



Pre-launch Calibration of the Planet Planetscope Constellation

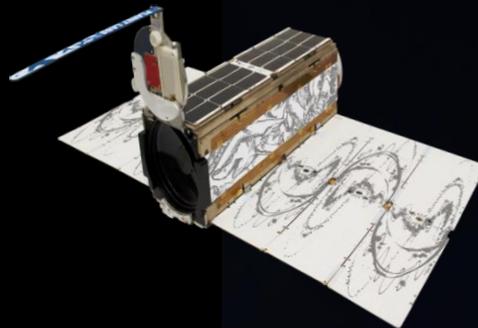
Nick Konidaris, Will Krantz, Joe Warga
2016-04-12



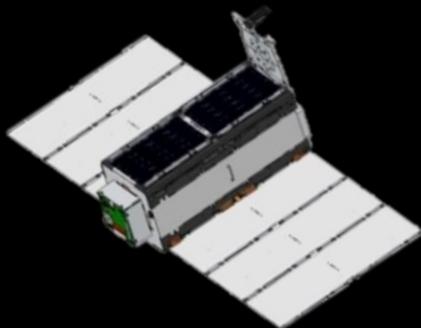
Planet Labs



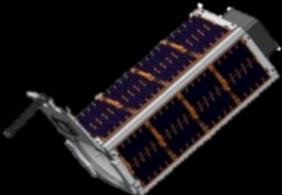
BUILD 13
JUN 2015



BUILD 6
APR 2013



BUILD 1
APR 2012



Agile Aerospace: 13 Builds in 4 years



Mission 1

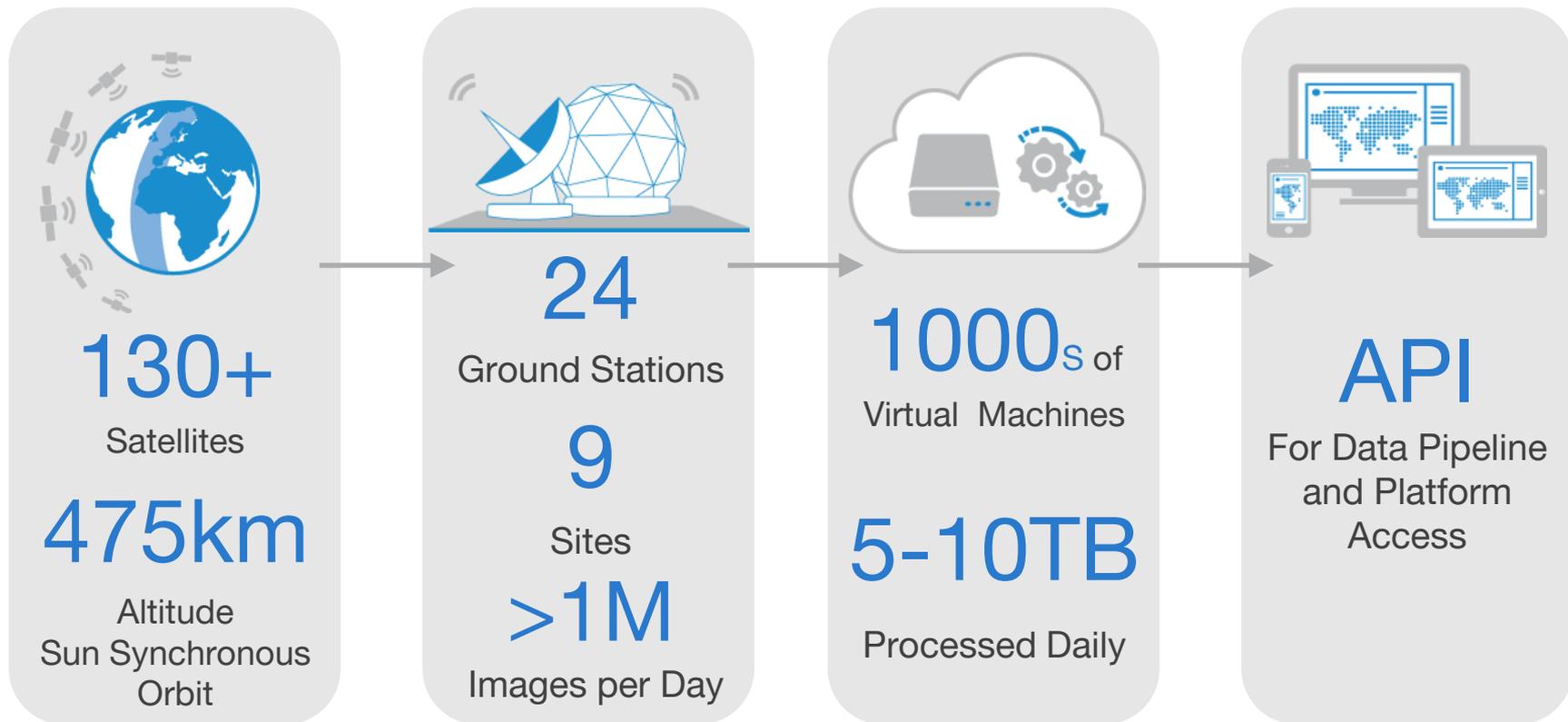
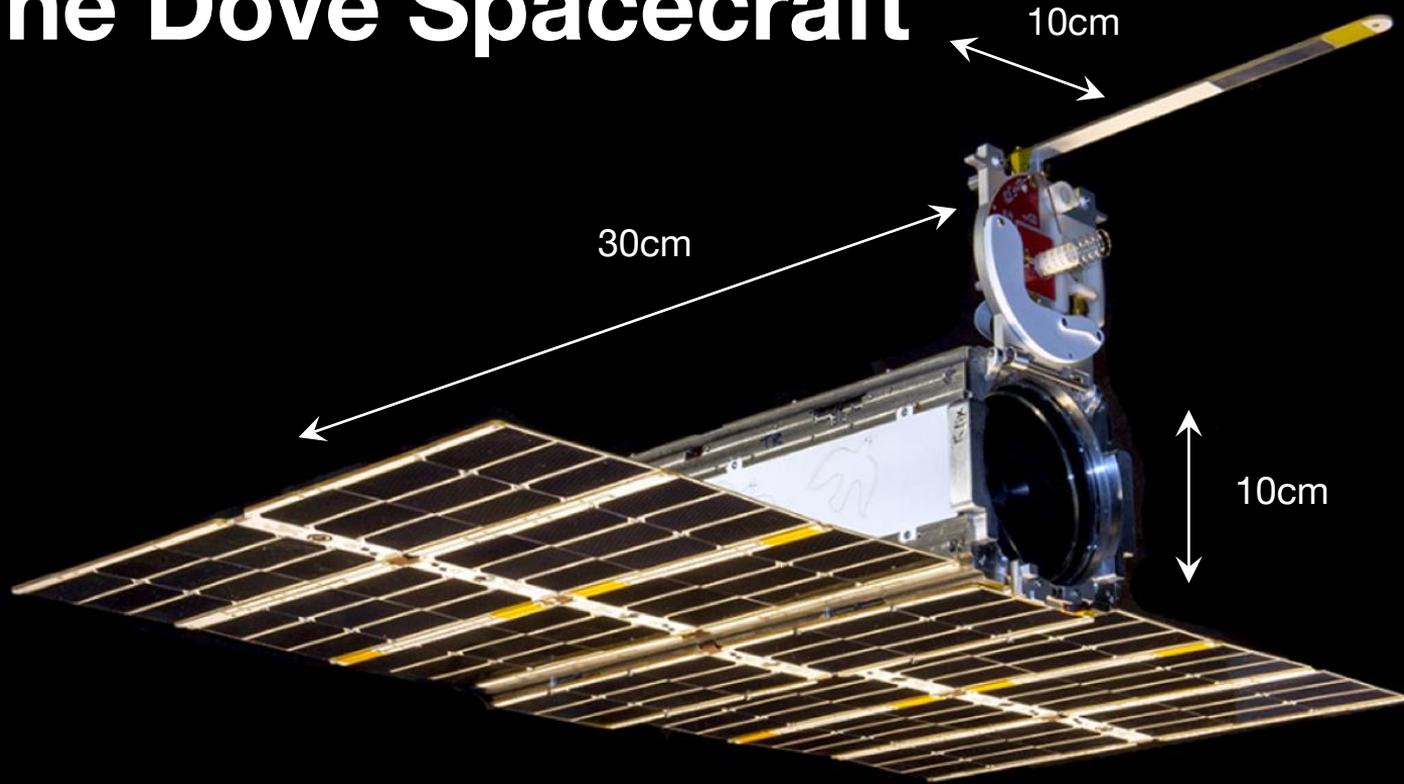


