



# The Arecibo Ionospheric Observatory

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## Summary

The Arecibo Ionospheric Observatory is a radio and radar telescope located in Barrio Esperanza, Arecibo, Puerto Rico. The Arecibo Observatory is managed, operated, and maintained by SRI International, under contract with the National Science Foundation (NSF). In 2005-2006, NSF's Division of Astronomical Sciences (AST) conducted a Senior Review of its portfolio of facilities. Among other things, the Senior Review was to identify potential reinvestment in the highest priority existing programs in AST and restructure the operational efficiency of the existing facilities. The Review reported that the scientific value of the Arecibo was modest when compared to other existing and proposed projects and recommended decreasing the telescope's annual \$12.0 million budget to \$9.0 million in FY2009, and securing partnerships for the remaining necessary funding. If alternate funding sources or partnerships could not be obtained by 2011, the Review recommended dismantling the facility.

In February 2011, a report of the Senior Review estimated that closure of the Arecibo could approach \$88.0 million, approximately eight times its current operating cost. The Review determined that AST should carefully examine the priorities of continuing to operate older facilities while simultaneously transitioning to newer facilities. The issue before the 112<sup>th</sup> Congress is whether the Arecibo is more cost-effective than replacing it with newer, available technology.

In June 2011, NSF announced that it awarded a \$42.0 million, five-year contract to SRI International to manage, operate, and maintain the Arecibo. SRI International will partner with the Universities Research Association, the Universidad Metropolitana, San Juan, and the University of Puerto Rico. The Arecibo will, among other things, expand its research on the study of the ionosphere, the remains of imploded stars, and also search within and beyond the Milky Way for asteroids and pulsars.

The Administration's FY2013 budget request for the Arecibo in the NSF totals \$8.2 million; the FY2012 estimate is \$8.7 million. Requested funding for the Arecibo Observatory in the FY2013 request includes \$5.0 million from the AST, and \$3.2 million from the Division of Atmospheric and Geospace Sciences (AGS).

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## Background

The Arecibo Ionospheric Observatory is a radio and radar telescope located on approximately 120 acres of federally owned land in Barrio Esperanza, Arecibo, Puerto Rico.<sup>1</sup> Currently, the Arecibo Observatory is managed, operated, and maintained by SRI International.<sup>2</sup> (SRI International partners with the Universities Research Association, and the Universidad Metropolitana, San Juan, and the University of Puerto Rico). Built in a natural depression in the jungles of Puerto Rico, Arecibo is the world's largest single-dish radio-wavelength reflector, measuring approximately 1,000 feet across and 167 feet deep. The 900-ton receiver platform is suspended 450 feet above the reflector dish. The 40,000 aluminum panels of the structure cover 20 acres. Arecibo can receive signals from 25 megahertz to 10 gigahertz. Transmitters include an S-band 2,380-megahertz radar system for solar studies and a 430-megahertz radar system for ionospheric studies. Arecibo can access approximately 40.0% of the sky and "has an unrivalled sensitivity due to its large size."<sup>3</sup> The fixed spherical telescope has the ability to predict and track the movement of potentially hazardous near-Earth objects.<sup>4</sup>

Construction of the Arecibo Observatory began in 1960 at the initial cost of \$9.7 million. The Defense Department's Advanced Research Projects Agency provided funding for the project, the Air Force administered it, and Cornell University managed the project for the Air Force. Arecibo was commissioned for service on November 1, 1963. Initially designed for radar studies of Earth's ionosphere, it was also found to be valuable for research in radio and radar astronomy. In 1970, ownership of Arecibo was transferred from the Department of Defense to the National Science Foundation's (NSF) Division of Astronomical Sciences (AST),<sup>5</sup> with NSF subsequently taking responsibility for funding of the telescope. It was at this time that the NAIC was established at Cornell University to manage the facility.

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<sup>1</sup> The primary instrument on the grounds is the Arecibo Observatory. Also on the grounds are laser radar (lidar) systems used for atmospheric observations.

<sup>2</sup> There was a management changeover for the Arecibo in October 2011 as a result of recompetition. The NSF awarded a contract to SRI International to maintain and operate the Arecibo beginning October 1, 2011. The Arecibo had been operated by Cornell University, under a cooperative agreement with NSF.

