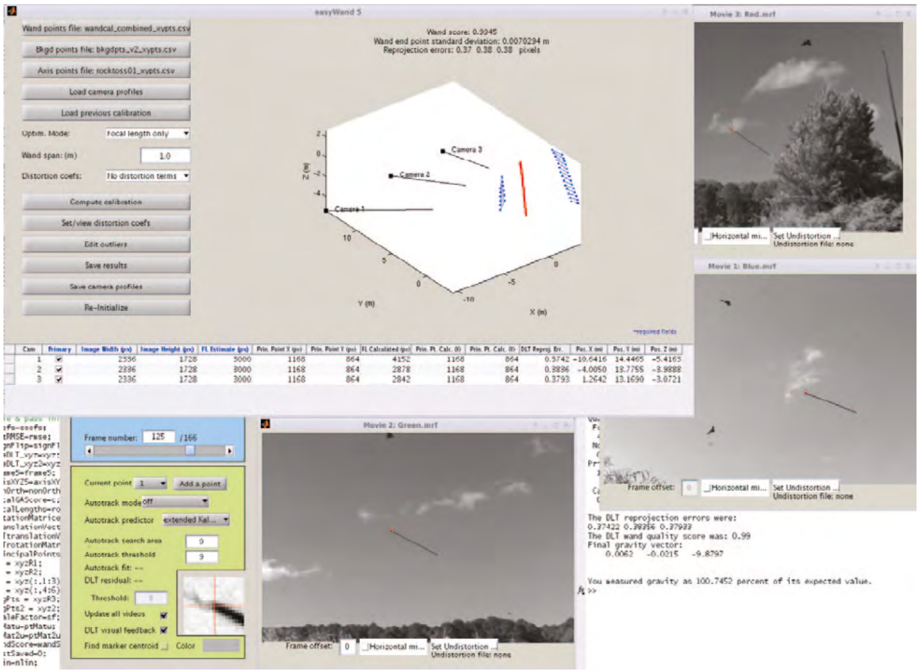

Figure S1:

Software packages for easyCamera, easyWand, and easySBA and documentation can be downloaded from the OpenBU repository at http://hdl.handle.net/2144/8456. The Python SBA source code is also available at https://bitbucket.org/devangel77b/python-sba and the Python PIP stable release at https://pypi.python.org/pypi/sba/1.6.0