Image the whole Earth every day

The Dove Spacecraft

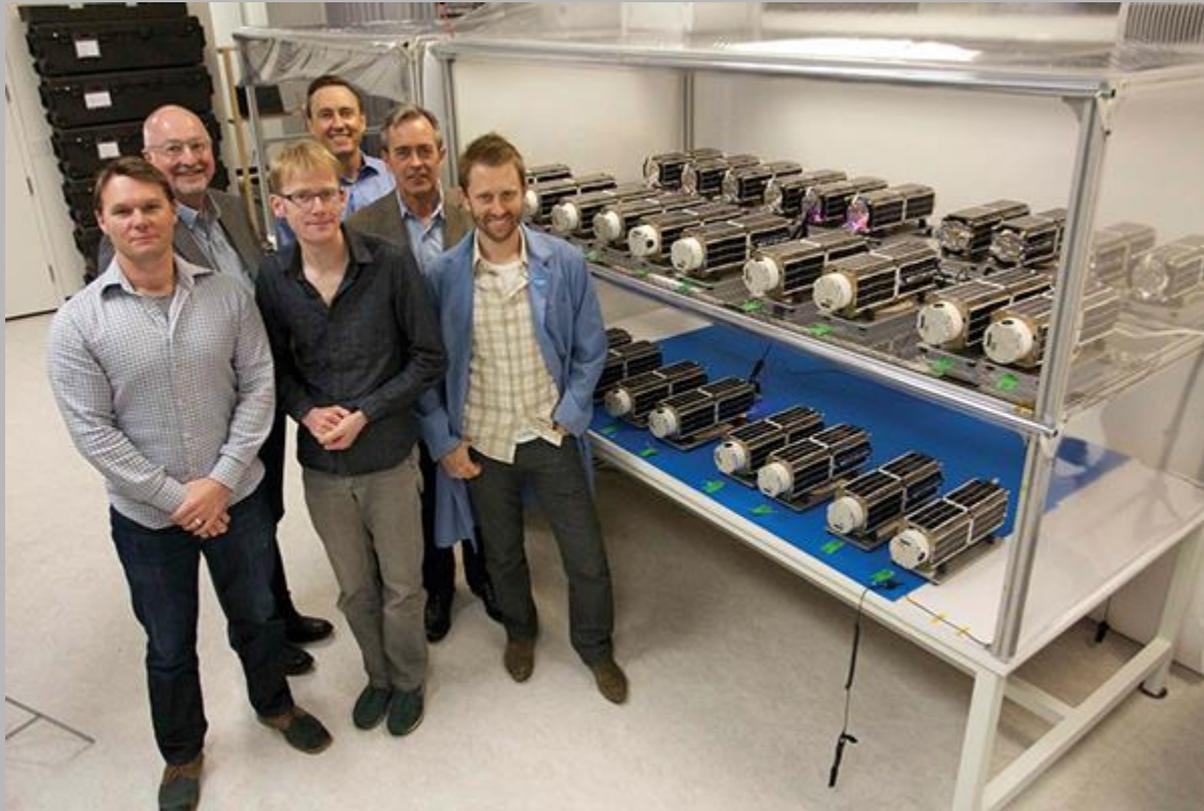


How is a Dove made?



@planetlabs

How is a Dove made?



Guiding principles

- Our goal is to present the best possible calibration and uncertainty
- Our measurements and effort are guided by a formal error budget
- To meet schedule, we take enough data to achieve our budgeted numbers, and no more

We start at the error budget

	<u>Accuracy [1 standard deviation]</u>	<u>Precision [1 standard deviation]</u>
Satellite temp variations	A few% [uncorrected]	A few% [uncorrected]
Filter differences (sat-to-sat)		A few% uncorrected
Stray light	A few%	A few%
Nonlinearity in device		1% calibrated to 0.2%
Flat field noise		3% calibrated to 0.1%
Standard transfer uncertainty	3%	
All the rest	1%	1%
On-orbit calibrations	To be determined	To be determined

Bold items are correctable or calibratable. We focus our time on these calibratable terms.

