Dear Sun,

The Odin Chronicles

S.A. Torchinsky
Forward

The Odin satellite was a Swedish initiative with participation by Canada, France, and Finland. There were two distinct science objectives for Odin: Astronomy and Aeronomy.

For astronomy, Odin was designed to measure emission from water molecules, as well as molecular oxygen. The versatile receiver system also permitted spectroscopic measurements of various other molecules. These molecular species are of special interest to studies of the interstellar medium and star formation, as well as solar system studies, in particular, the study of comets.

Many of the same molecules are of interest in Aeronomy, and Odin performed limb-sounding of the Earth’s upper atmosphere for a number of molecular species, but most importantly ozone and molecular oxygen. Every fourth day, Odin made detailed measurements of the Earth’s upper atmosphere, before returning to astronomical studies.

From 1995 through 1999, I was a member of the team in Sweden developing the radiometer for Odin, and from 2000 I was based in Calgary. My work on the Odin radiometer development was part of the Canadian contribution to the project, and I was funded by the Canadian Space Agency through a contract to the University of Calgary. Each month, I provided a report to my supervisor in Canada, Sun Kwok, Principal Investigator for Odin Astronomy in Canada, and Professor of Astronomy at the University of Calgary. The reports almost always began the same way:

Dear Sun,

“The Odin Chronicles”

best regards,
Steve

S.A. Torchinsky
January 2008
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Part I

Pre-flight Development
Report for March, 1995

Dear Sun,

Here’s a report of the Odin work here at Chalmers. I’d like to outline not only the technical aspects, but also the administration of the project. A copy of my monthly reports will go to Roy Booth at his request.

You may already know that there have recently been personnel changes here. In particular, the departure of a few people over the past year has had a serious impact on the Odin work being done at Chalmers. Two of the people who have left were only occasionally associated with Odin, offering their expertise for design considerations. More importantly, last November, the head of the group left Chalmers for personal reasons. The Odin group at Chalmers is now composed of four people, including myself. The head of the group is Magne Hagstrom, who is also head of Electronics at Onsala. The others are a microwave circuits/components expert named Anders Beillon, and a mechanical technician with experience in optics named Christy Confrey. On a private contract, we also have a machinist who is expert in the use of computer aided machining. He is making the mirrors for Odin.

Urban Frisk at the SSC is the head of the entire Odin technology effort. There are meetings approximately every two months with all the Odin collaborators, including the Finnish and the French. To date, there has never been a Canadian representative at these meetings. The last meeting was in February, and I’m told the next should be at the beginning of May. You might like to keep this in mind when you schedule the Canadian Odin Astronomy Working Group meeting. It’s likely there will be an Odin Technology meeting in September. I wouldn’t want this to conflict with the COAWG meeting. If the COAWG meeting is just after the Odin Technology meeting, I can give an up-to-date report on the entire Odin project.

The radiometer work is divided into three stages: the Prototype, the Engineering Model (EM), and the Flight Model (FM). The design for the prototype is somewhat different than for the EM and the FM. The mirrors have different focal lengths, and
the optical path is arranged differently. The EM and FM are meant to be identical, and there is some talk of doing away with the EM stage, and simply going straight into FM. My feeling is that we do need the EM for testing in the lab, since it is closer to the receiver which will fly. I would like to spend less time on the prototype instead.

Some of the components for the Flight Model have already been delivered, (mixers and Gunns) but they have not been tested yet. Before work on the flight model is begun, the lab must be converted into a clean area. I’m not sure when this will take place, but I know there has already been a bit of discussion on how to do it.

We are presently testing the prototype in the lab and should have some system noise temperatures to report before long. Although Erik Ordell, the former head of the group, has left Chalmers, he remains on contract to the Swedish Space Corporation as a private consultant, and he is responsible for the optics design. Erik was here the other day, and I had a chance to discuss the quasi-optics with him. While looking through the design of the prototype optics, I noticed a problem with the separation of the mirrors. The distances accounted for in the design were different than the actual, and most significantly, there was an extra 10cm between two mirrors unaccounted for in the design. Erik agreed there was a problem and has since redesigned the optical path. I will be checking the optics of the flight model in the same way.

For data reduction software, the SSC has decided that we will be using a commercial package called IDL. I am now responsible for acquiring and installing this software for our group. I’m not sure how much pre-processing of data will happen before it goes to the astronomers, but I think if you are using the same software to analyse your data, it will avoid some communication problems which might otherwise come up. I have already installed a demonstration version of IDL, and it seems very powerful, and user-friendly. If you like, I can send you the instructions to install it on your computer.

I hope this report is helpful. I’ll be happy to provide more details on anything in particular if there is something you want to know more about.

best regards,
Steve
Dear Sun,

During the past few weeks I have been concentrating on looking at the optics design for the flight model radiometer. As of today, Erik Ordell is supposed to submit a paper describing the final design. Since I began working in this area for Odin, I have been finding small errors in the design. A couple of weeks ago I noticed that the beam was being partially truncated at the first mirror from the mixer. In addition, the beam was instead impinging on the next mirror, which was very close to the first, and I can’t say what effect this would have. My feeling was that it was a bad situation. I brought this to the attention of our group, and finally last Friday, Erik was here to discuss the situation. It turns out that he had knowingly truncated the beam at the first mirror, but hadn’t taken into account the possibility of setting up multiple reflections, and possibly a standing wave, due to radiation hitting the wrong mirror. He agreed to look into changing the design, but since he is required to submit his report today, I wonder if he can have had enough time to analyse the situation properly. I hope that his document will not be considered as the final word, and I will have a chance to alter the design.

I am working on an alternative optics design. One of the main difficulties is the cramped area in which everything must fit. I am working with a 3-d drawing of the radiometer platform, and this helps me make sure that the components can fit into the space available. In doing this, I have turned up some possibility of problems with the proximity of the 119GHz receiver. The amplifiers for the 560GHz and the 119GHz seem to occupy the same space. This problem can be easily remedied, but I think it shows that we must be careful with accounting for space.

The lab work is being carried out by Magne Hagstrom, and so far he hasn’t had a chance to measure a noise temperature from the prototype model. There is some question about the quality of the mirrors, and Magne has been concentrating on aligning the optics, and checking the mirror shapes, and also measuring the beam pattern from the mixers. I believe he will be measuring the system noise temperature next week.
I am concerned by the fact that we are still in the initial testing phase of the prototype model, and yet the design for the flight model is supposed to be tied down this week. I think this is another reason to allow for flexibility in the radiometer design.

I think a general meeting must be coming up soon, after which I will be able to provide details on the work being done outside Chalmers.

best regards,

Steve
Report for May, 1995

Date: Thu, 1 Jun 95 17:42:56 METDST
From: Steve Torchinsky
To: Sun Kwok
Cc: Roy Booth
Subject: monthly Odin report

Dear Sun,

My main activity during the past month has been with the Quasi-Optics design. As I mentioned last time, there has been a great emphasis on freezing the design but I felt there were some major problems with beam truncation.

On 8 May I attended a meeting at the SSC in Stockholm to discuss the optics. There were representatives from all the partner countries at this meeting. Erik Ordell presented his design, which was unchanged even though I had previously pointed out the problems. He argued that only part of the beam was truncated at 24dB and it wouldn’t be too bad. I disagreed since it meant that the mixer could partly see the amplifiers, which is relatively a hot load, and the solution of placing absorber everywhere in the cold box was likely to be very problematic. Nevertheless, Urban Frisk was willing to adopt this design. Fortunately, I was prepared with an alternative, which after some discussion, became the adopted proposal. During the next week, Erik Ordell worked through my design to verify that it was feasible, and to calculate its efficiency. At the same time, I also produced an analysis which I sent to Urban Frisk. The new design has the advantage of using one less mirror, and Erik Ordell’s calculations show that it also has improved spherical aberrations. This is now the optics design for Odin, and it has been incorporated into Erik Ordell’s final report.

Of the other things discussed at the meeting, I believe the main worry is the correlator. They continue to have problems manufacturing satisfactory chips, and the delivery date is now quoted as “after August”. Other elements, such as the AOS, Cooler, 119GHz receiver, all appear to be on track.

The astronomers at Onsala held a workshop on 3 May where they had a general discussion on astronomy with Odin. I attended this meeting. The meeting was mostly an overview presented by Ake Hjalmarson and was really a lead-up to the workshop which took place the following week. On 9-10 May, the astronomers gathered again,
this time with all those in Sweden and Finland interested in using Odin for studies in the Interstellar Medium. Although there were some science presentations, the meeting served mostly as a means of organizing people and assigning tasks (such as compiling source lists, and integration times, and other details for observing proposals). I believe much of this will be presented at the upcoming meeting in Finland to which I think you will be going.

As for my health insurance, I’m sorry to say that this has yet to be sorted out. Apparently, there is one person in Chalmers responsible for this area, and she has been away sick for quite some time. This seems to have crippled the system. I am still waiting to receive the forms to fill out to apply for private insurance. I was hoping that I could rely on the Chalmers administration to help me with this and other matters, but I think I may have to sort things out on my own.

regards,
Steve
Report for June, 1995

Date: Thu, 29 Jun 95 15:32:18 METDST
From: Steve Torchinsky
To: Sun Kwok
Cc: Roy Booth
Subject: Monthly Odin Report

Work on the prototype radiometer continued this month. The Double Side Band noise temperature at 557.5GHz was measured to be 4110K. This can be compared to the figure 2990K which was measured by Zimmermann before they delivered the Schottky mixers. Our losses are most probably in the diplexer grids and mirrors. Removing the grids and mirrors for the single side band operation, shows an improved DSB noise temperature of 3363K, which is closer to Zimmermann’s figure.

There had been a problem with the Numerically Controlled machining of the off-axis elliptoid mirrors. The mirrors were being fabricated with the wrong shape. Once this was detected, and the program corrected, new mirrors began to be fabricated. Now, almost all the mirrors in the prototype radiometer have been replaced, except for two. Those two may be partly responsible for the degraded system noise temperature. Although, they are nearly flat mirrors, which means the error in shape would not be too pronounced, so we didn’t think they could make a large contribution to losses. Eventually, these mirrors will also be replaced.

Another problem continues to be the softness of the Schottky diode I-V curve. Over the winter, there had been several instances of the mixer diode going open circuit. Precautions have been taken to prevent electrical spikes reaching the diode, and we haven’t lost a mixer for some time now. Nevertheless, the diode does seem to degrade with time. A new electrical filter has been installed right at the mixer SMA to avoid spikes coming through the bias cable. Also, the mixer is now always stored in dry conditions (a chamber flushed with dry nitrogen gas).

This past weekend, we were expecting the delivery of the AOS by a team of seven French scientists and technicians. Unfortunately, the brague cell broke just days before they were to deliver the AOS. I attach a portion of a report from the AOS meeting of 24 June:

> The EMC test started 19 june, ended 22 june.
>
> On 20 june 12.00 hours, the brague cell broke during start-up for unknown reasons. It worked at several occasions after vibration tests. A short-circuit
> in the electronic drive circuit is suspected. The AOS was after test brought
> back to Marseille for repair. The failure meant that the EEM could not fully
> be tested for conducted and radiated susceptibility.

we are now expecting delivery of the AOS on the 4th of September.

I continue to work on the packaging of the radiometer. We have nearly solved all
the problems of space constraint. I am in regular contact with H.G. Floren, and
Goran Olofsson in Stockholm who are in charge of the cold box design. Together
with my 3-dimensional drawing of Odin, we are reaching a final design for the cold
box innards.
Dear Sun,

During the first week of July there was a great rush to finalize the design for the cold box and diplexer platform. The deadline imposed at that time was somewhat artificial as it has to do with the fact that just about everyone in Sweden takes holidays during most of the month of July. It was desired to get drawings in to those subcontractors who would not be on holiday at that time and who would be machining components.

Although the people at Stockholm Observatory are responsible for the design of the cold box, our group at Chalmers is intimately involved with this work. This situation arose out of the Quasi-Optics analysis I did which required an accurate 3-dimensional drawing of the Odin radiometer platform. I am in contact with the various labs providing components, and so have here what has become the reference for the radiometer packaging. As a result, I provide the information required to design the cold-box and diplexer platforms. This is mainly the positions of components, and the volumes that are free to use for support structures. The rush before the holiday season meant that I was providing a lot of drawings with the detailed information to the people who required it.

During the quiet time of the last few weeks, I have been improving my Quasi-Optics model in order to calculate the minimum required mirror sizes. There is a desire to reduce the overall mass of Odin, and my program can now show exactly where we can shave off not-needed material on the mirrors. I have also been preparing for my presentation in Waterloo, and I will be able to demonstrate my Quasi-Optics work more clearly at that time.

There has been no work in the lab this month on the prototype receiver, but with people returning this week, we will begin again soon. I hope that work on the clean room will also begin this month, though I’m not sure about that. There is lab space set aside for the clean room, and we are waiting for the installation of
the ventilation system and some partition structure (pressed cardboard walls with aluminum supports).

best regards,
Steve
Report for August, 1995

Date: Mon, 4 Sep 95 14:36:32 METDST
From: Steve Torchinsky
To: Sun Kwok
Cc: Roy Booth
Subject: Odin monthly report for August

Dear Sun,

Lab testing of the prototype receiver continued in August. We are now set up to measure the noise temperature across the IF band. The DSB noise temperature at 574GHz is 3500K, and SSB is 6000K, but this result is with the A1 mixer whose range does not include a frequency as high as 574GHz. We are using the LO B1 to pump the mixer A1. When we use the correct LO the noise figure should go down closer to 2000K DSB.

One of the problems from early on has been the failure of the mixers. A couple of these occasions were due to electronic spikes in the bias system, but now that the bias is isolated, and battery operated, this is no longer a problem. However, the IV characteristic of the mixers continues to degrade for some reason, and we are now working with a “soft” diode. Mixer B1 is back at Zimmerman for re-contacting the Schottky diode, while we continue with tests on mixer A1. When mixer B1 returns, we will send A1 back for recontacting. Meanwhile, our LO A1 has been at Omnisys where they were using it to characterize the PLL/Bias circuit.

On Friday, we went to collect the PLL unit from Omnisys. There were some problems with the unit drifting out of lock, and the lock being somewhat noisy. I’m told this has to do with the fact that the LO is more noisy than expected. Nevertheless, we have taken the PLL back to Chalmers, and will continue tests with it here. One of the obvious sources of noise was the poor cabling. New cabling is being made here, and this week or next, we hope to have a phase locked receiver, using the A1 mixer with its proper LO source.

