THE ARIZONA VLBA SITE

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I. CONSTRAINTS ON THE SITE LOCATION

The first consideration in siting a VLBA antenna is the uv-plane coverage for the array as a whole, since this controls the quality of the synthesized beam. It is especially restrictive for elements which, like the Arizona antenna, are near the centroid of the array. Computer simulations of the transfer function show that the sampling is best with an antenna near Kitt Peak. It is noticeably worse if the antenna is more than 20 miles north of Kitt Peak, or more than 50 miles to the east, south, or west.

Economic factors are important. Antenna sites should be near existing all-weather roads and 3-phase distribution lines. In a largely open area like southern Arizona, this is a severe restriction. Stations usually will be unattended, hence effective security is necessary. Nearby logistic support of various kinds enhances operational efficiency. All of these affect the cost of site development and operation, so the opportunity to put a station at an already developed facility (Kitt Peak, in this case) is very attractive.

Data are vulnerable to man-made interference, which can be minimized by care in site selection. The practical desideratum is that interference levels be low enough that they do not sensibly affect the system noise temperature. Jim Oty's RFI measurements show that interference levels are acceptable at the picnic area on Kitt Peak, but potentially troublesome on the flats toward Tucson (VLB Array Memos 423 and 433). The picnic area is shielded from Tucson by the Kitt Peak summit ridge. As a result of light pollution problems from Tucson, Kitt Peak is now known as a site with special environmental needs and the local population is sympathetic. If the VLBA antenna encounters RFI problems in the future, it is likely that association with Kitt Peak will make doing something about it considerably easier.

The wind on Kitt Peak has caused much concern. The entire Southwest experiences strong winds when the jet stream is over head (this occurs most frequently during the spring). Because of the sparseness of vegetation and the paucity of cloud, solar heating induces strong convection during the day. The consequent vertical mixing of the atmosphere brings some of the momentum of the jet stream down to ground level. The result is howling winds that persist from late morning until sunset, for as long as the jet stream remains above. The wind problem will be discussed in some detail in the next section.

II. ARGUMENTS AND RECOMMENDATIONS

It was assumed initially that the Arizona station would be on Kitt Peak. This was natural, given the good uv-plane coverage and the excellent logistics. In March of 1984, Kellermann and Wade staked a site near the edge of the picnic area and close to the NRAO 12-meter telescope. At the time, the staked location seemed quite good. It was soon objected, however, that the ridge on which the picnic area and the 12-meter telescope are located is too windy, perhaps windier even than the summit. It also was argued that the wind would be stronger on the mountain than on the surrounding flats, and hence that we should consider abandoning Kitt Peak for a lower site. There was little objective information behind these views, although they had a certain intuitive plausibility.

The concern had its roots in the adopted 15 mile-per-hour maximum wind speed for precision-mode operation, a number we had accepted without really understanding. A study of the effects of wind as a function of velocity was made and is presented in a recent VLBA Memo by Walker. The pointing performance of the antenna in wind is expected to exceed the specification. The performance that the design was required to achieve in winds of 15 mph is now expected to be met in winds of about 25 mph. Thus observations at 43 GHz should be possible in winds up to about 25 mph and observations at lower frequencies will be possible in much stronger winds. Please note that this is the expected performance and is by no means guaranteed.

In order to establish wind statistics for the Kitt Peak 12-meter site, Bob Brown analyzed anemometer records taken from April 1984 through February 1985 (VLB Array Memo No. 447). Combining his numbers for all 10 months, one finds that the hourly mean wind was >15 mph for 34.1 of the time, >20 mph for 12.5, and >25 mph for 5.5. Brown also considered "peak" winds -- not brief gusts, but sustained episodes of speeds appreciably exceeding the hourly means. These necessarily are hard to quantify, but the final plot in Memo No. 447 indicates that peak winds over 25 miles per hour are not common (generally less than 10 of the time) although they sometimes are frequent enough to be annoying (peak winds were over 25 mph for about a quarter of the time during January 1984). The peak wind speeds are probably the

ones that should be compared with the antenna performance. Observations made in mean winds that are at the limit will suffer from frequent periods when the pointing is poor, resulting in poor calibration.

Considering the expected performance of the antenna and the frequency of occurence of winds in excess of 25 mph, we conclude that winds on Kitt Peak will not seriously impede operation of the array. We therefore recommend that the antenna be built on Kitt Peak, as originally planned.

The picnic area still seems the best location because of its relatively favorable terrain, good access, proximity to electric power, convenience to the present NRAO 12-meter facility, and availability. The summit ridge provides useful shielding from Tucson, at the expense of a rather high horizon (8 degrees) in the northeastern quadrant. We now think that the site should be on the northwest side of the ridge rather than on the southeast where KIK and CMW originally staked it. This might provide some protection from the strongest winds, which generally come out of the quadrant from southeast through southwest. In the area chosen, there is some opportunity to trade horizon for wind shielding. Our current inclination is to opt for the better horizon but the final choice must await the soil tests.

