* What is the tolerance of the perovskite outline? For instance, unit 1775 seems to have one side that is 0.1 mm longer than the others.
  + I’ll check with our vendor today.
* What is the pressure rating of the glass used for the perovskites? We noticed that the metal cover started cracking the edges of the perovskites, so we moved to a different approach for a temporary connection.  Our payload will still be using the pressure fit, so a pressure rating would be useful for that design.
  + I’ll check with our vendor today. These samples were on ~1 mm thick soda lime glass.
* We have taken curves of all the perovskites sent to us and noticed that some pixels seem to be damaged, if you look at panel 1778, there are three pixels that are not producing much effective power.  Could you give us some more insight into what damage/age looks like in the JV curve?
  + I plotted the original 1778 JV curves (attached), where all pixels were working as expected. Without having the sample it’s tough to say why some are failing. Is there any obvious mechanical damage or scratching to the failing pixels? What environment were the samples stored in since you received them? These were all unencapsulated so we would typically store in a dark N2 environment.
* If I look at your output files, I see that the pixels are named A through F.  How do we identify which pixel corresponds to each designator?  I’ve included an image of our designators that correspond to the image of the JV curves.
  + I attached an image showing the pixel layout.
* I attached some images of curves, the Keithley\_comparison.png is from our testing at OU last year, where we got pretty good agreement with their Keithley setup minus a voltage reference issue.  There looks to be an artifact of a spike in current density at the short circuit condition.  Looking at the 1778 all pixels.png, you can see the same artifact.  Do you have any insight into what could be causing this?  In the resistor ladder, the short circuit condition (last step) goes from 50 Ohms to 1.4 Ohms (the internal resistance of our semiconductor switches), so is this some type of surge current?  Is there a recommended settling time?
  + I haven’t seen this JSC spike in our samples before. Hysteresis when scanning from JSC to VOC and then from VOC to JSC is very common, especially at rapid scan rates, but this usually affects the fill factor or voltage and not the current density at short circuit. Sweeping this over 10-15 seconds is usually long enough to minimize hysteresis.
* I’ll check with our vendor today. These samples were on ~1 mm thick soda lime glass.
  + Will the final perovskites be soda lime glass? I remember there being a preference for borosilicate glass.
    - Final perovskite will be on quartz, which will also be 1 mm thick. Soda lime glass turns brown from radiation damage.
* I plotted the original 1778 JV curves (attached), where all pixels were working as expected. Without having the sample it’s tough to say why some are failing. Is there any obvious mechanical damage or scratching to the failing pixels? What environment were the samples stored in since you received them? These were all unencapsulated so we would typically store in a dark N2 environment.
  + There doesn’t seem to be any obvious mechanical damage.  The units were stored in their original N2 environment in a dark cabinet until testing.  They are no longer in an N2 environment.  How long does it typically take for them to degrade?
    - Cells should be stable under N2/dark for at least a year. I sent you a batch that I had on hand from another experiment since it was quick, but we haven’t tested the stability of those cells. I’ll send you standard samples next week that will be more stable.
* I haven’t seen this JSC spike in our samples before. Hysteresis when scanning from JSC to VOC and then from VOC to JSC is very common, especially at rapid scan rates, but this usually affects the fill factor or voltage and not the current density at short circuit. Sweeping this over 10-15 seconds is usually long enough to minimize hysteresis.
  + We currently scan from Voc to Jsc, so maybe reversing the order may help with settle time at the higher current density?
    - Yes, you can try scanning Jsc to Voc instead. Typically we measure Voc to Jsc followed by Jsc to Voc. Are you able to capture a scan in each direction? Some cells degrade with an increase in hysteresis, where the scan in one direction may look nearly constant over time but the scan in the other direction shows a dramatic drop in efficiency, and the actual cell output is roughly averaged between the two scans.

1. Would six points on the curve be sufficient for the testing needed in LEO?  That would simplify our communication strategy, but we want your feedback.

6 points is sufficient. I plotted a typical IV curve below with all our data and 6 points. We would want 1 point near Jsc, 1 point near Voc, and the remaining 4 around the max power point at 0.12-0.04 V steps. Would these 6 points be static for all cells? E.g. if we send two cell architectures, one with a 150 mV higher Voc, the 6 points would need to be chosen per sample to account for the varying max power point.

1. Because we changed the perovskite contact method for the laboratory curve tracer, we think it would be more useful if we sent you our payload because the encapsulated units will need to fit in that piece.  Which address should we send the pieces to?

                Great, I’ll make sure our cells fit then return ship your payload. Here’s the address:

                National Renewable Energy Laboratory

                ATTN Kelly Schutt SERF C221

                15013 W Denver Parkway

                Golden, CO 80401

1. When the perovskites are not being used on the satellite’s payload, where in the curve should they be biased?

Ideally, the cells should be at the max power point when they’re not being actively tested. Holding at VOC accelerates degradation. Holding at Jsc might be helpful for stability, but we’ve never tested it and it isn’t realistic for operation.