**Subject:** Re: thermal analysis of CCR with strong contact of lower ring with the back faces, Tsat=30°C
**Date:** Friday, August 4, 2017 at 11:08:39 AM Eastern Daylight Time
**From:** David Arnold
**To:** Antonio Paolozzi
**CC:** Giuliano Battaglia, Ignazio Ciufolini
**Attachments:** Case12.doc, Case12.pdf

Dear Antonio,

Attached is an analysis of the performance. There is significant degradation. I do not recommend this design.

Unfortunately, the magnitude of the axial temperature gradient is not a good predictor of performance. The performance depends on the total temperature distribution. The ray tracing is the only reliable test of the effect on the phase front.

I have no way to predict the effect on the range correction of these thermal gradients which will change under different orbital conditions. I also have no way to model the effect of partial loss of total internal reflection on the range correction.

The floating mount is critical to the performance even with the smaller cubes. I would not recommend using the smaller cubes if it requires abandoning the floating mount. It solves the vibration problem at the expense of creating other problems that cannot be solved.

Is it possible with computer programmed manufacturing to provide custom mounts for the measured dimensions of each cube to deal the large +/- .25 mm tolerance on the position of the front face? That would be a much better solution than putting pressure on the cube. The positional uncertainty is within the 1 mm design goal. The largest problem with all retroreflector arrays is the uncertainty caused by the thermal gradients. The isothermal calculations do not predict the actual performance in orbit. Lab testing of all possible orbital conditions is not practical. The small cubes offer the possibility of virtually eliminating the uncertainty due to thermal gradients. But this is conditional on using a floating mount.

Can you send me the simulation with no contact also? Do you know the total conductance per cube in watts/deg?

Best,

David Arnold

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**From:** Antonio Paolozzi <antonio.paolozzi@uniroma1.it>
**Date:** Friday, August 4, 2017 at 9:17 AM
**To:** David Arnold <david-arnold2006@earthlink.net>
**Cc:** Giuliano Battaglia <b.giuliano.3@gmail.com>, Ignazio Ciufolini <ignazio.ciufolini@gmail.com>
**Subject:** thermal analysis of CCR with strong contact of lower ring with the back faces, Tsat=30°C

Dear Dave,
Battaglia, that reads in cc, has performed some thermal analysis, the most interesting of which is the number 12. We assumed a satellite temperature of 30°C which may be possible with the new alloy. The thermal contact conductance is assumed very high from lower ring and back faces of thee CCR as well as from lower ring and the cylindrical part of the CCR. This will be an interesting case. The axial gradient does not change much eliminating the contact (-0.93 with high contact -0.73 with no contact).
If from your analysis the thermal behaviour is acceptable that will allow us to use the spring at the bottom the CCR. We will check also about the TIR issue but I do not expect large influence since only a very small portion of the back

faces are touched.
The problem of the COTS CCRs is that the front face position is defined with a very large tolerance +/-0.25 mm. That means, to be sure to avoid concact of back faces with lower ring slanted surfaces, we need a gap of at least 0.5 mm. This could become 0.25 if we purchase twice as much CCR, but still we have a large gap to which we have to add at least another 0.2 mm for mechanical tolerance and a small thermal deformation. Such an half a millimiter gap will affect accuracy in ranging. What do you think?
Anyway if we can use a spring, the front face will be in contact with the teeth of the upper ring and no gap will be present, so higher accuracy can be expected.
Antonio