First Resolved Images of a Spacecraft in Geostationary Orbit with the Keck-II 10 m Telescope

Jack D. Drummond[a] and Richard H. Rast[b]

[a] Air Force Research Laboratory, Directed Energy Directorate, RDSAM
3550 Aberdeen Ave SE, Kirtland AFB, NM 87117-5776
[b] Air Force Research Laboratory, Directed Energy Directorate, RDTE
3550 Aberdeen Ave SE, Kirtland AFB, NM 87117-5776

ABSTRACT

Resolved images of a geostationary satellite were obtained on October 30, 2009, with the adaptive optics on the largest telescope on the planet, the 10 m Keck-II on the 14000 foot summit of Mauna Kea.

1. Observations

As part of an engineering run at the Keck-II 10 m telescope on Mauna Kea, several adaptive optics images were obtained of geostationary satellite GE-23, a Spacebus 4000C3 built by Alenia Space, with solar panels spanning a total length of 39 meters. Table 1 contains the log for the observations made on October 30, 2009. The first set is comprised of four 0.053 s images at 1.25μm and the second set is comprised of six 0.053 s images at 2.17 μm.

Table 1. Observing Log for October 30, 2009

Set	UT	Wavelength	$\Delta\lambda$	Az	Elev	Range	Solar Phase
1	13:07	1.249 μm	0.163 μm	242.0°	46.6°	3.73×10^4 km	18.9°
2	13:09	2.169 μm	0.033 μm	242.0°	46.6°	3.73×10^4 km	19.1°

2. Images

Figure 1 shows the mean of the raw images in each set. Notice how the visibility of the solar panels and central bus depends on wavelength.