<sup>3</sup> National Science Foundation, *From the Ground Up: Balancing the NSF Astronomy Program*, Report of the National Science Foundation, Division of Astronomical Science Senior Review Committee, Arlington, VA, October 22, 2006, p. 42.

<sup>4</sup> For discussion of the near-Earth objects and the capabilities of Arecibo see for example House Committee on Science and Technology, Subcommittee on Space and Aeronautics, *Near-Earth Objects (NEOs)-Status of the Survey Program and Review of NASA's 2007 Report to Congress*, 109<sup>th</sup> Congress, 1<sup>st</sup> Sess. November 8, 2007.

<sup>5</sup> AST is in NSF's Directorate for Mathematical and Physical Sciences.

**Figure 1. The Arecibo Radio/Radar Telescope**  
National Astronomy and Ionosphere Center, Arecibo, Puerto Rico



**Source:** <http://www.aerospace-technology.com/projects/Arecibo/Arecibo4.html>.

The telescope has evolved and developed over its lifetime.<sup>6</sup> In 1974, the first upgrade was completed, replacing the original wire mesh surface with aluminum panels. The upgrade totaled approximately \$8.0 million—approximately \$5.0 million from NSF and \$3.0 million from National Aeronautics and Space Administration (NASA). The upgrade enabled Arecibo to operate at 3 gigahertz. Also, planetary radar studies were expanded with the installation of a 420 kilowatt transmitter, operating at 2.4 gigahertz.

In 1997, the second upgrade of the facility was completed, with the installation of a Gregorian reflector system, suspended approximately 450 feet above the telescope's 1,000-foot dish and a 1-megawatt radar transmitter. This upgrade allowed the telescope to operate at up to 10 GHz, increasing the telescope's "sensitivity, frequency coverage, and agility, and enabl[ing] dual-beam incoherent scatter radar capability, providing new research opportunities."<sup>7</sup> The upgrade was undertaken by NSF and NASA, with support from Cornell University, at a cost of \$25.0 million—\$14.0 million from NSF and \$11.0 million from NASA.

<sup>6</sup> Salter, Chris and Tapasi Ghosh, "Wider Bandwidths and a New 12m Antenna Will Keep the Arecibo Radiotelescope at the Cutting Edge of Science," June 28, 2010, [http://www.naic.edu/science/new12m\\_antenna\\_arecibo.html](http://www.naic.edu/science/new12m_antenna_arecibo.html).

<sup>7</sup> "The Arecibo Observatory Celebrates 40 Years-A Timeline," [http://www.research.cornell.edu/vpr/cwc172-04/pdfs/naic\\_timeline.pdf](http://www.research.cornell.edu/vpr/cwc172-04/pdfs/naic_timeline.pdf).

## Research Conducted at Arecibo

Arecibo is recognized for its research in radio astronomy, solar system radar astronomy/planetary radar, and ionospheric observations/terrestrial aeronomy. It has been used for research in such diverse areas as interstellar gas, pulsars and fundamental physics, variations in Earth's ionosphere, galactic structure formation and evolution, complex and pre-biotic molecules in the interstellar medium, planetary surfaces and moons, and the post-discovery characterization and orbital refinement of near-Earth asteroids. One of the first accomplishments of Arecibo was determining the correct rotation rate of Mercury, which was found to be 59 days instead of the previously estimated 88 days. Other Arecibo firsts include the first discovery of a binary pulsar, the first discovery of planets outside the solar system, and the first detailed three-dimensional mapping of how galaxies are distributed in the universe. In 1982, research conducted at Arecibo discovered a type of radio emission—hydroxyl megamaser—that has since been found to indicate a collision between two galaxies.

## Reports of the National Research Council

In 1997, the Board on Physics and Astronomy of the National Research Council (NRC) established the Astronomy and Astrophysics Survey Committee to assess the field of ground- and space-based astronomy and astrophysics for the decade 2000 to 2010. The committee was charged with recommending priorities for initiatives during that decade and to explore areas of development of new technologies. The report of the 2000 decadal survey, *Astronomy and Astrophysics in the New Millennium*,<sup>8</sup> made an effort to find the balance between long-term support for facility operations and research grants and priority for new technological opportunities and facilities. The committee made recommendations relating to coordination of the astronomy and astrophysics programs of the NSF, NASA, and the Department of Energy Office of Science (DOE). The committee also explored possibilities for international collaboration and private, state, and federal partnerships. The decadal survey recommended that NSF conduct competitive review of its astronomy facilities and organizations approximately every five years.

