National Radio Astronomy Observatory

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10 August 1989

Mr. Roy A. Cunniff
Physical Sciences Laboratory
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New Mexico State University
Las Cruces, New Mexico 88003-0001

Dear Mr. Cunniff:

Thank you for sending me copies of the official Notification of Intent to prepare an Environmental Impact Statement for the Department of the Air Force project, the Dynamic Coherent Measurement System (DYCOMS), and of the package of information dated 11 July 1989. This project could have a significant impact on the operations of the facilities of the National Radio Astronomy Observatory (NRAO).

The NRAO has four existing facilities in the state of New Mexico that could be affected by the operations of the DYCOMS if it were located on North Oscura Peak:

a. The Very Large Array radio telescope (VLA) centered at longitude 107° 37′ 03.819" W and latitude 34° 04′ 43.497" N;

b. The Very Long Baseline Array (VLBA) antenna at Pie Town located at longitude 108° 07′ 07.24" W and latitude 34° 18′ 03.61 N;

c. The VLBA antenna at Los Alamos located at longitude 106° 14′ 42.01" W and latitude 35° 46′ 30.33" N; and

d. The Array Operations Center (AOC) in Socorro located at longitude 106° 56′ 26" W and latitude 34° 04′ 11".

The NRAO currently is preparing plans to expand and improve the VLA which include two new antennas located near Bernardo and Dusty, New Mexico (approximate longitudes and latitudes 106.90° W and 34.35° N, and 107.65° W and 33.62° N, respectively) and one or two other new antennas located near Roswell New Mexico (104.53° W and 33.40° N) or near Vaughn, New Mexico (105.20° W and 34.60° N) and Holbrook, Arizona (110.20° W and 34.90° N).

In addition, the NRAO is designing a Millimeter Array radio telescope (MMA) to operate at frequencies between approximately 30 and 345 GHz. One of the preferred sites is the Langmuir Research site (longitude 107.20° W and latitude 33.96° N) on the summit of South Baldy in the Magdalena Mountains, which has been designated for atmospheric and astronomical research.

Finally, one antenna of the VLBA is located at Owens Valley, California (longitude 118° 16′ 33.98" W and latitude 37° 13′ 54.19" N), and its operations could be affected by the DYCOMS if it were located at China Lake, California.

THE VERY LARGE ARRAY

The VLA is the world's most powerful radio telescope and is located on the Plains of San Agustin, 50 miles west of Socorro. A brief history of radio astronomy, the NRAO, and the VLA is given in the enclosed booklet entitled "The Very Large Array." This booklet also includes a small sample from the great range of scientific projects carried out with the VLA. Technical descriptions of the VLA at the time of its completion in October 1980 are given in two enclosed papers by Thompson, Clark, Wade, and Napier (1980) and Napier, Thompson, and Ekers (1983).

Since 1980 the capabilities of the VLA have been greatly improved by the addition of receivers operating at new frequency bands and the replacement of existing receivers with improved models. As a result the VLA currently operates in the following frequency bands:

73- 75 MHz	8000- 8800 MHz
306- 340 MHz	14400-15400 MHz
1215-1730 MHz	22000-24000 MHz
4500-5010 MHz	

While these wide bands are necessary for some astronomical observations, most (perhaps ninety percent) VLA observations use a limited set of more narrow bands:

73- 75 MHz	8390- 8490 MHz
325- 338 MHz	14890-14990 MHz
1330-1427 MHz	22210-22260 MHz
1440-1540 MHz	22410-22510 MHz
1640-1690 MHz	23660-23740 MHz
4810-4910 MHz	23840-23910 MHz
4960-5010 MHz	

While several features of the design of the VLA greatly reduce its sensitivity to radio-frequency interference nonetheless, it is still quite sensitive to such interference. The nominal responses of the VLA and VLBA to interfering signals are described in the enclosed copy of VLA Scientific Memorandum No. 156, "The Responses of the Very Large Array and the Very Long Baseline to Interfering Signals." The Magdalena Mountains lie between the VLA and the proposed site for the DYCOMS on North Oscura Peak and would provide considerable terrain shielding. But because of the frequency agility of both the VLA and DYCOMS and because of the high effective radiated powers of the radars to be

used by the DYCOMS, the potential for serious radio-frequency interference to the VLA from the fundamental, harmonic, and spurious emissions of the DYCOMS remains.