What do we do?

Check: dust, noise, focus, effects of environmental testing

Calibrate: flat field, radiometric response, sensor offset levels, linearity over exposure time v TDI

Correct: spectral responses

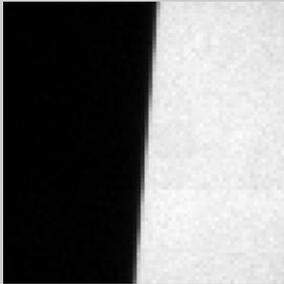
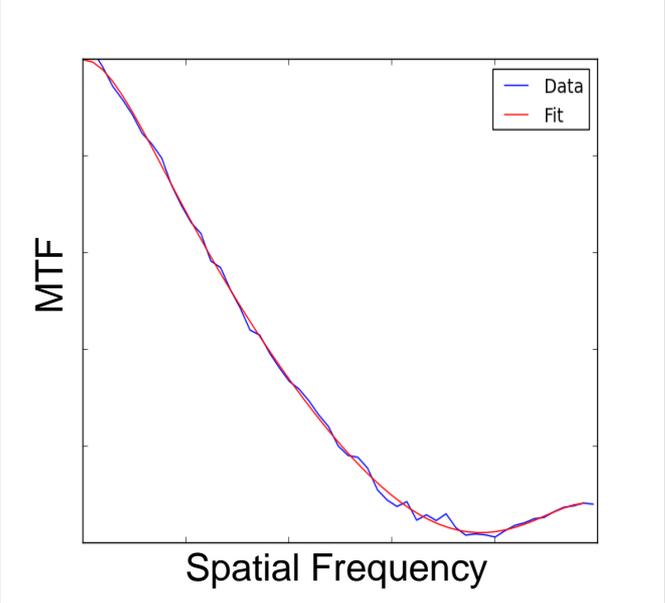
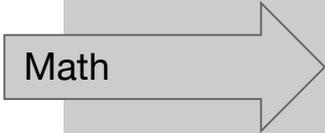
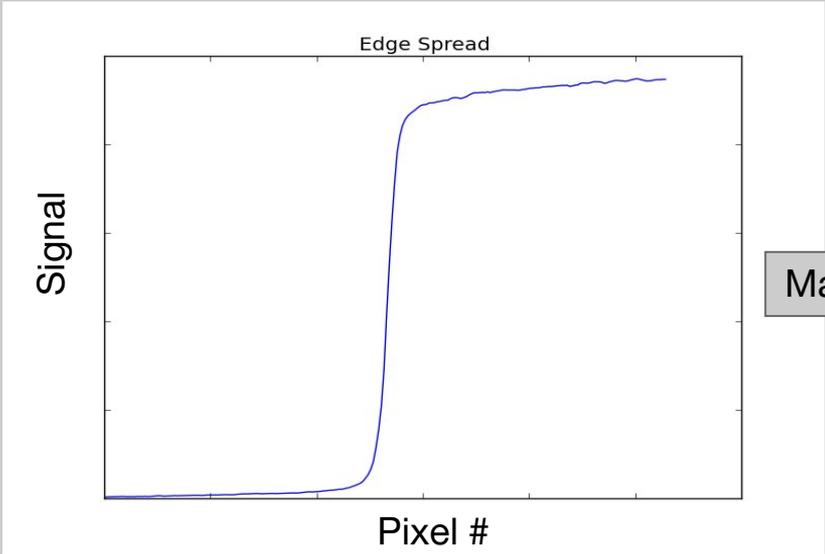
Today's discussion

Check: dust, noise, focus, effects of environmental testing

Calibrate: flat field, radiometric response, sensor offset levels, linearity over exposure time v TDI

Correct: spectral responses

Is the Dove in focus?