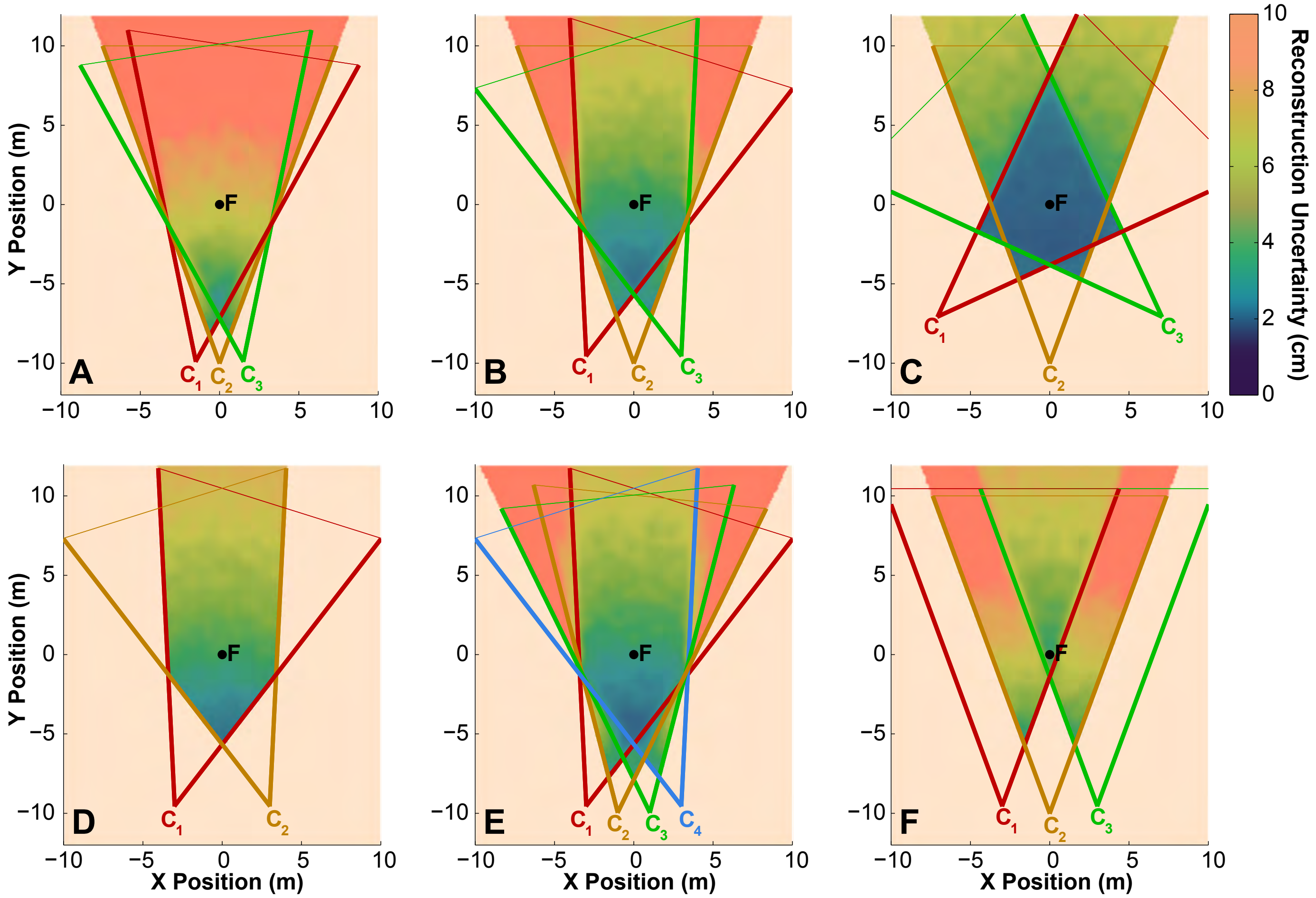

Figure S2: Reconstruction uncertainty due to quantization and localization ambiguity effects is shown for six hypothetical camera configurations. The cameras were simulated to have a pixel width of 18 μm and field-of-view angle 40.5° and be positioned at a fixed height Z and aimed at a common, equidistant fixation point $F = (0, 0, Z)$. Horizontal cuts of the 3D view cones of the cameras at height Z and lines at D_{max}=20 m are shown from above. Image localization ambiguity was modeled by adding Gaussian noise to the image points before image quantization. Noise added to the image points corresponding to the 3D points had a standard deviation that was one-sixth of the calculated apparent size of a 10 cm animal, given the distance between each camera and corresponding 3D point. When the 3D points are close to the camera, the image localization ambiguity contributes more to the uncertainty, whereas when the 3D points are further away, the image quantization effects contribute more.

