



VLASS Memo 27

A Pilot Web-Based Tool for VLASS User-Defined Imaging

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Abstract

The VLA Sky Survey (VLASS) is a wide-area S-band survey of the sky visible to the Karl G. Jansky Very Large Array. Its automated calibration and imaging pipelines provide essential first-order survey products, but a single set of standard imaging parameters cannot be optimal for all science cases. Extended radio galaxies, diffuse emission, complex fields, transient searches, polarization studies, and source-specific re-imaging often require customized choices of image size, phase center, gridding and w-planes, weighting, masking, and other pipeline parameters. This memo describes a pilot web-based VLASS User-Defined Imaging tool that allows a user to search for VLASS measurement-sets (MS) for their target source(s), request restored calibrated MSes from the NRAO archive, and submit standard VLASS imaging jobs with user-selected parameters. The tool is intended as a demonstrator for a future archive-integrated VLASS User-Defined Imaging service, analogous in concept to VLA User-Defined Imaging (VUDI) and user-defined imaging services developed for ALMA (AUDI).

1. VLA Sky Survey

The VLA Sky Survey (VLASS) is a wide-area S-band survey covering the sky north of declination $\gtrsim -40^\circ$, corresponding to $\sim 33,885 \text{ deg}^2$ of sky. VLASS observes over 2–4 GHz using the VLA B and BnA configurations, providing an angular resolution of $\sim 2.5''$ and sensitivity to angular scales up to a few arcminutes, depending on observing configuration, weighting, and imaging choices. The survey was designed as a multi-epoch, full-polarization, wide-band continuum survey spanning the 2017–2026 observing period. Its single-epoch images reach an rms sensitivity of order $120 \mu\text{Jy beam}^{-1}$, while combined images approach $\sim 70 \mu\text{Jy beam}^{-1}$. The survey design, science drivers, time-domain motivation, sensitivity goals, and full-polarization wide-band observing strategy are described by Lacy et al. [1]. VLASS observations were completed in February 2026, and Quick Look (QL) Stokes I images were produced and made available to the community within a short time

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after observation. These QL products provide rapid access to the survey data and are extremely valuable for source discovery, transient searches, visual inspection, and first-order science analysis. The VLASS team is now engaged in producing higher-quality science products, including self-calibrated single-epoch (SE) images, spectral-index SE products, cumulative or combined image products, and polarization SE coarse cube products. The large volume of VLASS data makes an automated calibration and imaging pipeline essential. The standard VLASS pipeline provides uniform, reproducible products over a very large survey area.

2. Motivation

There are two main motivations for developing a VLASS User-Defined Imaging capability. First, although the standard VLASS imaging parameters are appropriate for broad survey processing, they may not be ideal for all science applications. A compact-source search, an extended radio galaxy, a diffuse source, a transient field, and a polarization study may each require different imaging choices. In particular, extended radio sources can benefit from different weighting schemes, uv tapers, data combination, or parameter choices that better preserve low-surface-brightness structure. Second, some high-value imaging products are difficult to provide uniformly for the full survey because of computational cost and the wide range of possible science requirements. Examples include joint deconvolution of multiple VLASS epochs and tapered imaging for enhanced surface-brightness sensitivity. Joint deconvolution is particularly important when a user wants to combine multiple epochs at the visibility level rather than only combining final images. Since different VLASS epochs have different pointing centers and primary-beam responses, accurate multi-MS joint imaging requires an appropriate wide-field gridder[2]. Furthermore, as discussed in VLASS memos 14 and 24, for better positional accuracy and in-band spectral indices, for VLASS tiles with median zenith distance, $\zeta \gtrsim 45^\circ$, it is recommended to use w-term corrections (which is not available in the pipeline’s default `mosaic` gridder). In this context, the CASA’s `awp2` gridder is a promising option because it is an upgraded form of the `awproject` gridder, incorporating A-projection from aperture illumination models with azimuthally asymmetric beams, including beam squint correction, parallactic-angle beam rotation, and W-projection effects.

