

# **Coordination Agreement Regarding the Operation of the IRIDIUM<sup>®</sup> System and the Arecibo Radio Astronomy Observatory**

## **1. Introduction**

This Coordination Agreement arose out of discussions between representatives of Space System License, Inc., a wholly owned subsidiary of Motorola, Inc. under contract to Iridium LLC; and Cornell University, operator of the National Astronomy and Ionosphere Center (“NAIC”).<sup>1</sup> Those discussions led to a Framework Agreement dated March 19, 1997, and then to a Coordination Agreement dated March 1, 1998. In light of the pending assignment of the Mobile Satellite Service License that is the subject of the Coordination Agreement, from Space System License, Inc. to Iridium Constellation LLC (“ICL”), a wholly owned subsidiary of Iridium Satellite LLC (“ISL”) (ICL and ISL shall hereinafter be referred to collectively as “New Iridium”), NAIC and New Iridium have entered into this new Coordination Agreement which is intended to ensure that the mutual obligations set forth in the March 1, 1998 Coordination Agreement in connection with coordination between the IRIDIUM System and the Arecibo Radio Astronomy Observatory are fulfilled by New Iridium and NAIC.

## **2. FCC Regulations**

The FCC has established certain inter-service coordination requirements for satellite systems operating in the 1610-1626.5 MHz band. These requirements are contained in Section 25.213 of the FCC’s Rules and Regulations. They include:

47 CFR 25.213(a)(2):

“Mobile Satellite Service space stations transmitting in the 1613.8-1626.5 MHz band shall take whatever steps necessary to avoid causing harmful interference to [list of observatories, including Arecibo Radio Observatory] during periods of observation.”

47 CFR 25.213(a)(4):

“The Radio Astronomy Service shall avoid scheduling radio astronomy observations during peak MSS/RDSS traffic periods to the greatest extent practicable.”

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<sup>6</sup> The National Astronomy and Ionosphere Center is operated by Cornell University under a Cooperative Agreement with the National Science Foundation.

### 3. Principles of Coordination

The following basic principles have been agreed upon regarding the coordination of the IRIDIUM<sup>®</sup> System<sup>7</sup> with the Arecibo Radio Astronomy Observatory (“Arecibo”):

- a) New Iridium will operate the IRIDIUM System in a spectrum efficient and economic manner, without causing harmful interference to Arecibo. It is recognized that the main area of concern is potential interference to the radio astronomy observations scheduled at Arecibo in the 1610.6-1613.8 MHz band from the IRIDIUM System downlinks, covered by international RR S5.372.
- b) Arecibo is to be protected from harmful interference during those periods that radio astronomy observations are conducted in the 1610.6-1613.8 MHz band. The scheduling of these periods will, to the greatest extent practicable, be done in such a way as to coincide with the minimum traffic periods for the IRIDIUM System. It is anticipated that observations at Arecibo will not unnecessarily inhibit the ability of New Iridium to operate the IRIDIUM System in a spectrum efficient and economic manner.
- c) The IRIDIUM System mobile earth terminals will be capable of terminating operations after the first position fix of the terminals.
- d) The NAIC will provide New Iridium with scheduling information, either directly or through the Electromagnetic Spectrum Management Unit of the National Science Foundation (“ESMU”), regarding the periods when radio astronomy observations in the 1610.6-1613.8 MHz band are expected to be conducted at Arecibo.
- e) Motorola/Iridium has provided to the NAIC, at no charge, an air interface to the IRIDIUM System that provides a signal with a blanking period during approximately 50% of each 90 millisecond time frame. This signal will indicate when the transmitters on board the IRIDIUM System space vehicles are active. It is understood that the use of the air interface reduces the sensitivity of the Arecibo telescope, and that it allows carrying out only some types of radio astronomy observations. Nevertheless, it will enable NAIC, at its option, to conduct certain observations at Arecibo at any time, by “seeing through” the IRIDIUM System transmissions.
- f) The parties recognize that the provisions of this Coordination Agreement are based on the unique conditions and facilities of Arecibo, and may not apply to New Iridium’s coordination with any other radio astronomy observatory in the U.S. or elsewhere.

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<sup>7</sup> IRIDIUM is a registered trademark and service mark of Iridium Satellite LLC.

#### 4. Coordination

Arecibo is a unique national facility that accepts observing proposals from scientists all over the world. Observing time on the instrument is granted to projects reviewed favorably by external referees, solely on the basis of scientific merit. Therefore, prior to the proposal deadline, Arecibo can neither predict nor modify the total number of observing hours in any band during a particular scheduling period; this is set by proposal pressure and the reviewers. Nothing in this Coordination Agreement shall be construed as restricting or limiting Arecibo's ability to accept and review proposals, and to grant observing time solely on the basis of scientific merit.