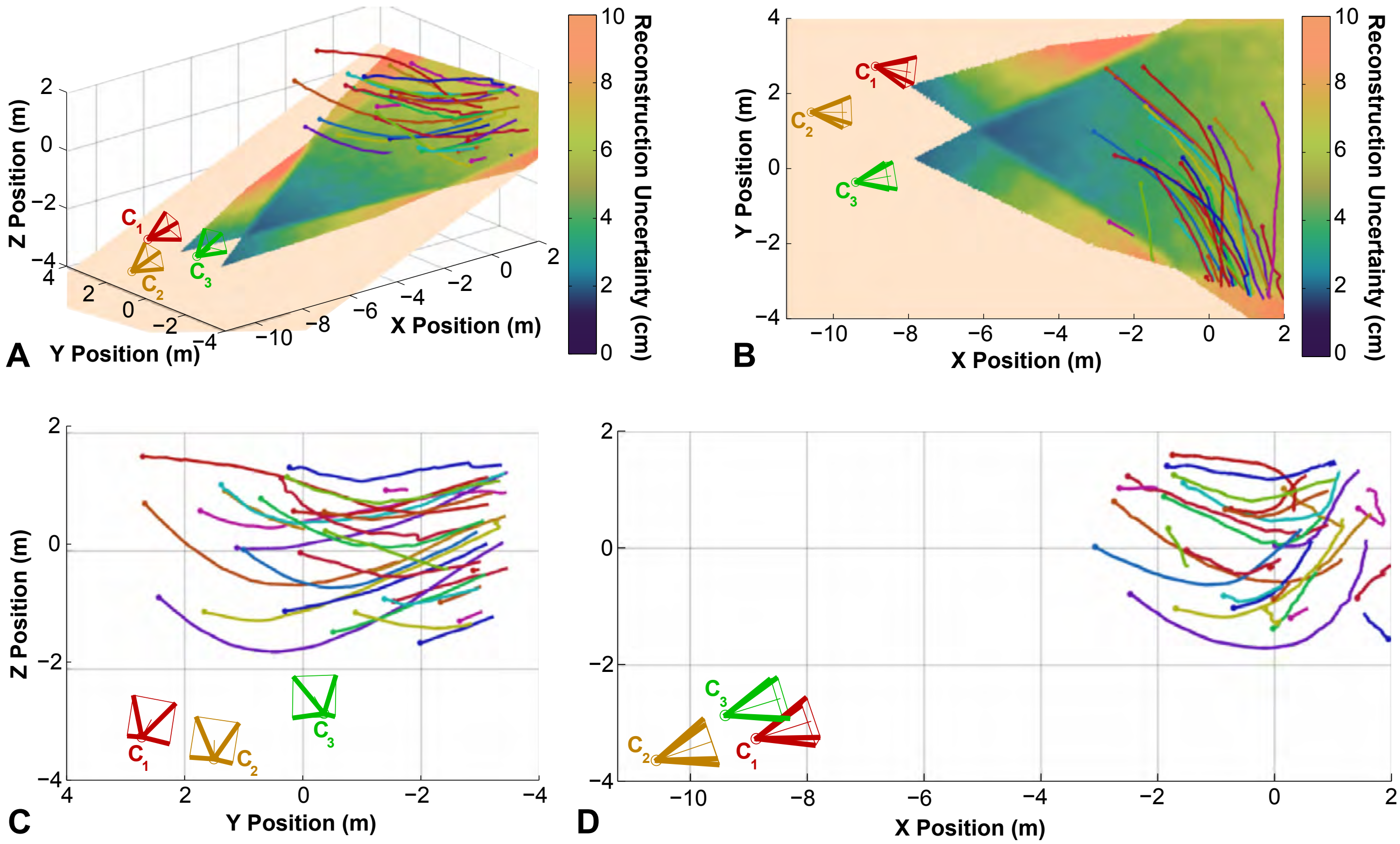

Figure S3: 3D flight trajectories of 28 Brazilian Free-tailed Bats during a 1-s interval are shown in the context of the spatially-varying reconstruction uncertainty arising due to both image quantization and image localization ambiguity from an oblique view (A) and from the top (B). The tracks are shown from the point of view of the cameras (C) and from the side (D). The observation distance between cameras and bats was approximately 10 m (B, D), chosen so that the nose-to-tail span of a bat in an image was at least 10 pixels. The baseline distance between the outermost cameras was approximately 6 m, chosen so that the expected uncertainty in reconstructed 3D positions at the observation distance due to image quantization and image localization ambiguity was less than 10 cm, the length of a bat. The RMS reconstruction uncertainty for the 1,656 estimated 3D positions shown was 7.8 cm.

