IMPLEMENTING ARRANGEMENT

A STATISTICS OF A STATISTICS O

THE REAL PROPERTY OF THE PROPERTY OF THE REAL PROPE

Marker Who and

BETWEEN

THE INDIAN SPACE RESEARCH ORGANISATION

OF THE REPUBLIC OF INDIA

AND

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OF THE UNITED STATES OF AMERICA

FOR COOPERATION ON THE

ACTIVE STATES

CHANDRAYAAN-2 MISSION

TABLE OF CONTENTS

PREAMBLE

ARTICLE 1 – PURPOSE OF COOPERATION

ARTICLE 2 - RELATIONSHIP TO THE FRAMEWORK AGREEMENT

ARTICLE 3 – RESPONSIBILITIES

ARTICLE 4 - POINTS OF CONTACT

ARTICLE 5 – DATA POLICY

ARTICLE 6 - REGISTRATION OF SPACE OBJECTS

ARTICLE 7 - OWNERSHIP OF GOODS AND DATA

ARTICLE 8 - INVESTIGATIONS OF MISHAPS AND CLOSE CALLS

ARTICLE 9 - ORBITAL DEBRIS AND DISPOSAL

ARTICLE 10 - PLANETARY PROTECTION

ARTICLE 11 – LUNAR HISTORIC SITES

ARTICLE 12 - AMENDMENTS

ARTICLE 13 - ENTRY INTO FORCE AND DURATION

PREAMBLE

The Indian Space Research Organisation of the Republic of India (hereinafter referred to as "ISRO") and the National Aeronautics and Space Administration of the United States of America (hereinafter referred to as "NASA"), (hereinafter referred to collectively as the "Parties" and individually as a "Party");

Considering the desirability of enhanced cooperation between the Parties in scientific lunar exploration; and

Recalling the terms of the Framework Agreement between the Indian Space Research Organisation and National Aeronautics and Space Administration for Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes, signed on February 1, 2008 (hereinafter referred to as the "Framework Agreement"),

Have agreed as follows:

NAMES OF THE OWNER O

ARTICLE 1

PURPOSE OF COOPERATION

The purpose of this Implementing Arrangement is to set forth the respective responsibilities of the Parties and the terms and conditions under which they shall cooperate on the Chandrayaan-2 lunar mission. This Implementing Arrangement covers cooperation related to the NASA-provided laser retroreflector array (LRA) and coordination with the NASA Lunar Reconnaissance Orbiter (LRO).

Chandrayaan-2 is India's second mission to the Moon comprising an orbiter, lander and rover. The mission will carry a six-wheeled rover that will observe the lunar surface and send back data, which will be useful for analysis of the lunar soil. The payloads on the orbiter will collect scientific information on lunar topography, mineralogy, elemental abundance, lunar exosphere and signatures of hydroxyl and water-ice.

The Lander's auxiliary payload shall include a NASA-provided LRA. The LRA is compact and lightweight and consists of eight (8) 1.25-centimeter (cm) diameter retrorcflectors mounted on a dome-shaped metal structure. The LRA is a passive optical device that contains no electronics or software. ISRO shall mount the LRA on the top surface of the lander. Current and future spacecraft capable of laser ranging, such as an orbiting laser altimeter, will be able to track the LRA. Tracking the LRA from orbit will provide accurate positioning measurement of the ISRO lander on the surface. The LRA also will become a long-term geodetic fiducial station on the lunar surface and a location marker for future landers.

ARTICLE 2

RELATIONSIIIP TO THE FRAMEWORK AGREEMENT

This Implementing Arrangement, concluded pursuant to Article 4 (Implementing Arrangements) of the Framework Agreement, incorporates by reference and is subject to the terms and conditions of the Framework Agreement, except as otherwise provided in this Implementing Arrangement.