Our study last year of the Dynamic Measurement System (DMS, an earlier incarnation of the DYCOMS) suggested that the operating frequencies of the DYCOMS should be restricted at all times to protect the limited set of narrower observing bands listed above that are used for most VLA observations and that coordinated scheduling between the VLA and the DYCOMS would provide satisfactory protection for the remaining VLA observations.

The Spectrum Usage Agreement with the White Sands Missile Range limits the operating frequencies of the DYCOMS. For DYCOMS bands 1, 2, 4, 5, 6, and 7 coordinated scheduling between the VLA and DYCOMS would provide satisfactory protection for the VLA from radio-frequency interference from the DYCOMS. In several cases installation of bandpass filters in the radar transmitters might limit the out-of-band emissions to a sufficient degree that coordinated scheduling would be unnecessary.

An exception is that the Agreement limits operations of the DYCOMS in band 3 to the frequency range 1350-1385 MHz. Operation of the DYCOMS in this frequency range would severely affect VLA observations in the frequency band 1330-1427 MHz. Approximately ten percent of VLA observations occur in this band and are used to study the emission from neutral atomic hydrogen in our own galaxy near 1420 MHz and at redshifted lower frequencies in other galaxies. The importance of such observations for radio astronomy is recognized by international footnote 718 and the newly approved footnote US311 (copy enclosed). The peak power flux density of -78 dBW/m^2 at these frequencies predicted at the VLA would exceed the harmful interference limit for spectral-line observations given in VLA Scientific Memorandum No. 156 by 109 dB. Observations at frequencies adjacent to 1350-1385 MHz could be affected by the out-of-band emissions. Assuming that such emissions were suppressed by 60 dB, the corresponding spectral power flux density of -202 $dBW/m^2/Hz$ would exceed the harmful interference limits of -213 $dBW/m^2/Hz$ and -234 $dBW/m^2/Hz$ for spectral-line and continuum observations, respectively. Since the average ERPs are 14 dB less than the peak ERPs, spectral-line observations at adjacent frequencies probably would not be affected while continuum observations would be. Other factors such as the fraction of time that the DYCOMS transmits in the direction of the VLA, whether the VLA is observing at low elevations and receives the interfering signal through the 10-dBi, rather than the 0-dBi, sidelobes, the possibility of reflections from the target aircraft, and the uncertainties in the propagation calculations are important but difficult to analyze.

Thirty-five percent of all VLA observations are at frequencies between 1215 and 1730 MHz and potentially could be

affected by radio-frequency interference from the DYCOMS operating in band 3. A bandpass filter to limit the out-of-band emissions from the DYCOMS would be essential. Coordinated scheduling between the VLA and DYCOMS would be required but because of the large fraction of all VLA observations involved, would be, at best, cumbersome.

THE VERY LONG BASELINE ARRAY

The VLBA represents the extension of the principles used in the VLA over a much greater geographical scale, with ten antennas scattered across the U.S. from Hawaii to New Hampshire and Washington state to Saint Croix, with two antennas located in New Mexico, at Pie Town and Los Alamos. The VLBA is described in the two enclosed articles by Kellermann and Thompson (1985, 1988).

The VLBA will operate in approximately the same frequency bands as the VLA and in four additional bands: 580-640 MHz, 2150-2350 MHz, 10200-11200 MHz, and 42300-43500 MHz. Because the astronomical signals are received at such widely separated antennas, each VLBA antenna is less sensitive to radio-frequency interference than the VLA (by approximately 25 dB as described in VLA Scientific Memorandum No. 156). The greater distances of the Pie Town and Los Alamos antennas from North Oscura Peak and the intervening terrain provide about 20 dB and 40 dB, respectively, of additional losses when compared to the VLA. Furthermore, the azimuth of the Los Alamos antenna as seen from North Oscura Peak is outside the azimuth range proposed for the DYCOMS, and the potential for interference is small.