Today's discussion

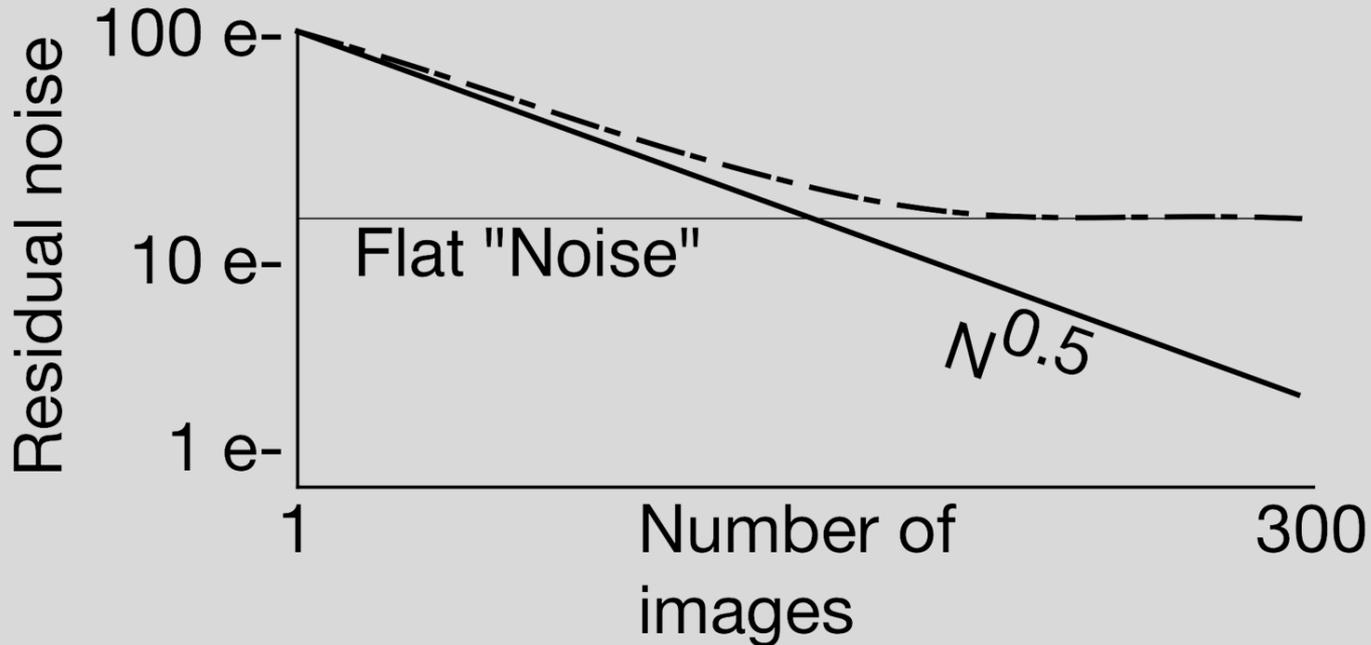
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E.g., Flat fields