Another report of the NRC, *Connecting Quarks with the Cosmos*,<sup>9</sup> proffered recommendations that paralleled those of the decadal survey. Both noted that AST should respond to emerging scientific opportunities and construct different operational models for future astronomy facilities and organizations.

The 2008 annual report of the federal Astronomy and Astrophysics Advisory Committee<sup>10</sup> mirrored many of the recommendations contained in the 2000 decadal survey and *Connecting Quarks with the Cosmos*. It stated that

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<sup>8</sup> The National Academies, *Astronomy and Astrophysics in the New Millennium*, 2001, 246 pp.

<sup>9</sup> The National Academies, National Research Council, *Connecting Quarks with the Cosmos, Eleven Science Questions for the New Century*, Washington, DC, National Academy Press, 2003, 205 pp.

<sup>10</sup> The Astronomy and Astrophysics Advisory Committee was established under the National Science Foundation Authorization Act of 2002 (P.L. 107-368). The Committee's charter was updated in 2005 to include advising the DOE in addition to NSF and NASA.

AST's focus must of necessity change to reflect the needs of these new, powerful and very expensive facilities. A robust program of support for the majority of our current facilities, combined with the operations funding needed for our new and immensely more powerful facilities..., mandate cuts in funding for some current facilities if we are to make a credible case for new funding!<sup>11</sup>

The report suggested that in order to bring long-term stability to Arecibo for the science community, alternative funding sources and partnerships should be explored with other institutions in Puerto Rico and possibly with support from NSF's Division of Atmospheric Sciences. It was suggested also that international partnerships should be explored. In a joint NSF-NASA response to the committee, it was noted that although partnerships and joint projects can be problematic by increasing managerial complexity, they do offer the benefit of sharing responsibility and authority.<sup>12</sup>

A January 2010 report of the National Research Council examined near-earth objects (NEOs) and hazard mitigation strategies.<sup>13</sup> Included in this report was an analysis of the costs of detecting potentially hazardous NEOs and the costs associated with mitigation efforts.<sup>14</sup> The survey sought to determine the role the Arecibo would have in detecting, tracking, and characterizing NEOs. One of the findings in the report was that

The Arecibo and Goldstone radar systems play a unique role in the characterization of NEOs, providing unmatched accuracy in orbit determination, and insight into the size, shape, surface structure, and other properties for objects within their latitude coverage and detection range.<sup>15</sup>

The report further recommended that

Immediate action is required to ensure the continued operation of the Arecibo Observatory at a level sufficient to maintain and staff the radar facility. Additionally, NASA and NSF should support a vigorous program of radar observations of NEOs at Arecibo and NASA should support such a program at Goldstone for orbit determination and characterization of physical properties.<sup>16</sup>

The current decadal survey, addressing the period 2010-2020, was released in August 2010—*New Worlds, New Horizons in Astronomy and Astrophysics*.<sup>17</sup> This survey provides a comprehensive

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<sup>11</sup> 2008 Annual Report, Astronomy and Astrophysics Advisory Committee, University of California, Santa Cruz, p.31. [http://www.nsf.gov/mps/ast/aaac/reports/annual/aaac\\_2008\\_report.pdf](http://www.nsf.gov/mps/ast/aaac/reports/annual/aaac_2008_report.pdf).

<sup>12</sup> Joint NSF-NASA Response, October 18, 2002 Report of the National Astronomy and Astrophysics Advisory Committee, p. 4. See also Cho, Adrian and Daniel Clery, "Astronomy Hits the Big Time," *Science*, v. 323, January 16, 2009, pp. 332-335.

<sup>13</sup> The National Academies, National Research Council, *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies: Final Report*, Washington, DC, January 2010, 136 pp. This study of NEOs was required by NASA in P.L. 110-161 (H.R. 2764), Consolidated Appropriations Act 2008, Title III, Division B-Commerce, Justice, Science, and Related Agencies Appropriations Act, 2008. Signed into law on December 26, 2007.

<sup>14</sup> See also Rosen, Elisabeth, "New Report Defends Cornell's Giant Arecibo Telescope as Funding Cuts Loom," *The Cornell Daily Sun*, January 27, 2010, <http://www.cornellsun.com/section/news/content/2010/01/27>.

