OPTICS TESTING AT PLANETARY SCALE

Scale

Planet has over 150 satellites in orbit today, enabling near-daily coverage of nearly every spot on earth. At peak capacity, we can build dozens of satellites per week, including all testing operations.

Even at peak capacity, we work hard to ensure that each and every satellite meets our exacting optical and radiometric standards. One of the biggest enabling factors for meeting this standard is our testing philosophy.

Taking humans out of the loop as much as possible during our testing allows for maximum efficiency, repeatability, and cost saving. All of the operations described here can be accomplished by fewer than a dozen employees in our manufacturing facility.

Testing Philosophy and Approach

Each and every telescope that ships inside a Planet Dove or Superdove goes through a vigorous testing procedure. These tests are designed so that the user does not have to be an expert to run the test, or to interpret the results. All of our optics tests can be run either at the satellite level, or at the bare telescope level. This gives us maximum flexibility during the manufacturing process.

All of our testing is done using in-house software. We have guides that allow users with any level of experience to run the tests. In most cases, it's as simple as placing the satellite or subcomponent in the fixture, plugging in data and power, selecting the test to run, scanning the serial number barcode on the device under test, and hitting run.

Our software will ensure that the device under test is properly connected, is in the state that it needs to be, and that all test equipment is set up. If there's any issues, the user will be presented with a helpful error message to help them resolve the problem. Once the test completes, the user is presented with a simple result that makes it clear if the unit passed or failed. All results are archived in an easy-to-access manner, allowing for further review, if needed.

It is critically important for at-scale testing that any technician be able to run the test, and with a single glance at the results, know whether they can proceed on to the next step in the process with the device under test.

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Testing Workflow

IQC

Every incoming telescope is examined for mechanical damage, visual defects, FOD, and any other issues when it arrives from the manufacturer.

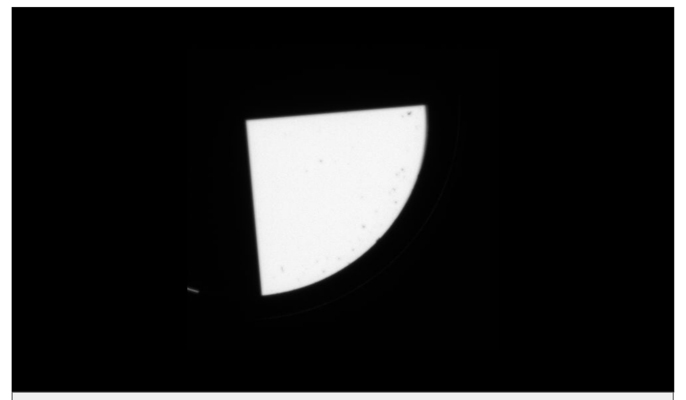
Assuming everything looks good, we proceed to functional testing.

Functional Testing

Before going through our full testing suite, the basic function of every telescope is tested.

We validate that all the electronic pathways are working correctly, and that the camera functions correctly when commanded.

After basic testing, the telescope proceeds with the full optics and detector testing suite.



Through-Focus

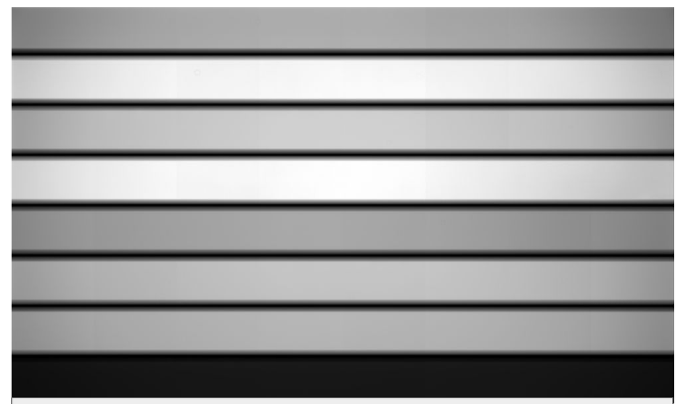
Procedure: Take a series of images of a corner target as it moves in and out of focus in a series of precise steps. Additionally, the telescope can be put in a variety of thermal states and the test can be performed at any location in the field of view.