As I mentioned in my last report, at the end of June there was a rush to specify the component positions in the cold box. This was because work on the cold box was meant to be done over the summer. In fact, no work on the cold box was done. Much of this mix up has to do with the number of labs involved in the project. Most of the satellite’s structure is being manufactured by a private contractor in
Stockholm named Lars Stenmark. While the Stockholm Observatory is responsible for the design of the cold box, Stenmark is the one manufacturing the components. It was the Stockholm Observatory that was pressing us for the cold box details, but Stenmark was actually working on the telescope support structure at the time. As a result of this, we at Chalmers, felt it would be a good idea to have a meeting of all people involved in mechanical components, in order to organize the work more efficiently. Anders Beillon here at Chalmers mentioned this to Gunnar Florin at SSC. Also, I sent an email to Urban Frisk on 21 August asking him about the possibility of calling such a meeting, but have not received a reply.

In my note to Urban, I also asked about having a Progress Meeting. I understood these were to take place every two months, but in fact there has only been one since I’ve been here, which was the one in May when we froze the optics design. Since the AOS team will be here soon, I thought it would be a good opportunity to call a meeting. Also, I was hoping there would be progress meeting before I give my report at the COAWG.

Unfortunately, the arrival of the AOS has been postponed again. We are now expecting the french scientists on the 18th of September. This is very bad timing for me because I will already be in Canada. If there is also a progress meeting at that time, then I will miss it. I hope this will not be the case since I understand that one of my main roles is to represent Canada and report back on the proceedings of these Progress Meetings. I sent another note to Urban Frisk on 31 August asking him to confirm whether or not there would be a progress meeting, but so far I have not had a reply.

regards,
Steve
Report for September/October, 1995

Date: Mon, 30 Oct 95 15:37:47 MET
From: Steve Torchinsky
To: Sun Kwok
Cc: Roy Booth
Subject: Odin report for September/October

Dear Sun,

I didn’t write you a monthly report for September, so I’ll fill in the details you don’t already know about from the report I gave at the COAWG on September 25th. Up until the Correlator Design Review meeting on the 11th September, I was working mainly on the specifications for the cold box components, and also on the final mirror designs for the workshop. The plates and brackets for the cold box and diplexer platforms were not yet finalized. Originally, the Odin submm receivers were meant to be on a platform split which would theoretically allow us to remove an entire channel (either the A or the B) while leaving the other channel in place. In fact, the design didn’t quite allow this, and finally we decided to go with a single plate with all components bolted in from the A-side. The result is that we’ve had to redesign, and redraw a lot of brackets and plates, showing where the mounting holes will be, but I think this design is simpler and less likely to cause problems from the complications involved in fitting things together.

As you know, I attended a number of meetings in September: the Correlator Design Review, the COAWG, and two of the Odin science meetings. Aside from these, while in Ottawa I also met with a former colleague, Luc Martin, who is now at the Bureau of Standards of the NRC. We discussed machining techniques and he was able to confirm that our method for making the mirrors is a sound one. We also discussed some work he is involved with to make an astigmatic mirror for use in an array receiver. I was able to help out with the CAM programming.

On the Thursday of that week in Ottawa, I went along with Urban Frisk and Lennart Nordh to visit Routes Inc where the optical/IR spectrometer is being built. After this, we visited Interoptics Inc where the optical components for Osiris are being manufactured.

While I was in Canada, the main activity at Chalmers was the delivery of the AOS, which was reported at the Odin Science meeting. When I returned to Chalmers on
October 2nd, I found that I had been made responsible for running the AOS. This decision was motivated partly by the fact that the AOS documentation is in French, but I’m a logical choice also because I am on the Data Reduction working group and will be working with Michael Olberg to produce the Level 0 to Level 1 reduction package for astronomy. There was a meeting of the Data Reduction Working group on 19 October (I sent you some notes about it on 20 October).

Last week a number of people from SSC were here to show us how to run the telemetry system, and the AOS. This is a set-up of five PC computers which control the systems on the satellite (tuning, bias, AOS, etc) and receive the data, and convert it to sensible output. We can receive the spectrum from the AOS, and plot it, using IDL, on one of the computers. So far we have only looked at the comb of the AOS, and also some noise output from one of the IF amplifiers.

Difficulties continue with the components contracted to Omnisys Co. Both the correlator, and the PLL/Bias unit are unsatisfactory. I sent you a note on 24 October summarizing the present status of the correlator. The PLL unit was delivered in early September, and has worked after much adjusting, and adding of external components. Magne Hagstrøm has done extensive testing on the unit, with detailed recommendations for fixing it. As it is, the PLL only provides an acceptable lock over half of its tuning range. We are supposed to get another set of two PLL/Bias units which will be the Qualification Models, and after that the Flight Models. Hopefully, the QM’s will have these problems worked out. I’m not sure when we can expect delivery of them.

Throughout all this time, the mechanical work continues. I have to specify all the mirrors, and design and draw the brackets and mounting plates to go with them. In addition, we are responsible for designing the 119GHz optics, which includes two lenses.

I’m afraid I still haven’t managed to write something for the CSP grant application, but I have done some work towards an Odin Radiometer homepage for the world wide web. The text therein should be useful for the CSP application, and I’ll try to work on something for the CSP this week.

regards,

Steve
Report for November, 1995

Date: Thu, 7 Dec 95 11:28:11 MET
From: Steve Torchinsky
To: Sun Kwok
Cc: Roy Booth
Subject: November monthly report

Dear Sun,

Since you used much of my report from last month for the Newsletter, I thought I would write this month’s directly in HTML. You can delete everything up to and including the line, and paste it into the November Newsletter file in your Odin homepage.

I tried to get some news about the correlator from Urban, but he hasn’t replied to my request. I guess things stand as they were reported last month. That is, the ASIC design should go to the foundary in February.

About the A2 frequency band: We haven’t yet verified the flight model LO frequency band, but it will be done. What is the lowest submm frequency you need to have?

Once again I have to apologize for being late with the monthly report. I’ve been working in the lab with the AOS, and haven’t managed to take the time away to write a report.

regards,

Steve
Dear Sun,

Here’s my November report, again, with the correction I mentioned yesterday.

I hope your cold is finished!

Steve

Radiometer Report

AOS

Torchinsky and Beillon have been working on characterizing the AOS which was delivered to CTH (Chalmers Technical University in Gothenburg) in September. The AOS has been powered up for over a month now, and continues to remain stable. Some parameters that have been measured are the following:

- 3dB resolution: 0.968MHz (at 3.90122GHz)
- 3dB bandwidth: 1.057GHz

The quote for the bandwidth assumes the 3dB resolution is 0.968MHz across the band, which is not really true. The 3dB resolution is more broad at frequencies which do not appear exactly on one of the AOS pixel channels, and the AOS may not have exactly linear behaviour across the band. The true 3dB bandwidth will be somewhat smaller than 1.057GHz. We will be measuring the resolution at many frequencies. We continue to verify the frequency stability, and we are calibrating the output level of the AOS.

A sample output from the AOS can be viewed by connecting to the Odin Radiometer WWW site in Gothenburg. In parallel with the AOS testing, Torchinsky is writing routines in IDL to analyse and plot the data from the AOS. The routines should also work with the Auto Digital Correlator.
Quasi-Optics and Mechanical Components

Flight mirrors are being manufactured by Leif Backstrom (subcontracted by OSO). Two of the submm mirrors have been delivered. The surface shape of the mirrors have been mechanically measured and found to have the correct shape to within 3um accuracy. This accuracy depends on a slight correction to the tilt angle of the mirror, which can be effected during the mounting of the mirror onto the cold-plate. As we have reached a satisfactory process for making the mirrors, we are now going ahead with the manufacture of the rest of them. There are a total of 14 focussing mirrors and two lenses in the Odin optical train which must be made (minus the two already delivered). Torchinsky is responsible for specifying these mirrors, as well as specifying the mounting position and the mounting system for each mirror. The mirror specifications go to Backstrom for manufacture, while the mounting positions go to ACR in Stockholm who will be making the optics support plates. There are three such plates: One in the cold box, one for the diplexer, and one for the rest of the optics. For more descriptions, and three dimensional views of the Odin Radiometer Platform, please have a look at the Odin Radiometer Homepage at CTH.

PLL/Bias

Hagstrom and Confey have spent a lot of time testing the prototype PLL units which were delivered to CTH by Omnisys in the Fall. As reported in the last Newsletter, the prototypes provide an acceptably low noise phase lock only over half the required band. Great effort has been put into isolating the many inputs and outputs with properly shielded cable. The main problem, as determined by Hagstrom, is the internal Harmonic Reference Oscillator which should be shielded from the rest of the electronics. This may mean that the flight model will have the reference oscillator external to the unit. If this turns out to be the case, then some space will have to be found in the busiest corner of the platform (have a look at View #3 in the radiometer homepage). Already, we have managed to squeeze in the external isolators and pre-amplifiers which are also needed to improve the PLL/Bias unit to the required level. The CTH radiometer group is in frequent contact with Omnisys about the PLL/Bias units, and especially through Hagstrom’s expertise, we should end up with a working flight model.

Observing Modes: Simultaneous Observing

Recently, there was a request for information regarding observations at more than one frequency simultaneously. Since this is something which is of general interest,
The Odin mm/submm radiometer is a very versatile instrument with five mixers and three backend spectrometers. All the receivers are Single Side Band receivers. Simultaneous observing is limited by the number of backends, and also by the optical train. By means of a chopper mirror, three of the mixers receive radiation from source while the other two look at the calibrating hot-load/cold-sky.

The five frequency bands are determined by the Local Oscillators and are designated A1, A2, B1, B2, and C as follows:

- A1: 547.8 to 559.8GHz
- A2: 490.5 to 499.8GHz
- B1: 567.0 to 576.0GHz
- B2: 545.5 to 553.8GHz
- C: 118.75GHz fixed tuned

We can also add 3.9GHz to either end of each band for the IF centre frequency.

The submm mixers A1 and A2 share all optical components and receive radiation at orthogonal polarizations by means of a grid beam splitter. The same is true for the two B mixers. In addition, the C receiver shares some of the optical train with B after beam splitting through a dichroic. The chopper flips the beam from source to hot load calibration. In this way, while the A mixers are on source, the B and C mixers are on hot load, and vice versa (ie. B,C on source, A calibrating). The chopper has a maximum frequency of 1Hz, so unless we are in a “stare” kind of observing mode, data can be taken continuously from all mixers, with intermittent source/calibration data. It is therefore possible to observe with any three mixers simultaneously, unless it is not desired to do source/calibration chopping. In that case, the optics constrain simultaneous observing to either A1 and A2 together, or B1,B2 and C together.

On board Odin will also be a Power Combiner designed by Anders Beillon of CTH. With this device, the IF from a mixer can be filtered to a window of 450MHz bandwidth, and combined with the 450MHz of IF from another mixer. In this way, the 1GHz band in the spectrometer is filled with two IF bands side by side. This is an option which allows all four submm mixers to be in operation at the same time. Two of the backends will have the IF output from four mixers. If the radiometer is chopping between source and calibration, then using this Power Combiner allows observations with all the Odin receivers simultaneously. If the Power Combiner is not being used, than the simultaneous observing is limited to three receivers, one for each of the three backends.
Report for January, 1996

Dear Sun,

As I was in the region during Christmas, I visited at the CNES lab in Toulouse on January 5th. We will be going there in July with the radiometer to do antenna tests on the main reflector. Although these will be primarily tests for the Odin telescope, it will also be a test of the entire radiometer optical system. I had a chance to meet some more of the people working on Odin, and I also saw the labs where the Odin tests will be performed.

Here at Chalmers, the main effort continues to be with the PLL units. We are still working with the prototype PLL units in order to determine how Omnisys can improve them so that they will work. The flight units will have added components: isolators, and additional amplifiers. Also, we will filter all the bias connections. A single connector will attach from the PLL unit to a small box near each LO unit. From there, after filtering out non-DC voltage, the five bias connections will be made to the doubler, tripler, and harmonic mixers in the LO chain. We have found that the 4.8GHz signal from the Reference Oscillator inside the PLL unit was getting into the Gunn and the Mixers through the Bias connections. Hopefully, this filtering will solve the problem. It’s been very difficult finding space for these extra components, but it is almost worked out now.

As of yesterday, we finally have a clean lab here. The laminar flow hood was installed, and we cleaned out the room. We now have the AOS and its fleet of computers, along with all the submm components together in one room. In February, we will begin noise temperature and beam alignment tests with the B-channel. We will also try and measure the loss through the diplexer.

I have finished specifying the Optics Plate, but work on this is not going ahead until we agree on a solution to a problem with interference from the bracket holding the cold-head. We were hoping to have all the optical components mounted together on a single plate, but because of this bracket, we can’t extend the Optics Plate out far
enough. The alternative is to attach the 119GHz mirror and lens to the outside of
the cold box, but it’s a less satisfactory solution. More importantly, the cold-head
bracket is interfering somewhat with the 119GHz beam.

We received the diplexer plate from ACR, but a slot was too narrow, and the plate
had to be modified. It has now been downgraded from Flight-Model, to Qualification
Model, and a new one will be manufactured.

The problem of organizing the mechanical work has never been resolved. As a result,
I am still getting simultaneous requests from people at SSC and here, with no way
of telling which job has the highest priority. Lennart mentioned at the last Science
Team Meeting that there was a job plan for work being done at ACR, but although
I asked him to send me a copy, he never did.

regards,

Steve
Dear Sun,

We received the flight mirrors this week. We now have all the mirrors in the signal path, and are waiting for the mirrors in the calibration chain. At the same time, we have sent away the diplexer plate for vibration tests. It has been mounted up with dummies of the LO and mirrors. When it returns we will be able to build up the diplexer with the mirrors, LO and tuning mechanisms. Hopefully receiver tests will get under way again within two weeks.

We continue to have problems with mixer diodes shorting out, or blowing open. Recently, a mixer only just re-delivered by Zimmerman became short circuit. It had tested fine on the curve tracer, showing a good I-V characteristic, but when attached to the bias, it was short circuit. In my experience with SIS mixers, we always biassed the junctions from boxes powered by batteries. Here in the lab, we are using bias circuits powered by a supply attached to the mains. I think this might be the problem, but my colleagues here claim that the power supply is well filtered and no spikes can get through. I had a chance to speak with Peter Zimmerman while I was at ESTEC earlier this month. He said that his son Rudiger, who is responsible for the Odin mixers, will try and visit us here at Chalmers. Perhaps he can help with this problem of mixer failure.