<sup>15</sup> The National Academies, *Defending Planet Earth: Near-Earth Object Surveys and Hazard Mitigation Strategies: Final Report*, p. 3.

<sup>16</sup> Ibid.

<sup>17</sup> The National Academies, National Research Council, *New Worlds, New Horizons in Astronomy and Astrophysics*, Committee for a Decadal Survey of Astronomy and Astrophysics, Washington, DC, National Academy Press, August (continued...)

and robust review of strategic planning process. In addition, it explores interagency issues among NSF's AST, NASA's Astrophysics Division, and DOE's Office of Science, High Energy Physics. The committee for this survey, known as Astro2010, was directed to make its recommendations and considerations for funding levels for astronomical research based on limited resources and a flat budget trajectory.<sup>18</sup> This survey included prioritization of "unrealized projects from previous decadal surveys that had not had a formal start alongside new research activities that had emerged from the research community."<sup>19</sup> The report recommended that

NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended elsewhere in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments, and (2) the science analysis needed to capitalize on the results from existing and future facilities.<sup>20</sup>

## Report of NSF's Senior Review

In 2005-2006, NSF's AST conducted a Senior Review of its portfolio of facilities. This review resulted from a combination of factors—projections for federal spending on research and development, growth of the AST budget, the proposed directions of the astronomical research community, and the recommendations and analyses contained in the aforementioned reports on ground-and space-based facilities. The Senior Review was to, among other things, identify potential reinvestment in the highest priority existing programs in AST and to restructure the operational efficiency of the existing AST-operated facilities. The Senior Review examined the balance within the full portfolio of projects and recommended changes that would provide savings from existing programs to be redirected in support of new activities. The Senior Review stated that Arecibo continues to produce scientific results, but when budgets are limited, choices have to be made to explore new science opportunities and new capabilities. The committee reported that the scientific value of the telescope was modest when compared to other existing and proposed projects funded primarily by the NSF. NSF has stated that

Identifying potential cost savings in our current portfolio of projects and devising an acceptable implementation plan for realizing these savings will allow progress to be made on the next generation of Astronomical instruments and better position AST for future budget augmentation.<sup>21</sup>

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(...continued)

2010, 324 pp. Note: This is the sixth decadal survey. The first was conducted in 1964 and subsequent surveys have been conducted approximately every ten years (1964, *Ground-Based Astronomy: A Ten Year Program*; 1972, *Astronomy and Astrophysics for the 1970s*; 1982, *Astronomy and Astrophysics for the 1980s*; 1991, *The Decade of Discovery in Astronomy and Astrophysics*; 2001, *Astronomy and Astrophysics in the New Millennium*; and 2010, *New Worlds, New Horizons in Astronomy and Astrophysics*).

<sup>18</sup> The National Academies, *Astro2010: The Astronomy and Astrophysics Decadal Survey*, <http://www7.nationalacademies.org/bpa/Astro2010.html>. The Committee on Astro2010 recommended priorities for the most important scientific and technical activities of the decade 2010-2020.

<sup>19</sup> The National Academies, *New Worlds, New Horizons in Astronomy and Astrophysics*, pp. xiii-xiv.

<sup>20</sup> *Ibid.*, p. 1-17.

<sup>21</sup> [http://www.nsf.gov/mps/ast/seniorreview/q\\_and\\_al-07.pdf](http://www.nsf.gov/mps/ast/seniorreview/q_and_al-07.pdf).



The Senior Review determined that the approximately \$200.0 million astronomy budget was facing a deficit of \$30.0 million by 2010. The Senior Review recommended decreasing the Arecibo's annual \$12.0 million budget to \$9.0 in FY2009 and securing partnerships for the remaining necessary funding. It stated that if alternative funding sources or partnerships could not be obtained by 2011, the Observatory should be dismantled.<sup>22</sup> The Senior Review anticipated that by FY2010, the \$2.5 million savings resulting from the proposed changes would be recovered by the AST budget and be made available for other projects and activities. The recommendation from the Senior Review as it relates to Arecibo is as follows