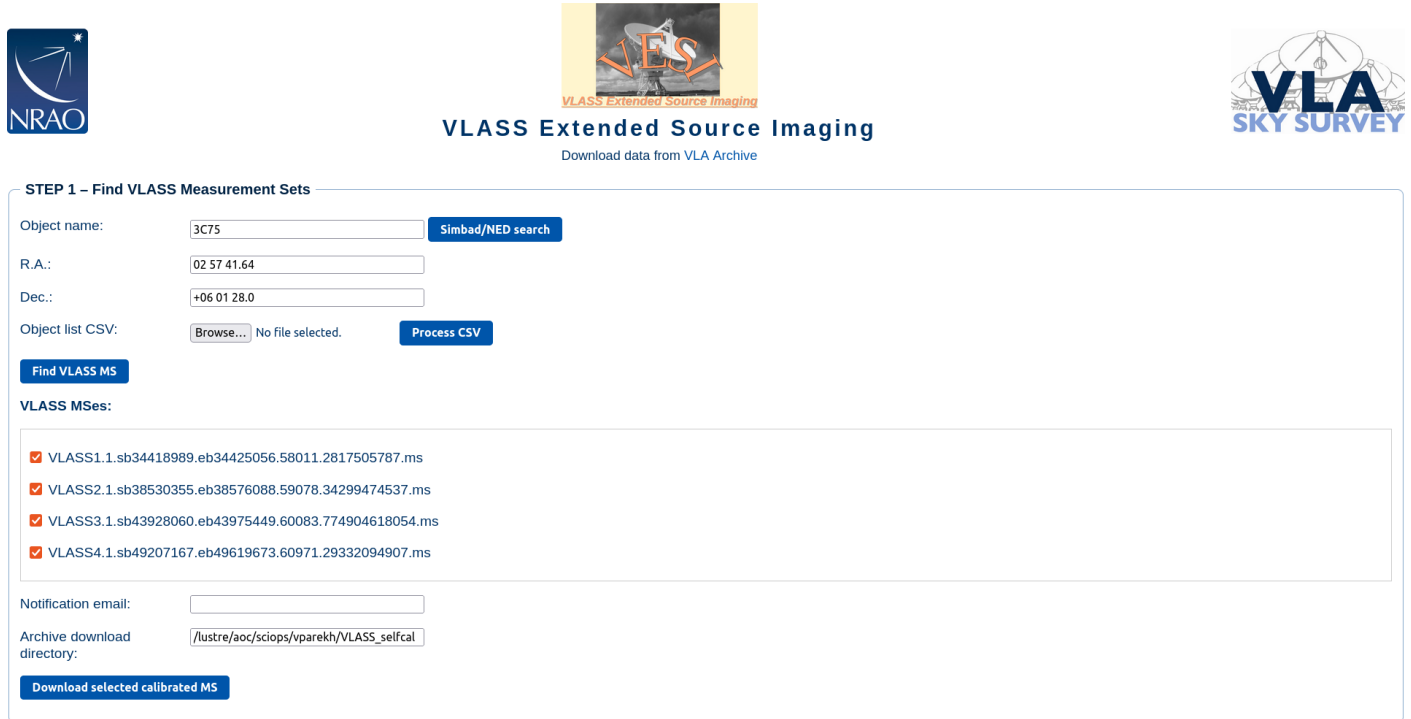
A user-defined imaging layer can therefore complement the standard VLASS archive products by enabling controlled re-imaging of selected targets without requiring every user to manually restore and download calibrated MSes, edit CASA scripts, construct parameter files, and submit jobs on NRAO or external computing resources. The pilot tool described here is a demonstration version of such a VLASS User-Defined Imaging system. It allows users to search for VLASS MSes, request calibrated-MS restoration from the NRAO archive, and run standard VLASS imaging with selected user-defined parameters, all via a web-based application. The immediate goal is not to expose every possible imaging option, but to test which parameters should be made available, how they should be validated, and how user-defined imaging can be integrated with NRAO archive and computing infrastructure.

3. Pilot web-tool for VLASS imaging

The pilot tool is a Flask-based web interface that organizes processing into user-facing steps. The interface allows the user to enter a target name or coordinates, find VLASS MSes, submit calibrated-MS restore requests to the NRAO archive, and run either single-epoch or multi-MS VLASS processing imaging jobs. The tool creates (in NRAO Lustre¹ area) per-user and per-object work

¹Lustre is a file system that provides fast, shared storage for high-performance computing.

directories, writes parameter files, generates pipeline and Slurm² scripts, and submits jobs to the cluster.