Gunnar Florin from SSC was here this week to discuss the cable harness. The PLL/Bias box has a total of 20 connectors. With the nearby Guns and multipliers for the LO, and the tuning mechanisms on the diplexer, and the added isolators and amplifiers for the PLL/Bias box, this busy corner must also accommodate all those cables. SSC were hoping to use some cables left over from the Freja mission, but they are very stiff because they are well shielded. Unfortunately, those cables cannot be used for most of the connections because we need the flexibility to get around the tight corners. This cable, which is the same as will be used for the tuning mechanism connections, will be used for the connection of bias to cold-box, but for the LO we will use more flexible cable.
The main contractor for most of the mechanical work on Odin is ACR in Stockholm. This is a one-man company and he designs the components and then has the parts made in sub-contracted workshops. Recently, SSC has taken on the task of designing some of the components that were meant to be done by ACR. This is because ACR has fallen behind. As you know, I have been somewhat critical of the way the mechanical work has been managed. There has never been a proper project plan in this area. Now we see that indeed the mechanical work was behind schedule, and SSC must take up the slack. SSC has always very strongly praised the work of ACR, but in my opinion, the reason for the falling behind has to do with the fact that ACR does all his drawings by hand. With the number of revisions that we have made to components in the cold box and near the diplexer, revision of drawings by hand becomes an extremely time consuming task compared to CAD work. Also, my impression so far is that ACR does not live up to its reputation. The diplexer plate and support legs have needed a number of alterations, and drawings we have received for approval of the cold-box and main platform contain several errors. They will have to be re-done.

I don’t have much details of work going on at Omnisys. I understand that the final design review for the ASIC has been delayed by a week or so. The chip design should be sent to the foundary next week, provided it is approved. For the PLL/Bias, apparently the effort is now being placed on completing the controller, so work on the phase lock loop and bias supply has not yet restarted since the Chalmers report on the prototype model was submitted by Magne Hagstrom last month.

regards,

Steve
Introduction: During the recent Odin Science Team meetings in Paris, I was asked by the Principle Investigators to write a memo outlining the present situation with the various components of the Radiometer still to be delivered to Chalmers. The two components contracted to OmniSys corporation are of particular concern. OmniSys corporation is responsible for both the Phase-Lock-Loop/Bias Unit, and the Hybrid Autodigital Correlator. I delayed writing this report until after today’s meeting at OmniSys in which we discussed the PLL/Bias units. There has been a major decision taken today regarding a total redesign of the PLL.

Phase Lock Loop/Bias Unit: Two PLL/Bias units were delivered by OmniSys to Chalmers last September. Upon delivery, they were not functional in any meaningful way. The obvious problem at that time was the RF pickup through the unscreened wires providing the DC bias connections, and the frequency reference connections for the phase lock. These wires were coming straight out of the box from the circuit board within because apparently OmniSys had not yet received delivery of the proper connectors which were to be mounted on the box. This meant, in effect, that the circuitry itself within the box was not properly screened.

Delivery of these prototype units was dependent on acceptance tests which were performed at OmniSys in September ’95. I was present at OmniSys at the time, along with the entire Radiometer Group from Chalmers. Although it was clear that the units were not working up to specification, it was decided to take them to Chalmers anyway since the Radiometer Group has a more complete lab for troubleshooting such devices. This decision was adopted in the hope that the collaborative efforts of Chalmers and OmniSys would be the most effective way to advance the project. As it turned out, the work load simply shifted entirely to Chalmers, and it is not clear that OmniSys would ever have undertaken themselves the detailed diagnostic work that was carried out at Chalmers.
In order to make the units work, modifications were made to the outside of the box to ensure proper shielding. Also, all the unshielded connections were replaced by properly shielded cable. Some pin connections were moved to avoid ground loops. This work is more completely detailed in a document by Magne Hagström, “Test Report of the Two Prototype PLL Units” submitted 8 December 1995. It should be noted that two of the radiometer group members worked exclusively on those PLL/Bias units from September through December. In my opinion, this work should have been done by OmniSys using the Chalmers facilities. Indeed, they were invited several times to take part in this troubleshooting exercise, but never joined in collaborative work with Chalmers.

The problems with the PLL/Bias units can be divided into two main contributors, the first being the internal Harmonic Reference Oscillator. Because of a lack of shielding within the box, the 4.8GHz signal from the HRO appears in all the lines, including the bias lines. That is, the Gunns, multipliers, and mixers which require a DC bias are in fact receiving an oscillating bias. This 4.8GHz signal easily finds its way into the IF as evidenced by the large noise spike appearing at that frequency in the spectrum. Furthermore, in the case of a mixer, this bias “pumping” actually converts the mixer into a multiplier causing RF signal to emanate from the mixer feedhorn. At Chalmers, we have undertaken to remedy this problem externally by adding filters to the bias lines. This means a filter box will sit with each LO chain, and also inside the Cold-Box with the mixers. It has been extremely difficult to find space for these added components.

The problem with the HRO was not limited to its contamination of the bias lines, but also its intrinsic properties were insufficient to provide the specified phase noise level. The HRO is not clean enough. That is, there is too much power emanated at frequencies other than the desired one (it has a broad power profile). This is identified in Magne’s report as an item which needs to be improved.

The second contribution to phase noise in the system comes from the loop circuit itself. In order to see this, the HRO within the unit was disabled. The external source used to replace the HRO had a much cleaner signal, but the improvement in phase noise was less than expected from the improvement of HRO signal. This indicates that there is noise contributed from the lock loop. More recently, a test was done using a crystal oscillator in place of the synthesized external HRO. The crystal oscillator has a frequency profile which, to the limit of our measuring equipment, is perfect. We now have a clear indication of the amount of noise in the lock loop, and it is evident that simply replacing the HRO with a better oscillator will not bring the PLL to within specification. At the request of SSC, Magne has prepared a second report on the PLL/Bias unit with even more detailed measurements, but the conclusion remains unchanged: the HRO is too noisy, and the lock loop is not
A lot of effort has been expended by the Chalmers group to understand the PLL/Bias units. The work continues to dominate our lab time. This necessarily means effort has been directed away from receiver testing. Now that enough components have been delivered to perform receiver noise tests, and optical alignment tests, the PLL work has a direct consequence to the delay of receiver testing.

As of today, the situation has taken an entirely new path. It was acknowledged in today’s meeting that both the phase lock loop and the HRO are not good enough, and the resulting decision taken was to redesign the PLL/Bias units. Now we will have the bias and filters sitting under the LO chains, integrated into the LO mounting brackets. The Chalmers group must redesign these brackets yet again. The PLL will contain added components which will remedy the phase noise problem. The ramifications of a redesign to the Odin timetable are obviously important. OmniSys were reluctant to give time estimates, but since we are starting again with a prototype development, we must expect a delivery date well after October ’96. For the present, rejected, prototype, the time estimate was nine months but in fact the time required was 18 months. Hopefully this second prototype work will go faster. We may have this prototype “breadboard” model by October, and after that a Qualification Model must be built, and finally the Flight Model.

This decision to redesign the PLL should properly have been taken four months ago after Magne Hagström submitted his report. It was clear at that time that the PLL had major flaws in the design, but instead we struggled on for four more months, testing the system. It’s unfortunate to have lost this time.

Hybrid Autodigital Correlator: We have seen the timetable for the correlator slip several times since the Preliminary Design Review on 11 September. The result of that meeting was for a Critical Design Review to be held in December, followed by release of the ASIC design to the foundary for manufacture. This milestone was pushed back to February very soon after the September meeting, and by December the date for the Critical Design Review was reset to March. According to the present Project Plan, the design phase of the ASIC runs until 30 April, followed by manufacture and delivery of the chip in August. The remainder of the correlator is meant to be built up in parallel with the ASIC manufacture ending with integration of the entire system, and delivery by the end of September.

Aside from the ASIC chip design, there are problems to overcome in the analog part of the correlator. In particular, the power divider does not provide enough Single Side Band suppression, and this will require a redesign of the filtering circuits in the correlator.
SSC has made an effort to manage the situation. They have an engineer, Karin Lundmark, in Gothenburg who keeps in weekly contact with OmniSys, and oversees the ASIC design progress, as well as the correlator work in general. In conversation with Karin Lundmark on 27 March, she told me that she is taking a conservative approach to the ASIC, which explains the delay. The intention is that the ASIC will definitely be functional upon delivery, and therefore they are being careful to get the design right. She believes the 30 April date for the ASIC design delivery is realistic.

Integrating the components into a working Hybrid Autodigital Correlator is not a trivial process. The SSC Project Plan has three months set aside for this work, but that includes one month without the ASIC installed. At Onsala, there is experience with this type of work, and fortunately Michael Olberg will devote one half of his time to Odin. He was instrumental in successfully getting the correlator working which is now being used on the Onsala 20m telescope. As it happens, that correlator was a project initiated by Anders Emrich, now of OmniSys, for his PhD thesis. Michael’s experience will help reduce the time required to integrate the correlator. In the case of the Onsala Hybrid Correlator, from the time of delivery of the “finished” correlator, to the time when it was working properly was a period of two years. As for the timetable presented by SSC, I can only say that Karin Lundmark feels it is realistic that a Qualification Model be delivered by the end of September.

**Project Plan:** The Project Plan as presented at the Odin Science Team meeting in Paris is overly optimistic. It will necessarily be revised because of the new decision regarding the PLL, but this could have been foreseen months ago. I’m sure by the time of the next Science Team meeting in October, we will be talking about a delay in the launch.

**Documents:** I am forwarding to CSA by ordinary post the following documents:

“Test Report of the Two Prototype PLL Units” Magne Hagström, 8 December 1995

“Testrapport #2 för PLL enheter” Magne Hagström, 24 March 1996

“Hybrid Spectrometer Report” Michael Olberg and Peter Hillerström, 29 January 1996
Report for April, 1996

Date: Wed, 8 May 1996 12:11:43 +0100
From: Steve Torchinsky
To: Sun Kwok
Subject: Odin April Report

Dear Sun,

I apologize for the lateness of this report.

The radiometer lab is now a properly clean environment. The laminar flow hood is installed, and we have anti static mats on the floor and on the lab bench. We are slowly building up the radiometer with the components as they arrive. We have the qualification model Main Platform, and on this is half the diplexer (the B channel) and the Optics Plate (prototype). Presently, we are using prototype mixer B1 together with its corresponding LO, and we are using the flight model version of the LO as a source signal.

The sideband rejection of the diplexer seems quite good: -30dB suppression at the centre frequency, moving up to -15dB at 500MHz offset (corresponding to the 1GHz of IF). The tuning for these tests was done using roof mirrors mounted on micrometers. The tuning mirror actuators had been delivered to us from ACR in Stockholm, but we returned them because they were unsatisfactory. After a test which showed the tuning dynamic range was only 5dB or so, we measured the roof mirrors mechanically, and found, in the worst case, that the 90degree roof mirror was really 91.6degrees. All four of the delivered tuning mechanisms have been returned for repair. We are supposed to receive these fixed up mechanisms within a short time, and meanwhile, ACR will build new (hopefully better) ones. We need eight tuning mechanisms in all.

We have a vacuum box for the receiver, which has been tested and it holds a good vacuum. When we get the tuning mechanisms, we can test the receiver under vacuum which will increase our signal levels when the attenuation by air is removed. We are not yet set up to cool the receiver.

We have all the flight mirrors for the B channel, and when the full diplexer is delivered next week, there should also be the remaining two A mirrors completed. The mirrors have been mechanically measured, and the surface conforms to the required shape to within 10um, even out to the 35dB beam edge taper level. The
alignment of the optics after mounting on our optics plate was excellent, so we’re optimistic that the receiver will be well aligned to begin with. All mirrors have pins corresponding to precisely positioned holes on the optics plate, and with high accuracy machining, the mirrors should be automatically set up properly. The optics plate we are using is a prototype which was manufactured by the Chalmers workshop. I am a little bit worried that ACR will not equal the Chalmers precision when they make the flight model Optics Plate. So far the parts we have received from ACR have been unsatisfactory, but we’ll have to wait and see.

Rudiger Zimmerman of Radiometer Physics visited us a couple of weeks ago. He’s responsible for the Odin mixers and LO (Gunn’s and multipliers). While he was here, he optimised the B1 mixer and advised us about proper procedure. We are very careful with the mixers and multipliers, and he was satisfied that we are operating properly. We also had discussions about the LO mounting plates which will be manufactured by Chalmers, but must fit the LO chain. During that day, Stefan Andersson of Omnisys also visited, and he discussed with Rudiger the plans for the new PLL.

Regarding the PLL, as I mentioned last month, it was finally decided to redesign the PLL entirely. Omnisys are now working on a breadboard version. They have already ordered some new components, most significantly an oscillator which will replace the reference oscillator in the old design. The new oscillator, called a YIG oscillator, is very much larger in volume than the crystal oscillator used previously. Stefan Andersson estimated that a working breadboard version of the PLL could be ready in June, but this is probably being overly optimistic.

The new design of the PLL has had ramifications for almost the entire platform. The PLL and bias will now entirely separate boxes. The bias for each LO will be integrated into the LO mounting plates. The bias for the mixers will probably sit under the cold box. We will also incorporate a filter-box/protection-circuit on the mixer mounting bracket in the cold box.

regards,

Steve
Report for May, 1996

Date: Fri, 31 May 1996 10:35:50 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc:
Subject: Monthly Odin report for May

Dear Sun,

Unfortunately, there’s not much hardware progress to report this month. We are waiting for the replacement tuning mechanisms, and so we can not do any testing of the receiver in vacuum, since we don’t have any remote control tuning.

There has been some more testing of the Gunn in order to get its characteristics for the PLL design. The PLL design is not yet finalized, and I haven’t heard yet when we can expect the breadboard model.

The Critical Design Review for the correlator ASIC will take place in Stockholm on 12 June. Perhaps you might like to attend? I haven’t yet heard from the CSA whether they want me to attend on their behalf as I did last September. The ASIC meeting occurs just before the meeting of the Agencies, so perhaps Victor Wehrle will attend the ASIC meeting also.

I am now working on the design of the 119GHz optics, which will be the last components to be delivered by the Chalmers group. There are two lenses and a mirror to design, plus the dichroic. It shouldn’t take much time.

I’m looking forward to seeing you in a week,

regards,
Steve
Dear Sun,

A few weeks ago, I worked out the direction of the polarisation vector for the 119GHz receiver. This was done at the request of Jussi Tuovinen of Finland. As it turns out, they needed this information in order to properly set up the holographic tests of the telescope, which will be done in Toulouse, probably in November.

During a meeting at Toulouse on January 22nd this year, the topic of discussion was the planning for the holograph tests. The holograph system is also linearly polarised, and must be oriented with the receiver polarisation axis. It was assumed at that meeting that the polarisation would be parallel to the radiometer platform, and work went ahead with the test set up. I was not present at the January meeting. When I worked out the polarisation of the 119GHz system, I found it to be oriented at 45deg to what was expected. Work had already gone ahead on the holograph, and rotating that, or the radiometer and main reflector, would be structurally too difficult. The alternative is to rotate the 119GHz receiver. This will be effected, not by rotating the whole receiver, but by putting a 45deg waveguide twist behind the feedhorn. Everything else will remain the same.