The [Senior Review] recognizes the significant and unique scientific contributions that the Arecibo Observatory has made to astronomy and astrophysics and it congratulates NAIC and Cornell on operating the facility so effectively.... However, the committee was not persuaded of the primacy of the science program beyond the end of the decade and found that the case for long term support at the present level was not as strong as that for other facilities. The [Senior Review] recommends a decrease in AST support for Arecibo to \$8 m (plus the \$2M from ATM) over the next three years. This should permit a reduction in the scientific and observing support staff and a discontinuation of the future instrumentation program without compromising the main science program.... The [Senior Review] recommends that NAIC plan either to close Arecibo or to operate it with a much smaller AST budget. This will require that NAIC seek sufficient external funding to continue to operate it fully. If Arecibo is kept operating beyond 2011, it is expected that this will only be a limited term extension, pending the deliberations of the next decadal survey.<sup>23</sup>

Supporters of Arecibo charge that the Senior Review made its recommendations based on anticipated flat budget forecasts. They contend that NSF's budget has been increasing over the years, and that should translate into additional funding for the AST and Arecibo in particular.<sup>24</sup>

There are some in the scientific community who believe that the NSF does not view solar system science as a high priority. In testimony before the House Subcommittee on Space and Aeronautics, Donald B. Campbell, professor, Cornell University, contended that the planetary/near-Earth objects radar research program at the Arecibo was in jeopardy as a result of the recommendations in the Senior Review.<sup>25</sup> Campbell charged that the Senior Review gave the planetary program scant attention in its report and failed to take into account the telescope's capabilities in detecting NEOs. The Arecibo radar system has conducted approximately 65.0% of all radar observations characterizing NEOs.

Others in the science community maintain that NASA should provide funding for the Observatory because it benefits greatly from its ability to track NEOs. The NASA Authorization Act, 2005,

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<sup>22</sup> There is the suggestion that the Square Kilometer Array (SKA), a new array of radio telescopes, could replace the capabilities of the Arecibo. The SKA is being planned by an international consortium. See National Science Foundation, *From the Ground Up: Balancing the NSF Astronomy Program*, pp. 63-64. In addition, China has started construction on a Five-hundred-meter Aperture Spherical Telescope (FAST) in Guizhou Province, China. With its anticipated completion in 2013-2014, FAST would be the world's largest radio telescope with an overall capacity 10 times larger than Arecibo. See "China Exclusive: China Starts Building World's Largest Radio Telescope," December 26, 2008, [http://news.xinhuanet.com/english/2008-12/26/content\\_10563849.htm](http://news.xinhuanet.com/english/2008-12/26/content_10563849.htm).

<sup>23</sup> National Science Foundation, *From the Ground Up: Balancing the NSF Astronomy Program*, p. 63.

<sup>24</sup> Weiss, Rick, "Radio Telescope and Its Budget Hang in the Balance," *The Washington Post*, September 9, 2007, p. A01.

<sup>25</sup> House Committee on Science and Technology, Subcommittee on Space and Aeronautics, 110<sup>th</sup> Cong., 1<sup>st</sup> Sess., November 8, 2007, Written testimony of Donald B. Campbell, Professor of Astronomy, Cornell University.

directs NASA to, among other things, track and catalogue, and characterize all near-Earth objects.<sup>26</sup> NASA counters that NSF should be the supporter of the Observatory.<sup>27</sup> NASA contends that it is focused on space-based programs and not ground-based programs.<sup>28</sup> The report of the Senior Review noted that

NASA has been very clear that it does not regard the support of ground-based telescopes as part of its mandate although on those occasions when it has contributed in this manner, the results have usually been scientifically highly productive. There are good reasons now to revisit the working relationship between the two agencies. The relationship with DOE has a shorter history but is currently more stable.<sup>29</sup>

In response to the Senior Review recommendations, Cornell University, which at that time operated the Arecibo<sup>30</sup>, said that it would terminate operations of the planetary radar in October 2007 in order to meet budget deadlines.<sup>31</sup> However, the University continued operation of the radar on a “less frequent schedule.” The Senior Review proposed that the Arecibo and the NSF seek partners, including international partners, to share operation costs and to allow the telescope to remain as a competitive scientific and educational facility.<sup>32</sup>

Within AST and in anticipation of a more constrained budget, efforts are being made to examine and balance both the operation of older facilities and the planning and construction of new facilities. In February 2011, the Senior Review Committee stated that the “AST Division must consider carefully the relative priorities of continuing to operate its older facilities and transitioning to the increased cost of operating the new facilities.”<sup>33</sup> The report also estimated that closure and decommissioning the Arecibo could cost an estimated \$88.0 million, approximately eight times its current annual operating cost. The Senior Review report further stated that “Despite the challenge, the budget and facilities planning process must identify and take such costs into account.”<sup>34</sup>

## Funding

An April 2010 NSF program solicitation indicated that the Arecibo Observatory would continue to operate at least until 2016.<sup>35</sup> It was anticipated that in addition to AST, the Arecibo would

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<sup>26</sup> P.L. 109-155.