The screenshot displays the 'VLASS Extended Source Imaging' web interface. At the top, there are logos for NRAO, VLASS Extended Source Imaging (with a 'VES' logo), and VLA Sky Survey. Below the logos, the title 'VLASS Extended Source Imaging' is centered, with a link 'Download data from VLA Archive' underneath. The main section is titled 'STEP 1 - Find VLASS Measurement Sets'. It contains a form with the following fields and buttons:

- Object name:** A text input field containing '3C75' and a 'Simbad/NED search' button.
- R.A.:** A text input field containing '02 57 41.64'.
- Dec.:** A text input field containing '+06 01 28.0'.
- Object list CSV:** A 'Browse...' button, the text 'No file selected.', and a 'Process CSV' button.
- A 'Find VLASS MS' button.
- VLASS MSes:** A list of four measurement sets, each with a checked checkbox:
 - VLASS1.1.sb34418989.eb34425056.58011.2817505787.ms
 - VLASS2.1.sb38530355.eb38576088.59078.34299474537.ms
 - VLASS3.1.sb43928060.eb43975449.60083.774904618054.ms
 - VLASS4.1.sb49207167.eb49619673.60971.29332094907.ms
- Notification email:** An empty text input field.
- Archive download directory:** A text input field containing '/lustre/aoc/sciops/vparekh/VLASS_selfcal'.
- A 'Download selected calibrated MS' button.

Figure 1: Target search and archive request portion of the pilot web-interface.

The first operational layer (Figure 1) is VLASS MS discovery and archive request handling. A user searches for a target source, selects any or all multi-epoch VLASS MSes, and provides an email address and an approved Lustre destination where to copy the selected VLASS data. The archive request handler converts the selected VLASS MS name into an SDM identifier and project code, then submits a calibrated MS restore request to the NRAO archive. In the current implementation, the request script uses the NRAO archive API, requests the calibrated-MS data format, identifies the appropriate CASA restore workflow, and directs the restored data to a user-defined Lustre path that should be restricted to an approved user or project area.

Once the calibrated MS is restored, the pipeline job resolves the actual nested archive path before CASA starts. This step is important because archive restores do not place the final MS directly in the top-level user directory. The Slurm job therefore searches recursively under the selected archive download directory, identifies the restored MS by basename, and updates the CASA script or configuration file before launching the pipeline.

The second operational layer (Figure 2) is input or user-defined imaging parameter handling. The pilot tool currently supports standard VLASS single-epoch imaging and multi-MS imaging pipelines. In the single-epoch mode, each selected VLASS epoch is submitted as an independent Slurm job with their own imaging parameters. In the multi-MS mode, the user supplies one shared set of imaging parameters and the tool injects multiple restored MSes into a standard CASA pipeline script. The multiple MS are passed to `hifv_importdata()` with matching session labels, allowing a pipeline run across multiple MS and perform joint deconvolution.

²Slurm is a system that schedules and manages computing tasks on a cluster of computers.

STEP 3 – Run Standard VLASS Pipeline

Per-Epoch Inputs

Image name:3C75_VLASS

Phasecenter (RA, Dec):02 57 41.64, +06 01 28.0

Cutout imsize:1500

☒ in pixel ☐ in arcmin

Gridder:

☐ mosaic ☐ awp2 ☐ awproject

W-projplanes:1

Robust value:0.3

UV taper:5arcsec

Job Submission & Email Notification (Standard VLASS)

Notification email:vparekh@nrao.edu

Create SEIP_parameter.list & Submit Standard VLASS Jobs

Figure 2: User-defined imaging parameters and job submission portion of the pilot interface.

4. Pipeline implementation

The current standard VLASS imaging script initializes the CASA pipeline context, imports the MS, applies imaging-parameter edits, splits the data from the corrected data column, builds VLASS masks, performs imaging and self-calibration, applies primary-beam (PB) correction, generates RMS map and standard cutout products, generates alpha images, and exports the final VLASS products. The important design feature for user-defined imaging is that the web interface writes `SEIP_parameter.list`, and the CASA pipeline reads it through:

```
hif_editimlist(parameter_file='SEIP_parameter.list')
```

The edited imaging list is then used by subsequent pipeline heuristics such as `hif_makeimages()` and the VLASS self-calibration sequence.