In other developments, we are working again to specify the brackets for the components within the cold box. This was done last summer, but now Lars Stenmark of ACR has asked for changes to accommodate the thermal links (metal straps or braids from the cold head to the mixer brackets). The mixer brackets have been redesigned, and new ones are being manufactured now at Chalmers. Meanwhile, the cold plate will be done at ACR, and we expect delivery in August.
Urban Frisk was planning to visit Chalmers in order to discuss the overall timetable. Our group will be able to provide input for the next version of the Odin timetable. The summer holidays are here now, and most people in Sweden take vacation during July for three to five weeks. I think Urban won’t visit until August.

regards,

Steve
Report for July, 1996

Date: Wed, 24 Jul 1996 10:19:07 +0100
From: Steve Torchinsky
To: Sun Kwok
Subject: Odin Report for July

Dear Sun,

July is very quiet in Sweden since everyone takes their holidays at that time. The Chalmers lab has been inactive for most of July since everyone but me is away from two weeks ago. I have been working mostly on the 119GHz design lately (lenses, dichroic, mounting brackets) which has been a more time consuming task than I thought it would be. However, we should have these components ready for the telescope testing in Toulouse.

The tests in Toulouse are due to begin in October, and continue right through to the end of December. Here is the present timetable, which I have from Fredrik Sjoberg of SSC:

1. QM telescope test (with collimator and bolometer) 14 October-10 November
2. FM telescope test (with collimator and bolometer) 11 November-24 November
3. Radiometer alignment (with collimator, radiometer and telescope FM) 25 November-1 December
4. Telescope antenna measurements (with hologram, radiometer and telescope FM) 2 December-8 December
5. Radiometer alignment (with collimator, radiometer and telescope QM) 9 December-15 December
6. Telescope antenna measurements (with hologram, radiometer and telescope QM) 16 December-22 December

This would mean that the CESR facility, personnel and equipment has to be available during the entire period October 14 to December 22, and that personnel from Chalmers and HUT with radiometer and hologram equipment has to be in Toulouse.
from around November 25 to December 22.

I had a call from Stefan Andersson of Omnisys last week regarding the new Phase Lock Loop. He has now finished the bread board version of the PLL and has tested it to the limit of his equipment. He has measured the lock on the Harmonic IF (he is not equipped to measure at 90GHz) and finds that the noise level is below the noise floor of his spectrum analyzer. He believes he is within the specifications now, and must borrow some equipment from Chalmers to continue testing. This will happen when Magne Hagstrom and Christy Confey return from holidays and can carry out the testing using our equipment at Omnisys. Hopefully, we can take this breadboard version of the PLL back to Chalmers by the end of August.

I will also take some holiday time now. I’m leaving on Saturday for France, and will return on 18 August. Since I will be in the area, I will probably visit at CNES where the telescope testing will take place.

Best regards,

Steve
Report for August, 1996

Date: Mon, 9 Sep 1996 09:23:11 +0100
From: Steve Torchinsky
To: Sun Kwok
Subject: Odin report for August

Dear Sun,

After the summer break the mixer which was mounted on the platform was found to be soft. That is, the I-V (current-voltage) characteristic was no longer sharp, and it is therefore no longer a good mixing device. All eight mixers were then tested (4 flight models and 4 qualification models) and all were fine except for the one. The mixer diode was shorted the whole time, which is normally ample protection from electrostatic discharge. We are investigating the possibility that the mixer can see voltage spikes despite being shorted. The shorting cap was placed at the end of a semi-rigid cable, which is as shielded a cable as any can be. This problem with the mixer is worrying if it turns out to be intrinsic to the mixer. Peter Zimmerman will be here this Thursday to check our set-up, and discuss procedure.

Meanwhile, we have a mixer undergoing a long term test. It is presently sitting in a box with a bias voltage applied, and has been there for a couple of weeks. That system is completely isolated. The bias runs on batteries, and the mixer and bias box together are sealed in a box, so no external fields can get in. This should show whether the mixer is prone to degeneration, or whether external factors are damaging the mixer. If it’s the latter case, we will have to think about how the satellite will weather EM pulses while in orbit: shielding will be a critical issue.

There has not been much testing of the submm radiometer lately since the LO sources had all been sent back to Zimmerman for reconfiguring. This has to do with the new PLL and the Gunns are now matched to the PLL. They are being sent back to us this week.

The situation with the PLL is unchanged since last month. Although it was reported to be ready, we haven’t had it here in the lab. Tests at 90GHz have not yet been performed, and these will take place at Ylinen Co. (who are responsible for the 119GHz receiver). Initially, the Chalmers spectrum analyzer was to be used for this test, but instead it was decided to use the Ylinen facilities where they have a network analyzer which can measure the phase noise directly at 90GHz. I’m not sure when
we will have the PLL here at Chalmers.

Regarding mechanical components, today (9 September) there is a meeting at SSC to discuss the workload at ACR. Magne Hagstrom is attending for Chalmers. ACR is responsible for the largest part of the mechanical components, including all the support structure, the cold box, and the tuning mechanisms for the diplexer. This workload has proven to be too much for them, and some of the work has been shifted around. Fredrik Sjoberg of SSC took on some of the mechanical design work, and Leif Backstrom, contracted to Chalmers, has taken over the mirror work for the tuning mechanisms. Today they are discussing how to further lessen the load at ACR, and possibilities may including adding another SSC person for design work, and moving more mechanical work to Backstrom.

Backstrom has delivered the flight model diplexer, including all the grids, absorbers, and corner mirrors. We are now assembling it, and testing it. Mechanically, the corner mirrors are acceptable. In the worst case, the deviation from 90degrees is only 0.1degree, with an average error for all the mirrors of around 0.05degree. We would like the maximum error to be 0.05degree, so a couple of the mirrors may be redone. The new mirrors for the tuning mechanisms, manufactured by Backstrom, are also as good, which is a huge improvement on the 1.5degree error we had on the previous versions. Now that the Gunns are returning to Chalmers, we will be able to test the RF performance of the diplexer.

best regards,

Steve
Report for September, 1996

Date: Thu, 3 Oct 1996 20:48:08 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc:
Subject: Odin monthly report for September

Dear Sun,

On September 12th, Peter Zimmermann of RPG in Germany (the supplier of the mixers and local oscillators) visited Chalmers to look at our set-up, and discuss the work required for the LO bias/mounting system. One of the topics of discussion was the sensitivity of the mixer to electrostatic discharge. As I mentioned last month, one of our mixers went soft over the summer. We are careful in the lab to short-circuit the mixer bias port when the mixer is not in use, and over the summer, the mixer was stored in this manner. However, the shorting cap was placed at the end of a 1m long semi-rigid cable, and according to Peter Zimmermann it is possible to generate a sufficient current in the cable to damage the mixer, even though it is a shielded cable. With this in mind, we think that some rather violent electrical storms in Gothenburg during July caused the mixer damage. Zimmermann’s advice was to place the shorting cap right at the mixer bias port so that there is no length of cable in which a current can be induced.

In order to further prevent damage to the mixer diodes, a protection circuit has been designed by Omnisys (who are responsible for the PLL, Bias, and the correlator). The boxes for these filter circuits were manufactured at Chalmers, and the boards with the circuit were delivered by Omnisys this week. The mixers will be protected from Electro-Static Discharge in space by the shielded cabling, the cold-box itself, and finally by the filter boxes, one for each mixer. This should be enough to allow the radiometer to pass ESD testing.

The second topic of discussion during Zimmermann’s visit was the Local Oscillator bias design. The bias circuitry has been moved away from the Phase Lock Loop electronics into the mounting brackets for each LO. The LO chain (Gunn, Harmonic mixer, and two multipliers) must be mounted onto its bracket by RPG since each component has a slightly different height, and the alignment of the waveguides is critical. Zimmermann would like to deliver the complete LO unit integrated on its bracket. However, the bracket will contain the bias circuit to be designed by Om-
nisys. Chalmers will manufacture the bracket once the location of the input/output ports is known, and then we will send it to RPG who will further machine the surface to fit the LO chain. At the moment, the manufacture of the brackets must wait until Omnisys designs the circuit. Unfortunately, there is only one person who is responsible for both the bias and the PLL, and presently the PLL is a priority. We continue to use the LO prototypes biased by the original PLL/Bias box (with no PLL).

I am working on the design of the dichroic, as well as the other 119GHz optical components. The original design of the dichroic was simply a wire grid with a calculated loss at 570GHz of 0.9dB (80% efficient). I’m hoping we can do a bit better than that, and we will try using a perforated plate. The perforations can take various shapes, but our first two designs have given disappointing results, so we may use the grid design afterall.

We continue to receive and verify the roof-top mirrors. We had set a limit of 0.05 degree deviation from 90 degrees for these mirrors. This is based on the dynamic tuning range of the diplexer for roof mirrors of different angles. The dynamic range goes from 30dB down to 5dB for the worst mirror which was 91.4degrees. According to this empirical curve, now based on six data points, a mirror of 90.05degree would have a tuning dynamic range of 28.5dB. Most of the mirrors have achieved the tolerance, but we allowed a couple through which were 90.07 degrees. The situation with the roof mirrors is well in-hand.

Concerning the second stage IF amplifiers (the warm IF) we experienced some drop in gain. Magnus Dahlgren is responsible for the IF amplifier work at Chalmers since Anders Beillon left the group last Spring. According to Magnus, the drop in gain comes from the slight separation of the amplifier chip from the ground plane. This could be due to a problem with the conductive glue used, or more likely because of insufficient cleaning before the gluing. Magnus says the situation is under control.

OTHER ACTIVITIES: The ESA Cornerstone Mission FIRST

As you requested, I will include a brief summary of my activities outside the Odin project, which is mainly my work with the ESA satellite FIRST. FIRST will be an orbiting observatory with imaging ability in the far and near infrared, and high resolution spectroscopy in the submillimetre. It is due to be launched in 2008 and will be the first mission to fly superconducting tunnel junctions in the mixers (Odin uses the less sensitive Schottky diodes).

My involvement in FIRST began with the Public Payload Presentation at ESA in February. At this meeting, the model designs for the three instruments were shown. There is a photo-conductor imaging receiver for the near IR, a bolometer array with
limited spectroscopy ability using filters for the far IR, and a heterodyne instrument for the submm. The meeting split into the three parts, and I joined the Heterodyne group. This has become the HIFI group (Heterodyne Instrument for FIRST) and includes approximately 60 people mostly from European labs but there is also a contingent from the US who hope to join in the project. I gave a short talk at this meeting showing a 3-dimensional Quasi-Optics analysis I did for the model payload heterodyne instrument, and also showing the work I’ve done for Odin.

At the next HIFI meeting, I presented an alternative design for the heterodyne instrument which I developed in collaboration with Victor Belitsky. Victor is the head of the receiver group for the Onsala Space Observatory. Our design draws largely from my experience with Odin, and we have kept in mind such things as ease of cooling, ease of integration, and modularity so that the work can be shared by several labs. This design is now one of the two considered for the heterodyne instrument. The other being the proposal from the US team led by Tom Phillips of CalTech, and represented mostly by Jonas Zmuidzinas also of CalTech. The original design published in the FIRST model payload has been dropped.

The HIFI group continues to work as a unit with the purpose of submitting a single proposal when the Announcement of Opportunity is issued next Autumn. I am now on the Optics Working Group of the HIFI team and we are working towards optimising the design according to the scientific objectives, and the ESA objectives of reducing the cost. The FIRST project is under financial pressure, and ESA is therefore willing to take on a partner for FIRST. In terms of hardware, there are many components, such as digital electronics and optical components, which could go to Canadian industry if Canada were to express an interest in joining FIRST. FIRST is obviously an ambitious project with a lot of work to be done, and Canada’s experience with Odin would be highly valued.

I should say that my work on FIRST has been supplementary to Odin, and I have taken care not to let FIRST interfere with my responsibilities for Odin. Financially, we have been supported by Chalmers who has paid the cost of the trips to the HIFI meetings.

my best regards,

Steve
Report for October, 1996

Date: Tue, 5 Nov 1996 17:21:32 +0100
From: Steve Torchinsky
To: Sun Kwok
Subject: Monthly Odin report for October

Dear Sun,

There was a meeting in Stockholm on October 4th concerning the delivery of the QM AOS, which I mentioned briefly in an earlier email. The French team has identified a number of tests which must be done before work on the FM can begin.

The Qualification Model AOS was on track to be completed by 15 October, but it was felt that with the delay of other components, the time could better be used to ensure that the AOS integrates well into the overall system. With that in mind, we determined to run some tests on the prototype AOS now in the Chalmers lab. This was scheduled to be done during the week of 11 November, with the help of the French team.

The main points to be investigated are the following:

1) Synchronisation of the AOS with the pointing, and Dicke switch.

2) interference from other electronic components(PLL,correlator, mechanism electronics)

3) Interference from adjacent input channels (there are five, one for each mixer).

The first point requires us to have the chopper and mechanism electronics. At the end of the day of the meeting, we took the chopper back to Chalmers with us. We have the electronics box for the tuning mechanisms, but this box will not control the chopper. Delivery of the refurbished mechanism electronics box was given by ACR to be 31 October. (They were phoned up during the meeting). As it turns out, this component was not ready last Thursday, as expected, and will not be delivered until the end of November. Therefore, we will delay the visit of the French team to Chalmers, and will do the AOS testing in December.

The second point above requires the PLL. We only have the prototype PLL which we know is extremely noisy, and would not give a realistic picture of system interference.
Certainly, however, if the AOS does not see stray signals from the PLL in its present state, then we should have no problems with the new PLL. The QM PLL will not be delivered before March. The new prototype PLL is meant to be finished by January, but this will not be used at Chalmers.

I spent some time this month working on the data reduction software, in preparation for the AOS testing. I now have several routines written in IDL which allow us to view the spectra in linear, or dB scale, and to view portions of a spectrum (windowing). We can also integrate any number of saved spectra, and plot the result directly, or referred to some reference spectrum (usually the no-signal noise characteristic of the AOS). I intend to incorporate the chopping information so that the integrated spectrum will be automatically calibrated. At present, I must first collect all the signal spectra and then all the reference spectra. For the moment, the signal is the Constant Wave coming from a signal generator through the IF amplifiers.

Meanwhile, we’ve been building up the flight model diplexer, complete with the tuning mechanisms. The roof top tuning mirrors were manufactured by our subcontractor, checked by us, and then sent to ACR where they were mounted in the tuning mechanisms. We notice that when the mechanisms come back to us, the roof mirrors are often widened slightly by 0.05degrees. We are almost always within our tolerance, especially for those mirrors which were originally slightly undersized.

There is also a tilt angle which must be corrected. We find that when the mechanisms are mounted flat, the roof mirror can be tilted up by as much as 0.5degrees. This tilt is measured, and we correct for it by putting an appropriate shim at the mounting face. It is reassuring to see that our mechanical measurements agree with the RF results. When we shim the mechanism by the calculated amount, we immediately see the expected amount of power falling on the mixer.