The operation of the DYCOMS in the band 1350-1385 MHz would potentially interfere with VLBA observations at the Pie Town antenna. The predicted peak power flux density of -98 dBW/m^2 at Pie Town would exceed the harmful interference limit in that band by about 42 dB.

THE ARRAY OPERATIONS CENTER

The AOC is located in Socorro and has an unobstructed line of sight to North Oscura Peak. The AOC includes electronics laboratories where the sensitive receivers and other electronic equipment used by the VLA and VLBA are constructed, repaired, and tested. While the expected power flux densities at the AOC are below the levels that would damage the equipment, they might be high enough to interfere with routine testing of such equipment.

THE EXPANSION OF THE VERY LARGE ARRAY

The NRAO is currently preparing a long-range plan for the expansion and improvement of the VLA. The plan includes adding additional receivers for three frequency bands - 580-640 MHz, 2150-2350 MHz, and 42300-43300 MHz - and replacing the existing

receivers at 1215-1730 MHz, 4500-5010 MHz, 14400-15400 MHz, and 22000-24000 MHz with new receivers 2-3 times more sensitive and perhaps with wider bandwidths. Three or four additional antennas would be built to be used with both the VLA and VLBA, with two located near Bernardo and Dusty, New Mexico and the remaining antenna(s) located near Roswell, New Mexico or near Vaughn, New Mexico and Holbrook, Arizona. The third aspect relevant to the present matter would be the installation of a new intermediate-frequency transmission system and correlator to allow observations using bandwidths perhaps as great as 1000 MHz for greater sensitivity. Because of the wider bandwidths that then could be used, the VLA would be more susceptible to radio-frequency interference and, consequently, coordination between the VLA and DYCOMS would be more difficult.

THE MILLIMETER ARRAY

The MMA is the NRAO's highest priority project for the 1990's. It would be an extremely versatile and powerful radio telescope designed to provide astronomers with the same sort of capabilities at millimeter wavelengths (frequencies between 30 and 345 GHz) that the VLA provides at meter and centimeter wavelengths (frequencies between 75 MHz and 24 GHz). These capabilities include fast, sensitive, and high-quality imaging with a wide range of angular resolutions and at many frequencies. The MMA would be used to study a very wide range of celestial objects - from the planets, comets, and Sun out to the most distant objects in the universe - as described in the enclosed copy of SCIENCE WITH A MILLIMETER ARRAY: MMA Design Study Volume I.

The enclosed copy of the MILLIMETER ARRAY DESIGN CONCEPT: MMA Design Study Volume II describes the technical specifications for the MMA as of January 1988. The specifications have continued to evolve in the eighteen months since then based upon research and development at the NRAO and elsewhere and now include continuous coverage from 30-50 GHz and from 70-115 GHz; recent developments indicate that such coverage may be possible with single receivers covering each band.

The astronomical interest in these bands is reflected in the National Table of Frequency Allocations, which includes the following allocations for radio astronomy in these two bands ("p" indicates a primary allocation and "f", a footnote): 31.2-31.3 (f), 31.3-31.8 (p), 36.43-36.5 (f), 42.5-43.5 (p), 48.94-49.04 (p), 72.77-72.91 (f), 86-92 (p), 93.07-93.27 (f), 97.88-98.08 (f), and 105-116 (p) GHz.

The Langmuir Research site on South Baldy in the Magdalena Mountains is one of two preferred sites for the MMA for several reasons: its high elevation (10,500 feet) places it above much of the atmospheric water vapor and oxygen so that atmospheric absorption is reduced and the phase stability is improved; its

physical dimensions are comparable to those needed for the MMA; and the site has been designated for atmospheric and astronomical research. Site testing over the past four years has shown it to be an excellent site for the MMA and other millimeter-wavelength radio telescopes.