The subsurface character of Kitt Peak must figure in the final siting of the antenna. The mountain is a monolith of granite locally veneered with thin soil. The rock is riven by deep joints and the outermost few feet are much weakened by weathering, matters which bear heavily on foundation design. A particularly hazardous condition can be seen at many places along the highway to the summit: steeply inclined joint planes, weak and prone to sliding. The exact spot for the antenna should be chosen only after test drilling has given a good picture of the underlying rock throughout the area under consideration.

ADDENDA

There are other related topics which have no place in the main body of the present report, but which nonetheless should be documented. These are (1) a listing of the sites which received some consideration as alternatives to Kitt Peak; (2) our experience with a hand-held anemometer on a typically bad windy spring day; and (3) the possibility of an eventual array of millimeter telescopes in the Tucson area sometime in the future.

I. Alternative sites

All of the sites noted here are low-lying, either on the open flats or in valleys. Their main attraction was that they might

be less subject to high winds than the mountain. All had problems in terms of access, security, and/or RFI and so lost appeal after we concluded that the wind problems on Kitt Peak are not so serious as we had feared.

(a) The missile silo sites: Three recently retired Titan II sites near Three Points were noted as possibilities. They were distinguished from the surrounding flats mainly by their status as Federally-owned land which was about to be declared surplus. They do, of course, have good paved access roads and ample three-phase electric power. RFI measurements were done at Three Points, a site that should be representative of any of the silo sites. The measurements showed the RFI environment to be worse than on Kitt Peak. The silo sites are the following:

Silo 9: On the SE side of Arizona 286, about 14.2 miles SW of Three Points. Coordinates and elevation: 31-53.7N, 111-23.3W, about 2900 ft MSL.

Silo 10: On the SE side of Arizona 286, about 5.6 miles SW of Three Points. Coordinates and elevation: 32-00.3N, 111-21.3W, about 2780 ft MSL.

Silo 11: On the N side of Arizona 86, about 3.3 miles E of Three Points. Coordinates and elevation: 32-06.1N, 111-15.7W. about 2490 ft MSL.

(b) Montosa Canyon: A rather deep and very scenic bowl traversed by the road from Amado to the Whipple Observatory on Mount Hopkins, suggested to us by Bobby Ulich. The road to this point is gravel but not bad, and the buried power line to Mount Hopkins is nearby. The surrounding terrain would give good shielding from interference and perhaps wind, but the horizon is unacceptably high (up to 19 degrees in the eastern quadrant). Coordinates and elevation: 31-40.6N, 110-55.0W, about 5000 ft MSL.

(c) Unnamed valley in the Roskruge Mountains: North of Arizona 86, west of Three Points, on state-owned land just outside the Papago Indian Reservation. Horizon under 5 degrees; the surrounding hills would give some protection from interference but not much from wind. The dirt road through the valley, intended for ranch service, would require considerable upgrading. Electric power would have to be brought several miles from Arizona 86. Approximate coordinates and elevation: 32-05N, 111-25W, about 2740 ft MSL.

II. Some anemometer measurements

On 26 April 1985, we borrowed a high-quality hand-held anemometer from the Department of Atmospheric Physics at the University of Arizona in order to check the accuracy of the recording anemometer at the 12-meter telescope (the source of Bob

Brown's wind data). The wind was strong and gusty, quite typical of the spring howlers so common in the Southwest. After confirming the accuracy of the recording anemometer, we made measurements at several points in the picnic area. Each took about 5 minutes; Walker called out the anemometer reading 8 to 10 times per minute, while Peery and Wade recorded. Shortly thereafter, we repeated the measurements first at the foot of Kitt Peak (junction of the Kitt Peak road with Arizona 86), next in the valley in the Roskruge Mountains described above (2 miles from the highway), next where the road into the valley left Arizona 86, and finally at Ryan Field. The results were much the same everywhere (mean speed about 18 knots from the SSW, with frequent gusts up to 30 knots), although they tended to be a somewhat less (but gustier) on Kitt Peak than at the lower locations.

The wind measurements at the Tucson airport during the same time period were very similar to ours (in speed, gustiness, and direction). It appears that on this day the wind characteristics were nearly identical everywhere in the area. Certainly we found no indication that Kitt Peak suffers higher winds than the surrounding low country. Note, however, that the data compiled by Brown in VLBA Memo 448 indicate that, on average, the winds are lower at the airport than on Kitt Peak.

III. A future millimeter VLBA?

It has been suggested that the VLBA antenna should not be placed adjacent to the 12-meter antenna. If a site a few tens of kilometers away were chosen, a mm wavelength interferometer with baselines up to roughly 200 km could be formed using the various mm telescopes now, or soon to be, in the Tucson area. Several questions arise: How useful will such an instrument be? To what extent can the VLBA antenna contribute considering its limited frequency coverage and high demand for use with the rest of the VLBA? How long will the 12-meter be kept operating? How does this capability trade against the ease of operation on Kitt Peak vs. a new site? We have chosen to recommend Kitt Peak but the community should be aware of this capability that might be possible with another choice.