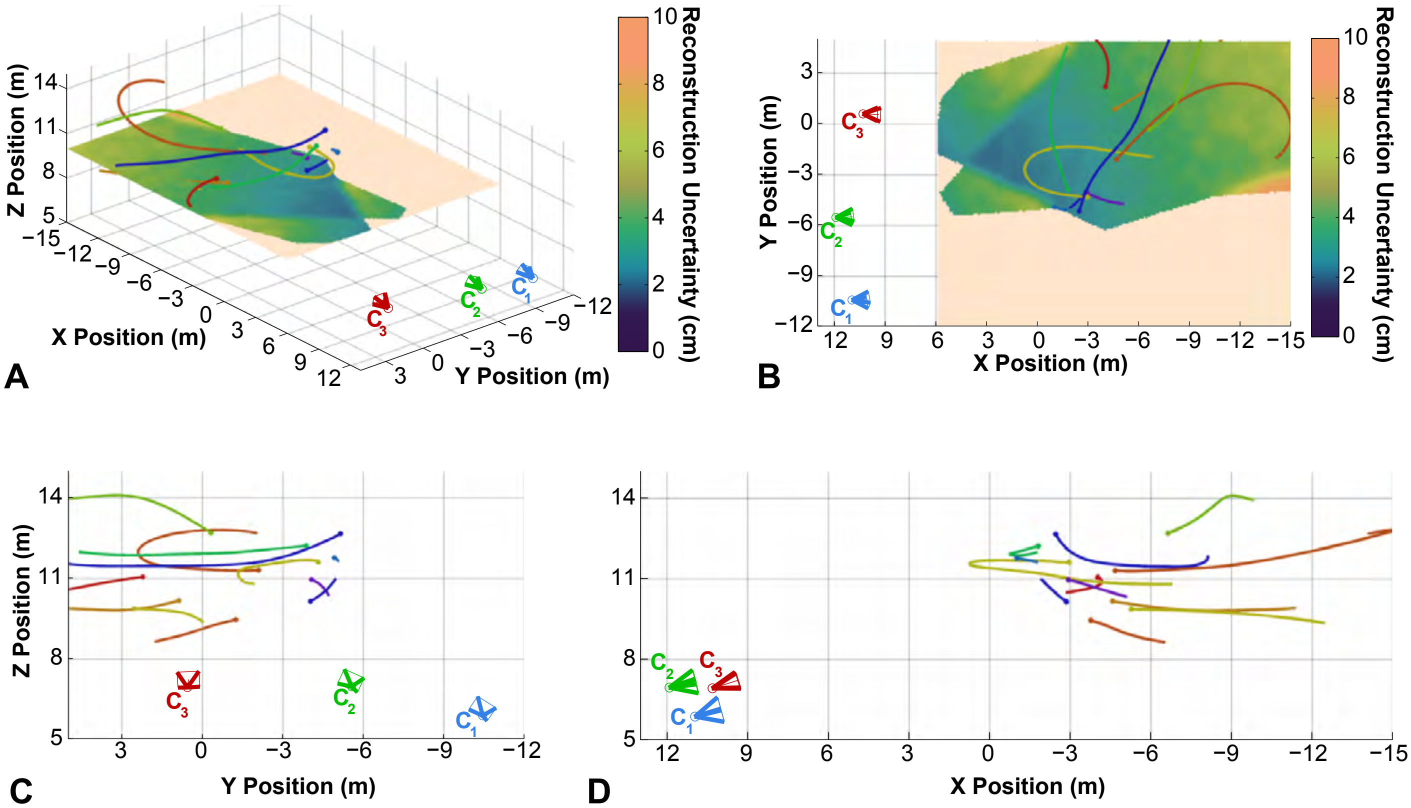

Figure S4: The flight paths of 12 Cliff Swallows during a 2.3-s interval are shown in the context of the spatially-varying reconstruction uncertainty arising due to both image quantization and image localization ambiguity from an oblique view (A) and from the top (B). The tracks are shown from the point of view of the cameras (C) and from the side (D). At an observation distance of approximately 20 m (B,D), the birds, which are approximately 13 cm long, were imaged at an average length of 18 pixels. The baseline distance between the outermost cameras was approximately 11 m. The RMS reconstruction uncertainty for the 2,796 estimated 3D points shown was 5.9 cm, less than half the length of a bird.