South Baldy, however, has a direct line of sight to North Oscura Peak 79.4 km away. The DYCOMS as proposed includes radar transmitters in two bands not included in the DMS - bands 8 and 9 at 35 and 95 GHz, respectively. The corresponding peak power flux densities at South Baldy at these two frequencies would be -25 and -28 dBW/m^2, respectively; atmospheric absorption would attenuate the signals by perhaps an additional 1-2 and 5-10 dB, respectively. The peak power flux density at 35 GHz, if received through the isotropic sidelobes of the MMA antennas, would exceed by 7 dB the level of -32 dBW/m^2 (interpolate between entries in Table 2 of VLA Scientific Memorandum No. 156) that would cause one-percent gain compression in a HEMT-based receiver. The receiver technology at 95 GHz, on the other hand, would be based upon superconductor-insulator-superconductor (SIS) junctions which saturate at much lower power levels than do HEMTs. While a quantitative evaluation of such saturation is not available, the received power corresponding to the above power flux density at 95 GHz received through isotropic sidelobes would exceed that from any known celestial source and might be strong enough to damage the receiver. At the minimum, observing much weaker sources (by perhaps 100 dB) in the presence of such a strong interfering signal would be impossible.

One other concern is that the even stronger (by about 10 dB) signals from the tracking radar might leak into the intermediate-frequency electronics of the MMA.

SUMMARY

Protection of the Very Large Array (VLA) from radio-frequency interference from the Dynamic Coherent Measurement System (DYCOMS), if it were located on North Oscura Peak, will require a combination of restrictions on the operating frequencies of the DYCOMS and coordinated scheduling between the VLA and DYCOMS. Installations of bandpass filters on the radar transmitters would reduce the potential for radio-frequency interference. However, operation of the DYCOMS in the band 1350-1385 MHz would present significant difficulties for the VLA.

Protection of the Very Long Baseline Array (VLBA) needs to be studied but several factors combine to make the individual VLBA antennas much less sensitive to radio-frequency interference than the VLA.

The expanded and improved VLA now being planned would be much more sensitive to radio-frequency interference from the

DYCOMS.

The Millimeter Array, if it were located in the Langmuir Research site on South Baldy in the Magdalena Mountains, would be seriously affected by radio-frequency interference caused by the operation of the DYCOMS in bands 8 (35 GHz) and 9 (95 GHz). The interference at 95 GHz would be especially harmful.

Another option that should be considered is further limiting the maximum operational limit for the DYCOMS. The Spectrum Usage Agreement limits the maximum operational azimuth of the DYCOMS to 295 degrees, while as seen from North Oscura Peak the southernmost azimuths of the VLA and the MMA configuration on the Langmuir Research site, and the azimuths of the Pie Town antenna and the AOC are, respectively, 285, 287, 291, and 304 degrees. If the operational azimuth range of the DYCOMS were limited so that the maximum antenna gain in the direction of the VLA (and consequently the other facilities) would not exceed 0 dBi, the potential for harmful radio-frequency interference at our facilities would be greatly reduced, by factors between 28 and 50 dB. Operation of the DYCOMS at 1350-1385 MHz and 95 GHz would still be of concern to the VLA and MMA, respectively, and additional study is necessary. Without examining the appropriate beam patterns for the DYCOMS, I only can estimate that the appropriate azimuth limit might be 275-280 degrees.

Sincerely yours,

Patrick C. Crane

Patrick C. Crane
Frequency Coordinator

PCC/pcc
Enclosures

cc: M. Goss
P. Napier
R. Perley
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P. Vanden Bout
T. Gergely
S. Greene

New project proposed at WSMR

By GWEN ROATH

WSMR—The Air Force is proposing to construct and operate a Dynamic Coherent Measurement System (DYCOMS) on the White Sands Missile Range near North Oscura Peak.

If approved, the project could bring a few more jobs to the Socorro area, according to Roy A. Cunniff, project manager at Las Cruces.

The North Oscura Peak, in the north-eastern end of the range, was selected as the preferred site over several other sites including China Lake, Calif.