Purpose: Provide a robust pass/fail MTF metric for our telescopes, and enable a comprehensive understanding of optical performance across a wide variety of on-orbit states.

Spectral Response

Procedure: Use a monochromater to measure the transmission of every filter on the detector at 1 nm spectral sampling, from 400 nm to 1000 nm.

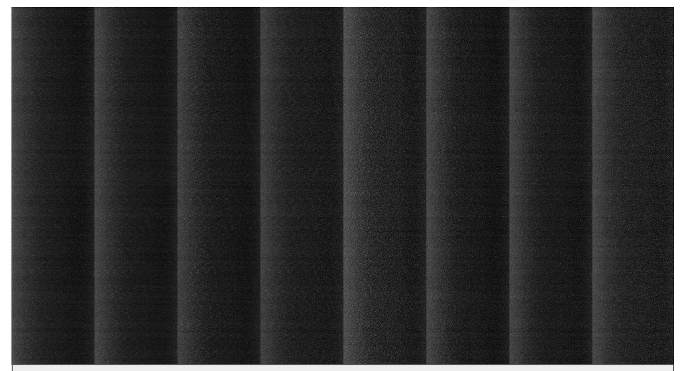
Purpose: Provide a comprehensive view into the spectral response of every filter, which is vital for pass/fail metrics, experimentation with new filters, and calibration of downlinked images.



Flatfields

Procedure: Take a series of images of an integrating sphere with the camera held at a specific temperature.

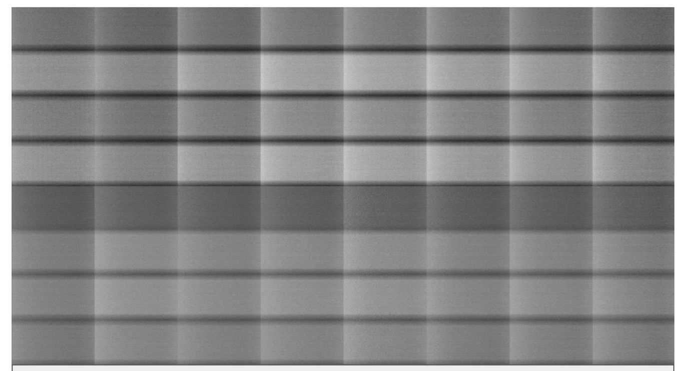
Purpose: Inspect the filters with great accuracy, characterize hot/cold pixels, detect any FOD in the optical system, and prepare initial calibration for processing of on-orbit images.



Temperature Ramp Darks

Procedure: Continuously capture dark frames as the detector naturally heats up.

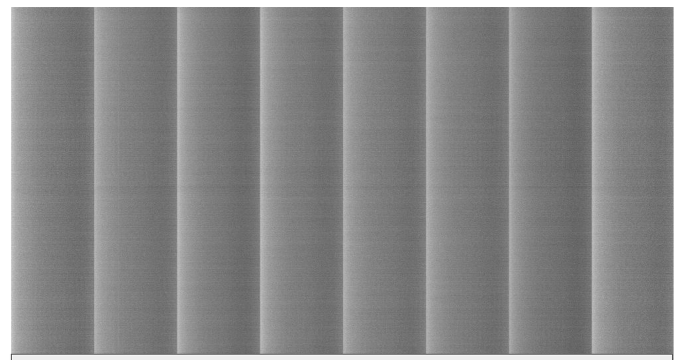
Purpose: Characterize dark current and other temperature-dependent noise at a variety of thermal states. This is important for calibration of downlinked images.



Range Sweep

Procedure: Take a series of images of the integrating sphere using a range of exposure times, at a controlled temperature.

Purpose: Characterize the SNR, well capacity, dynamic range, linearity, and other characterizations of the detector. The resulting photon transfer curve is used to precisely calibrate every downlinked image, delivering accurate results to our customers.