$$[\text{Noise}^2 - (\text{Flat Noise})^2]^{0.5}$$



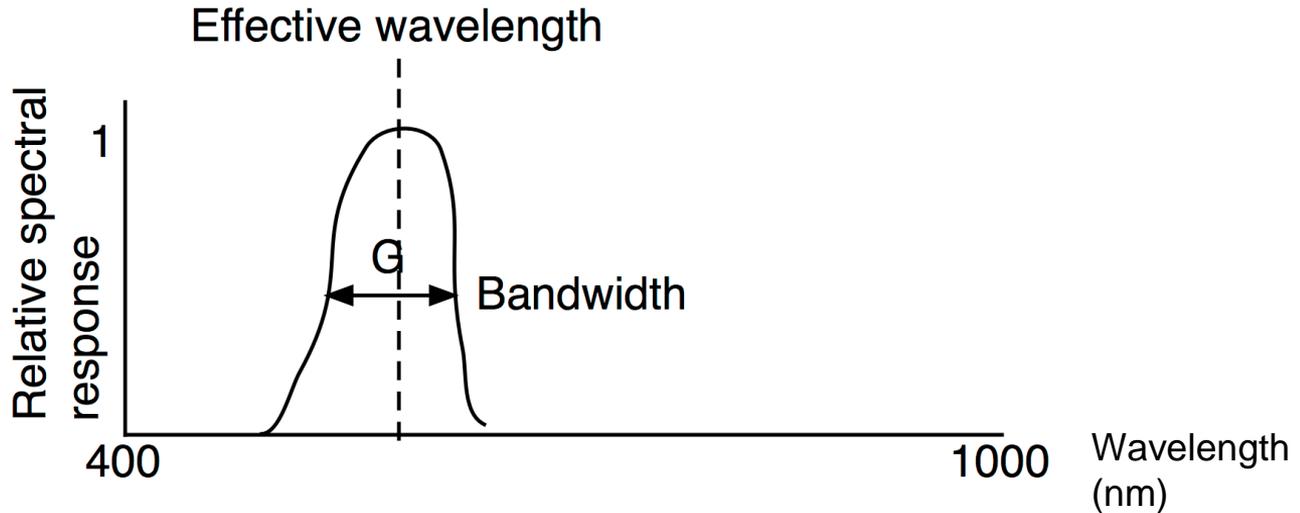
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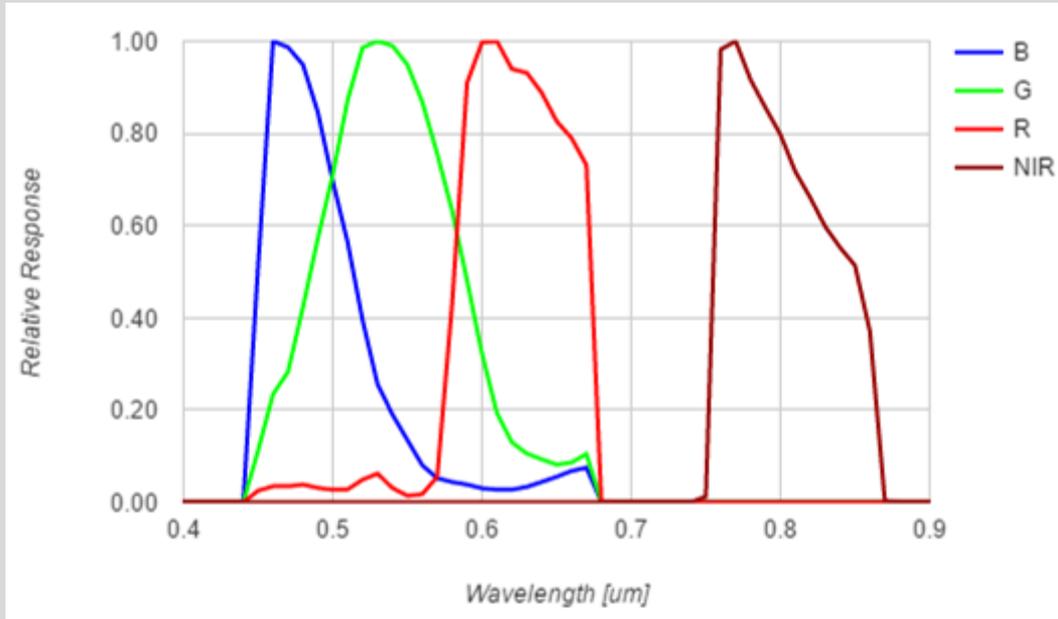
Relative Spectral Response



Effective wavelength is the average wavelength of the band.