The FM diplexer with all the grids and mechanisms mounted will undergo vibration tests this Friday.

Best regards,

Steve
Dear Sun,

As it turned out, the delay in the delivery of the chopper mechanism electronics has become more serious, and we will not be doing the AOS synchronisation testing before Christmas. According to Gunnar Florin at SSC, the tuning mechanisms encountered problems during vibration testing in mid November. ACR are reworking part of the design, and this implies changes to the drive electronics as well. The chopper and the tuning mechanisms will share the same drive electronics box, so the problem with the FM tuners directly affects the chopper. The redesigned tuners will undergo environmental tests in December, and we will not have the drive electronics before that, so the AOS synchronisation tests will not take place before the end of the year.

After working with the AOS, I see that there is some drift over a period of time. That is, the pixel number on the CCD does not always correspond to the same IF frequency. The AOS has an internal calibration system for determining its frequency response. Alain Lecacheux has written some routines in IDL which uses the internal comb generator of the AOS for calibration. The comb is a series of eleven evenly spaced spikes, and this is used to determine the frequency response of the AOS. I have incorporated Alain’s routines into my data reduction routines. I think the AOS needs to be recalibrated regularly, perhaps as much as once per orbit (ie. per hour) but this can be done during the Earth blockage time.

We are also ready to do automated system noise temperature measurements, once we have the chopper electronics. Through the telemetry, the system will know whether the receiver is looking at the calibration load or at the sky, by knowing the chopper position. In the lab, we can use the two optical paths after the chopper for warm and cold loads, and have continuous on-off measurements giving us the system noise temperature across the IF band. We have already used the Odin ground unit (our network of five PC’s) together with the AOS to measure the system noise temperature of the first stage IF amplifiers (they were not cooled at the time).
As of Tuesday this week, we have the FM platform in the lab. The platform is mounted up with a mixture of FM, QM and dummy components. Among the Flight components are the platform itself, the Quasi-Optics platform (on which sits all the mirrors), all the submm mirrors in the signal path, and the diplexer tower including the 16 grids. We have QM mixers and LO’s, and QM tuning mechanisms (four out of eight). We also have a QM calibration mechanism which switches the beam between cold sky positions, and a warm load position. At Chalmers we are now manufacturing the mirrors in the calibration chain (three of them), and we are planning to redo two of the signal mirrors which are not quite as good as we’d like.

Since the bias circuits for the LO will be housed in the LO brackets themselves, the design of the bracket has waited for the approval of Omnisys who must use the space in the bracket for the bias circuit. We have finally closed the loop on that design circle, and Omnisys have decided on the design, the brackets have been manufactured here at Chalmers and sent off to Zimmermann where they will be mounted with the LO’s. Already two LO’s have been done and delivered: The ones we call Standing LO’s. The other two, which are the Resting LO’s proved more difficult to create the required space and geometry for the bias circuits. However, it’s been done, and the Resting brackets were sent off to Zimmermann this week.

The delays with the various components of the radiometer (not including the correlators) has also meant a delay in the antenna testing in Toulouse. At present, the telescope itself is meant to be delivered to Toulouse next month, with the telescope alignment tests taking place in January. The radiometer tests, including the holography work, are to be done in March. The holography depends on the 119GHz receiver which is being built at Ylinen co in Finland which won’t be ready before that time. Also, the 119GHz receiver must be mounted on the radiometer platform here, and then the whole platform will be sent to Toulouse.

The hologram was designed to view polarisation perpendicular to the floor of the test site, but because of the way the Odin telescope is oriented with respect to the radiometer platform, there is a 45 degree polarisation rotation. Originally, we meant to solve this mismatch problem by rotating the feedhorn and waveguide of the 119GHz receiver, but this proved to be too difficult. Instead, the entire Odin satellite will be propped up at an angle of 45degrees during the holography work.

In December I will be at MRAO, Cambridge on the 16th and 17th for the next meeting to discuss the Heterodyne Instrument on FIRST. On the 20th I will be at CNES in Toulouse for a meeting about the Odin antenna testing.

Best regards,

Steve
Report for December, 1996

Date: Wed, 18 Dec 1996 09:23:48 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle
Subject: Monthly Odin report for December

Dear Sun,

Urban Frisk and Gunnar Florin were in Gothenburg last week for a meeting at Omnisys. Afterwards, they came to Chalmers. Here is a brief update on some components.

Correlator: The A/D converters were delivered and tested. They consume less power than the specification required, which is of course good news. There was a fault in the board layout which was corrected manually by cutting out a portion of a conductor line, and manually making the correct connection. This is obviously not acceptable as a flight component, but the Flight Model A/D will have the error corrected. Apparently, Omnisys will deliver a partial correlator to us by the end of January 97. It will have 4 out of 8 bands giving a total of 500MHz bandwidth (4 X 125MHz).

Phase Lock Loop: A prototype PLL with the new design that was implemented last Spring, will also be delivered by the end of January, according to Urban. This will not be contained within the box envisaged for the Flight Model, but will be very useful for our testing of the radiometer. If we have the PLL, and the correlator we will have everything needed to do system noise tests, and system interference tests. Last week, Magne Hagstrom was in Finland for a meeting about the 119GHz receiver, and also to help with the testing of the phase noise of YIG oscillator which will be the basis of the Phase Lock Loop. The YIG is within specification.

PLL/Bias Control box: This control box will not be delivered at the same time as the PLL and the bias boards, so we will continue to control the mixer, LO and PLL supplies from the LabView program which runs on a Macintosh in our lab. The control box has a much lower priority than the PLL and bias.

Mixer protection box: This was delivered to us some time ago, and seems to adequately cut out spikes that might come into the mixers from the bias lines.
LO Bias: We're expecting these soon. The designs for the LO baseplates was finally agreed upon. They were manufactured here at Chalmers and sent to Zimmermann where the Flight Model LO’s were mounted. Two of these were delivered last month, and the remaining two should arrive this week. Omnisys has to deliver the biasing circuit boards which we will install inside the LO mounting brackets.

Tuning Mechanisms: The Flight Model tuning mechanisms failed the vibration tests. A spring was damaged resulting in uneven force on the spring, and therefore hysteresis in the position control (it does not have repeatable position control) This spring is being redesigned and the tuning mechanisms will have to undergo another series of environmental tests. This delayed the work on the electronics box which controls all the mechanisms because all the effort at ACR is going into fixing the tuning mechanism. The lack of the mechanism electronics box has delayed the AOS tests that were originally planned for 11 November.

Cold Box: The cold box has been delayed by one month, with delivery now scheduled in mid February at the earliest. The next shake test is scheduled for 16 January.

119GHz HEMT: I’m afraid the prospect for the 119GHz HEMT is not good. The difficulty arises from the losses in the substrate. In order to overcome this, they must use Indium Phosphide wafers, but there is only one supplier of this material: Weinreib in California. SSC is trying to obtain wafers, but there may be some difficulties since the U.S. might consider this to be “sensitive” (military) technology, and therefore not exportable. This material is the state of the art for high frequency HEMTs, and really is still in the development stages. It is not a mature technology, as one should be using on a space mission. There is the further practical problem that once obtaining an Indium Phosphide wafer, there will be at least two iterations of the amplifier design to be done. Unless the 119GHz HEMT is going to delay the launch date, I don’t think we can expect to have it incorporated in the 119GHz receiver. I believe you should use the numbers I sent to Christine for the noise temperature at 119GHz (the HEMT would have improved this by a factor of 2 or so).

As you can see, a number of components have delays in their delivery dates. In the last schedule presented by Urban, he said there was no slack. That is, any delay immediately implies a delay in the launch. He mentioned that when the launch contract was renegotiated, there was included a three month launch window. I should think we’ve used up at least one or maybe two of those months putting our launch into April 1998.

I was in Cambridge Monday and Tuesday (16, 17 December) for a meeting about the Heterodyne instrument on FIRST. Our French Odin colleagues are also participating in this so I had the chance to talk to Alain Lecacheux and Carlo Rosolen about the
AOS testing we want to do. They are anxious to get started on the Flight Model AOS and are only waiting to do some system level tests with the radiometer. Hopefully, if we really do get the correlator and PLL in January, we can go ahead at least with the system interference testing.

I will be at CNES in Toulouse on Friday where they have already set up the collimator and are ready to do the antenna testing. Unfortunately, the telescope preliminary alignment measurements at SSC are not yet completed, and we won’t begin in Toulouse before the end of January. The discussion beforehand should still be useful, however, especially concerning this question of the polarisation orientation.

As part of my travel back to Canada, I am planning to visit at CSA on 6 January. Victor Wehrle has offered to take me to Routes Inc. to see Osiris. I will probably also visit the NRC standards institute where one of my colleagues from the JCMT group is now working. Luc Martin made the recent 345GHz mixers for Receiver B3, and I’d like to discuss machining techniques with him.

I look forward to seeing you in January.

Best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
on secondment to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
fax. +46 31 16 45 13
Progress on the radiometer was rather slow in January with a number of components away from Chalmers.

The diplexer tower and mechanisms underwent vibration testing in mid January. The mechanisms had been refurbished to solve the problem with a spring which did not come through the vibration testing the first time. The mechanisms are now flight qualified.

The diplexer tower itself exhibited some vibration amplification at two frequencies: 180Hz and 550Hz. Also, one the LO brackets had a resonance frequency of 873Hz. In order to reduce the amplitude of vibration, the radiometer group was asked to make additions to the diplexer tower. We added plates, and a bracket which connected the top of the diplexer tower to the cold box. After this work was done, the tower mounted up with the mechanism dummies was returned for another series of vibration tests. The set up was instead measured to simply find its natural frequencies of vibration, and the results were used in a vibration simulating computer program. Finally, it was decided that our additions to the tower would only change the frequency of vibration and not the maximum amplitude, and afterall it was acceptable the way that it was. This unnecessary work unfortunately lost us about a week, including the design and shop time, and the delivery time.

The AOS engineering model was shipped back to Marseille on 17 January where it was needed to validate their on-board software. The team at Marseille noticed a drop in gain compared to when they first shipped it. I sent them the results of some of our measurements to help them try and track down when the drop happened, but I haven’t had any news about it yet.

The work with the LO bias supplies continues to cause problems. We noticed last week that a couple of SMA connectors which sit on the back of the LO bracket (which also houses the bias supply) interfere with the adjacent tuning mechanism
connector. Fortunately, we were able to solve this problem rather simply by rotating the mechanism 180 degrees, putting the connector on the opposite side from the LO bracket.

I was reading through the Odin newsletter sent out just before Christmas in which a number of components were said to be scheduled for delivery in the end of January. I can comment on a few of these. A prototype PLL bias was meant to be delivered by now. Stefan Andersson of Omnisys has been working only on the LO bias circuits, so it was unrealistic to expect that he could also get the PLL work done. The chopper mechanism and blade are undergoing vibration testing this week, and we have also not received the mechanism electronics box, as mentioned in the Newsletter. The AOS synchronisation tests require the chopper, the mechanism electronics, and the AOS (which is now in France) so the synchronisations tests did not take place at the end of January.

As of this week, we are rebuilding the radiometer. We have the tuning mechanisms and the diplexer tower back here. SSC has sent the chopper mechanism and blade, and the French team should be sending back the AOS; they were meant to have it for a week of testing. We should soon have a working receiver again.

The telescope was delivered to Toulouse and there will be a “kick-off” meeting for testing on 3-4 March. Initially, alignment testing will be done using a bolometer as a receiver, and later on, the radiometer platform will be mounted into the set-up. Tests with the hologram at 119GHz should begin in April.

Best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
on secondment to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
fax. +46 31 16 45 13
Report for February, 1997

Date: Thu, 27 Feb 1997 23:08:55 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle
Subject: Monthly Odin Report for February

Dear Sun,

Earlier this month the engineering model AOS was returned to us with a new laser diode. We did some testing of the frequency calibration using a wave generator, and also using the internal comb generator. It seems there is some drift of frequency over time, and according to Dominique Pouliquen in Marseille, this can happen if the AOS is not in a temperature stable environment. A temperature change of 1.5 degree could result in a drift of one pixel on the CCD which corresponds to about 1MHz in the IF band. We will have to monitor the temperature of the AOS, and do an internal comb frequency calibration as often as required by the temperature change.

Last week Urban Frisk and Gunnar Florin came here from SSC to deliver the engineering model mechanism electronics box. They also brought the chopper and calibration mechanisms. With this electronics box we should control all eight tuning mechanisms as well as the chopper and the calibration mechanism. This component is essential for the AOS synchronisation tests we’ve been wanting to do since last November. We were able to control all eight tuning mechanisms, but unfortunately, there was no response from the chopper nor the calibration mechanism. This seems likely to be an addressing problem from the computer sending commands through the telemetry control unit. We have sent the mechanism electronics box back to SSC, and hopefully they will soon figure out the problem. Meanwhile, synchronisation testing with the AOS will continue to wait.

Urban and Gunnar were also in Gothenburg for a meeting at Omnisys regarding the correlator. They are now saying that we will have one complete channel as a prototype working by April. That would be a correlator with 125MHz bandwidth which we could use at least to test system noise levels, and whether there is any cross talk into the AOS. This April date is of course in contrast to what was said before Christmas about having 4 channels working by mid January.
Work on the phase lock unit seems to be at an early stage with effort going into testing components as they arrive, such as the YIG oscillator, and the harmonic IF amplifier. The bias for the “standing” LO bracket is reported to be ready for final testing in the most recent Progress Report from Omnisys. The bias for the “resting” LO bracket must also be completed, which will affect the progress on the PLL since it’s the same person doing both jobs in the PLL/Bias system.

I spoke to Itcho Angelov of the Microwave Department here at Chalmers about the 119GHz amplifier. Sandy Weinreib has agreed to supply the indium phosphide substrate, and they are expecting delivery in July. Itcho says that it’s possible then to have a working amplifier by the end of this year. I expect this is too late for Odin since the radiometer will already have been integrated by that time.

In the radiometer lab here we have been testing the side band rejection of our diplexer. There are four SSB filters for the four submillimetre channels, and in two of them the side band suppression is an incredible 44dB in the centre of the band. We have side band levels of less than 30dB out to 100MHz from the centre, and less than 25dB out to 200MHz. There is less than 20dB coming from the unwanted sideband across the entire 1GHz band.

The other two side band filters are not quite so good, giving 34dB suppression at the centre, 24dB out to 100MHz, 22dB out to 200MHz, and 15dB out to the end of the band. This difference seems to be in the mounting of the grids because we achieved better results (the ones I quote here) after adjusting the grid. Hopefully we will get the excellent results in all four SSB filters, but even as they are, all four are doing the job very well.