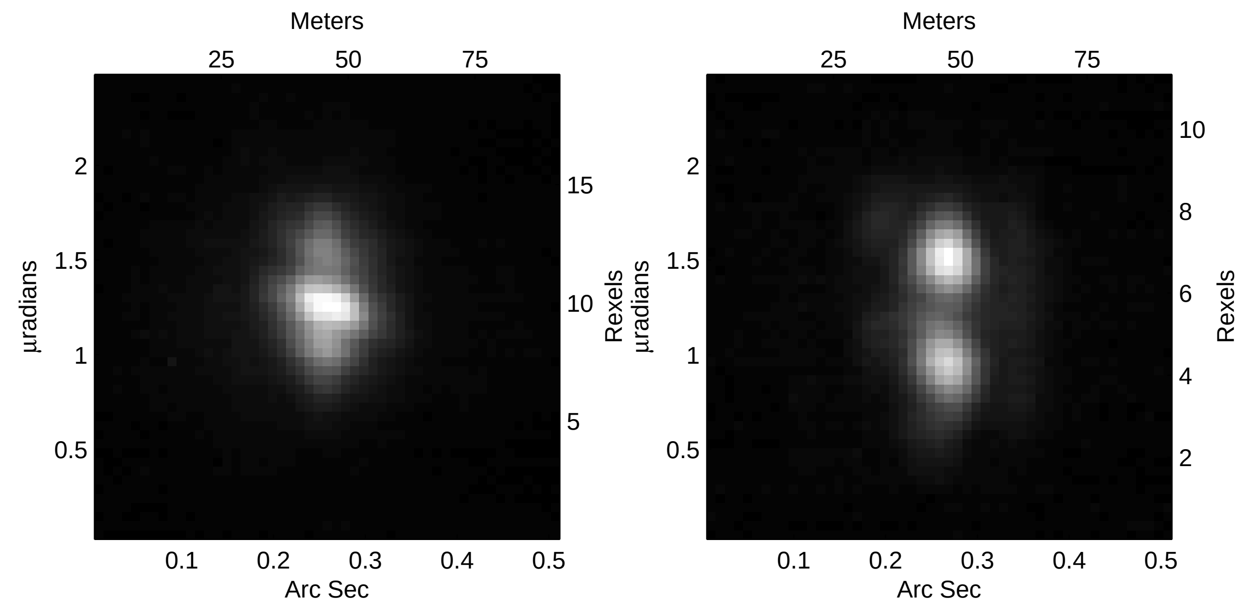

Fig. 1.— The mean of the raw images in set 1 (left; 1.25 μm) and set 2 (right; 2.17 μm). The rexel scale on the right side of each image is in units of the 10 m telescope diffraction limit, $0.026''$at 1.25 μm and $0.045''$at 2.17 μm. Notice that the bus is much more prominent at the shorter wavelength at left, but the solar panels are more prominent at the longer wavelength at right. North is up and East is to the left in all of the figures.

From a multi-frame Lucy-Richardson method of deconvolution, Fig 2 shows the reconstructed image from each set of images. The last panel, in color, shows the contribution from each wavelength, where red is for the longer wavelength at 2.17 μm and blue is for 1.25 μm. At 1.25 μm, the high-efficiency silicon solar cell stacks employed on this spacecraft are only 6% reflective and appear darker than the bus and antennae near the middle, but their cut-off wavelength of 1.8 μm makes them highly reflective at 2.17 μm where they appear brighter.

