

NATIONAL RADIO ASTRONOMY OBSERVATORY  
Green Bank, West VirginiaMEMORANDUM

December 14, 1984

To: VLBA Site and  
Electronics Groups

From: W. Brundage

Subj: 50 cm  $\lambda$  RFI in Massachusetts

## BACKGROUND

UHF television signals are a significant RFI problem for the 50 cm band at many VLBA sites. The only certain RFI-clear band at all sites is the radio astronomy band at 608-614 MHz, which also is UHF TV Channel 37. Strong signals at adjacent TV channels 36 and 38 threaten Ch 37 use even for a highly filtered Ch 37 receiver. Harmful signal levels for Ch 36 and 38 will be determined for the filtered receiver being developed. Even if the harmful levels should be rather high, we should find sites with relatively low Ch 36 and 38 levels from azimuths where the antennas may point at low elevations.

## ALTERNATIVE SITES

Since Haystack Observatory was eliminated as a site because of RFI problems from nearby radars as well as a very strong Ch 38 signal (VLBA Memo 383), we are looking at 50 cm signal levels at alternative sites. Staff at Haystack Observatory and at the Five College Radio Astronomy Observatory have made measurements which are summarized here. The most promising site(s) will be monitored at all VLBA bands  $\leq$  15 GHz in 1985 by the VLB/VLBA RFI trailer.

## RFI LEVELS

Table I lists the measured signal levels in dBW<sub>i</sub> for many UHF TV channels at several sites. It lists levels of the visual carriers because the visual carrier is typically 7 to 10 dB higher than the audio carrier. The audio carrier of Ch 36 and visual carrier of Ch 37 are the most troublesome. Table I includes the approximate azimuth toward the probable source. The FCRAO azimuths are those for apparent maximum signal, and are rather uncertain because signal levels may vary by 6 dB or over several hours. Table II gives data about the sites. Table III gives data about the probable UHF TV transmitters.

## DATA SOURCES

Dick Ingalls reported the Haystack measurements at several sites. They used a vertically polarized omnidirectional antenna about 5 feet above ground. This memo includes his letter and summary, but not the photos of the spectrum analyzer displays. Al Rodman made the FCRAO measurements at the Quabbin Reservoir site using a horizontally polarized antenna about 40 feet above ground.

## DISCUSSION

The only channel clear of intentional emissions in the 50 cm  $\lambda$  VLBA band at all VLBA sites at all times is TV Ch 37.

The adjacent UHF TV channels 36 and 38 are by far the most troublesome signals in the Massachusetts area, and at most VLBA sites. Therefore, the 50 cm receiver being developed has a narrowband, highly filtered option with maximum useable bandwidth of  $\sim 4$  MHz and maximum rejection ( $\geq 30$  db) of Ch 36 audio signal and Ch 38 visual signal. Harmful interference levels (HIL) at these two frequencies (607.75 and 615.25 MHz) will be measured on the prototype receiver. This HIL would have to be  $\gtrsim -110$  dBW<sub>i</sub> ( $\gtrsim 51$  dB rejection) in order for the FCRAO Quabbin site to be useable most of the time, and  $\gtrsim -134$  dBW<sub>i</sub> ( $\gtrsim 27$  dB rejection) for the Happy Valley site to be useable most of the time.

These levels assume the Ch 36 audio and CH 38 video emission spectra cut-off sharply above 608 MHz and below 614 MHz, i.e., no spurious spectral sidebands within Ch 37. Although FCC Rules (73.699, Figure 5) require the video lower sideband rejection be only 20 dB below the visual carrier for transmitters having power output  $> 1000$  watts, FCRAO measurements of Ch 40 indicate lower sideband levels  $< -50$  dB relative to the visual carrier.

One must be careful when comparing sites on the basis of measured RFI levels at specific UHF frequencies. The measuring antenna height can be significant. The NH sites were measured at 5 feet, the Quabbin site at 40 feet and the VLBA prime focus feed will be 90 feet above ground. There can be a 3 dB to 10 dB increase in signal from 5 to 90 feet above ground depending on local terrain. The NH sites were measured with a vertically polarized monopole antenna. Because all existing Ch 36 and 38 transmitters use horizontal polarization, the NH site signal levels in Table I could be lower than actual by a few dB. Measurements are only a snapshot at a certain time. Propagation changes with time and weather. Troposcatter and tropoducting can increase signal levels from distant VHF/UHF transmitters by 10 dB to 20 dB or even more during certain weather conditions which may persist for many hours. New transmitters will appear in the future. The FCC will be licensing low power drop-in stations. Some rural areas use UHF frequency translators to re-broadcast distant stations. NRAO will need to find a mechanism to limit new transmitter signal levels for Ch 36 and 38 (maybe even Ch's 34, 35, 39 and 40) at all sites. UHF TV signals are

nearly ubiquitous now and surely will be. For example, almost every UHF TV channel has detectable signal levels at Green Bank most of the time.