I will be making two trips in March. Next Monday and Tuesday we’re having the meeting for the antenna testing in Toulouse. We will discuss the set-up, and which tests to perform. This will be attended by the Finnish group since we will be doing holography with the 119GHz receiver and with the hologram they are providing. There will also be some submillimetre work.
From 13 to 18 March I will be at meetings for FIRST. There is an Opto-Mechanical workshop at Groningen on the 13th and 14th at which I will present another iteration of the design for the heterodyne instrument on FIRST. There is the more general Heterodyne Instrument meeting in Paris on the 17th and 18th at which we will hopefully decide on the final design to be submitted. The Announcement of Opportunity for FIRST will be at the end of this summer.

Best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
on secondment to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
fax. +46 31 16 45 13
Dear Sun,

The mechanism electronics box has been away from Chalmers during the entire month of March. It seems there was a fault in the circuitry which allowed the 28V source onto the wrong lines. Last month, when we tried to use the box to control the calibration and chopper mechanisms, the mechanisms behaved erratically, and it turns out that a relay was damaged inside the electronics box. ACR in Stockholm is working to repair the mechanism electronics box, and we hope to have it back here in two weeks.

ACR is quite overloaded with work. They are also responsible for the cold box, and the support structure within the cold box. Presently, the mixers on the radiometer platform are mounted on a temporary plate while we wait for the flight brackets which are mounted within a web of kevlar threads. The cold box and brackets are essential for doing the antenna testing in Toulouse since the 119GHz receiver must be integrated onto the platform, and the associated optics are mounted on the outside of the cold box.

Unfortunately, ACR is also doing work for PIROG, which is a Swedish/French balloon experiment. This may have an impact on the delivery of the cold support brackets. The Odin antenna testing with the radiometer is presently scheduled for the beginning of July, so we must have the brackets and cold box before that with enough time to integrate the 119GHz receiver.

During 3-4 March there was a kick-off meeting in Toulouse to discuss the antenna testing. The preliminary alignment is presently being done with the large collimator at CESR and a bolometer detector. The radiometer was meant to be sent to Toulouse today (2 April), with radiometer alignment work starting 9 April and continuing during that week. This would be followed by further work aligning the entire structure as a unit (radiometer and telescope) and finally, the telescope beam profile using the 119GHz receiver and the hologram developed by Antti Raisanen’s...
group at Helsinki. This schedule had the radiometer returned to Chalmers in May.

During transport of the telescope to Toulouse at the end of February, a ball joint was damaged. This was discovered during the preliminary alignment work which began after the antenna kick-off meeting. As a result, the telescope tests have been pushed back a couple of months, which takes into account replacing the ball joint, and the availability of the CESR lab. This is probably better for the radiometer since it will be equipped with more flight components. Had we done the testing now, it would be with the temporary brackets in place of the cold box.

I have put a couple of photographs on my web page showing the telescope in the CESR lab. You can see them at:

http://www.oso.chalmers.se/~steve/photos

One of the problems we discussed in Toulouse was the orientation of the polarisation from the satellite. This is at 45 degrees to the satellite base plate, which means the same angle with respect to the laboratory floor during the antenna testing. For the holography, it is necessary to have the hologram co-aligned with the polarisation vector. When the Helsinki group began work on the hologram last year, it was with the understanding that the polarisation was vertical. It was only last summer when I was asked to work out the polarisation direction that we realised it was tilted at 45 degrees. Since that time, we’ve been thinking that we will have to rotate the satellite during the holography work. It was clear that rotating the whole telescope and platform by 45 degrees was going to be very difficult, especially if we want to make the pointing direction adjustable. Finally we decided to get around the 45 deg polarisation problem by using a grid (ie throwing away half the power from the hologram source), and another grid to ensure that no cross polarised radiation reaches the receiver. Rejected cross-pol radiation from the receiver can set up standing waves in the system which would cause ripples to appear in the beam profile measurements. Antti Raisanen finally agreed that we can filter out the cross polarised component with a grid, as long as we also use a second grid which will eliminate cross pol power by reflecting it onto an absorber. This solution is very much simpler than rotating the whole satellite, and we were all very relieved that we could go ahead this way.

During the week of 30 March, Jacques Narbonne and Roger Pons from Toulouse CESR came to Chalmers to work with the AOS. I had been seeing some problems with missing spectra and also broad calibration lines from the internal comb generator. As it turns out, the problems were mostly to do with confusion over the telemetry format. There had been some changes made at SSC and these were not communicated to CESR. When the AOS was working on our telemetry simulator, some data was missing in the resulting spectra coming from the AOS software be-
cause some addresses were not correct. Jacques, Roger and I worked with the AOS
the whole week, both with the Chalmers set-up, and the Toulouse computer which
they brought with them. The AOS is working well. The missing data problem was
solved. The problem with the internal calibration had to do with the way I had set
up the on-off sequence. There was still a bit of “on” data integrated in the “off”
spectra. Jacques and Roger showed me how to set the timing properly. It still
remains to quantify the response of the AOS across the band. There is some slope
which can be taken out in post processing with proper calibration. This may be
important only for very broad lines.

The definition of the telemetry format has to be worked out with Gunnar Florin at
SSC and defined conclusively. The Telemetry Control Unit was sent back to SSC
again for reprogramming, and possibly for changes to circuit boards. This effectively
ends use of the AOS until we get the TCU back. At the end of April, the French
team will return, this time also with Alain Lecacheux and Carlo Rosolen. At that
time we want to finally do the synchronisation tests with the chopper and calibration
mechanism. We must have the mechanism electronics box and the TCU before those
tests can be done.

Regarding the PLL, Magne Hagstrom went to Omnisys to help with PLL testing
during the second week of March. The lock on the harmonic mixer in the LO
chain seems good enough, based on a synthesised reference signal. They are now
waiting for delivery of the YIG oscillators on which the lock loop is based. One such
oscillator was tested in Finland a few months ago, and found to have good phase
noise characteristics. The final test for the PLL will be to mix together two locked
LO’s together and make sure we get a spike in the IF.

Magne also saw some hardware related to the correlator. We haven’t seen any results
here, but Urban reported that they have successfully correlated a synthesised sine
wave signal.
There was a HIFI meeting in mid March which was for the Heterodyne instrument on FIRST. I am now one of the co-team leaders of the optics working group. At the upcoming conference in Grenoble “Far Infrared and Submillimetre Universe” (15-17 April) I will have a poster presentation on the HET design. The conference is devoted to science with FIRST, but there will also be related talks. For Odin, Lennart Nordh will give a talk, Urban Frisk has a poster on the radiometer, Anders Emrich of Omnisys will show a poster on the correlator, and Alain Lecacheux has poster on the AOS.

my best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
on secondment to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
fax. +46 31 16 45 13
Report for April, 1997

Date: Fri, 2 May 1997 16:43:55 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle
Subject: Monthly Odin report for April

Dear Sun,

I mentioned last month that the telemetry control unit (TCU) was shipped back to SSC for refurbishment following the week of work with the AOS when the French team were here. A couple of issues arose from that week which are rather important and may also have implications for the hardware/software work done at Routes in Ottawa. It seems the telemetry format was changed by SSC without having sent a memo to all the labs with the new definitions. This caused some of our troubles with the AOS last month. The other issue has to do with the external surfaces of components on the platforms. SSC wants all components to be black. The French team had not anticipated this, and the AOS has a gold metallic finish.

As a result of these two lapses in communication, the French Space Agency, CNES, wrote an official letter to SSC and the Swedish Space Board complaining about the telemetry and surface finish issues. I was told about the letter by the Paris/Meudon people, but I haven’t seen it myself. I don’t know if a copy was sent to CSA.

In mid April the TCU was returned to Chalmers, and with it the mechanism electronics box. These items now work properly, and we have control over the chopper and calibration mechanism. It will finally be possible to do the synchronisation testing with the AOS.

I haven’t had a chance to run the AOS with the new TCU yet since Magne Hagstrom has been doing beam profile measurements with the radiometer, and I didn’t want to disturb his set-up. The beams so far seem a bit broader than expected, and also the beam centre is slightly offset compared to the location expected by the laser alignment. These results are not conclusive since beam measurements are very difficult to do, and we will be improving our set up. A new optical bench has been ordered, along with automated high precision stepper motors for moving our test signal across the beam. Next week will be spent setting up the new equipment, and I am responsible for most of that, including writing programs to control the mech-
anisms. When that is set up, we will do more reliable beam profile measurements. Meanwhile, the Quasi-Optics plate has been sent back to Stockholm where it will receive a black coating.

During the week of 14 April, I was in Grenoble at the conference “Far Infrared and Submillimetre Universe”. This conference was completely devoted to the submillimetre space telescope FIRST to be launched in 2005. ESA has decided to merge this mission with the Planck mission, formerly called Cobras/Samba, which is an experiment to measure the anisotropy in the Cosmic Microwave Background. I also attended meetings on hardware for FIRST, specifically the heterodyne instrument. The Announcement of Opportunity will come out in September this year. My European colleagues have mentioned yet again that Canada is encouraged to take part in the FIRST/Planck mission.

The poster I presented at the conference can be seen on the web at the following address: http://www.oso.chalmers.se/~steve/FIRST/

Anders Emrich of Omnisys presented a poster on the correlator and PLL work. He included a spectrum of a synthesised signal at 4GHz in a 125MHz band. They have since tested the correlator over an integration of two hours, and claim that the noise integrates down as $\sqrt{\text{time}}$ as expected. Apparently, we can have the full 1GHz band correlator at Chalmers in a few weeks, and Anders would like to test it out on the Onsala 20m telescope. This would be a real test of the system, and a positive result would be very encouraging.

The French team want to return to Chalmers to test AOS synchronisation with the chopper and calibration mechanism. We had planned it for early May, but with the change of set-ups in the radiometer lab, we thought it best to postpone a bit. Also, if the correlator is here at the end of May, then we could also test the AOS for possible interference from the correlator. This is a potential problem since all the backends are connected together. Any return signal from a backend can leak into another. All the backends are supposed to be properly filtered against this possibility.

The telescope testing with the radiometer platform remains scheduled for the first week of July.
I am planning only one trip in May, again for FIRST. I will be at the meeting for the heterodyne instrument on 28-29 May at ESTEC in the Netherlands.

My best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
on secondment to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
fax. +46 31 16 45 13
Dear Sun,

During the first week of May, Gunnar Florin was here and he gave me the following delivery times for the Omnisys components. The flight model LO bias boxes should be mounted with their circuit boards and sent off for environmental testing by the second week of June. A complete set of bias systems for the LO’s is scheduled to be delivered during the week of 29 June. The FM phase lock loop boxes should be ready for environmental testing by mid June. Gunnar reported that the phase lock on the harmonic mixer in the LO chain was good, but I will comment on this further down.

A prototype correlator is meant to be ready now. Gunnar mentioned when he was here that the prototype correlator would not be delivered to Chalmers since it would mean that Omnisys would lose three days of work. I find this quite strange that Omnisys should be allowed to build a prototype and not deliver it. The reasoning was that the prototype with its PC-computer set-up which controls it would require three days of work to dis-assemble it at Omnisys, and re-assemble it at Chalmers. I found this explanation unsatisfactory, but could get no further with it. We therefore do not have the prototype. It’s very important that the correlator is operated outside Omnisys by our own people here at Chalmers. It’s the only thing that can convince us that it is really working properly. As it happens, there is a partial prototype working (4 out of 8 chains) but it remains at Omnisys.

The purpose of Gunnar’s visit was to cover the tuning mechanisms with a black absorbant coating which will allow heat to radiate out to space. The coating is a tape which is fastened to the mechanism by first applying a strip of double sided adhesive tape. I’m a bit worried about the air bubbles that are trapped under the tape. When the platform is in vacuum, the air will expand and possibly take the tape off the mechanism. We will probably cut lines across the tape which will allow the air to escape.
During the week of 19 May, the entire French team involved with the AOS came to Chalmers, and we spent the week testing the AOS. The AOS performs extremely well. We did long integration tests, and “off-on” tests which show a stable behaviour. The AOS was also tested in synchronisation with the chopper, which it did perfectly. After a long integration we noticed a signal towards one end of the IF band. It took us some time to find it, since it required testing the radiometer in a number of different set-ups. Eventually it became clear that the chopper was sending a spike to the mixers through the mixer bias lines each time the chopper moved.

This also explained the unfortunate fact that we had damaged a mixer diode earlier that week. The problem was related to the shielded semi-rigid cable used to transmit the bias current. After a number of connections and disconnections, the SMA connector seems to have been slightly damaged and no longer properly grounded to the shield. As a result, radiation, such as from a spark that’s created when a switch somewhere in the room is turned on, was able to get into the mixer bias lines. This was our first lost mixer in over a year. We must be careful to limit the number of times we make connections with the same cable.

At the end of that week, Alain Lecacheux, Carlo Rosolen, Michael Olberg, and our radiometer group went for a visit to Omnisys. Anders Emrich showed us the PLL and the correlator. As I mentioned, the PLL seems to have a good lock on the LO. What we saw in fact was the lock on the harmonic mixer, which in turn locks the Gunn. The phase noise is “riding” on the phase noise of the reference oscillator, so we can’t really say anything about the absolute phase noise level. However, the oscillator had already been tested in Finland and found to meet specifications. The real test for the phase lock will be when we take two locked LO’s and mix them together at 600GHz and then look at the spike that should appear in the IF. When the first prototype PLL was delivered at the end of ’95, this test showed a very broad bump and not a spike and then it was clear that the PLL was not good enough. I’m somewhat concerned by the fact that the PLL as demonstrated on 23 May had an external amplifier on the reference oscillator. If it turns out that the PLL requires this amplifier in order to work properly, then we will again be searching for space on the radiometer platform.

Anders Emrich also demonstrated the correlator by showing us the spectrum of a synthesized signal at 4GHz in a band of 200MHz. There seems to be quite a bit of work left to do on the correlator, especially in software. The correlator is controlled by a PC running the LabView software, but it is not yet equipped to understand the commands coming from the telemetry. Another possible area of concern is the fact that the present prototype correlator differs somewhat to the EM and FM models presently under fabrication. With the accelerated model philosophy used by SSC, Omnisys will be in a position of dealing with the EM model before the prototype
has been fully tested.

The radiometer lab is now finally air conditioned. We also have a new optical bench which makes a very rigid and precise set-up for the radiometer platform. At the end of the optical bench is a computer controlled x-y-z track which we will use to measure the beam profile of the radiometer.