Except when lightly loaded, it is anticipated that the IRIDIUM System will produce an average SPFD not exceeding  $-223 \text{ dBW m}^{-2} \text{ Hz}^{-1}$  in the 1610.6-1613.8 MHz band at the surface of the Earth at Arecibo. This figure reflects the fact that IRIDIUM space vehicle antennas will transmit in one polarization only, that the transmissions are averaged over a 2000 second interval, and that the satellite is in the 0 dBi sidelobe of the Arecibo antenna.

Recommendation ITU-R RA.769, Table 2, provides detrimental interference threshold levels for spectral line radio astronomy observations in the 1610.6-1613.8 MHz band as  $-238 \text{ dBW m}^{-2} \text{ Hz}^{-1}$  assuming, inter alia:

- 2000 second integration time and 20 kHz bandwidth for the radio astronomy observations;
- interference is received through 0 dBi sidelobes of the radio telescope.

Coordination between the parties to this Coordination Agreement is based upon the following provisions:

- a) Starting in 2001, New Iridium will provide quarterly to the NAIC the best available information about the expected IRIDIUM System traffic patterns in the vicinity of Arecibo, in the form of an hourly ranking for a typical week. NAIC will provide New Iridium with the best available information about the scheduled observations in the 1610.6-1613.8 MHz band, a month in advance of the observations. The parties will establish mutually convenient dates for the exchange of this information.
- b) New Iridium agrees to protect Arecibo to the SPFD level  $-238 \text{ dBW m}^{-2} \text{ Hz}^{-1}$  or better from 10 p.m. to 6 a.m. (Miami local time) seven days a week during periods when observations which have been notified to New Iridium in accordance with the procedure set forth in 4(a), above, are being taken. These levels will be adjusted to reflect actual sidelobe performance of the Arecibo antenna as determined by Arecibo and evaluated and jointly agreed upon by the parties.

- c) A few observations of special celestial objects (comets, supernovae, and other celestial objects of heretofore unknown type) may need to be accommodated outside the agreed 10 p.m.-6 a.m. scheduling window. To the greatest extent practicable, these observations will be carried out using the blanker described in 3(e), above. Special observations that cannot be done using the blanker will be protected to the  $-238 \text{ dBW m}^{-2} \text{ Hz}^{-1}$  level as set forth in 4(b), above. Such observations shall not exceed 8 passes per calendar year.
- d) New Iridium will comply with Section 25.213(a)(2) of the FCC's Rules as currently formulated (see Section 2 herein) as applied to the Arecibo Observatory.
- e) New Iridium will attempt to reduce emissions of any future generation satellites in the IRIDIUM System into the 1610.6-1613.8 MHz band. The NAIC will continue to attempt to decrease the Arecibo telescope's susceptibility to interference from spaceborne systems (e.g., by reducing sidelobe levels, effects on the antenna pattern due to screen illumination, and by incorporating blanking or other signal processing techniques into the observations).

## **5. Disclosure**

The terms and provisions of this coordination agreement will not be held as confidential. Certain information, to be exchanged under the terms of this agreement, and information that was exchanged in the course of negotiations leading to the March 1, 1998 Coordination Agreement, and was or is marked as "Confidential Proprietary," will remain confidential.

## **6. Modification**

This Coordination Agreement may be modified only by mutual agreement, in writing. In the event the parties reach an impasse on changes to this Coordination Agreement, they agree to submit the issue to the FCC and NTIA for mediation and resolution.

## **7. Review**

The parties agree to work on the items listed in the Annex and to meet annually beginning in February 1999 to review this Coordination Agreement.

## **8. Benefit**

This Agreement shall inure to the benefit of and be binding upon the parties hereto and their respective successors or assigns.

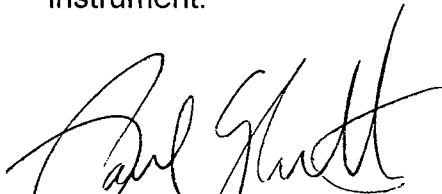
**9. Assignment.**

ICL agrees to notify NAIC prior to or the day of the filing with the FCC of an application to assign or transfer control of its Mobile Satellite Service License to a third party. ICL also agrees to obtain from such third party and deliver to NAIC prior to any assignment or transfer of the Mobile Satellite Service License, a written assumption of this Coordination Agreement, with such assumption being effective upon the consummation of the assignment.

**ACCEPTED AND AGREED UPON:**

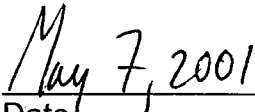
It is understood that the undersigned have the actual authority necessary to bind their respective companies and organizations to this Coordination Agreement.

This agreement may be executed by counterparts, each of which shall be deemed to be an original but all of which together shall constitute one and the same instrument.

