Schedule tracking and development; and
    - Budget and funding analysis.

The primary responsibilities of Noblis, Inc., to the F-7/C-2 Program are:

- Provide systems engineering and program management support to NOAA.

The primary responsibilities of **Orbital Systems, LLC,** to the F-7/C-2 Program are:

- Support the development and installation of the RTS and GNS for the the Australian Bureau of Meteorology tracking site in Darwin, Australia.
- Support the validation and operations of the RTS and GNS for the the Australian Bureau of Meteorology tracking site in Darwin, Australia.

The primary responsibilities of Atlas Space Operations, Inc., to the F-7/C-2 Program are:

- Lead the development and installation of the F-7/C-2 tracking site in Sunyani, Ghana.

- Support validation and operations of the F-7/C-2 tracking site in Sunyani, Ghana.

The primary responsibilities of Technical Adventures, LLC, to the F-7/C-2 Program are:

- Provide program management and engineering support to the US Government, specifically NOAA, for the development and operations of the integrated F-7/C-2 ground, launch, and space segments.

The primary responsibilities of University of Maryland to the F-7/C-2 Program are:

- Provide support to NOAA related to the calibration, validation, and utilization of GNSS RO observations. This includes assessment of GNSS RO data quality and their utilization within numerical weather models.

The primary responsibilities of Science and Technology Corporation (STC), to the F-7/C-2 Program are:

- Provide programmatic, aerospace and systems engineering/technical assistance (SETA) support to NOAA in the planning and execution of the F-7/C-2 GNSS-RO Program.
- Provide technical liaison support to parties to the TAA, specifically NOAA, NSPO, and the USAF.

The primary responsibilities of Taiwan's National Space Organization (NSPO) to the F-7/C-2 Program are:

- Procure, integrate, and test spacecraft and scientific payloads.
- Develop a Satellite Operations Control Center (SOCC) to operate the satellites and payloads for the duration of the F-7/C-2 mission.
- Development of Remote Terminal Stations (RTSs) ground tracking stations and Ground Network Services (GNS) in Taiwan used for TT&C of the F-7/C-2 spacecraft.
- Operation of RTSs and associated GNS in Taiwan for the duration of the F-7/C-2 mission.
- Provide Data Processing Center (DPC) in Taiwan to retrieve, process, disseminate, and archive F-7/C-2 data products in near real-time. The DPC is a ground science data processing center and is considered non-ITAR.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's National Applied Research Laboratories (NARLabs) to the F-7/C-2 Program are:

- Provide funding and direction to the NSPO regarding programmatic decisions.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's Ministry of Science and Technology (MOST) to the F-7/C-2 Program are:

- Provide funding and direction to the NSPO regarding programmatic decisions.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's Central Weather Bureau (CWB) to the F-7/C-2

Program are:

- Manage and operate the Taiwan Data Processing Center (TDPC) for F-7/C-2
- F-7/C-2 science data processing in Taiwan
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's National Central University (NCU) to the F-7/C-2 Program are:

- Provide consulting services to NSPO for mission development.
- Scientific research with F-7/C-2 data.
- Possibly provide secondary scientific payloads.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's National Cheng Kung University (NCKU) to the F-7/C-2 Program are:

- Scientific research with F-7/C-2 data.
- Possibly provide secondary scientific payloads.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's Typhoon and Flood Research Institute (TTFRI) to the F-7/C-2 Program are:

- Provide consulting services to NSPO for mission development
- Provide assistance to NSPO for the development of the Taiwan Data Processing Center (TDPC) for F-7/C-2
- Provide for data utilization in Taiwan
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Taiwan's Academia Sinica to the F-7/C-2 Program are:

- Provide supervision of the execution of FORMOSAT-7/COSMIC-2 program as a member of the executive steering committee.

The primary responsibilities of Taiwan's National Taiwan University to the F-7/C-2 Program are:

- Provide supervision of the execution of FORMOSAT-7/COSMIC-2 program as a member of the executive steering committee.

The primary responsibilities of KSAT to the F-7/C-2 Program are:

- Development of the RTS and GNS and Operation of RTS and GNS at KSAT downlink sites for the F-7/C-2 mission.

The primary responsibilities of Surrey Space Technology Limited (SSTL-UK) to the F-7/C-2 Program are:

- Design and develop the F-7/C-2 satellite buses.
- Provide hardware and software interface and control information to successfully integrate and operate all payloads for the F-7/C-2 mission.
- Integrate and test the first F-7/C-2 satellite.