We are still scheduled to send the radiometer to Toulouse at the end of June for the antenna testing. I am planning to remain with the platform the entire time it is in Toulouse to help with the testing. This schedule now depends on the 119GHz receiver being delivered to Chalmers with enough time to integrate it onto the platform and test it. Ylinen Co. in Finland has had some trouble with the ring filter which is used for LO injection, but so far we are still expecting them here by the third week of June.

best regards,

Steve

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Steve Torchinsky
Canadian Space Agency Research Fellow
Dept of Physics and Astronomy, University of Calgary, Canada
on secondment to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
fax. +46 31 16 45 13
Report for June, 1997

Date: Tue, 1 Jul 1997 18:49:43 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle
Subject: Monthly Odin Report for June

Dear Sun,

I'm writing to you from the CESR in Toulouse where we will begin to integrate the radiometer with the telescope this week. Magne Hagstrom arrived today with the radiometer and its support equipment (PC’s, bias supplies, etc). We packed everything on Friday into a mini-van, and Magne has been driving down from Gothenburg (ferry from Gothenburg to Kiel, Germany first of all, and by road the rest of the way). I flew down on Saturday.

The last few weeks at Chalmers has been very busy. We successfully set up our beam measuring system which consists of a precise x-y track with stepper motors controlled by computer, and the IF from the mixers is also recorded directly to computer from the spectrum analyser. It takes about an hour to do a map of the beam down to the -15dB level. We still have some work to do to get a better dynamic range on the system, but it is very useful now to find the main lobe of the beam.

Our initial measurements seem to show that the submm beam is not coaligned with the “mechanical” beam centre which we define using an ordinary laser beam through the optical system. However, this may be an artifact of our measuring system. In particular, we are using one of the LO’s as a source which is scanned across the radiometer beam. There is an absorber with a small aperture in front of the source feedhorn which should create something which looks like a point source in the radiometer far field. However, if there is still some directivity in the source beam, then what we are measuring is the convolution of the two beams. An angular offset in the source would then appear as an offset in the beam map. My feeling is that this is what is happening. We’ll repeat these experiments when the radiometer returns to Chalmers in August.

During last week we integrated the 119GHz receiver onto the platform. This went relatively smoothly, with a few problems that were solved along the way. At one point we thought we had a big problem with the optics when the beam turned out to
be double lobed with a big 3dB dip in the middle. As it turned out, this was being caused by a bracket on the optics plate which was holding an absorber. The bracket is just for our testing and not part of the flight optics. We removed the bracket and let the absorber stand free (leaning against the optics plate). This cured the problem immediately. Diffraction from metal objects along the beam path, even if they are outside the 30dB edge taper of the beam, can still cause dramatic results in the receiver beam profile. I’m reminded of the original optics scheme for the submm which had the beam truncated at the 20dB level by the corner of another mirror. This would have been totally disastrous.

We seem to be measuring a beam at 119GHz which is broader than expected. I’m curious to see if this is verified by the measurements we will do here. It may mean redesigning one of the mirrors on the optics plate, but that is not a big job. I want to do more testing first, and make a cleaner measurement before we decide to change anything in the design. I had been worried that the two lenses in the 119GHz chain would cause problems with reflections, but our anti-reflection grooves seem to be doing the job. We mapped the beam coming directly from the cold box through the lenses (and not through the rest of the optics). It looked very good.

Unfortunately, there is a big problem now with the telescope. The measurements here in Toulouse that are done with a bolometer and a large collimator showed last week that the position of the focus is displaced by 23cm from where it should be. Repeated measurements have confirmed this. We haven’t yet tracked down the cause. The test set up seems correct. The mechanical alignment of the reflectors was verified today and appears correct.

We will go ahead with integrating the radiometer with the telescope. On Thursday and Friday we will do more synchronisation testing with the AOS and the chopper. If we can’t solve the problem of the focus position, then the beam measurements at 119GHz with the hologram will have to be postponed. This is obviously a major problem, so I’ll try to keep you informed as things develop.
Regarding FIRST, my activities were very limited in June since Odin has been going through such a critical phase with the integration of the cold box, the 119GHz, and the preparation for the Toulouse tests. The next optics meeting for the heterodyne instrument will be on 15 July. I am organizing this meeting and it will be here in Toulouse, which saves me the travelling time.

best regards,

Steve

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Steve Torchinsky
Canadian Space Agency Research Associate
Department of Physics and Astronomy, University of Calgary, Canada posted to
Onsala Space Observatory, Gothenburg, Sweden
for the Odin Satellite Project

Date: Mon, 7 Jul 1997 17:21:22 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle
Subject: Odin antenna

Dear Sun,

It turns out that the error in the telescope alignment is due to the misplacement of reference pegs on the reflectors. These are small steel spheres of 3mm diameter sitting on legs of 1.5mm height from the mirror surface. Alignment of the reflectors is done by positioning the reference pegs to the right place relative to one another. There are three reference pegs on each reflector and the distance between each is checked so that the subreflector and main reflector are aligned properly with respect to one another. This was done here in Toulouse by people from SAAB aerospace in Sweden, who manufactured the telescope.

At SAAB, the surfaces of the mirrors were measured and found to conform to the designed surface to within 10microns. The positions of the reference pegs was also measured at that time so that the surface position, relative to the pegs was known. The error in the telescope alignment comes from the fact that the surface of the mirror is closer to the pegs than assumed in the calculation. That is, although the
reference pegs are correctly positioned, the mirrors are therefore too close together. The error is of the order of 4mm. We don’t know how this error came about since the mirror surfaces and peg positions were measured at the same time, in the same set-up.

Our present plan is to continue as much as possible with the radiometer during the next three weeks before returning to Chalmers. We have mounted it up with the telescope to be sure there are no mechanical problems in the set-up. On Wednesday, Urban Frisk and Fredrik Sjoberg will be here, and we will move the reflectors apart and test the submm response through the telescope. A proper alignment of the reflectors can not be done until the group from SAAB arrive, since they are responsible for the telescope. This will be done in the third week of August.

As a result, the beam profile testing at 119GHz with the Finnish hologram has been postponed. Magne Hagstrom and I will remain here in Toulouse with the radiometer for another three weeks, and then we will return to Chalmers where will do more beam profile testing. At the moment, we think we will return again to Toulouse with the radiometer in September at which time we will have integrated all the flight components that we have onto the platform. Presently, the platform is still a mixture of EM and FM components.

best regards,

Steve

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Steve Torchinsky
Canadian Space Agency Research Associate
Dept. of Physics and Astronomy, University of Calgary, Canada posted to Onsala Space Observatory, Gothenburg, Sweden
for the Odin Satellite Project ph. +46 31 772 1833
fax. +46 31 16 45 13
Dear Sun,

When Urban and Fredrik returned to Toulouse in the second week of July, they spent a couple of days readjusting the reflectors of the telescope. They were able to move the reflectors apart, but not as much as required. This was because the mechanical mounting system reached the end of its travel. It was not designed to adjust the mirrors to such a large amount as 5mm. However, the adjustment resulted in a very significant improvement: the focal plane moved from 230mm away from the designed position to within 20mm. As a result, we could do some meaningful testing with the radiometer.

It turned out to be rather difficult to align the radiometer platform along the optical axis as given by the Toulouse bolometer tests. Before we arrived in Toulouse, the antenna focus and beam axis was measured by Isabelle Ristorcelli and her group. A large aperture beam collimator is used to illuminate the entire aperture of the Odin main reflector with a plane wave. This simulates a point source in the far field of the telescope. The source used is a mercury lamp, and the radiation at around 200um is received by a cooled bolometer. A flat mirror after the telescope secondary mirror reflects the beam to the bolometer, and when we want to use the radiometer, we remove the flat mirror. The distance from the flat mirror to the bolometer is measured, and this distance is then used to position the radiometer platform. A laser is then mounted between the subreflector and the flat mirror so that it points directly at the bolometer. When the flat mirror is removed, the laser should strike the first mirror of the radiometer and continue along the optical path. In order to verify that the laser is directed properly, it must pass through two separate plates on the radiometer platform with 0.8mm diameter holes in them. We can also mount another laser on the radiometer platform, and shoot it out to see that it hits the subreflector in the centre.

The difficulty was in the mechanical adjustment of the radiometer. The platform is standing on its side and mounted on four legs whose height can be adjusted.
by turning bolts, and the position on the base plate is also adjustable since the legs are mounted in sliders. Although we had all the degrees of freedom necessary, the geometry turned out to be complicated. To make a desired rotation around the radiometer tertiary mirror we had to adjust every bolt. This is because our reference for alignment, which is the laser, strikes first of all the tertiary mirror. We must then adjust the radiometer platform by rotating it around the tertiary mirror, but the mounting system for the platform is far from the tertiary and it is not co-aligned with the tertiary’s normal axis. I was able to use AutoCAD to calculate the coordinate transformation required, but then it turned out that the adjustment required was beyond the play in the mounting system. This again is due to the fact that the telescope focal plane is 20mm offset from the expected location.

While verifying the radiometer, we measured extremely high receiver noise temperatures. We don’t know yet what the problem was, but it was strange that the submm receivers as well as the 119GHz receiver all showed this bad sensitivity. The 119GHz system was only just delivered to us a week before we went to Toulouse, and it is completely separate from the submm receivers. Either all mixers were damaged during the travel down from Sweden, or else there was something wrong with our measurement set-up that we used in Toulouse. We are back in Chalmers now, and we’ll be setting up the radiometer for tests this week to verify the noise temperatures.

Finally, on a positive note, we can claim we saw “first light” with the system. Despite the alignment difficulties, we decided to go ahead and try and map the beam at 574GHz using one of the submm mixers. For the first time, the radiometer received radiation coming through the complete Odin system. That is, all the optics of the radiometer platform as well as the telescope itself. We mounted a Gunn oscillator with multipliers at the source position of the collimator, and measured the beam with the radiometer. We also saw the mercury lamp with the radiometer, which is useful because that eliminates a variable between the set-up with the bolometer and with the radiometer.

In a next test, we moved the radiometer platform back to the position it should theoretically occupy if the telescope had been mounted perfectly. Interestingly, we still could map the beam. Of course, the beam centre was offset from the previous measurement, but not so much that it was out of the field of view. I think this indicates that aligning the system to optical precision using a laser is too stringent for a mm/submm telescope. It may be more reasonable to mount the radiometer in the nominal position, and then measure the beam at the RF. Afterwards, the star-trackers could be slightly adjusted to be co-aligned with the telescope beam. This methods can be used provided we carefully measure the antenna beam and ensure that we have a symmetric profile.
Overall, our stay in Toulouse was very useful, and we consider it to be a practice session for the next time we bring the radiometer and telescope together. We will bring with us the bits of equipment that we were missing this time, and Fredrik Sjoberg has promised to come up with a more convenient mounting/adjusting system for the radiometer. There will be fewer surprises next time, and things will go smoothly. At the moment, Urban thinks we can return to Toulouse in September, but I think that might be a bit too soon. It would be best if we could go down with a complete radiometer, including the phase lock system and the correlators. It’s especially useful to have a phase locked system when we measure the beam.

Regarding FIRST, on 15-16 July, I hosted a meeting of the Optical Working Group for the Heterodyne Instrument which took place in Toulouse. We are now dividing the work amongst the participating labs. I am responsible to design a subsystem of the optics before October, in time for the Announcement of Opportunity. The work I’m doing now will be considered part of our Canadian contribution, if Canada becomes a participant in FIRST. The main role for Canada can be with the phase lock electronics. It’s a very big job to provide the lock system for ten of the mixers in the frequency range 500GHz to 1200GHz divided into five bands. This could be developed by Canadian industry under the supervision of a University (or CSA or NRC) scientist.

Best regards,

Steve

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Steve Torchinsky
Canadian Space Agency Research Associate
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
office +46 31 772 1833
lab +46 31 772 1838
fax +46 31 16 45 13
Report for August, 1997

Date: Wed, 3 Sep 1997 17:21:04 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: David Kendall, Victor Wehrle
Subject: Monthly Odin Report for August

Dear Sun,

Most of August was spent testing the 119GHz receiver. We have not yet cooled the receiver, but at room temperature we measured a system noise temperature of 2850K. Ylinen Co in Finland were already aware of a slight mistuning on the receiver, so when we ship it back to them they will retune it. They expect we should measure 1500K at room temperature, and down to about 800K when the receiver is cooled to 100K. These are single side band noise temperatures.

The noise temperature we measure now is much better than what we saw in Toulouse, and it seems the problem was with a power detector on the network analyser, and nothing to do with the receiver itself. We suspected (or rather, hoped) the problem might be something like that, and it’s quite a relief to measuring a reasonable noise temperature.

I spoke to Iltcho Angelov today about the 119GHz pre-amplifier. In May this year he received four amplifier chips from Sandi Weinreb, of which three survived the trip over. These are experimental and were given to the Microwave Dept here. In October, Weinreb will have another wafer of chips and we have paid to receive some chips from that batch. Meanwhile, the first three chips can be used for experiments and to gain experience. There are also chips developed here at Chalmers, but Iltcho doesn’t think they could pass environmental testing. He says he’s sure that an amplifier can be working by January, and that it should have about 15dB of gain, which would improve the 119GHz receiver noise temperature by about three times.

In June we had measured the beam profile at 119GHz and we found it to be broader than expected at the output of the lenses in front of the cold box. We spent a lot of time this month making repeated measurements in different configurations. By measuring the beam at different distances from the receiver, we can build up a picture of the expansion of the beam which can be compared to the theoretical calculations. We’ve discovered a bit of trouble with our set-up when we didn’t get...
repeated results of measurements we had taken a few days earlier. This was three weeks ago, and we’ve been working ever since to try and figure out why the beam looks different now. At first it seemed to be a problem with the measurement set-up, or the displaying software (which I wrote in IDL) but we’ve gone over it many times, and the same set up is used to measure the submm beam, which has a very nice profile.

The 119GHz beam appears now to be not only too broad, but it is also asymmetrical. This is not a problem with the receiver itself, since the measurements we did of the horn without any optics in front shows what we expect to see. I’ve designed a new lens to go in front of the feedhorn, and I have a scheme to replace the first three elements entirely. I think there may also be a problem with the a focusing mirror sitting very close to the waist position, and in the new design, that mirror will be flat instead. Otherwise, the new system will couple to the rest of the optics in the same way. We’re planning to continue testing for the rest of September before sending the 119GHz receiver back to Finland for retuning and environmental testing. Tomorrow we will test the new lens, which sits closer to the feedhorn, and if this cures the problem we will go ahead with the new design and then test it.