In this work, we used multi-epoch VLASS data of the radio galaxy 3C75 to demonstrate the pilot web-tool framework. First, we processed and imaged the central region of 3C75 using the VLASS 2.1 epoch. For this test, the following `SEIP_parameter.list` was generated by the web interface:

```

imagenam='3C75_VLASS'
phasecenter='J2000 02:57:41.64 +06.01.28.000'
cutout_imsize=[1500,1500]
gridder='mosaic'
wprojplanes=1
robust=0.3
uvtaper=['5arcsec']

```

In this parameter list, `imagenam` defines the output image name and `phasecenter` sets the requested image center at the 3C75 position. The `gridder='mosaic'` and `wprojplanes=1` define the imaging gridder and W-projection setting used by the pipeline. The parameter `cutout_imsize=[1500,1500]` corresponds to a 15 arcmin image size for the default VLASS imaging cell size of 0.6 arcsec. This angular size is comparable to the primary-beam scale at the 3 GHz S-band center frequency and is useful for imaging only the central region around the extended radio source 3C75, rather than imaging the full default $\sim 1^\circ$ VLASS field. One can also supply the image size in angular size instead of pixels via the web interface. In this first test, we supplied `robust=0.3` and `uvtaper=['5arcsec']` to modify the visibility weighting and effective angular resolution. The resulting PB-corrected Stokes I image and corresponding alpha map are shown in Figure 3.

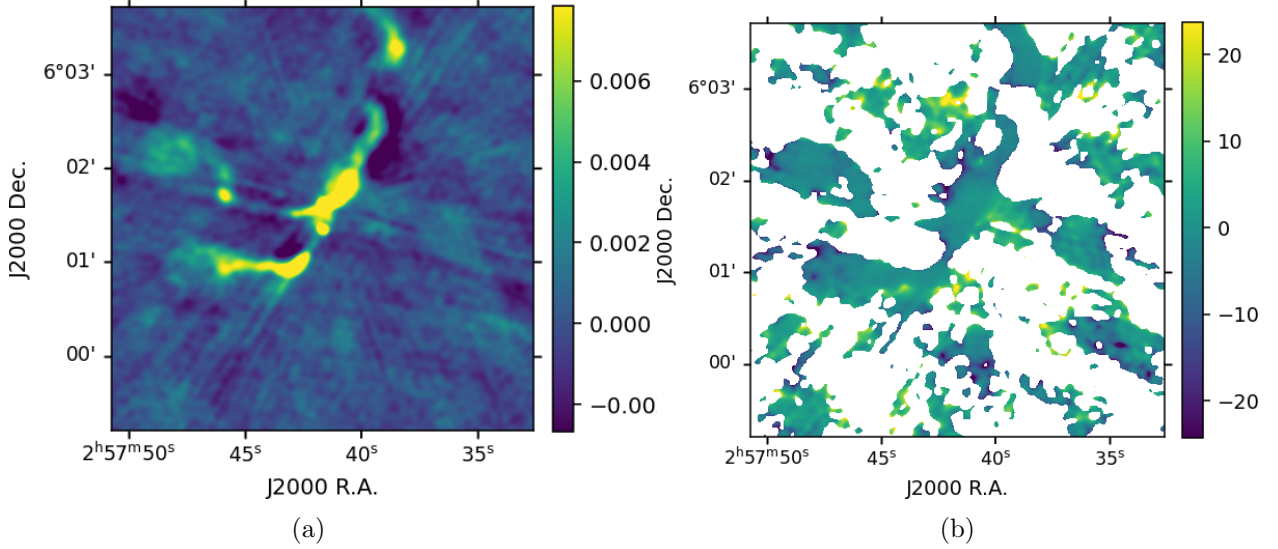


Figure 3: VLASS single-epoch 2.1 imaging result for the radio galaxy 3C75 using user-defined imaging parameters. (a) PB-corrected Stokes I cutout centered on 3C75; the colorbar unit is Jy beam^{-1} . The beam size is $5.49'' \times 4.84''$ and RMS value is $\sim 0.54 \text{ mJy beam}^{-1}$. (b) Corresponding alpha map. This run used `robust=0.3` and `uvtaper=['5arcsec']`.