- Provide support to launch mission planning activities and launch vehicle interface definition activities.
- Provide operations and troubleshooting support.
- Control access to technical data at its facility, train its personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of Instituto Nacional de Pesquisas Espaciais (INPE) of Brazil to the F-7/C-2 Program are:

- Provide for the procurement, construction, installation, operation, and maintenance of an S-band ground station compatible with COSMIC-2. If the ground station is used to support multiple satellite programs, COSMIC-2 satellite support will have the highest priority.
- Provide all downlinked COSMIC-2 data to all IP addresses that NOAA provides.
- Provide a secure internet connection that supports S-FTP Multicast.
- Seek to have the ground station operational at least 6 months prior to the first launch.

The primary responsibilities of the Australian Bureau of Meteorology to the F-7/C-2 Program are:

- Facilitate the installation of and operate and maintain a ground station for the reception of the F-7/C-2 data, to include the following:
    - Facilitate the installation of the antenna system on site,
    - Provide regular maintenance and first-in return to service, and
    - Perform monitoring.
- Provide raw data back to NOAA/UCAR for processing as per system design.

The primary responsibilities of UENR to the F-7/C-2 Program are:

- Host the equipment for the F-7/C-2 tracking site in Sunyani, Ghana.
- Support tracking site installation, validation, and operations.
- Control access to the facility, train UENR personnel regarding the definition of authorized personnel, and control the transfer of technical data and defense services.

The primary responsibilities of In-Space Missions Ltd. to the F-7/C-2 Program are:

- Provide spacecraft systems engineering, integration & testing, and launch processing support.

3 Areas of Collaboration

The division of responsibilities as noted above creates many technical interfaces, which requires the U.S. signatories to provide defense services and disclose technical data to the foreign signatories for successful F-7/C-2 Program execution. The defense services and technical data transfers to be performed under this TAA are detailed in the following sections.

3.1 Program Management

NOAA, USAF, and NSPO will jointly manage the F-7/C-2 Program. NOAA, USAF, and NSPO will establish, implement and maintain a management system integrating disciplines (scientific and technical), functions, and systems into an overall activity to achieve cost-effective planning, organizing, controlling, and reporting of the F-7/C-2 Program. NOAA and the other U.S. signatories will co-plan and co-execute the F-7/C-2 mission with NSPO and the other foreign signatories through personal contacts, phone calls, emails, exchange of visits, document

preparation and review, and attending and providing feedback at technical design review meetings.

The U.S. signatories will assist the international Joint Program Management team with the preparation of the following documents: Level 1 Requirements Document (L1RD), Payload Requirements Document (PRD), Mission Requirements Document (MRD), and Management Control Plan (MCP). This document preparation will include: technical, scientific, and programmatic input, detailed review and feedback of documents, and participation in meetings in person and via teleconference. The U.S. signatories will attend and actively participate in all program technical meetings including, but not limited to: Feasibility Design Review (FDR), Mission Design Review (MDR), System Requirement Review (SRR), System Design Review (SDR), Preliminary Design Review (PDR), Critical Design Review (CDR), Interface Control Working Groups (ICWG), Integration and Test Review (ITR), and Pre-Ship Reviews. Representatives from the U.S. signatories will provide technical, scientific and program management input, and feedback on the meeting documents and presentations. UCAR will review and monitor all ITAR-controlled technical communications, including email, teleconferences, documents, and meeting presentations. UCAR will maintain a library and document release log of all ITAR-controlled information transferred to NSPO and make it available upon request for U.S. Government inspection and audit.

3.2 Mission Design Support

The F-7/C-2 mission design includes the definition of the spacecraft, payloads, launch vehicle, RTSs, and DPCs. NOAA and the other U.S. signatories will provide assistance to NSPO for the final mission design. This support will include technical, scientific, and programmatic input, detailed review and feedback of documents, and participation in meetings in person and via teleconference. The U.S. signatories will also provide technical and scientific input related to mission design (e.g. measurement sampling, ground station visibility studies) with analyses of current COSMIC data and simulation studies of proposed constellation architectures.

3.3 Frequency Coordination

NOAA will take responsibility for ITU frequency filing (via NTIA) for the F-7/C-2 mission, including all frequencies used for TT&C and scientific payloads. NOAA will provide technical services to complete all necessary frequency coordination prior to launch in order to comply withthe ITU Radio Regulation and continue the best effort to ensure that no unexpected interference situation arises (both to and from Spacecraft) during the period of F-7/C-2 spacecraft network operation.

3.4 Science Payload Support

The U.S. signatories will transfer technical data and defense services to the foreign signatories to allow for the successful operation of the GNSS RO science payloads and the secondary space weather science payloads on the F-7/C-2 spacecraft. This information will be provided through written documentation, oral presentations, phone calls, emails, and exchange of visits. Technical data related to detailed design, internal workings, or manufacturing of the GNSS RO instrument, the IVM instrument, or the RF Beacon will not be transferred to NSPO or the other foreign signatories. UCAR will provide export services for the scientific payloads and associated mass models and test equipment.