## CONCLUSIONS

The Happy Valley and Annett State Reservation sites have the lowest level signals at Ch 38 and 36 as well. Channel 38 level at the Quabbin site is as low or lower than the other NH sites considering differences in measuring antenna polarization and height above ground. Quabbin has the advantage of a "prepared" site and "local" staff, but has the disadvantage of local RFI sources in the FCRAO mm  $\lambda$  telescope (LO leakage, computer radiation) unless the separation distance is large. At 50 cm  $\lambda$ , TV Ch 40 may be a problem at Quabbin. When the VLBA antenna points at  $\lesssim 10^\circ$  elevation, to the SW (a frequent event in operation), the harmful interference level (HIL) increases by  $\gtrsim 10$  dB. Thus, the receiver HIL at Ch 40 video frequency of 627.25 MHz would have to be  $\gtrsim -80$  dBW, assuming Ch 40 Springfield does not increase its EIRP or antenna height in the future. We must wait for measured receiver HIL's at the critical frequencies of Ch's 36, 38 and 40.

WDB/cjd

## Attachments:

Tables I, II, and III  
Letter to Brundage from Ingalls  
dated 14 November 1984

TABLE I  
Measured Signal Levels

Site	Signal Level (dBW <sub>i</sub> )								
	TV CH	Azimuth							
	29	30	31	36	37	38	40	41	
0 Haystack .....		-117 SW	-113 N	-112 S		-82 SE	-121 WSW	-117 NW	
5 Pratt Pond .....			-121 N			-106 SE		-135 NW	
6 Happy Valley .....			-110 N			-141 SE	-132 SW	-108 NW	
7 Annett State Reservation .....		-138 SW	-120 N	-138 S		-127 SE	-131 SW	-106 NW	
8 Perry Road .....				-138 S		-110 SE			
9 Little Watatic Mtn. ....		-129 SW	-123 N			-117 SE	-130 SW	-119 NW	
10 Temple Road .....	-136		-134 N			-119 SE		-136 NW	
11 Miller Highway .....	-135	-133 SW	-124 N	-140 S		-114 SE		-132 NW	
12 Route 31 .....			-137 N			-121 SE			
FCRAO Quabbin Resvoir .....		-102 S	-135 ? NW N	-139 ? NW SE		-114 E	-91 SW	-137 ? NW N	

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Note: Azimuths with ? are uncertain measurements.

TABLE II  
Site Data

<u>Site</u>	<u>Location</u>	<u>Latitude</u>	<u>Longitude</u>
0 Haystack Obs.	Tyngsboro, MA	42° 37'	71° 29'
5 Pratt Pond	Mason, NH; Abbott State Forest	42° 47'	71° 46'
6 Happy Valley	Peterborough, NH; Old Greenfield Rd.	42° 56'	71° 55'
7 Annett State Resv.	Rindge, NH	42° 46'	71° 58'
8 Perry Road	New Ipswich, NH	42° 43'	71° 51'
9 Little Watatic Mtn.	Ashburnham, MA	42° 41'	71° 55'
10 Temple Road	New Ipswich, NH,	42° 47'	71° 51'
11 Miller Highway	Temple, NH	42° 49'	71° 50'
12 Route 31	Wilton, NH at King Brook Rd.	42° 48'	71° 47'
FCRAO	Quabbin Reservoir	42° 24'	72° 21'

TABLE III

## Probable UHF TV Transmitters

CH #	f Visual (MHz)	f Audio (MHz)	Probable Location	EIRP (KW)	Latitude			Longitude		
					°	'	"	°	'	"
29	561.25	565.75	?							
30	567.25	571.75	Hartford, CT							
31	573.25	577.75	Hanover, NH							
36	603.25	607.75	Providence, RI	2380	41	18	12	71	28	24
37	--NO TRANSMITTERS AUTHORIZED BY FCC--									
38	615.25	619.75	Boston, MA	3160	42	18	12	71	13	08
			Poughkeepsie, NY	53	41	43	09	73	59	49
40	627.25	631.75	Springfield, MA	3.7?	42	14	30	72	38	56
41	633.25	637.75	Windsor, VT	708	43	26	17	72	27	08

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
HAYSTACK OBSERVATORY  
WESTFORD, MASSACHUSETTS 01886

14 November 1984

Area Code 617  
692-4765

Mr. William Brundage  
National Radio Astronomy Observatory  
P. O. Box 2  
Green Bank, West Virginia 24944

Dear Bill:

Since the RFI environment at Haystack itself has been found to be hostile because of both UHF TV and radar interference, we concur with your judgement that it is not ideally suited for a VLBA antenna site unless no better site satisfying all other requirements, including RFI, is found. Because of this situation, we felt that it would be useful, as we previously discussed, to make a survey of UHF of interference levels northwest of Haystack at locations that seemed likely to minimize the signals from Boston's channels 38 and 44. This should be a guide in suggesting locations for survey by the NRAO RFI trailer when it arrives in this area. The experimental setup was the same as used for the April 1984 field measurements described in my 1 June 84 report (Figure 2.3 of that report).