As a second demonstration, we processed the VLASS 3.1 epoch of 3C75 without applying additional `robust` or `uvtaper` values through the user-defined parameter list. This run demonstrates the standard single-epoch VLASS imaging mode (except the image size) within the same web-tool framework. The resulting PB-corrected Stokes I image and alpha map are shown in Figure 4.

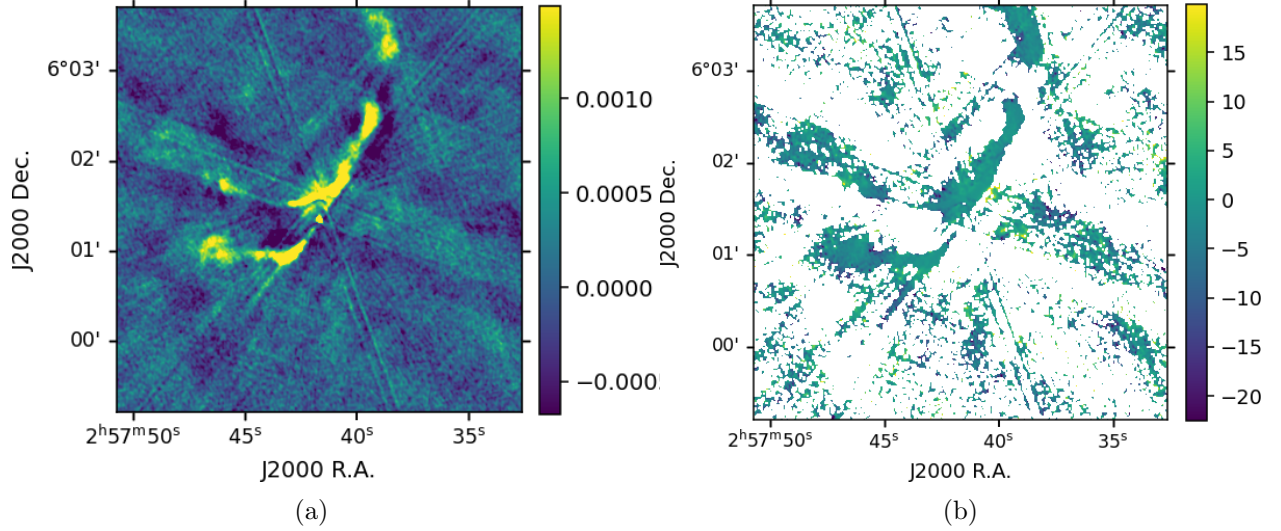


Figure 4: VLASS single-epoch 3.1 imaging result for the radio galaxy 3C75. (a) PB-corrected Stokes I cutout centered on 3C75; the colorbar unit is Jy beam^{-1} . The beam size is $2.51'' \times 2.00''$ and RMS value is $\sim 0.23 \text{ mJy beam}^{-1}$. (b) Corresponding alpha map. This run was processed without additional user-supplied `robust` or `uvtaper` values.

Finally, we tested the multi-epoch processing capability by combining VLASS epochs 1.1, 2.1, 3.1, and 4.1 for 3C75. For this combined run, the same pilot web-tool framework was used to select multiple restored calibrated MSes and generate a common `SEIP_parameter.list`. No additional user-supplied `robust` or `uvtaper` values were applied for this test. The resulting combined PB-corrected Stokes I image and corresponding alpha map are shown in Figure 5. Figures 4 and 5 shows comparison between maps of single epoch vs multi-epoch joint deconvolution (with the same imaging parameters).

At present, a typical end-to-end run requires approximately two days for single-epoch imaging and approximately three days for multi-epoch imaging, including the time required for the archive system to restore and copy the calibrated MS to the selected Lustre area and for the standard VLASS imaging pipeline to produce the final self-calibrated image products. For large image size, the image processing time will be varying.

5. Scope, feasibility, and future development

The current pilot web tool is just for demonstration and requirements-gathering purpose that running on one of the reserved Lustre node. One can download the VLASS-UDI from <https://github.com/viralp/VLASS-UDI>. The current version is more suitable for using on the NRAO computing system. Its immediate scope is to verify that archive-based calibrated-MS restoration can be connected to the VLASS user-driven imaging; test a safe and useful set of exposed imaging parameters; validate single-epoch and multi-MS VLASS standard pipeline execution; evaluate run-time, disk usage, and failure modes; collect feedback from internal and expert users; and produce reproducible products with saved parameter files, generated scripts, Slurm output, and CASA logs.