3.4.1 GNSS RO Science Payload

The GNSS RO science instrument is the primary payload on the F-7/C-2 spacecraft. It consists of GNSS receiver electronics and multiple antennas to measure the phase and amplitude of GNSS satellite signals. These measurements will be downlinked to a ground DPC where they will be processed and disseminated for use in operational numerical weather prediction, atmospheric and ionospheric scientific studies, and climate research. The GNSS RO payload can track transmitted signals from three navigation systems (U.S. GPS, European Galileo, and Russian GLONASS), and thus has been named TriG. TriG will be a GPS Standard Positioning Service (SPS) receiver and will have no Y-code capability. The TriG payload hardware and software are being developed by CalTech/JPL and the F-7/C-2 engineering and flight units will be manufactured by Moog USA.

A functional block diagram of the TriG is shown in Figure 2 (taken from presentation by Tom Meehan of JPL at the 4th FORMOSAT-3/COSMIC Data Users Workshop in Boulder, CO, Oct 2009). The upper right box is the radio frequency (RF) front-end that receives signals from the antennas and performs the analog-to-digital conversion. The upper left box (IGOR GNSS Baseband Processor) performs the RF baseband processing, real-time navigation processing, and scheduling of GNSS satellite tracking. The bottom right box is a reconfigurable digital processor. The bottom left box is the Science Processor, which outputs phase and amplitude data that is sent to the ground DPC to produce the science data products for the mission. The Science Processor will also have an Application Interface (API) that will allow scientists to test new data processing algorithms.

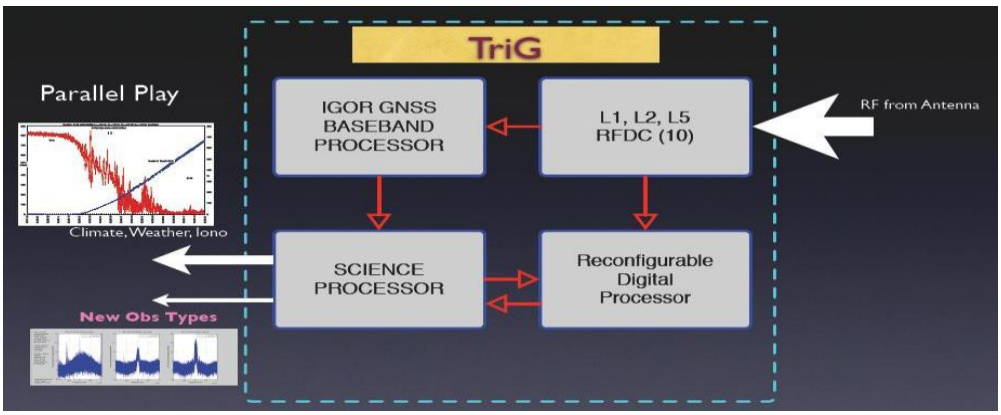

Figure 2 TriG Functional Diagram

3.4.2 Secondary Space Weather Science Payloads

The RF Beacon and the IVM are secondary science payloads on the F-7/C-2 spacecraft. The RF Beacon consists of a radio frequency transmitter capable of transmitting in three RF bands: UHF, L-band and S-band. A series of ground receivers intercepts the transmissions and measures ionospheric scintillation from the received signal characteristics. The IVM instrument measures ion density, ion velocity and direction, and ion composition. These measurements will be downlinked to a ground DPC where they will be processed and disseminated for use in operational ionospheric condition reporting and prediction, and atmospheric and ionospheric scientific studies.

3.4.3 Software Support

Software interface and control information will be provided to the foreign signatories to successfully integrate and operate the primary and secondary payloads for the F-7/C-2 mission. This will include information on: software configuration and upload, commanding formats and procedures, and data formats for output of science data and state-of-health data.

For the primary GNSS RO payload, software API information necessary for custom applications to run in the GNSS RO Science Processor may be provided. Source code and software design documentation will also be provided if necessary for the development and integration of custom science applications into the payload Science Processor. The TriG flight software will be transferred as a software binary executable. Software source code, with the exception described above in this paragraph related to custom science applications in the Science Processor, will not be transferred.

3.4.4 Integration and Test (I&T) Support

Support for I&T at SSTL-UK in the United Kingdom and at NSPO in Taiwan related to primary and secondary payload instrument activities will be provided by the U.S. signatories to the foreign signatories. The support services include the following tasks:

a) Provide review comments on Spacecraft Test Requirements related to payload.
b) Provide review comments on Spacecraft Test Plan related to payload.
c) Provide review comments on all the procedures related to payload integration and test prepared by NSPO for Spacecraft integration and test.
d) Provide on-site assistance in Taiwan to NSPO team for troubleshooting related to payload during the Spacecraft I&T.
e) Provide support for ground-to-spacecraft end-to-end test as it relates to payload and ground system.
f) Participate in the Test Review Board for the Spacecraft I&T.