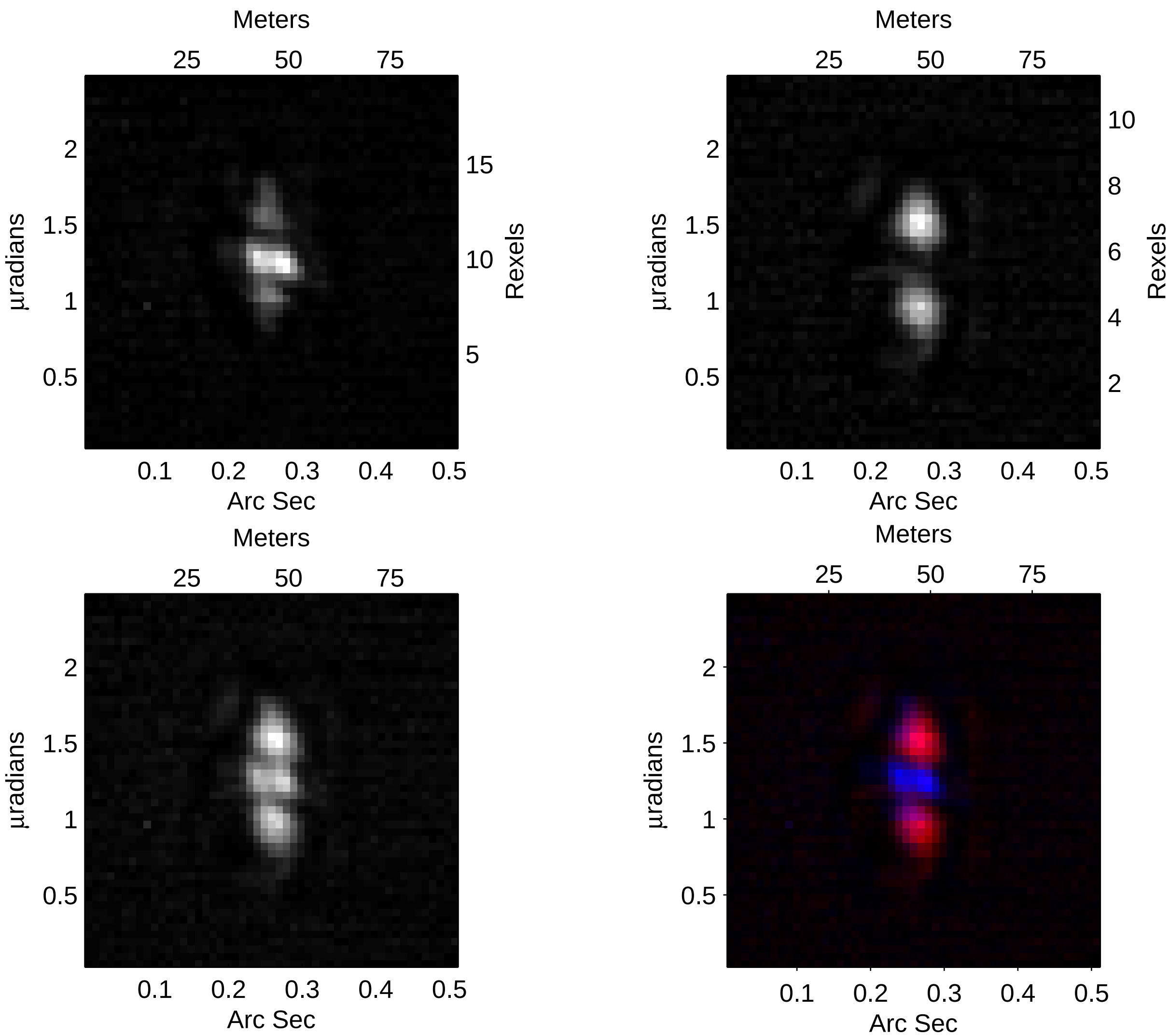

Fig. 2.— Reconstructed images of satellite GE-23. At upper left is the image at 1.25 μm, and at upper right is the image at 2.17 μm. At lower left is the sum of the two and at lower right is the same sum but where color distinguishes the wavelength.

For comparison, an artist's rendition of GE-23 is given on the left in Fig 3, and on the right a GE-23 model is posed for the time and location of our observations by Lyon Luksik and Waid Schlaegel. In the middle we repeat the image from the lower left in Fig 2.

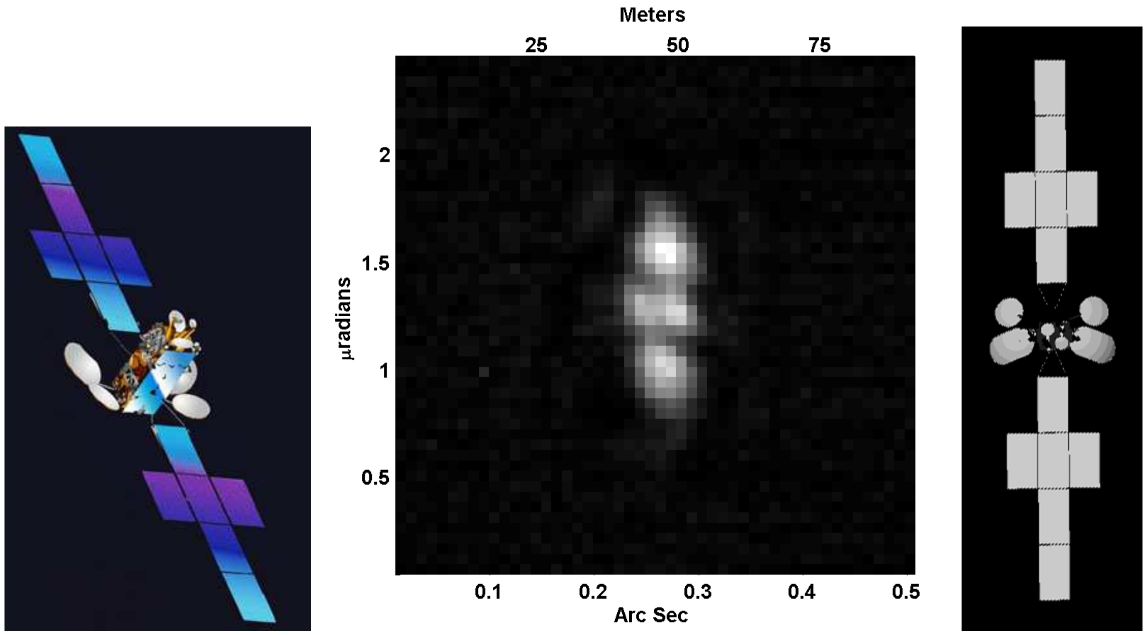

Fig. 3.— Satellite GE-23. On the left is an artist's illustration, and on the right a model is posed to match our image in the middle.

