Draft October 19, 2010

Suggested protocol for establishing the stability and repeatability of the Resonon instruments.

For sake of discussion I would like to divide up the characterization of the instruments into two categories, 1) performance, and 2) stability/repeatability. The performance issues can be taken to be those measurements that ascertain how the instrument meets its specifications and design goals. Mark has outlined a series of tests to determine the main features of the instrument performance and they are presented in two documents on the web page describing the Resonon data. http://data.moby.mlml.calstate.edu/moby2_testing/sudirlsit.html.

The outline of the tasks are Word documents under the following headings on the webpage;

Mark Task with Carol comments

Stray Tasks

Studies according to Mark's instructions have only been taken on the blue instrument and in these measurements the second part (Stray Tasks) has faults that require its redoing. Hence one task is to complete the performance tests that Mark has outlined in these documents.

The second part of the effort to characterize the instrument is to ascertain the short and long term stability of the instruments as determined by monitoring of a known source of known stability, for example the NPR, NPRjr or an appropriate Optronics source. The source used must have a monitor system for stability and a known history of repeatability and performance. The Resonon instrument's temperature must be monitored and logged during the testing as well as monitoring the environmental temperature. It is my understanding that there are internal thermistors incorporated in the instruments and hopefully they can be utilized for the stability characterization. Once the basic repeatability and stability issues are understood, a separate study of temperature coefficients should be undertaken.

Experimental setup;

The Resonon instruments should be outfitted with fiber inputs in the manner in which it will be used. It is likely that the setup used in performing Mark's performance tests could be utilized for the stability measurements. It would be good to have all the inputs be illuminated by the test sphere and whose input ends are secured in some sort of holder. I will leave it to the experts to devise some sort of input arrangement that will allow us to arrange the inputs in a repeatable manner. Appropriate shutters and shielding to eliminate scattered radiation from entering the input region will have to be devised. The MLML and NIST staff have the appropriate experience in this sort of measurement arrangement and I defer to them to work out the details of the illumination structure.

Once the experimental arrangement is devised and tested for mechanical stability, the optical and electronic testing can commence. The instrument should be turned on an allowed to warm up and equilibrate prior to testing. This will mean that a time sufficient for the CCD temperature controller to achieve its design setting should be met and all electronics allowed to arrive at their ambient operating temperatures. The temperature should be monitored if possible on the instrument to see if constancy is reached.

Testing;

The taking of the data should be a sequence of measurements of light off and light on. If we see any problems with background drift, we may want to take a second measurement of light off so we have as a data set, off-on-off. If the measurement is done 2 or 3 times in fairly close in time then the sequence would be off-on-off-on----.

The instruments have three gain settings and if possible all three gains should be checked in each set of measurements. This could mean the accumulation time could be different for the three gains in order that we do not overflow the registers. It will be necessary to do some testing of the instrument and the light source to find the optimal operational parameters.   Once the operating parameters are elucidated, recorded measurements could begin. It would be desirable to do some preliminary measurements on determining if we are using an appropriate warm up time. For example, if we start out using 10 minute warm up time, after a measurement we should turn the instrument off and let it return to ambient conditions and then use warm up times of 15 minutes and perhaps 20 minutes to ensure there are now significant differences. It might be wise to spend a day at the start determining what the minimal appropriate warm up time is so this value can be built into future use. Temperatures should be monitored and recorded for this work.

I suggest a regiment of measurements beginning on day 1 that measures the source in all the channels 2 or 3 times and are recorded in the data files. I would leave the equipment on and wait about 15 minutes and repeat the measurements, keeping track of the sphere output monitor. Repeat the measurements again and record. I suggest doing this for an hour or so to get an idea of the short term stability of the system response and the repeatability of the measurements. The data should be examined for any major drift or inconsistency. For example, if three repeat measurements are done each time, we could print out a graph of the rms differences, pixel by pixel. The same could be done for the time-separated measurements.

I suggest repeating the same measurement scenario in two to three days and look for any significant differences and then do again in about 3 days. This gives us measurements over a period of a week and also a number of sets of measurements that are closely spaced. If there are no significant rms deviations, I suggest waiting a week and repeating the measurements. One must make sure that the instrument has reached thermal equilibrium and all the appropriate temperatures are stabilized and monitored.

If the measurements seem stable and consistent after the weeks wait, we could conclude that the instruments have some stability over the two week period and we should have some idea of the rms fluctuations. If things seem reasonable, I would repeat the measurements in a week and look at the results and compare to the previous measurements. If the results are within our expectations then I would suggest we try to characterize environmental temperature effects using an environmental chamber if available. This probably only needs to be done for 5 or so degrees above and below average room temperature but the MLML team should decide on what would be most useful for their operational needs. If temperature coefficients were non-zero and determined, then we could retroactively correct our stability data to remove any such effects.

In outline form I suggest the following plan;

Day 1; Measure 2 or 3 times every 15 minutes for an hour or so, or at least 4 sets of measurements on all the gain settings.

Day 3; Repeat measurements and check for deviation from previous measurements

Day 6 or 7; Repeat and compare

Day 14; Repeat and compare

Day 21; Repeat and compare

Day 22 and forward; Perform temperature coefficient studies.

If we can design the software appropriately or if we can ship the data in real time to Stephanie for analysis, we can make decisions as we go along as to how to possibly adjust our strategy. For example if we some large deviations from time to time, we should stop and try to see what the causative factors are. If things work smoothly, we may be able to abbreviate the process and move on to other tasks in the characterization process.

After the temperature coefficient studies, it would be useful to repeat a sequence of stability measurements to ensure the instrument has not been affected by the temperature excursions.

Conclusions and explanation

I feel that if we have data of this sort over a period of 3 or 4 weeks and along with temperature coefficient data, that we would have enough information to move forward with use of the instrument and for a publication. In fact one could probably argue that the suggested regiment is a bit overdone.

In any event, the basic idea is to get measurements on all the channels over a 3 or 4 week period and look at the deviations when normalized for any sphere output drift. It might be good to have another radiometer measure the sphere at the start and at the end in order to get a sphere stability check.

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I hope that the NIST and MLML teams can fill in the details of the operation of the instruments and exactly how to perform the measurements. The experimental details are not something I am qualified to specify in detail.

We should keep in mind also that the low levels (background and low signal) may in fact move about as the error in comparing small numbers is proportionally larger than the regions of significant signal.

I feel strongly that an effort to keep up with a rudimentary data analysis while the process in ongoing is essential in order to understand the instrument. I feel it is not best practice to have someone take all this data and only then look at it. The analysis is potentially simple and hopefully can be done in real time. If three measurements are made for each gain setting at a particular time, the computer could easily calculate the average on a pixel by pixel basis and plot the deviations on the computer for the operator to see. If things look amiss, remediation could immediately be started rather than uncovering problems only later when looking at the data. A simple approach would be to use the first day's numbers as the starting point set and then plot the ensuing data normalized to it and the sphere monitor. One would then have a line about unity across the spectra and departures thereof would indicate drift and it would be easy for the operator and MLML staff to see problems immediately.

In any event, some thought should be placed into how the information will be displayed during data taking in order to best utilized the time and get meaningful results. I suggest that the data and programming experts, Bob and Stephanie work out something useful in this regard.