3.4.5 Hardware to be Exported

All hardware is owned by the United States Air Force (USAF). The USAF hardware is to be integrated into the spacecraft in the UK and Taiwan for launch by the US from Florida. After launch, the payload data end use will be by the USAF, NOAA, and other government agencies and private partners for use in weather forecasting.

1. TriG GNSS Atmospheric Sensing Payload and associated test equipment
    a) Model: TriG Blackjack GNSSRO Payload
    b) Federal stock number: N/A
    c) Export type: Permanent
    d) Quantity: 6
    e) Description: The TriG Atmospheric Sensing Payload is a satellite GPS Receiver that is used for atmospheric sensing. The total payload includes the instrument chassis and 4 antennas and cabling.
    f) Value for each complete payload is $2.2M.
    g) Manufacturer: **Moog USA**

2. TriG GNSS Atmospheric Sensing Payload Engineering Model and test equipment
    a) Model: TriG Blackjack GNSSRO Payload
    b) Federal stock number: N/A
    c) Export type: Temporary
    d) Quantity: 1
    e) Description: The TriG Atmospheric Sensing Payload is a satellite GPS Receiver that is used for atmospheric sensing.
    f) Value for Engineering Model payload is $600K.
    g) Manufacturer: Moog USA

3. Ion Velocity Meter Payload and associated mass models and test equipment
    a) Model: 1
    b) Federal stock number: N/A
    c) Export type: Permanent
    d) Quantity: 6
    e) Description: The Ion Velocity Meter satellite payload is a small space weather sensing instrument for detecting ion speed and direction.
    f) Value for each Ion Velocity Meter payload is $1,009,000.
    g) Manufacturer: University of Texas at Dallas.

4. Beacon Payload and associated mass models and test equipment
    a) Model:1
    b) Federal Stock Number: N/A
    c) Export type: Permanent
    d) Quantity: 6
    e) Description: The Beacon satellite payload is a small transmitter and antenna for detecting ionosphere structure. This payload is coupled with a ground receiver (not part of this export) for receipt of the beacon transmissions.
    f) Value for each Beacon payload is $809K.
    g) Manufacturer: SRI International (SRI).

5. Beacon simulator and test equipment
    a) Model: 1
    b) Federal Stock Number: N/A
    c) Export type: Temporary
    d) Quantity: 2
    e) Description: The Beacon satellite payload is a small transmitter and antenna for detecting ionosphere structure. This payload is coupled with a ground receiver (not part of this export) for receipt of the beacon transmissions. Test equipment consists of a laptop and connected custom hardware chassis.
    f) Value for the Beacon simulator and test equipment is $30K.
    g) Manufacturer: SRI International (SRI).

6. Ion Velocity Meter Payload simulator and test equipment
    a) Model: 1
    b) Federal stock number: NA
    c) Export type: Temporary
    d) Quantity: 1

e) Description: The Ion Velocity Meter satellite payload is a small space weather sensing instrument for detecting ion speed and direction. Test equipment consists of a laptop and connected custom hardware chassis.
f) Value for the Ion Velocity Meter simulator and test equipment is $50K.
g) Manufacturer: University of Texas at Dallas and Ball Aerospace.

3.4.6 Operations Support

After launch, support will be provided to the foreign signatories on the operations of the F-7/C-2 constellation related to science direction and advice on the operations of the payloads. Support will be provided on payload configuration, commanding, state of health and science data monitoring, data analysis, and software uploads. NSPO will also receive periodic interface control documentation updates and flight software updates for upload to the spacecraft.

3.4.7 Troubleshooting Support

Support for hardware and software troubleshooting will also be provided to NSPO and other foreign signatories as needed in order to maximize the quantity and quality of the payload science data, maximize payload health and longevity, and minimize negative impact of payloads on spacecraft health. This support will involve analysis of payload science and state-of-health data, and may also involve spacecraft state-of-health data. Troubleshooting analysis result reports will be provided to NSPO. Details of troubleshooting analysis procedures may also be transferred to the foreign signatories if they would improve the payload or spacecraft operations and health.

Software engineering debugging support will also be provided to the foreign signatories to assist in integrating custom scientific applications into the GNSS RO Science Processor. This support will be provided on-site at NSPO or via phone or written correspondence in email or report documentation.