<sup>27</sup> Rivera-Lyles, Jeannette, “Huge Observatory Now Needs to Spot a Rescuer,” *Technology News*, chron.com, April 5, 2008, <http://www.chron.com/dispatch/commnts.mpl/nation/5676855.html>.

NASA’s response is that it has the Deep Space Network 70 meter antenna at Goldstone to track NEOs. In addition, NASA anticipates that several telescopes are to be completed in the next five years that have the capabilities of tracking NEOs. The Large Synoptic Survey Telescope is expected to be completed in 2012.

<sup>28</sup> See for example “Arecibo Radar Observatories Help Fly NASA Spacecraft,” November 1, 2010, [http://www.naic.edu/science/ao\\_hartley.html](http://www.naic.edu/science/ao_hartley.html).

<sup>29</sup> National Science Foundation, *From the Ground Up: Balancing the NSF Astronomy Program*, p. 30.

<sup>30</sup> See *supra* note 2.

<sup>31</sup> NASA terminated support of the planetary radar in FY2006.

<sup>32</sup> It is both a research and teaching facility. Approximately 24.0% of the Arecibo users are graduate students.

<sup>33</sup> National Science Foundation, Division of Astronomical Sciences, “Report of the Committee of Visitors”, February 7-9, 2011, Arlington, VA, p. 20.

<sup>34</sup> *Ibid.*

<sup>35</sup> National Science Foundation, “Management and Operations of the National Astronomy and Ionosphere Center (continued...)”

receive funding from NSF's Division of Atmospheric and Geospace Sciences (AGS)<sup>36</sup> and NASA. The proposed funding structure would allow for additional astronomical research at the Observatory and an increase in asteroid-detection efforts and atmospheric research.<sup>37</sup> The AGS would increase its support of the Arecibo, rising from \$2.3 million to \$3.0 million in FY2011 to approximately \$4.0 million in FY2015. Funding from AST decreased from \$6.2 million in FY2011 to an estimated \$5.5 million in FY2012. It is estimated that support would further decrease to approximately \$4.0 million by FY2015. NASA provided funding of \$2.0 million in FY2011 and has provided budget plans to support planetary radar in FY2012 and beyond.

In June 2011, NSF announced that it awarded a \$42.0 million, five-year contract to SRI International to manage, operate, and maintain the Arecibo.<sup>38</sup> SRI International partners with the Universities Space Research Association,<sup>39</sup> the Ana G. Mendez-Universidad Metropolitana, San Juan, and the University of Puerto Rico.<sup>40</sup> The Arecibo will, among other things, expand its research on the study of the ionosphere, the remains of imploded stars, and also search within and beyond the Milky Way for asteroids and pulsars. At present, the Arecibo is operating on a \$10.7 million budget.

The Administration's FY2013 budget request for NSF provides a total of \$8.2 million for the Arecibo Observatory—\$5.0 million from the AST and \$3.2 million from the AGS.<sup>41</sup> Support provided in FY2012 is estimated at \$5.5 million from AST and \$3.2 million from AGS.

## Congressional Activity

Language in the FY2008 Omnibus Appropriations Act stated

The Appropriations Committees express concern over the conclusion of the NSF's division of Astronomical Science Senior Review with regard to the Arecibo Observatory. The Committees believe that this Observatory continues to provide important scientific findings on issues of near-space objects, space weather, and global climate change, as well as numerous other research areas. The Committees believe that these endeavors will have scientific merit far beyond the end of this decade. As such, the Committees hope the

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(NAIC)," Program Solicitation, NSF10-562, Arlington, VA, April 2010, 18 pp.

<sup>36</sup>AGS is in NSF's Directorate for Geosciences.