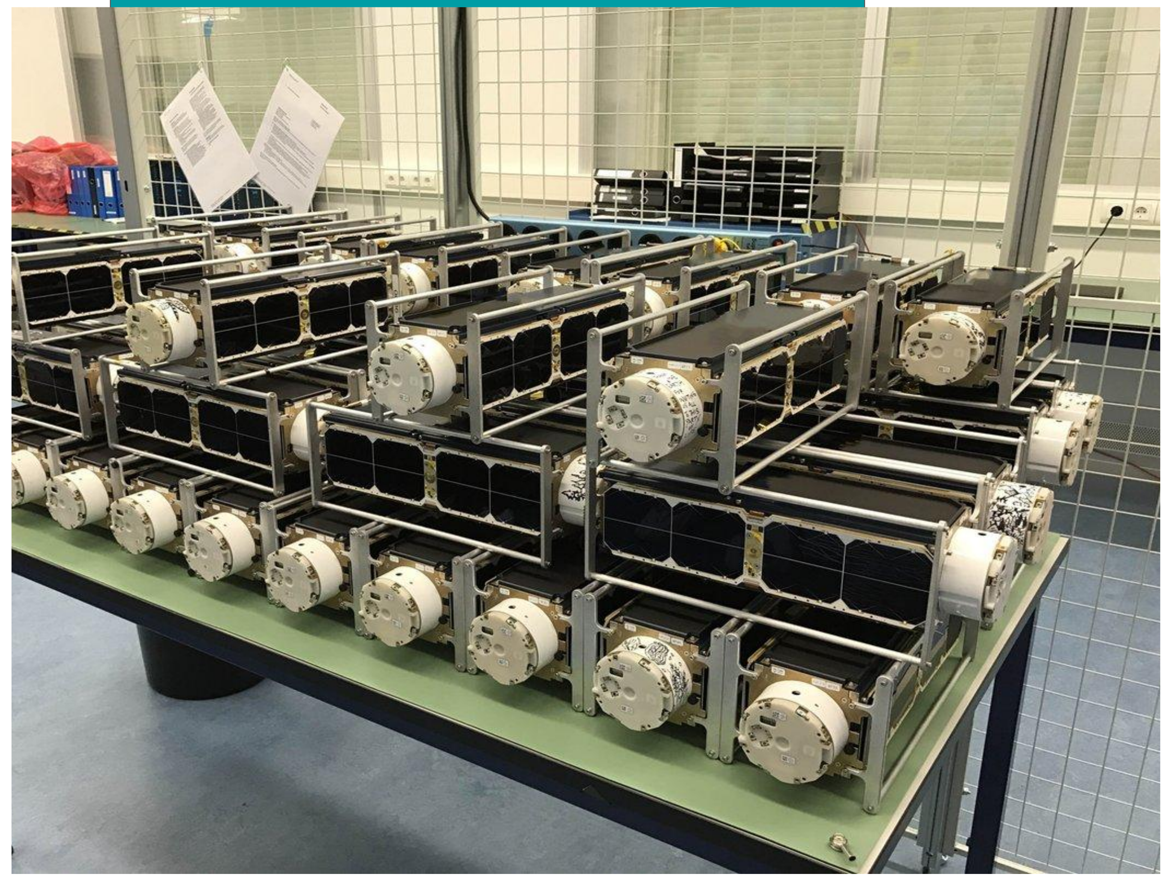


Camera Bias

Procedure: Capture dark frames at variety of shorter integration times and in various camera states, at a controlled temperature.

Purpose: Characterize the read noise inherent in every detector. This information is vital for calibrating every image that's downlinked from our orbital satellite constellation. In addition, these dark frames are used for calibrating the data gathered in the flatfield and range sweep tests.

Manufacturing at Scale!



Integration and Environmental Testing

After passing the optics testing suite, the telescope is integrated into the satellite. Every component and subsystem is tested using the same test automated framework that enables the optics tests.

Once all subsystems are fully tested and found to be within spec, the satellite proceeds to environment testing.