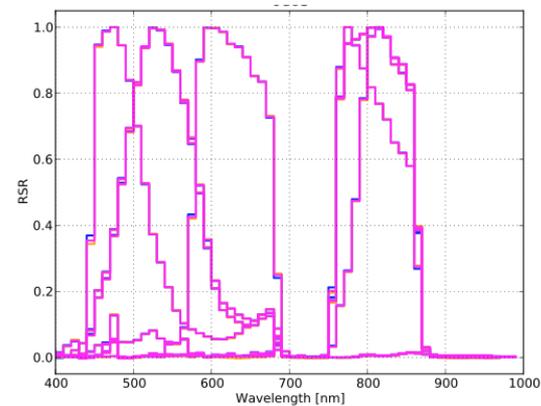
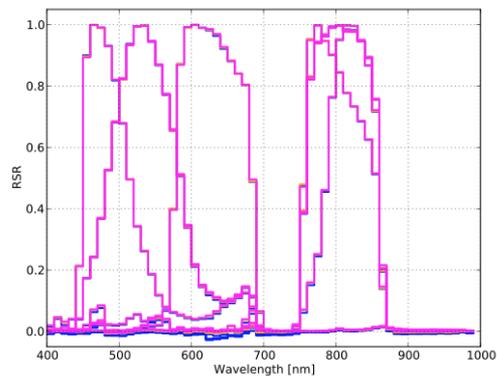
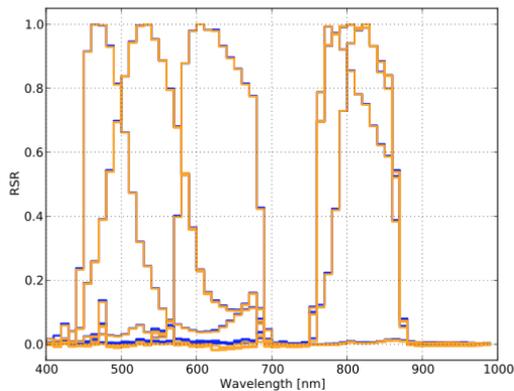
Bandwidth is the width of the filter. Both are in units of wavelength.

Relative Spectral Response

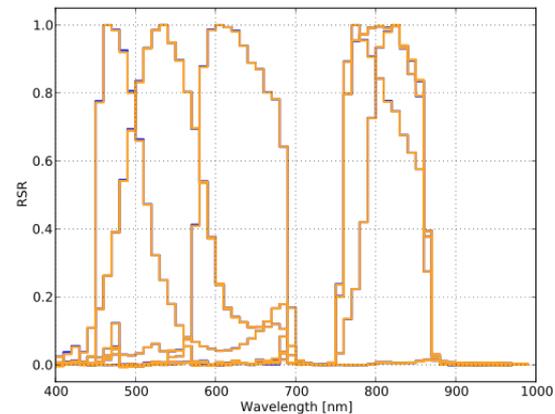
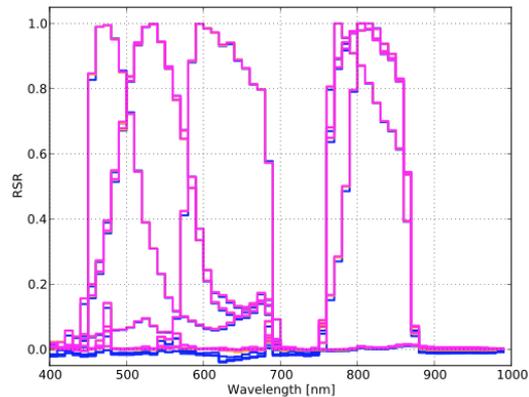
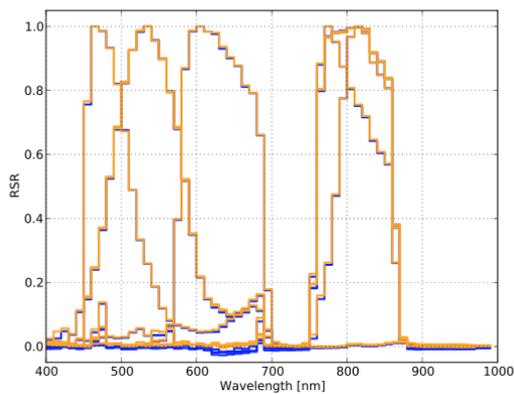


We summarize the RSRs into a pair of numbers:

- Bandwidth
- Effective wavelength



Just a few percent of the total # of satellites!



Summary

- Planet is an agile aerospace company
- Mission 1 and PlanetScope will deliver daily images of earth
- We described the calibration process for PlanetScope:
 - Understand how to take the minimum amount of data needed



An aerial photograph showing a dense green forest interspersed with agricultural fields and a network of light-colored roads. The fields are mostly rectangular and appear to be planted with crops, possibly corn. The roads form a complex web across the landscape. The overall scene suggests a rural or semi-rural area where agriculture and forestry coexist.

Questions?