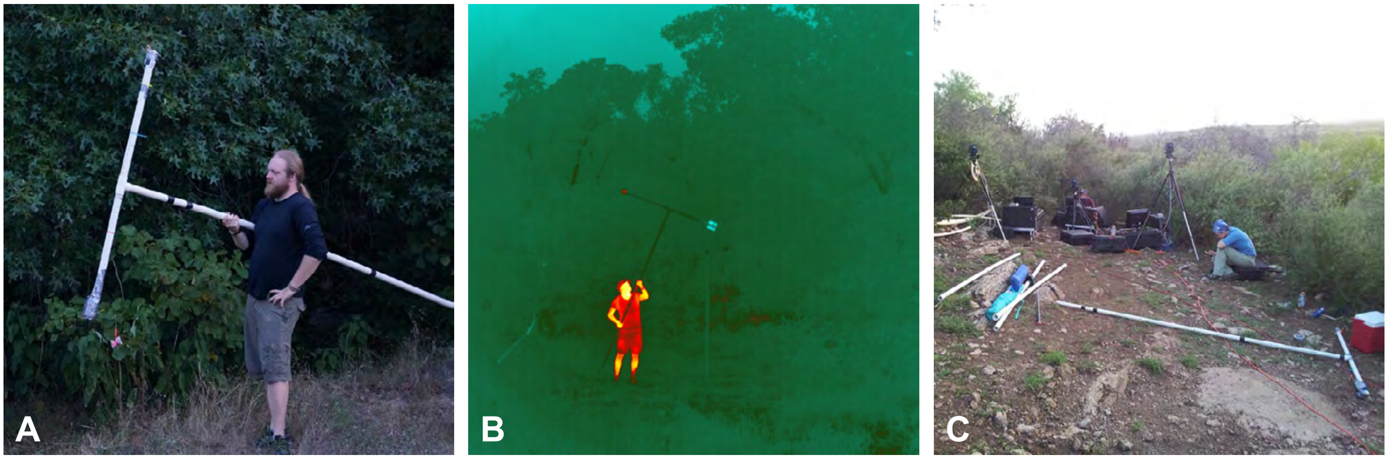

Figure S5: Bat field recording wand and site. The 1.56-*m* wand is shown attached to an approximately 3.5-*m* pole (A), which was used to wave the wand through the camera scene (B). The wand was equipped with hot and cold packs to provide thermal infrared contrast between points on the wand and the background sky and vegetation. The bat field site is shown with three thermal infrared cameras arrayed for recording and the calibration wand in the foreground (C).

Figure S6: Bird field recording wand The 1.0-*m* calibration wand (A) used in the swallow recordings was attached to a stout fishing pole, also shown (A), to facilitate tossing the wand through the camera viewing volume and retrieving it afterward. The calibration wand itself was painted white and black to enhance contrast and visibility against different backgrounds. A video frame from a wand calibration toss is shown with the wand visible against the sky and the fishing pole appearing in the lower left corner (B).

# of bird points	Calibration RMSE	Bird RMSE	Wand score
Wand only (0)	0.2653	4.5150	0.6475
5	0.3800 (0.0533)	2.2002 (0.5969)	0.7007 (0.2645)
10	0.4580 (0.1011)	1.8825 (0.3664)	0.6926 (0.2771)
50	0.8403 (0.2044)	1.4389 (0.1207)	0.6146 (0.1627)
500	1.1477 (0.0808)	1.1021 (0.0404)	0.5418 (0.0466)
1000	1.1818 (0.0718)	1.0738 (0.0277)	0.5238 (0.0332)
All (4946)	1.1985	1.0480	0.5235

Table S1. Effect of including animal points in the calibration set. Here we examine the effect of including animal data in the calibration procedure by creating a swallow scene calibration using 58 points on the wands only, the wand and a range of randomly selected bird points from 5 to 1000, and the full set of bird points used in the calibration (4946). In cases where a random sample of points was used, 100 samples were drawn for each case and the results are reported as: median (inter-quartile range). The results are assessed by the root mean square reprojection error (RMSE) in pixels for all calibration points, the RMSE for a second set of 4303 bird points not used in calibration and the ratio of the standard deviation of wand length divided by its mean, multiplied by 100, listed as the wand score. Note that the bird points were less precisely digitized than the wand points. This causes the calibration RMSE to rise as additional bird points are added since the RMSE reflects the distance in the image between the reprojected points and the observations; if the observations are less precisely known then the RMSE rises. Incorporation of bird points also causes a negligible rise in the wand score when only a few bird points are used; in all cases the wand score indicates a high quality calibration. On the whole, incorporating bird points in the calibration greatly increases the reconstruction fidelity for other bird points, not used in the calibration, as shown by the middle column. This is because the bird points used in the calibration provide image correspondences in regions not accessible to a ground-launched wand. Generally, the more points that can be used, the smaller the errors become (middle column, last row). Even incorporating 5 bird points in the calibration decreased the RMSE of bird points not used in the calibration by more than one half (middle column, row 2). In all cases we allowed optimization of the focal length and principal point; focal length estimates were always 10% greater than the manufacturer-provided values.