3

RESPONSIBILITIES

3.1 ISRO Responsibilities

ISRO shall use reasonable efforts to carry out the following responsibilities:

- (a) Provide to NASA the environmental requirements (vibration, shock, thermal,) the LRA must be designed and tested against;
- (b) Provide overall accommodation requirements and system engineering while conducting technical meetings or email correspondence to monitor the LRA's progress, and ensure the LRA's performance and compatibility with ISRO mission technical and programmatic requirements;
- (c) Identify a location on the top panel of the Lander to mount the LRA, facing local zenith and having a mostly unobstructed view to the sky 45 degrees above the horizon on a best effort basis;

- (d) Design and fabricate the mechanical interface with the LRA;
- (e) Provide fasteners required to attach the LRA to the ISRO Lander;
- (f) Fit check the mockup LRA to the Lander for testing at ISRO facilities in India;
- (g) Integrate the LRA with the ISRO Lander prior to integration with the launch vehicle in India;
- (h) Perform a visual inspection and take photos of the LRA prior to integration on the launch vehicle to make sure there is no apparent physical damage and obstruction of the field of view by other objects, such as thermal blankets;
- (i) Provide NASA the coordinates of the LRA in the Lander reference frame for precision geolocation of the ISRO Lander on the Moon via laser ranging from orbit;
- (j) Provide NASA necessary information for possible laser ranging to the LRA from orbit, including the launch and landing times, location on the Moon, and the time windows to avoid laser ranging to the LRA to prevent interference with the ISRO activities;
- (k) Work with the NASA LRO Science team and participate in science team meetings about laser ranging to the LRA, as necessary;
- (1) Return the LRA mockup to NASA after integration of the flight LRA after launch;
- (m) Use any NASA-provided property only for the purpose described in this Implementing Arrangement, inform NASA prior to altering, loaning, or relocating any NASAowned property, and maintain suitable records for property management, as mutually agreed by the appropriate program managers; and
- (n) Provide information prior to the ISRO Lander's landing on the Moon that will allow NASA to image the plume of the landing and obtain related data.

3.2 NASA Responsibilities

NASA shall use reasonable efforts to carry out the following responsibilities:

(a) Provide ISRO with a full-size aluminum mockup LRA for the mechanical interface design and fit check on the Chandrayaan-2 Lander;

- (b) Perform a vibration test of the flight model LRA as per specification provided by ISRO;
- (c) Perform a thermal cycle test in vacuum chamber as per temperature limits and transient rate on the surface of the Moon near the ISRO Lander landing site on the Moon;
- (d) Deliver to ISRO one (1) flight model LRA for integration to the ISRO Lander prior to integration with the launch vehicle;
- (e) Deliver to ISRO the vibration and thermal cycle test data to demonstrate that the LRA meets ISRO requirements prior to integration;
- (f) Based on the request by ISRO, assist in the installation of the LRA onto the ISRO Lander, and in performing a visual inspection by ISRO, of the LRA after the installation;
- (g) Provide to ISRO the necessary interface and safety information for accommodation of the LRA onto the Lander;
- (h) Provide ISRO with an interface control document that includes the LRA technical information necessary for installation to the Lander, field of view, list of materials, operating temperature range, and vibration test levels;
- (i) Support, consistent with Article 8 (Investigations of Mishaps and Close Calls) below, any LRA-related anomaly investigations during the mission;
- (j) Work with the ISRO team on safe opportunities for laser ranging to the LRA from orbit with orbiting laser altimeters, such as the Lunar Orbiter Laser Altimeter (LOLA) on the Lunar Reconnaissance Orbiter (LRO) after the Lander has landed on the surface of the Moon;
- (k) Work with the ISRO Science team, participate in science team meetings and organise workshop on laser ranging to the LRA, as necessary;
- Coordinate with ISRO on the times of the laser ranging from NASA's LRO to avoid interference with the operation of other laser and optical instruments on the Lander, Orbiter and Rover; and
- (m) Attempt to take science measurements during the landing (if sufficiently close) and image the landing site post landing to locate the lander after landing on the Moon and share data with ISRO.

POINTS OF CONTACT

4.1 The ISRO point of contact is:

Programmatic: Ms. S. Megala Programme Manager Space Science Programme Office ISRO Headquarters Antariksh Bhavan, Bengaluru, Karnataka 560231 India Phone: +91-80-22172078 Email: megala@isro.gov.in <u>Technical:</u> Dr. P. Veeramuthuvel Deputy Director Space Infrastructure Programme Office ISRO Headquarters Antariksh Bhavan, Bengaluru, Karnataka 560231 India Phone: +91-80-22172196 Email: muthuvel@isro.gov.in

4.2

The NASA point of contact is:

Programmatic:

Mr. David Schurr Deputy Director Planetary Science Division Science Mission Directorate NASA Headquarters Mail Suite: 3B26 NASA Headquarters Washington, DC 20546-0001 United States Phone: +1-202-358-4489 Email: david.schurr@nasa.gov

Technical:

Mr. Xiaoli Sun NASA Goddard Space Flight Center Code 698 Building 33, Room D424 8800 Greenbelt Rd. Greenbelt, MD 20771, USA Phone (301) 614-6732 Email: xiaoli.sun-1@nasa.gov

4.3

Any change in a Party's respective contact information shall be communicated in writing to the other Party.