3.5 System Mission Assurance

The U.S. signatories to this TAA are committed to the successful deployment and operation of the F-7/C-2 system. To facilitate assurance of this success, the U.S. signatories will review the system, spacecraft, payloads, and ground network design through analyses, independent assessments, and review of test data. In addition, the U.S. signatories will review plan and process documentation for manufacturing, testing, integration, and verification activities. Reports on these activities, to include areas of concern or insufficiency, will be provided to the foreign signatories.

3.6 Launch Vehicle Preparation Support

Note: This TAA only includes planning and development of the Launch Vehicle (LV) services, not actual SC/LV integration or launch services. Actual SC/LV integration, launch, and early orbit activity will be the subject of a separate TAA or an amendment to this TAA.

3.6.1 Launch Vehicle Program Management

The U.S. signatories have a need to attend all spacecraft contract review meetings. USAF will provide program management to ensure that the launch vehicle program schedule and performance objectives are achieved. The detailed implementation will be documented in an Integrated Management Plan (IMP). This IMP will describe the

organization and management controls to be utilized in the implementation of the F-7/C-2 Launch Services Contract.

3.6.1.1 Reviews and Meetings

The U.S. signatories will conduct Program Management Reviews and attend Interface Control Working Group (ICWG) Meetings. U.S. signatories may prepare and deliver the Review Reports and Meeting Minutes/Reports, as they apply to the launch vehicle procurement and mission planning, to the foreign signatories.

3.6.1.2 Launch Program Management Reviews (PMR)

USAF will host and document PMR Meetings in conjunction with ICWG and/or progress reviews. The PMR will include, as a minimum, status of program, progress of contracted tasks, managerial and schedule issues, and technical interface issues. In addition to PMR, U.S. signatories will hold telephone conferences with the foreign signatories as deemed necessary to discuss any major issues. The U.S. signatories may provide the conference minutes to the foreign signatories.

3.6.1.3 Interface Control Working Groups (ICWG) Meetings

USAF and NSPO will develop and control the interfaces of the LV and the spacecraft. Interface issues will be resolved through participation at the SSTL-UK Spacecraft design reviews and at any Interface Control Working Group (ICWG) meetings. NSPO will conduct the ICWG meetings quarterly after spacecraft SDR to define and control all spacecraft interfaces that may impact the launch vehicle. The U.S. signatories will report the status of related activities.

3.6.2 Progress Reviews

All signatories may participate in the progress reviews described herein. Review Meetings may be held at the designated facilities of the launch service provider.

3.6.2.1 Launch Mission Design Review (MDR)

All signatories to the TAA may actively participate in the program Mission Design Review. The design review will be conducted such as to assure evaluation of the specifications for all services as defined in this document. This design review will cover, as a minimum:

a) Mission Requirements and Compliance
b) Flight Environments
c) Coupled Loads Results
d) Interface Definitions and Mechanical Clearances
e) Mission Trajectory Profile and Timeline of Events
f) Status of LV Program Schedule
g) Summary of RF Compatibility Results
h) LV and Spacecraft Integration Plan

SSTL-UK will also present the status of the Spacecraft program schedule, Mass Properties, and interface requirements during the meeting. The U.S. signatories will provide minutes of the design review to the foreign signatories and issue

reports, which will include the attendance record, summary of discussions and agreements, action items placed, copies of any presentations, and copies of all documentation tabled.
A final Mission Design Review report will be provided to the foreign signatories.

3.6.2.2 Launch Vehicle Pre-Shipment Review (PSR)

The purpose of this review is for USAF to demonstrate to NPSO that the LV is physically and functionally ready for launch processing. This review will be held at the designated Facility of the launch service provider according to the schedule negotiated by NSPO and USAF, and a Pre-Ship Review Report will be provided to the foreign signatories.

3.6.3 Launch Vehicle

3.6.3.1 Launch Vehicle Development and Qualification

The U.S. signatories will support a USAF-led qualification test program to verify the design and performance of any new LV flight components or structures, designed specifically for use on the F-7/C-2 program. The results of any required qualification tests will be summarized at the appropriate PMR, ICWG, and Progress Reviews and provided to the foreign signatories.

3.6.3.2 Launch Vehicle Manufacture and Test

USAF will arrange for the manufacture and test of the LV to be used for the F-7/C-2 mission to ensure proper acceptance of all components using Contractor's and US Government's standard test methods and procedures. USAF will provide the necessary logistics, hardware and software for the production, integration, and launch site operations of the LV. The results of these activities will be summarized in each of the appropriate PMR, ICWG, and Progress Reviews and will be provided to the foreign signatories.