The DYCOMS would require construction of a new building and eight radars at the North Oscura Peak site and a new building in the north central portion of WSMR, according to a notice from the Department of Defense. Other existing buildings also would be used, according to the Air Force.

The Air Force is beginning to conduct the required Environmental Impact Statement on its proposal. A scoping meeting is slated for Wednesday, July 12 in Las Cruces. The meeting is to solicit input on what significant environmental issues are associated with the construction and operation of DYCOMS.

"There are lots of reasons—both operational and financial—Oscura Peak was selected as the preferred alternative site," said Cunniff.

If it is determined there would be no adverse environmental impact, Cunniff said, construction could begin in early 1991. Some 30-35 workers probably would be employed during construction. Employees probably would come from Carrizozo and Socorro, Cunniff said.

Operation of DYCOMS probably would employ 20 permanent employees and 15 "transient" workers, Cunniff said, again with half those people coming from Socorro and half from Carrizozo.

"Since Socorro has bigger motels," probably the part-time workers would stay in Socorro, Cunniff speculated.

According to the "Intent to Prepare an Environmental Impact Statement" (NOI) from the Department of the Air Force, DYCOMS during the first year would conduct flights in the WSMR area of one 2-hour sortie each day, three days a week.

After the first year, sorties activity would increase to two per day, each lasting 2 hours, 5 days a week, according to the NOI.

"Sortie activity at WSMR would be during early morning hours or after sunset at flight levels between 1000 feet and 25,000 feet above ground level. The airspace required would be primarily within the WSMR airspace corridors around North Oscura Peak," the NOI states.

The airspace would be scheduled through the WSMR range control and "varied fighter and bomber aircraft in the DoD inventory would be tested," the NOI states.

Cunniff said flight activity would depend on the type of aircraft being tested, but he added he didn't see any use of airspace north of the U.S. Highway 380.

"The radars would be running very carefully controlled tests," Cunniff said, with flights running north and south from North Oscura Peak. "They shouldn't have any impact on the commercial flight area," he said.

Cunniff conjectured that flights would be completed some 10 to 15 miles south of U.S. 380 and said it was "likely" that there would not be any fights going into the northern extension of the range area.

"All the fights are sub-sonic, no supersonic flights," Cunniff noted.

The Environmental Impact study will take about a year to complete, Cunniff said, with a decision of record hoped for by August, 1990 and construction—if all goes well— to begin six months later. Operation of DYCOMS would begin within two years after the EIS is completed, he said.

The scoping meeting Wednesday in Las Cruces is scheduled for 7-10 p.m. at the Carbine auditorium, Physical Sciences laboratory on the New Mexico State University campus.

Questions or comments on the proposed project may be mailed to the Physical Sciences Laboratory, attention Roy A. Cunniff, box 30001, NMSU, Las Cruces, 88003-0001; or telephone Cunniff at 522-9100.

Law Office of
James D. Grandjean
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The Socorro City Council will hold a regular meeting on Monday, July 10, 1989 at 7:00 P.M. in its chambers at City Hall, 111 School of Mines Road, Socorro, New Mexico.

AGENDA

1. ROLL CALL
2. LEGAL MATTERS
3. CONSIDERATION OF MINUTES: June 5, 1989
   June 19, 1989
   June 22, 1989
4. SAFETY POLICY ADOPTION
5. MOBILE HOME ZONING PERMITS DISCUSSION
6. BID AWARD: FIRE APPARATUS
7. COMMITTEE REPORTS
8. MAYOR'S REPORT
9. ADJOURNMENT

The Socorro County Commission will hold their regular meeting July 11, 1989 at 7 P.M. at the Socorro County Courthouse, Socorro, New Mexico.

AGENDA

1. Approval of minutes
2. Reports: County Manager, Landfill Supervisor, Road Department
3. Old Business:
   Legal matters
4. New business:
   1. Bid opening
   2. Lee Deschamps
   3. ABO Ranch
   4. Charles Henderson
   5. Jo Ann Bellow (San Francisco Road)
5. Other county business
6. Approval of resolutions
7. Approval of warrants
8. Adjournment