3. Previous Work

A 2006 AFRL Technical Report from the VS Directorate (AFRL-SR-TR-06-0042) details the first attempts to image a geostationary satellite. Led by LtGen (ret) Pete Worden and Babu Singaraju, a few unrecognizable images were obtained of two satellites with AO on the 6.5 m MMT. Since they reveal nothing, they are not shown here.

However, Fig 4 shows the only other large telescope image of a geostationary satellite (Hart et al 2009[1]) obtained at the MMT. It is a Multi Frame Blind Reconstruction at 1.65 μm of an ANIK satellite.

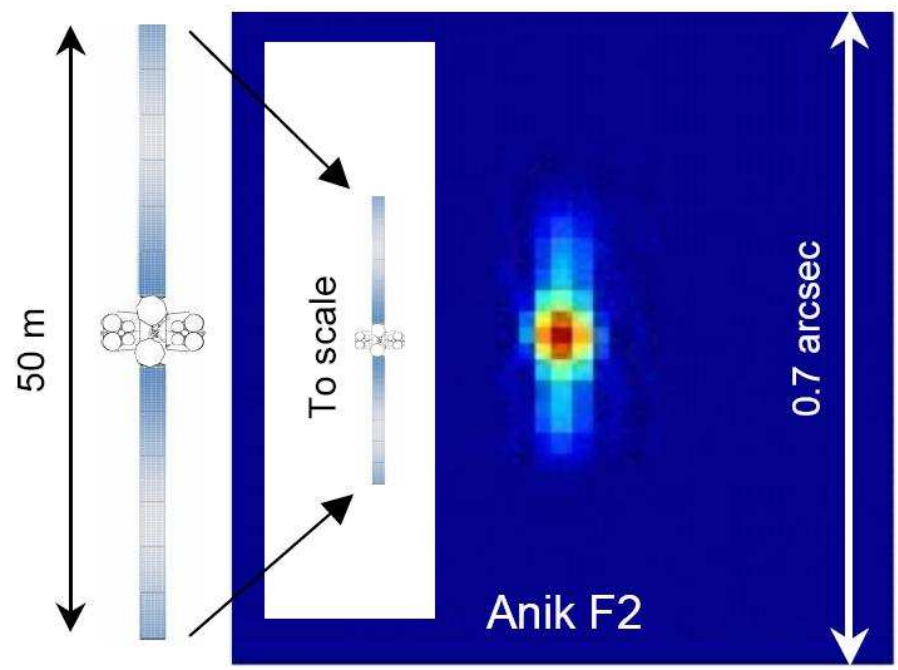

Figure 1. Diffraction-limited image of the geostationary communications satellite Anik F2 at 111° W recorded by the MMT AO system at 1.65 μm. A cartoon of the Boeing 702 satellite is shown for comparison.

Fig. 4.— ANIK F2 satellite, taken from Hart et al (2009).

---

[1]http://www.astro.caltech.edu/~baranec/publications/SPIE_GLAO_2009.pdf

4. Conclusions

The potential for studying satellites in geostationary orbit currently exists on large ground based telescopes. Not only do these present opportunities for the highest resolution, but spectral signatures over nearly a factor of two in wavelength can be accomplished with standard astronomical filters. However, in all likelihood, time at these observatories will have to be bought rather than competed for, since large telescopes are heavily over-subscribed and Telescope Allocation Committees award time based solely on astronomical merit.

Acknowledgments

The images from Keck-II were obtained by Al Conrad, without whose efforts on more than one occasion, we could not have made this report.