3.6.4 Launch Mission Analyses

USAF will assure compatibility of the spacecraft with the LV interfaces and environment through a series of Mission Analyses. The U.S. signatories will provide for appropriate mission-unique flight, ground, simulation, and checkout software necessary to perform the various integration analyses. The U.S. signatories will perform or support, as a minimum, the following tasks:

3.6.4.1 Trajectory Analysis

The U.S. signatories will provide for a preliminary and a final Trajectory Analysis which will include sequence of events, vacuum impact point prediction, tracking information, and insertion accuracy as well as range safety parameter and lines of sight for down-range acquisition. A summary of the results of these analyses will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.2 Separation Analysis

Since the spacecraft provides the separation system, the U.S. signatories will supply SSTL-UK with the pertinent mass properties information for them to perform a preliminary and a final Separation Analysis of the spacecraft separation. The U.S. signatories will verify the Collision Contamination Avoidance Maneuver (CCAM) through analyses to avoid contamination and re-contact. The deployment sequence and thruster actions from the LV attitude control system will be performed in a manner to avoid interaction of the plumes with the spacecraft. A summary of the results of these analyses will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.3 Ascent Pressure/Venting Analysis

The U.S. signatories will provide for a preliminary and a final Ascent Pressure Analysis defining the Payload Fairing internal pressure and venting (pressure gradient) during ascent. A summary of the results of these analyses will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.4 Clearance/Coupled Loads Analysis

The U.S. signatories will provide for a preliminary and a final Coupled Loads Analysis (CLA) as a baseline to determine the flight dynamic loads and responses of the Spacecraft and the LV. The U.S. signatories will provide briefings summarizing the results of these analyses to the foreign signatories, and make available to SSTL-UK and NSPO the electronic data files, including the time histories at the spacecraft interface and levels within the spacecraft. The U.S. signatories will perform a preliminary and a final Clearance Analysis to validate the dynamic envelope clearance among the Spacecraft, PLA, and PLF. A summary of the results of this analysis will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.5 Thermal Requirements Verification

The U.S. signatories will provide for preliminary and final Thermal requirements verification as specified in the LV-to-Spacecraft Interface Control Document for the period from pre-launch through power-up and launch operations, up to insertion into the Insertion Orbit. The Spacecraft thermal model will be provided by NSPO to be used for the verification. A summary of the results of this analysis will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.6 RFI/EMI/EMC Compatibility

The U.S. signatories will provide for verification of RFI/EMI/EMC compatibility of the spacecraft, the LV, and launch site. The U.S. signatories will provide the measured data of RF environment at the launch site to the foreign signatories to support the spacecraft evaluation of potential RF damage to the spacecraft. The U.S. signatories will support SSTL-UK in evaluating options to resolve any RF

issues, and implement improvements to the vehicle on a best effort basis. The U.S. signatories will conduct an RF link analysis to ensure a sufficient RF link margin exists for both the telemetry and flight termination systems. The U.S. signatories will perform the analysis and/or test to ensure electromagnetic compatibility of the LV with the Spacecraft and the appropriate Range. A summary of the results of this analysis will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.7 Environments

The U.S. signatories will provide to the foreign signatories, as part of the LV-to-Spacecraft Interface Control Document, the Loads/Shock/Vibration/Acoustic Environmental inputs for the spacecraft. The environments as specified in the LV-to-Spacecraft IRD will be used as the baseline for the spacecraft design. Any updates of LV environments will be coordinated with NSPO in a timely manner to assure the spacecraft design is not affected.

3.6.4.8 Power Budget Verification

The U.S. signatories will maintain a power budget for this launch mission. USAF will verify that sufficient energy and peak load margin exist to satisfy both the LV and the spacecraft requirements. Battery charging time for the LV and the Spacecraft will be optimized through this analysis to ensure that adequate margins exist at launch time. A summary of the results of this analysis will be presented to the foreign signatories at the appropriate PMR, ICWG, and Progress Reviews.

3.6.4.9 Integrated Mechanical/Structural Testing

A series of mechanical/structural tests will be conducted at the designated facility of the launch service provider with NSPO and SSTL-UK participation. USAF and SSTL-UK will provide flight representative hardware to support conduct of the testing.

3.6.4.9.1 LV/Spacecraft Mechanical Interface Verification

The U.S. signatories will make available the appropriate hardware for performing a Fit Check between the LV and the spacecraft. This test will verify ICD mechanical compatibility between the LV and the Spacecraft including cable routing, connections, and any areas where there are potential interference issues. Results will be provided to the foreign signatories.

3.6.4.9.2 LV/Spacecraft Structural Test

Structural loads tests will be performed to verify structural capability of the spacecraft, its adapter hardware, and its attachment to the LV. The tests may be run individually or integrated to qualify new flight hardware. Static loads will be applied to represent worst-case steady state and transient load environments. Instrumentation will be provided to measure deflections and strain at appropriate locations. For separate testing, a flight representative interface/engineering test unit shall be provided for use by the U.S. signatories and SSTL-UK to conduct structural testing. Results will be provided to the foreign signatories.