The area surveyed was northwest of Haystack within a 1.5 hour drive. There is a prominent low mountain range including Pack Monadnock, Temple Mountain and the Watatic mountains just east of Peterborough, NH, that are in the 2000 foot class. Moreover, there are significant hills east of this mountain ridge between Townsend, MA and Wilton, NH. The sites investigated are spotted on the attached map. The map site numbers sequentially follow the four sites listed in my earlier memo, also adding site #0 for a hilltop check location at the Observatory itself. RFI measuring expeditions were made on 17 October and 1 November 1984 with our inverter equipped van.

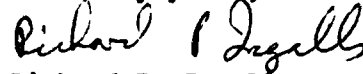
The results are summarized in the attached table and three diagrams illustrating measured spectra are included. No attempts to look at property questions were made except that State reservations were preferentially chosen where available. The results may be summarized by saying that the Boston UHF TV signals could be reduced 30-40 db below the levels at Haystack by judicious siting but at no location was the elimination of a general background of UHF stations possible. This was hardly a surprise. The one location to the west of the mountain range did knock channel 38 way down but picked up strong New Hampshire and Vermont transmissions. The general area surveyed is about 45 miles northwest of the Boston transmitter location and 60 miles northeast of Springfield, about three times the distance of the Quabbin Reservoir from there.

Overall, the best sites were 8, 10 and 12, at least by my subjective judgement. Unfortunately, site 12 is in a narrow river valley right on a

state highway. The other two were off the main highway. All of them are a big improvement over Haystack in this UHF band. In the northeast, I am of the opinion that one would have to go into a deep valley in the White Mountains of New Hampshire (125 miles away) or way into the vast forest areas of Maine owned by the paper company to obtain low levels of UHF TV interference.

We will be happy to assist NRAO in measurements when the RFI trailer arrives in this area. We have acquired more detailed topographic map information including three-dimensional maps on the various site areas which we can review with you, and we can help in the actual measurements if this would be useful.

Sincerely yours,



Richard P. Ingalls  
Associate Director

RPI/kw

xc: A. E. E. Rogers  
J. E. Salah  
B. Peery, Site Committee Chairman  
H. Hvatum

NOTE : VLBA MEMO DOES NOT INCLUDE 10 PHOTOS OF  
SPECTRUM ANALYZER DISPLAY. ~ W. BRUNDAGE



# SUMMARY OF UHF TV INTERFERENCE MEASUREMENTS

MEASUREMENT SITE AND LOCATION			UHF TV CHANNEL - LEVELS DBM							
#	SITE NAME	LOCATION	29	30	31	36	37	38*	40	41
0	HAYSTACK	TYNGSBORO MASS.	/	-87	-83	-82	/	-52	-91	-87
5	PRATT POND	MASON, N.H. ABBOTT STATE FOREST	/	/	-91	/	/	-76	/	-105
6	HAPPY VALLEY	PETERBOROUGH, N.H. OLD GREENFIELD RD.	/	/	-80	/	/	-111	-102	-78
7	ANNETT STATE RES.	RINDGE, N.H.	/	-108	-90	-108	[100']	-97	-101	-76
8	PERRY RD	NEW IPSWICH, N.H.	/	/	/	-108	/	-80	/	/
9	LITTLE NATATK Mtn	ASHBURNHAM, MASS.	/	-99	-93	/	/	-87	-100	-89
10	TEMPLE RD.	NEW IPSWICH, N.H. AT TEMPLE LINE.	-106	/	-104	/	/	-89	/	-106
11	MILLER HWY.	TEMPLE, N.H.	-105	-103	-94	-110	/	-84	/	-102
12	ROUTE 31	WILTON, N.H. AT KING BROOK RD.	/	/	-107	/	/	-91	/	/

UHF TV TRANSMITTERS			NOTES
CH.	PICTURE SOUND	PROBABLE LOCATION	
29	561.25 565.75	??	1. SITES 5-9 MEASURED 17 OCT 84 AND SITES 10-12 1 NOV 84.  2. * CHANNEL 44 NOT ON AIR DURING HOURS MEASUREMENTS MADE. SIGNAL LEVELS OBSERVED AT HAYSTACK ARE SIMILAR TO 38.  3. SPURIOUS AT 600MHZ, SITES 10-12.  4. SIGNAL OF UNKNOWN ORIGIN
30	567.25 571.75	HARTFORD, CONN.	
31	573.25 577.75	HANOVER, N.H.	
36	603.25 607.75	PROVIDENCE, R. I.	
37	609.25 613.75	CLEAR CHANNEL	
38	615.25 619.75	BOSTON, MASS.	
40	627.25 631.75	SPRINGFIELD, MASS.	
41	633.25 637.75	WINDSOR, VT.	
44	651.25 655.75	BOSTON, MASS.	