The project is feasible because it builds on existing components: the NRAO archive restore mechanism, VLASS calibrated MSes, CASA pipeline scripts, Slurm job submission, and a working web-interface prototype. A controlled pilot can run with a small user group and manual oversight. A production service would require authenticated user workspaces, approved Lustre destinations,

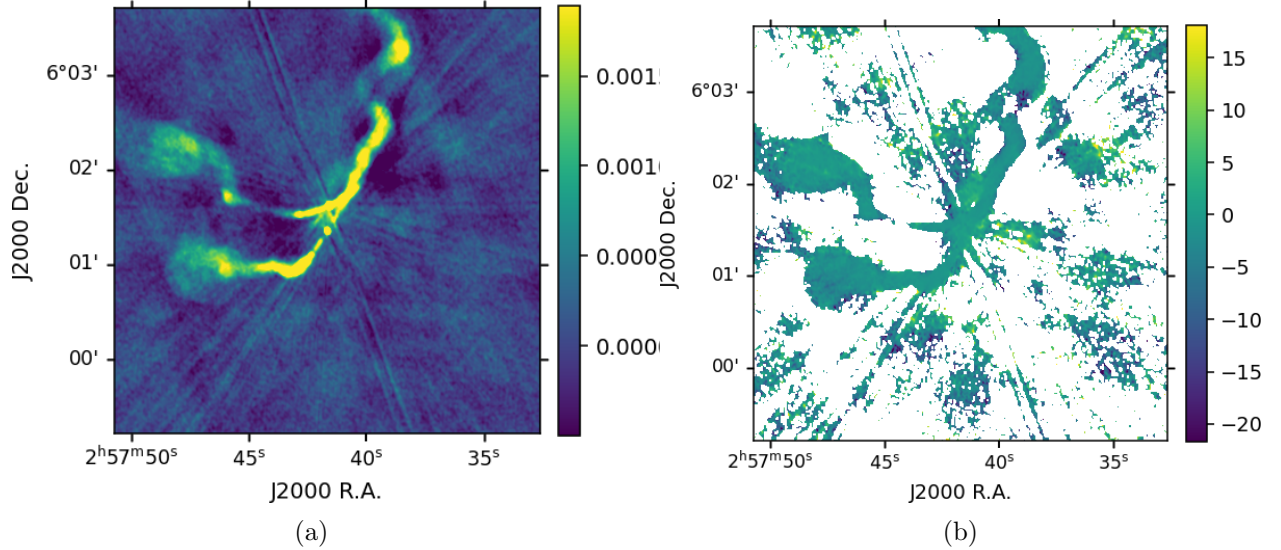


Figure 5: VLASS four-epoch combined imaging result for the radio galaxy 3C75 using epochs 1.1, 2.1, 3.1, and 4.1. (a) PB-corrected Stokes I cutout centered on 3C75; the colorbar unit is Jy beam⁻¹. The beam size is $2.63'' \times 2.06''$ and RMS value is ~ 0.13 mJy beam⁻¹. (b) Corresponding alpha map. This combined run was processed without additional user-supplied `robust` or `uvtaper` values.

path sanitization, storage quotas, cleanup policy, job-state tracking, parameter validation, script versioning, and a product browser for FITS images, PNG quicklooks, tar files, logs, and QA reports.

The next development phase should test more advanced imaging and calibration strategies, including direction-dependent calibration, namely ‘peeling’ (VLASS Memo 23), for VLASS data in order to produce high-dynamic-range products. The framework should also support the generation of science-ready catalogues alongside imaging products and spectral-index maps. The production of per-SPW polarization maps is also under test within the current pilot web-tool framework. Another important requirement is to test and validate the choice of gridded and number of W-projection planes for both single-epoch and multi-epoch VLASS data, particularly as a function of source declination. The pilot tool allow us to test a new `awp2` gridded for a variety of sources and fields, and compare them with the old `mosaic` gridded. The tool can increase the scientific return of VLASS by enabling better imaging for extended sources, multi-epoch targets, and specialized science cases that are not fully served by uniform survey products alone.

Acknowledgments

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References

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