<sup>37</sup>The Puerto Rico Infrastructure Financing Authority provided \$3.0 million for major improvements at Arecibo in FY2010.

<sup>38</sup> See for example Coto, Danica, "World's Largest Radio Telescope Under New Boss", *Associated Press*, June 7, 2011, <http://www.google.com/hostednews/ap/article/ALeqM5h7XQzbxsvIKuLjIil84Zj9nSolqQ?>

<sup>39</sup> The Universities Space Research Association (USRA) is an independent, nonprofit research corporation that combines academic expertise with in-house talent in order to advance space and technology. The USRA operates in a multi-disciplinary environment, including biomedicine, astrophysics, and engineering, to create an integrated climate of applications ranging from fundamental research to facility operations and management.

<sup>40</sup> The program solicitation had stated that the proposal should "... consider alternative models of operations and governance, changes to programmatic scope, and/or effective partnerships that would leverage NSF support to sustain Arecibo Observatory as a national, multi-user center that is responsive to its stakeholders in the scientific community and in the Commonwealth of Puerto Rico." "Management and Operations of the National Astronomy and Ionosphere Center (NAIC)," Program Solicitation, p. 5.

<sup>41</sup> U.S. National Science Foundation, *FY2013 Budget Request to Congress*, NSF12-036, Arlington, VA, February 13, 2012, pp. MPS-6, and GEO-7.

Division of Astronomical Science will reconsider its conclusion regarding future funding for the Arecibo Observatory.<sup>42</sup>

In the 110<sup>th</sup> Congress, S. 2862, a bill to provide for NSF and NASA utilization of the Arecibo Observatory, was introduced on April 15, 2008. The bill would have provided for operation of Arecibo to continue. It would

- (1) ensure that the facility is fully funded to continue
  - (A) its research on Earth's ionosphere, and
  - (B) its research in radio astronomy, and
  - (C) research on the solar system; and
- (2) coordinate with the Administrator of NASA to ensure that the capabilities of the Arecibo Observatory continue to be available for NASA in characterizing and mitigating near-Earth objects, and other research as needed.

A similar bill, H.R. 3737, was introduced on October 3, 2007.

The 112<sup>th</sup> Congress may choose to consider increased funding for Arecibo. NASA has received a legislative mandate to observe and detect near-Earth objects. Considering the capabilities of Arecibo to characterize the physical properties of near-Earth objects, some say NASA could benefit from its continued support. In addition, preliminary estimates for dismantling Arecibo and restoring the land to its original state could exceed the cost of maintaining it for several years. It is anticipated that continued operation of the Arecibo will be assessed in a mid-decade independent review that was recommended in the August 2010 decadal survey.<sup>43</sup> Also, it was noted in a January 2012 presentation of NSF's AST outlook that budget realities and constraints<sup>44</sup> are expected to have a long-term impact on several programs, possibly leaving many of the recommendations of the decadal survey unfunded or not addressed.<sup>45</sup>

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<sup>42</sup> P.L. 110-161, H.R. 2764, House Appropriations Committee Print, Consolidated Appropriations Act, 2008, Title III, Division B-Commerce, Justice, Science, and Related Agencies Appropriations Act, 2008, p. 316. Signed into law on December 26, 2007.

<sup>43</sup> The National Academies, *New Worlds, New Horizons in Astronomy and Astrophysics*, pp. 79-102.

<sup>44</sup> In a memorandum to federal agencies, the Office of Management and Budget (OMB) requested that FY2013 budget request submissions reflect a 5.0% reduction, relative to the FY2011 enacted discretionary appropriation. In addition, the agencies were asked that their FY2013 budget submissions identify additional discretionary funding that would bring the request 10.0% below their FY2011 enacted discretionary appropriation. Jacob J. Lew, Director, OMB, "Fiscal Year 2013 Budget Guidance," M-11-30, August 17, 2011, <http://www.whitehouse.gov/sites/default/files/omb/memoranda/2011/m11-30.pdf>.

<sup>45</sup> National Science Foundation, "NSF/AST Outlook", Town Hall Meeting, Presentation by Jim Ulvestad, Director, Division of Astronomical Sciences, NSF, January 9, 2012, <http://www.nsf.gov/mps/ast/portfolioreview/2012AASTownHall.pdf>. See also U.S. National Science Foundation, *FY2013 Budget Request to Congress*, p. MPS-9.

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