Capabilities of the Jansky VLA for Sky Surveys

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The NRAO has announced the Jansky VLA Sky Survey (VLASS) initiative[1] to conduct a new wide-area centimeter wavelength sky survey in support of multi-wavelength synoptic surveys using existing and future facilities. Community input is critical to the success of the VLASS. This document is a quick reference guide outlining the capabilities of the VLA for surveys, for use in writing White Papers in response to the recent call.

The performance of the VLA for large surveys at 100 μJy continuum image rms is:

Band (freq)	Bandwidth	t_{int} sec	θ_{PB}	θ_{res} (B)	SS deg^2/hr	$\dot{\theta}$ arcmin/s
P (230-470 MHz)	200MHz	8553	122′	24.0″	0.98	0.01
L (1-2 GHz)	600MHz	37	30.00′	5.6″	13.90	0.65
S (2-4 GHz)	1500MHz	7.7	15.00′	2.7″	16.53	1.56
C (4-8 GHz)	3.03GHz	4.4	7.50′	1.3″	7.21	1.36
X (8-12 GHz)	3.50GHz	3.9	4.50′	0.78″	2.96	0.93
K_u (12-18 GHz)	5.25GHz	3.5	3.00′	0.55″	1.45	0.68
K (18-26.5 GHz)	7.20GHz	7.0	2.05′	0.36″	0.34	0.23
K_a (26.5-40 GHz)	7.20GHz	9.5	1.45′	0.25″	0.12	0.12
Q (40-50 GHz)	7.20GHz	50	1.00′	0.18″	0.011	0.02

The "Band" column gives the VLA band designations and their accessible RF span ("freq"). The "Bandwidth" column is the effective correlator bandwidth (RFI free) within that band used for sensitivity calculations – the intrinsic maximum bandwidths are 2 GHz (8bit mode, below 4 GHz) and 8 GHz (3bit mode, 4 GHz and above). Natural weighting is assumed for the calculation of integration times t_{int} needed to reach 100 μJy image rms (using the VLA Sensitivity Calculator). The primary beam FWHM θ_{PB} and the image resolution θ_{res} are at calculated at band center. Synthesized resolutions θ_{res} are given for the B-configuration. Depending on science goals you can achieve higher resolution with 3.2 times smaller θ_{res} in A-configuration, or more sensitivity to larger scales at 3.3 times larger θ_{res} in C-configuration, and 11 times larger in D-configuration. The SS column gives the survey speed (SS) in deg^2/hour at 100 μJy image rms. The final column gives the estimated on-the-fly scanning rate $\dot{\theta}$ in arcmin/sec required to attain that survey speed in an optimally sampled mosaic. Note that scanning rates in excess of 6 arcmin/sec have not been verified for successful use on the VLA at this time.

[1] For more information, go to https://science.nrao.edu/science/surveys/vlass

These survey speed calculations assume a continuum image rms level of 100 μJy using the full bandwidth available (width in 2^{nd} column of table). This number is not intended to define the survey, but is chosen for reference purposes in the Table, and is scalable to other depths and assumed bandwidths. For bands at 2 GHz and above, the data will be taken using 2 MHz channel width (for L-band 1-2GHz these will be 1 MHz channels, and the standard setup uses 125 kHz channels at P-band). If you need sensitivity numbers in some smaller bandwidth for line work, then adjust the speed numbers accordingly (e.g. by the ratio of the new bandwidth to the assumed bandwidth). You may wish to also adjust the image rms levels to compensate (e.g. by the square of the ratio of rms levels). For example, at 1.2 GHz a 1 MHz channel has a velocity width of 250km/s for HI at z=0.18, but the survey speed at 100 μJy in this single channel is 600 times slower than that given for the 600 MHz continuum bandwidth given in the table, or 0.023 deg^2/hour, while at an image rms of 1 mJy, the survey speed is 2.32 deg^2/hour. Further information on VLA performance can be found at
https://science.nrao.edu/facilities/vla/docs/manuals/oss2014a/performance

The survey speeds given above can be used to calculate integration times required for different survey strategies. Example strategies:

- A large NVSS-style 30000 deg^2 survey at 2-4 GHz would require 1815 hours of integration time to reach an imaging rms of 100 μJy. This could be split into two configurations, e.g. A and C spaced by about 8 months. The A-configuration resolution of 1" allows for identification in optical/infrared surveys, while the addition of C-configuration gives sensitivity to larger scale emission.
- A large FIRST-style 10000 deg^2 survey at 4-8 GHz would take 1387 hours of integration time per epoch to reach a single epoch rms of 100 μJy.
- A medium-area 1000 deg^2 synoptic survey from 8-12 GHz at 100 μJy rms would take 337 hours of integration per epoch. This could be repeated every 16 months when the configuration recurs in the cycle, and would build up a much deeper image of the static sky over multiple epochs. These could cover the Galactic Cap and/or Galactic Plane for extragalactic and galactic science respectively.

The choice of observing band(s), array configurations, sky coverage, and cadences to be chosen for the VLASS depends on the science goals. The above examples are for continuum survey sensitivities – spectral surveys, targeting HI, OH, and redshifted CO, for example, could be carried out in parallel with the continuum studies, with a possible cost of increasing data rates and volumes if higher spectral resolution modes are needed.

The times calculated above are the total on-sky integration time. Calibration and slewing overheads must be added to these to arrive at the total duration required to schedule the survey. We estimate that 25% overheads are achievable for a large survey (multiply the integration times by 1.25 to get total duration).

For help regarding VLASS and White Paper submission, contact us at *vlass@nrao.edu* or through the NRAO helpdesk at https://help.nrao.edu