ARTICLE 5

DATA POLICY

The Parties shall have access to and use of all data generated under this Implementing Arrangement. The scientific data generated under this Implementing Arrangement shall be made available for public access as soon as practicable and consistent with good scientific practice.

REGISTRATION OF SPACE OBJECTS

Pursuant to Article 13 (Registration of Space Objects) of the Framework Agreement, ISRO shall request that its Government register the Chandrayaan-2 spacecraft as a space object.

ARTICLE 7

OWNERSHIP OF GOODS AND DATA

Unless otherwise agreed in writing, each Party shall retain ownership of all goods and data it provides to the other Party under the terms of this Implementing Arrangement, without prejudice to any individual rights of ownership of the Parties' respective Related Entities. To the extent feasible and recognizing that goods and data sent into space or integrated into the other Party's goods and data cannot be returned, each Party agrees to return the other Party's goods and data in its possession at the conclusion of activities under this Implementing Arrangement.

ARTICLE 8

INVESTIGATIONS OF MISHAPS AND CLOSE CALLS

In the case of a close call, mishap or mission failure, the Parties agree to provide assistance to each other in the conduct of any investigation, bearing in mind, in particular, the provisions of Article 11 (Transfer of Goods and Technical Data) of the Framework Agreement. In the case of activities that might result in the death of or serious injury to persons, or substantial loss of or damage to property as a result of activities under this Implementing Arrangement, the Parties agree to establish a process for investigating each such mishap.

ARTICLE 9

ORBITAL DEBRIS AND DISPOSAL

- 9.1 ISRO shall comply with the Space Debris Mitigation Guidelines of the United Nations Committee on the Peaceful Uses of Outer Space, endorsed by the United Nations General Assembly in its Resolution 62/217 of December 22, 2007.
- 9.2 In furtherance of the previous paragraph, the Parties agree to plan for the mitigation of orbital debris originating from the launch, operation, and of life of mission, as part of the mission planning process. Such a plan shall include which Party has the lead for the end of mission planning, conjunction assessment, and the standards to be used for the mitigation of orbital debris.

ARTICLE 10

PLANETARY PROTECTION

The Parties shall observe the guidelines contained in the Committee on Space Research (COSPAR) Planetary Protection Policy of 2011 ("COSPAR Planetary Protection Policy"), as amended, in place as of the signature of this Implementing Arrangement.

LUNAR HISTORIC SITES

ISRO and NASA share the objectives of preserving lunar sites of historic and scientific value and ensure taking necessary precautionary measures for protecting such sites during the Chandrayaan-2 mission.

ARTICLE 12

AMENDMENTS

- 12.1 This Implementing Arrangement may be amended through mutual written agreement by the Parties.
- 12.2 The Parties will amend this Implementing Arrangement to extend it, as required from programmatic or scientific point of view, after review and mutual decision of the Parties.

ARTICLE 13

ENTRY INTO FORCE AND DURATION

- 13.1 This Implementing Arrangement shall enter into force upon the last date of signature and shall remain in force from that date for a period of six (6) years, unless terminated by one Party providing at least 90 days' advance written notice to the other Party of its intent to terminate.
- 13.2 In addition to the continuing obligations undertaken by the Parties in Article 18(3) (Termination) of the Framework Agreement, the obligations of the Parties set forth in Article 5 (Data Policy) of this Implementing Arrangement shall remain in effect, notwithstanding termination or expiration of this Implementing Arrangement.

DONE in two originals in the English language.

FOR THE INDIAN SPACE FOR THE NATIONAL RESEARCH ORGANISATION OF AERONAUTICS AND SPACE THE REPUBLIC OF INDIA: ADMINISTRATION OF THE UNITED STATES OF AMERICA: Unamaheswaran.R) Scientific Secretary, ISRO ASSOCATE AMPUSTERIOR FOR STEENKIDONAL AND ILIEVARU ELADONS Place: Bangaluru Date: 26-12-2018 Place: WAStewiston Date: 2/11/2019

8