Vibe and Shock

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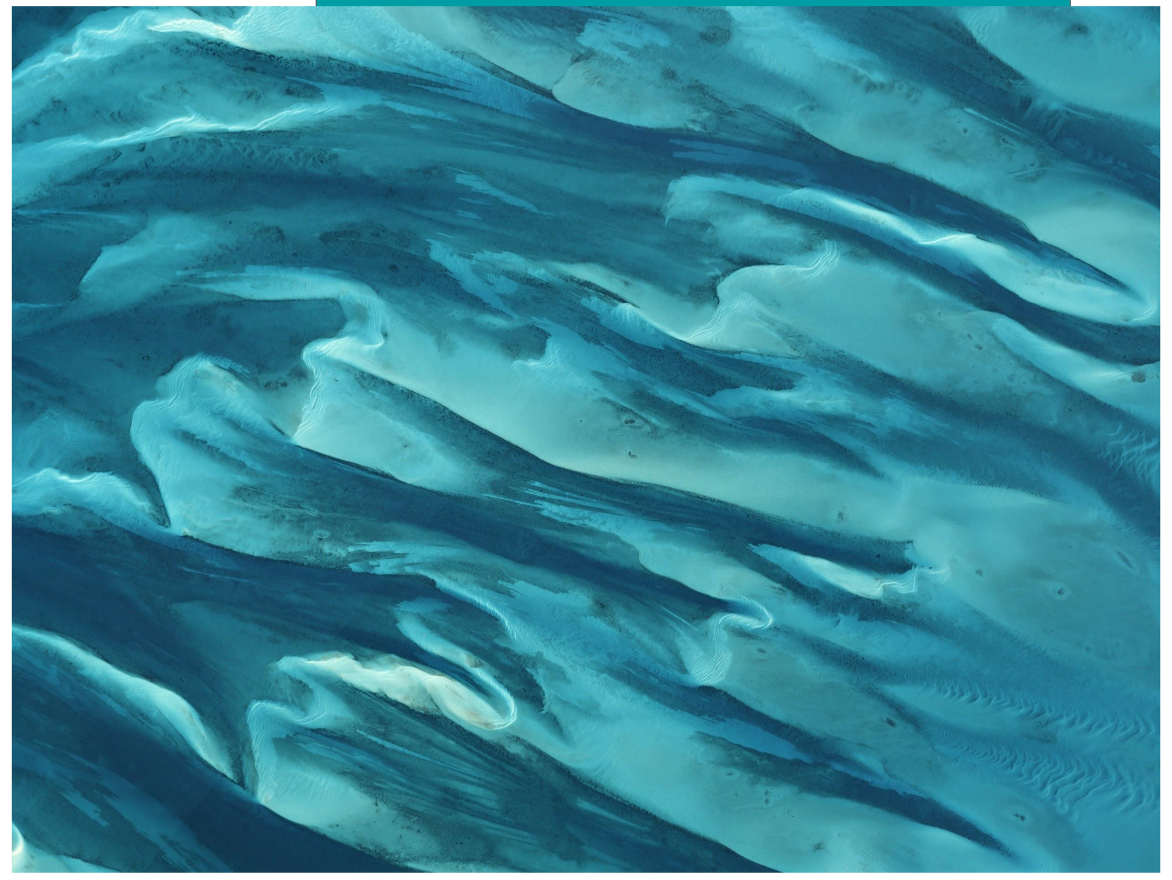
Thermal Vacuum Testing

The extreme temperature swings between full sunlight and eclipse can be punishing for electronics and optics. Similarly so, the vacuum environment of low earth orbit are very stressful for many materials.

Every dove that goes through the factory undergoes a lengthy thermal test, simulating the environment of low earth orbit, and ensuring that the camera and other subsystems work correctly in a variety of flight-like conditions.

In addition, a sample set of satellites for every design revision will go through a more comprehensive thermal vacuum test to ensure that all the materials and manufacturing techniques can handle a flight-like vacuum environment.

Lovely Images!



Final Optical Testing

After environmental testing is complete, every Dove undergoes a few final optics tests.

Through-Focus

The through-focus test is run again to ensure that all optical elements in the telescope are still exactly where they need to be after vibration and shock testing, and similarly that the flight-like environment of the thermal vacuum test didn't damage anything.

Abbreviated Flatfields

In order to make sure that the detector is still functioning correctly across the full field of view of the camera, that no filters have been shaken loose, and that no additional FOD was generated during the vibration, shock, or thermal vacuum testing, an abbreviated flatfield test is run.

This is essentially the same test as the full flatfields, but with fewer images, and looser thermal controls.

Packout!

When all final testing and configuration is complete, the satellites are packed up, and shipped to the launch site for their ride to orbit!