Subject: Re: Choice of material for LARES-2
Date: Saturday, August 18, 2018 at 3:46:35 PM Eastern Daylight Time
From: David Arnold
To: Antonio Paolozzi
CC: Ignazio Ciufolini

Dear Antonio,

I have submitted an abstract for a paper on the design of Lares-2 for the International Laser Workshop in Australia, in November, 2018. Which array configuration and which thermal analysis represents the latest design? Can you give me the date of the email and file names of the reports on the array configuration and thermal analyses of the cube corner?

Best,

David Arnold

From: Antonio Paolozzi <antonio.paolozzi@uniroma1.it>
Date: Monday, August 6, 2018 at 6:43 PM
To: David Arnold <david-arnold2006@earthlink.net>
Cc: Ignazio Ciufolini <ignazio.ciufolini@gmail.com>
Subject: Re: Choice of material for LARES-2

Dear Dave, indeed to have an upper bound of the temperature from our tests is simple. In fact if we neglect the cooling effect of the CCR (they have very high emissivity (0.82) and low absorptivity (0.15) and the cooling effect of the eclipses as well as the heating effect of earth infrared, the determination of satellite temperature is straight forward. For instance a brick of Nickel alloy treated with sandpaper number 60 (very rough) reached a temp of 90°C but a sphere of the same material and surface treatment would reach a temperature of 63.7°C. This can be obtained with the simple formula T_sat=G T_specimen
where G=(1/4*A_tot/A_crosssection)^(1/4).
With this Ni alloy and that surface treatment we would have a temperature of 63.7°C if the satellite would not have CCRs, no eclipses and no earth infrared. For the satellite with CCRs I would say that the temperature is somwhere between 50 and 60°C. So from your calculation performed with 70°C and 29% emissivity I remember no significant loss of performance on the CCR was found. So I am pretty confident that with this alloy and surface treatment we are pretty safe. Of course a more accurate calculation is welcome and we can do once a more accurate thermal model is available.
Antonio

2018-08-06 21:28 GMT+02:00 David Arnold <david-arnold2006@earthlink.net>:

> Dear Antonio,
>
> The satellite temperature cannot be assumed. It has to be calculated. I have not seen any calculations of the satellite temperature.
>
> The calculation of the satellite temperature is difficult because there are no models for how much radiation is reflected from the cube corners and how much is transmitted through the cube corners into the cavity. There are no models for what happens to the radiation that is transmitted into the cavity. It will be partly

absorbed and partly reflected back out of the cube corner.

I think it would be difficult to do a thermal vacuum test to determine the satellite temperature because of the size and weight of the satellite.

How is the satellite temperature determined? The temperature is needed to do the thermal-optical simulations.

Best,

David Arnold

From: Antonio Paolozzi <antonio.paolozzi@uniroma1.it>
Date: Monday, August 6, 2018 at 2:06 PM
To: David Arnold <david-arnold2006@earthlink.net>
Cc: Ignazio Ciufolini <ignazio.ciufolini@gmail.com>
Subject: Re: Choice of material for LARES-2

Dear Dave,
as a baseline nickel alloy was chosen, so if procuring and manufacturing will not give surprises that is the alloy for LARES 2. However we keep still as an option the copper alloy. We do not have any further info from ASI because now is vacation time. We do not know how procuring is going, Anyway from our thermal tests we found that Nichel alloy guarantee a slightly lower temperature and a higher stability wrt to surface treatment. In other words a variation on surface roughness produces higher temperture variation on copper alloy rather than nichel alloy. Furthermore nickel alloy fulfill all the mechanical requirements. The disadvantage is the low thermal conductivity of nichel alloy, but we already discussed with you this issue which does not seem to affect sensibly ranging accuracy, although it will produce a higher thermal trust whose effects, likely can be modeled with sufficient accuracy. From the simulations that you have already performed I do not think we should have problems, I remember a case with satellite at 70°C with 29% emissivity which was ok, while the same at 120 or at 140 (I do not recall exactly) was bed. To our best knowledge we are close to the first case.
Antonio

2018-08-06 18:18 GMT+02:00 David Arnold <david-arnold2006@earthlink.net>:

> Dear Antonio,
>
> In your email below dated June 15, 2018 you say that the material for LARES-2 will be chosen shortly. This changes all the thermal calculations. The thermal simulations will need to be redone. The results of the thermal simulations will be used to recalculate the optical performance. The design of the cavity may need to be changed depending on the results of the optical simulations. The emissivity of the cavity must be kept as low as possible to minimize thermal effects.
>
> Has any decision been made on the material?
>
> Best,
>
> David Arnold
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> ---
>
> **From:** Antonio Paolozzi <antonio.paolozzi@uniroma1.it>

Date: Friday, June 15, 2018 at 11:45 AM
To: David Arnold <david-arnold2006@earthlink.net>
Cc: Ignazio Ciufolini <ignazio.ciufolini@gmail.com>
Subject: Re: Abstract deadline for Australia

Dear David,
is the workshop of ILRS?
I think the material will be chosen shortly. However I would like not to disclose yet the CCR distribution or satellite drawings. The optical part no problem, we or you can say as we did in the paper for Jog that the CCR distribution is random.
Antonio

2018-06-15 13:43 GMT+02:00 David Arnold <david-arnold2006@earthlink.net>:

> Dear Antonio,
>
> The abstract deadline for the workshop in Australia is June 20, 2018. My intention was to give a paper on the design and transfer function of the LARES-2 satellite. However, once the material has been chosen the thermal calculations will have to be recomputed. The thermal calculations are critical to estimating the accuracy of the range correction.
>
> Do you think the design will be completed in time to give a paper at the workshop? The dates are November 4 – 9, 2018.
>
> Best,
>
> David Arnold