  
\_\_\_\_\_  
Dr. Paul F. Goldsmith  
Professor  
Cornell University  
Director, NAIC

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[officer]  
Iridium Constellation, LLC

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[officer]  
Iridium Satellite, LLC

  
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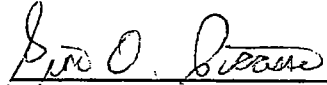
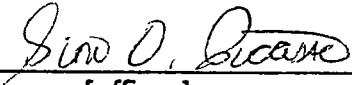
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_____ Dr. Paul F. Goldsmith Professor Cornell University Director, NAIC [officer]	 _____ [officer] Iridium Constellation, LLC President and CEO	 _____ [officer] Iridium Satellite, LLC President and CEO
_____ Date	4/30/01 _____ Date	4/30/01 _____ Date

## ANNEX

### 1. Areas of Investigation by Motorola

In accordance with the “Areas for Further Investigation” in the Framework Agreement dated 19 March 1997, and the associated Work Plan, Motorola has:

- a) Provided preliminary information on expected 24-hour IRIDIUM System traffic patterns, ranked hourly. No weekday/weekend data is currently available, but it is expected that such data will become available as the system becomes operational.
- b) Provided estimates of SPFD of a single IRIDIUM System burst transmission in the band 1610.6 - 1613.8 MHz, and the spectral signal characteristics of the IRIDIUM System within the same band, as a function of loading.
- c) Investigated the grouping of carriers to higher frequencies and local channel crowding, and found that this approach will not reduce emissions into the band of interest to radio astronomy under the current constraints on the IRIDIUM System. Channel crowding will be further investigated in future generation IRIDIUM System satellites.
- d) Conducted a study on the IRIDIUM System satellite elevation angle statistics at Arecibo. The study shows that, in relation to the Arecibo telescope, all IRIDIUM satellites are at off-axis angles of:
  - i) More than  $48^\circ$  about 80% of the time;
  - ii) More than  $30^\circ$  about 95% of the time;
  - iii) More than  $19^\circ$  about 98% of the time.
- e) Provided information on filters used during testing of the IRIDIUM System with National Radio Astronomy Observatory, which reduce emissions from the IRIDIUM space vehicles in the 1621.35-1626.5 MHz band.

### 2. Areas of Investigation by NAIC

In accordance with the “Areas of Further Investigation” in the aforementioned Framework Agreement, and the associated Work Plan, NAIC has:

- a) Determined, based on 1988 data, that:
  - i) Most Arecibo observations in the 1610.6 - 1613.8 MHz band could be scheduled between 8 p.m. and 6 a.m. local time every day of the week and one full day per week, e.g., Saturdays or Sundays;

- ii) A small number of observations (approximately 36 hours during the year) could not be fit into such a schedule and require additional time.
- b) Provided a study of bandwidth and integration time distribution, based on 1988 data, to show that, relative to the  $-238 \text{ dBW m}^{-2} \text{ Hz}^{-1}$  detrimental interference level specified in ITU-R RA.769:
  - i) 5% of the observations required 3-6 dB less sensitive measurements;
  - ii) 13% of the observations require 0-3 dB less sensitive measurements;
  - iii) 18% of the observations require 0-3 dB more sensitive measurements;
  - iv) 52% of the observations require 3-6 dB more sensitive measurements;
  - v) 12% of the observations require 6-9 dB more sensitive measurements.
- c) Provided information on the current estimate of the Arecibo telescope's sidelobe structure.
- d) Provided information showing that using simulations of dual beam switching techniques of the Arecibo receivers reduced the effect of GLONASS interference to an acceptable level approximately 70% of the time.

### **3. Future and Ongoing Work**

- a) The NAIC will, as soon as practicable, measure the actual Arecibo antenna sidelobe characteristics. NAIC will promptly provide a copy of the results to New Iridium.
- b) New Iridium/NAIC will evaluate the effect of interference from the IRIDIUM System using techniques similar to those employed in 2(d) of this Annex.
- c) The parties agree to jointly evaluate new data and techniques which may affect this Agreement. This evaluation includes, but is not limited to, data regarding actual traffic loads and actual demand for observing time; test results of the levels of interference generated by the IRIDIUM System; averaging techniques that would ameliorate interference from the IRIDIUM System; and improvements to the Arecibo antenna's sidelobes.

## CERTIFICATE OF SERVICE

I, Joan P. George, a secretary in the law firm of Fletcher, Heald & Hildreth, do hereby certify that a true copy of the *Comments of Cornell University and Motion for Leave to File* was sent this 14<sup>th</sup> day of July, 2003 by e-mail where indicated and via United States First Class Mail, postage prepaid, to the following:

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/s/ Joan P. George  
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**\* By e-mail**