3.6.4.9.3 Modal Survey

A modal survey test will be conducted to determine resonant frequencies, linearity characteristics, damping, and mode shapes of the LV structure and interfaces, and of the spacecraft structure. Instrumentation will include accelerometers to measure responses in order to provide data to verify analytical models used for loads and control analyses. The test will be conducted by the U.S. signatories and SSTL-UK using flight representative hardware. The test verified models will be provided to the U.S. signatories to design the softride hardware for the F-7/C-2 mission. The U.S. signatories will develop an integrated dynamic model for the LV, softride and the spacecraft. Results will be provided to the foreign signatories.

3.6.4.10 Launch Range Interfaces

3.6.4.10.1 Launch Permits and Licenses

USAF will assure submission of applications for and obtain all permits and licenses required for the performance of the launch service from those national or international public or private authorities having jurisdiction over any aspects of the F-7/C-2 launch mission.

3.6.4.10.2 Range Service Interface

USAF will secure all Range approvals and Range services that are needed for the launch of the F-7/C-2 Spacecraft. USAF will assist NSPO with the efforts to prepare, and/or coordinate, review, submit to the Range, and ultimately gain the Range approval of all the necessary documentation.

3.7 Develop the Remote Terminal Stations (RTS) and Ground Network Services (GNS) and Perform Prior-Launch Testing, Pre-Launch Testing and Operation of RTS and GNS

The U.S. signatories will provide required services and personnel to integrate, test, operate, and maintain the Remote Terminal Stations (RTS) at all RTS locations, and the associated Ground Network Services (GNS) at all RTS locations. The RTS's will provide for spacecraft bus and payload telemetry reception and commanding.

The U.S. signatories will provide test plans and test procedures and provide on-site support to perform the integration and testing among NSPO SOCC, the DPC, and the RTSs. The results of tests between NSPO and the RTSs will be included in reports to the foreign signatories. The U.S. signatories will provide all the interface and the network connectivity equipment required to deliver the data communication services, including terminating the data at NSPO in Taiwan.

The U.S. signatories will present the status for each Remote Terminal Station's development testing and operation during the Interface Control Working Group meetings and teleconferences. The U.S. signatories will provide information to the foreign signatories for preparing Spacecraft to Ground Segment ICD. The U.S. signatories will provide information to the foreign signatories for developing interface control document between the SOCC, RTS, and the DPC.

The foreign signatories will endeavor to attend several of the review meetings for the RTS & GNS. The U.S. signatories will supply necessary interface and configuration technical documents to the foreign signatories regarding RTS & GNS operation.

3.8 Continuous Operations of RTS and GNS

The U.S. signatories will provide support as required to maintain RTS and GNS services to all RTS stations for the duration of the F-7/C-2 mission.

4 Limitations on Technology to be Released to the Foreign Signatories Under This TAA

1. This authorization expires September 30, 2020

2. Export or temporary import of hardware in furtherance of this agreement is not authorized. This proviso does not limit the use of separate license for repair and replacement purposes. (Original from TA-2780-11)

3. Agreement of TA-0834-10 and all associated amendments was terminated within 30 days of execution of the re-baselined agreement per 22 CFR §124.6; (Original from TA-2780-11)

4. This agreement is limited to providing support for the design, development, integration and test, and launch vehicle planning for a constellation of approximately twelve operational micro-satellites with Global Navigation Satellite System (GNSS) radio occultation payloads (RO) and the additional secondary payloads described in this re-baseline agreement that are applicable to weather and space weather prediction, atmospheric and ionospheric science, and climate research. Technical data and assistance provided during the installation, testing, and training for the Data Processing Center IS also authorized. The applicant MUST submit an amendment or separate agreement(s)/license(s) for Launch Vehicle/Spacecraft Integration, launch, on-orbit operations and follow-on support. (Original from TA-2780-11)

5. Design methodology, engineering analysis and manufacturing know-how, as defined in 22 CFR 124.2(c)(4)(i-iii), MUST NOT be released. (Original from TA-2780-11)

6. The applicant MUST NOT augment or suggest changes that optimize, enhance, improve or increase the foreign licensees' processes or their capability to design, develop, or manufacture. This limitation DOES NOT affect the applicant's ability to discuss requirements, specifications, interfaces, integration, functions, operation and performance. (Original from TA-2780-11)

7. The applicant's independent analyses products and test data MUST BE limited to results only. Anomaly reports, including associated analyses products, to be released MUST BE limited to descriptions of the anomaly, cause, analyses rationale, and resolution. All anomaly/failure resolution, repair, or modification MUST BE accomplished strictly by

the appropriate party for their respective system. Collaborative anomaly/failure analysis with foreign licensees MUST NOT occur. (Original from TA-2780-11)

8. Discussions regarding launch vehicles, launch services, and launch support MUST BE limited either to information already available in the public domain or to general information the applicant possesses from past experience concerning pricing, insurance and launch integration issues (subject to approval from the launch services provider). (Original from TA-2780-11)

9. Satellite payload on-board software source code, and source code design documentation (to include algorithm and Kalman filter implementation/flow charts used for developing source code) shall not be released. However, the following may be released:

   a. Ground control system software, documentation for operator console interfaces, configuration, telemetry processing, archiving/retrieval (i.e., databases), display/event driver format, tabular data/text files (i.e., dataword/parametric/numeric listing), data plot/flows, command format, and simulation scenario data entry;

   b. Satellite payload on-board software documentation such as high-level algorithm (definition only), software interface data, operation modes and databases. (Original from TA-2780-11)

10. Any other software documentation transfer beyond design description and configuration control requirements MUST BE the subject of a separate specific request which must comply with the DoD Guidelines for International Transfers of Software Documentation (including source code) dated 07 April 1997. Email: dodsoftwareguidelines@dtsa.mil. (Original from TA-2780-11)

11. Information/data on U.S. Government (USG) programs that is NOT already in the public domain may ONLY be released by applicant after obtaining a written approval letter from the cognizant government program office and/or agency. All released data with USG approval letters MUST BE included in the data library. (Original from TA-2780-11)

12. The applicant MUST ensure compliance with 22 CFR 125.5(c) for foreign licensee visits to the U.S. Signatories' facilities and:

    a. Foreign licensee personnel MUST NOT have access to any areas at U.S. Signatories' facilities where activities occur pertaining to USG systems.

    b. Foreign licensee personnel MUST NOT be permitted to operate a Local Area Networks (LANs) or Wide Area Networks (WANs) computer with access to additional data sources/files or technical data NOT authorized under this license. (Original from TA-2780-11)

13. The applicant MUST maintain a library of released technical data, subject to USG inspection and audit. (Original from TA-2780-11)

14. This application does not meet the requirements of 22 CFR 130.2. No foreign armed forces or international organizations are involved in this transaction. The correct section is now marked in Block 22. (New from TA-2780-11A)

15. Prior to execution, Exhibit A was modified to reference the agreement number (TA-2780-11). (New from TA-2780-11A)

16. Foreign Person Employees of U.S. signatories participating in this agreement are authorized only as long as their employer maintains a valid DSP-5 for their employment. The scope of Foreign Person Employee (FPE) access to defense articles, including technical data and defense services, is limited to that identified within the DSP-5 for Foreign Person Employment. If the scope of this agreement is not contained within the DSP-5, then the DSP-5 must be amended/replaced to include the scope prior to FPE access. (New to TA-2780-11B)

17. In future submissions, the applicant must include all applicable USML categories in the transmittal letter. (New to TA-2780-11D)

18. U.S. signatories to this TAA MUST release technical data or engage in any technical meeting/discussions with the foreign licensees ONLY through the applicant, via a separate license, or with the applicant's specific consent. (New to TA-2780-11D)

19. The applicant must provide NASA HQ, Export Control and Interagency Liaison Division/David T. Flynn, 300 E Street, SW, Washington, D.C., 20546, copy of the Department of State approved license signed/executed (TAA). Provision of an electronic copy (.pdf) will satisfy this requirement. (New to TA-2780-11D)

20. The applicant and U.S. signatories to the TAA are authorized to transfer the NASA controlled technical data necessary to fulfill its obligation under this agreement and its Exhibit A. Transfer of other NASA non-public domain technical data in support of this TAA requires prior NASA approval. Contact David T. Flynn for approval (phone 202-358-1792, fax 202-358-4080, email: David.Flynn@nasa.gov). (New to TA-2780-11D)

21. The applicant must brief applicable NASA project managers/staff on the scope and limitations of access allowed by this license. (New to TA-2780-11D)

22. To the extent that DOD participation in any audit or meeting performed by the U.S. Government is reimbursable to the DOD, NASA provided funds shall not be used for such reimbursements. (New to TA-2780-11D)

If any future amendment grants any rights to sublicense, prior to the release of any technical data, the sublicensee must execute a Non-Disclosure Agreement (NDA) incorporating all the provisions of the basic Agreement which refer to the US Government and the Department of State (i.e., 22 CFR 124.8 and/or 124.9). Copies of the executed NDA's, referencing this DDTC case number, must be maintained for five years from the expiration of the amendment.