During August, Omnisys delivered some components to Chalmers. The Phase Lock Loop box was here briefly before being returned for environmental testing. We haven’t yet had a chance to test it here, but we opened it up and at least on first sight it’s much improved from the first version we had a year ago. In particular, the oscillators are well shielded from other parts of the circuitry, and the bias circuits are in another box entirely. They also delivered two of the Local Oscillator bias supplies which are integrated on the mounting block of the LO’s themselves and are working here now. The mixer bias box was delivered at the same time. They also delivered to us a PC running LabView software which controls the bias supplies. This is temporary until they deliver the controller for the front end electronics. So, still to come is the controller for the bias supplies and for the Phase Lock Loop, the PLL itself, and of course, the correlator.
On August 26th Lars Stenmark of ACR was here to see about a problem with the submm assembly entering the cold box. The bracket inside the cold box doesn’t allow for the passage of one of the mixers, and some material must be removed. This was discussed a couple of months ago, but apparently a sketch sent to ACR wasn’t clear enough and the blockage is still there. The cold box structure is quite complex with the main ring suspended by kevlar threads and mylar blankets surrounding the receiver unit. Taking apart the cold box to alter the bracket and then putting it back together is a task requiring at least a month. Stenmark will instead removed the necessary material after first protecting the box with an inner lining, securing the bracket, and then machining it within the cold box. The process of protection takes two days itself, so the modification of the box should take about a week. Meanwhile we are working with the EM version of the cold box.

Best regards,

Steve

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Steve Torchinsky
Canadian Space Agency Research Associate
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Dear Sun,

I'm sorry to be reporting a number of setbacks this month, mainly to do with environmental testing.

Last week, four LO’s underwent vibration testing while mounted on the diplexer plate. These are the “resting” LO’s, two flight and two qualification models, complete with their integrated bias supplies. None of the LO’s survived. In three cases at least one of the multipliers had damaged diodes, in the fourth case it was the harmonic mixer (which is essential for phase locking). This is a surprising result since all LO’s are vibrated at Radiometer Physics and tested before delivery. The main difference here is that the LO’s were mounted on the diplexer platform together with the grid tower, and there may be resonance at a frequency which was not duplicated in Zimmermann’s vibration testing.

Due to the highly integrated nature of the LO’s with their bias supplies, it is not a simple matter to refurbish them. The LO’s can only be released from their mounting bracket by first removing the bias circuit board, and the circuit board in turn must have its connectors de-soldered before it can be removed. Dismounting and remounting the LO bias cards will be a job of a few days for each unit, to be done at Omnisys Instruments. I’m not sure how long it will take to repair the LO’s themselves.

The loss of the LO’s poses problems for our testing here at Chalmers. We will not be able to integrate and test half the submm channels. We were due to begin testing the submm beams, and to make sure that all four are co-aligned on the sky.

Another component which did not survive vibration was the PLL. One of the units lost its 10MHz reference oscillator. This will also have to be repaired at Omnisys.

Although the PLL and correlator engineering models have been built, we have not yet tested them here at Chalmers. SSC has the components undergo environmental
testing before electrical testing at Chalmers. Of course, the units are tested at Omnisys before delivery, but it’s a different matter to have them working together within the Odin system as a whole, and also operated by us and not by the people who built it. We would prefer if the units were delivered here before they underwent environmental testing. This would also be useful for the AOS testing to see if there is any contribution to system noise from the correlator and PLL. The failure of the PLL in vibration testing means that we cannot do the system level tests with it here.

Last week Jacques Narbonne and Roger Pons from CESR Toulouse were here to test the control software of the AOS. Gunnar Florin from SSC was also here for one day to help. The Marseille Lab (LAS) and CNES would like to be finished with the AOS, and in order to do that, we need to freeze the software design so it can be burned into the PROM. We checked out the synchronisation of the AOS with the chopper, the calibration switch mirror, the Attitude Control, and the Frequency Switch mode of the 119GHz receiver.

Synchronisation of the chopper had been done before, and we re-verified it last week. The calibration switch mirror is also properly synchronised with the AOS. At first we noticed a fluctuation in the identification bit for the calibration mirror, even though it was stationary. After some investigation, and inquiries at ACR in Stockholm who manufactured all the mechanisms, the problem was identified with the connections of the cables of all the mechanisms. It seems we must have everything connected in order to avoid erroneous information passing into the telemetry format. I’m a bit worried about this since I wonder if we are susceptible to bad telemetry if a mechanism fails. That is, would a failed mechanism have the same affect as an open connection.

In order to search for the cause of the bad bit in the telemetry, the mechanisms were disconnected and reconnected one by one. This was done to see if a particular mechanism was responsible for the erroneous data in the telemetry. Unfortunately, it seems at one point a short circuit happened which momentarily brought the 28V power supply to zero. Meanwhile the laser diode in the AOS was running on full current, and the sudden drop caused it to burn out which rounded out our week of disasters.

Jacques and Roger returned to Toulouse on Thursday taking the AOS with them. It will be repaired in Marseille. In November when I return to Chalmers the refurbished Engineering Model AOS, and the Qualification Model will both be delivered. Jacques and Roger along with Alain Lecacheux and Carlo Rosolen will be here at that time to help integrate the QM AOS, and check out the software once again.

The only aspect of the control software which was unsatisfactory was the synchro-
nisation with the frequency switching mode of the 119GHz receiver. We get signal in the off-switched frequency. This is happening because of a difference in timing between the AOS, the telemetry pulse, and the 119GHz frequency switch. The telemetry format is sent 16 times per second (once every 63msec). The AOS stores a spectrum every 23msec, and keeps a co-added stack of spectra in memory until the next telemetry pulse. When the switch bit is read at the AOS, it discards the spectrum it is working on, since the frequency was switched in the middle of that integration. The problem arises because the frequency switch can occur anytime within the 63msec time frame of the telemetry format and the AOS already has time to put a spectrum on the stack. The spectrum that is sent in the format is therefore contaminated with the undesired switched frequency.

Roger has come up with a solution to the problem, but it requires changes in the Finnish 119GHz software. The frequency switching should be synchronised with the telemetry pulse. This way there is no slippage between the frequency switching and the time that the AOS knows that the frequency was switched. I understand that modifying the 119GHz control software is problematic because the person who did the job is no longer with Ylinen Co.

Next week the cooling system is meant to be delivered and cooling tests will begin. The platform will go in the vacuum box, the cooler tested, and noise temperatures measured for the first time at a cold physical temperature.

I was told that at the recent Agencies Meeting, the launch date was agreed to be 30 September 1998. It’s difficult to see how this can be achieved. We don’t have a fully integrated radiometer yet. We haven’t yet operated the cooling system, the correlators nor the PLL here at Chalmers. I’m sure there will be some system problems to iron out with those components. Of course, the failure of the LO’s in the vibration tests must also be considered. It’s not yet clear to what extent that will delay us.
I will be at the Paris Observatory this Thursday and Friday 2-3 October. I'm at the CSA on Friday 10 October, and in Calgary on the 15th.

Best regards,

Steve

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Steve Torchinsky
Canadian Space Agency Research Associate
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Dear Sun,

While I was in Canada, the main effort here at Chalmers was with the cooler for the radiometer. The cooler system was purchased from British Aerospace/Matra by the CSA as part of the Canadian contribution. It has already been tested in Stockholm where it cooled down the flight cold box with dummy loads to a temperature of 120K. It took three days before that temperature was reached.

We had the cold box loaded with true components (brackets, mixers, amplifiers, and connectors). After one day of cooling the temperature got down to 195K. The cold box components were not completely in flight configuration. Most importantly, the connections from mixers to amplifiers were not made with low thermal conductivity cables. With the heat flow coming through the copper wires, it was decided not to be worth trying to get down to 120K.

This week Magne Hagstrom will go to Stockholm to discuss the cabling scheme with Lars Stenmark of ACR. Magne will take the cold box with him on Wednesday and return with it on Thursday. Next week the cold box will be completely in flight configuration, and we will do another cooling test.

The LO’s which had been damaged in the vibration testing last month have now been repaired at Radiometer Physics in Germany. They are presently at Omnisys in Gothenburg where the bias circuit boards are being remounted into the LO brackets. Afterwards, they will be returned to Radiometer Physics to undergo vibration testing. Zimmerman’s vibration testing will be done on the dummy diplexer platform, whereas last time he had only vibrated the LO’s on their mounting brackets. It was later in Stockholm that they were vibrated on the diplexer platform, and where they failed. Our dummy diplexer tower and platform need some modifications to better emulate the flight hardware. These will be sent to Radiometer Physics this week, ie before the LO’s are ready at Omnisys.

When I returned from Canada, I expected the 119GHz receiver to have been returned
from Finland, but unfortunately it is not here. I’m not sure what has happened with that, and I’m waiting to hear from Petri Jukkala of Ylinen in Helsinki. Meanwhile, our work to straighten out the beam at 119GHz must wait.

I’m also waiting before asking the French to deliver the refurbished AOS engineering model. The AOS is ready, but I would like to redo the synchronisation verification of the AOS with the 119GHz frequency switching mode. This question has not yet been resolved. I sent an email to Urban last week asking whether we will modify the 119GHz control software. He has not yet responded. There is probably a reluctance to change the control software because I believe it is already burned into a PROM chip in the 119GHz controller. In this case, a change in software becomes expensive. This is the reason why the French have been waiting before delivering the qualification model AOS. Once the telemetry interface is established, they can burn the PROM and deliver the QM.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Dear Sun,

The radiometer was mostly occupied this month with vacuum and cooling tests. Cooling never reached a satisfactory level with the minimum temperature we reached being 180K. We seem to be hampered by a poor vacuum. The chamber is quite large since it must house the entire radiometer platform, and our pump was probably not powerful enough. This week we fitted a pump with a much higher capacity, and we also polished away a scratch in the rim of the vacuum chamber which may have been the source of a leak. Now our vacuum is better: about 2X10^-5mBars.

Meanwhile, the cooler itself is back in Stockholm. There is a problem with the power cable connector which sticks out into our diplexer tower. We have modified one of the roof-top mirrors in the diplexer to allow more space, and the connector on the cooler will also be modified.

We haven’t been using the flight model mixers for these cooling tests so we don’t have a noise temperature to quote at the cold physical temperature. We want to minimise the number of times a mixer is cycled between warm and cold so we are using a prototype mixer which also happens to have a soft diode. The noise temperature of that mixer is very poor, but it’s not representative of the flight hardware.

At the end of next week Jacques Narbonne and Roger Pons from Toulouse will deliver the EM AOS and we will perform the synchronisation testing. The Finnish company, Ylinen, have made the changes to the control software of the 119GHz receiver so we can see how the frequency switching mode works with the AOS. We will have the 119GHz receiver for a week to do the synchronisation tests, and also to do some beam measurements.

The next lens we will try has horizontal grooves. The lens itself has circular symmetry of course, but we want to try grooves which are not rings but which are instead oriented along the polarisation axis of the beam. The geometry is no longer simple.
when we cut a straight groove across the surface of an ellipsoid (in fact, it’s not exactly an ellipsoid). The lens itself was turned on a lathe, and the grooves were then cut using a computer controlled milling machine and a program I wrote to cut the horizontal grooves. The lens came out quite nice in the end and I’m curious to see how the beam looks.

We have some good news from the Helsinki group regarding the trouble we’ve had with the 119GHz beam. They measured the beam from the receiver with our lens in front of it. That is, the lens with the circular grooves. When we had measured the beam with that configuration we saw a highly elliptical beam pattern. We had also measured elliptical beams from various other lens designs. Petri Piironen at Helsinki told us today that they measured a circular beam, so it seems clear that we have a problem with our measurement set-up here at Chalmers. This is preferable to the alternative, which would be that the 119GHz optics were not designed/manufactured properly. Petri will come here on 9-10 December and we will make measurements together. Perhaps he can see what we’ve been doing wrong. It probably has to do with the radiation source we’re using.

There is a slight chance that we will also have the correlator here on Monday 8 December. Anders Emrich of Omnisys is interested to test the synchronisation of the correlator with the chopper, calibration switch, and 119GHz frequency switching. Since the French will be here doing the same, and the 119GHz receiver will also be here, he felt it was a good opportunity to carry out those tests on the correlator. However, Anders is not sure if he will be ready in time. We certainly would like to see the correlator here, not only for synchronisation testing, but also to see how it behaves within the entire radiometer system. There is a question as to whether the backends might suffer from cross-talk between one another. Anders assures us that there is no problem with that, but we’d like to verify it empirically.

Regarding the 119GHz HEMT pre-amplifier, there is a set-back. At the beginning of November Iltcho Angelov suffered from a very fierce virus. He had extremely high fever for a few days, and was lucky that the doctor who treated him recognized what it was at an early stage. Iltcho has been recovering in the hospital for the past three weeks, and is finally at home this week, but he will probably not be back at work until the new year. He has been the main person in the design and assembly of the 119GHz amplifier. Herbert Zirath can take on some of the load, but I’m sure the amplifier work will be delayed.

I will be in the Netherlands next week. On Monday and Tuesday I will be at SRON Groningen to discuss the FIRST optics with Herman van de Stadt and Nick Whyborn. On Wednesday we have the “AO Clarification Meeting” at ESA, and finally on Thursday it’s a meeting of the Heterodyne Instrument Consortium. We are beginning to put together the proposal to answer the AO.
best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Dear Sun,

During the first week of December, Jacques Narbonne and Roger Pons came to Chalmers from Toulouse with the refurbished Engineering model Acousto-Optic Spectrometer. The AOS had its laser diode replaced in Marseille and it is working well. At the same time, the 119GHz receiver was sent to us from Finland and we were able to re-do the synchronisation testing of the frequency switching mode. This is performing properly with the AOS producing clean spectra. There is no contamination in each spectrum from the signal before the frequency switch occurs. The 119GHz receiver now sends a signal on the telemetry pulse 30msec before the frequency switch occurs. This gives the AOS time to react, and by rejecting two 23msec spectra stored in the AOS, the integrated signal no longer has any spurious signal from the wrong frequency switch.

With the control software working satisfactorily, the French will go ahead and burn the PROM. The Qualification Model AOS will be delivered to Chalmers soon afterward, probably at the end of January. Unlike the Engineering Model, the QM AOS can be operated in vacuum which is useful since we are now doing testing with the radiometer in the vacuum box for cooling.

The cooler was returned to Chalmers this week, but we continue to have difficulty getting down in temperature. At the moment, the temperature of the first stage IF amplifiers is 185K and they should be down at 120K. The mixers are at 140K. We had suspected that our vacuum was not good enough and that heat was being transferred by convection to the vacuum chamber walls, but this is not the case. The vacuum chamber has been refitted with a higher capacity pump, and we now achieve quite a good vacuum. It could be that there is more heat transfer than expected coming through the cables connecting the mixers to the amplifiers and to the electronics boxes outside the cold box, or that we simply don’t have enough cooling power.
The 119GHz receiver has spurious signals appearing in the IF at 100MHz intervals. Petri Jukkala at Ylinen in Helsinki tells us this is from the 100MHz reference oscillator used in the phase lock loop. Eventually the 119GHz receiver will be returned to Helsinki to have this problem cleared up, but first it will be sent to ACR in Stockholm where the cold box will have its cable harness set-up for the 119GHz receiver. This will be done over the Christmas break. Afterwards, we will have the receiver here in Chalmers again to complete our optics work, and then, in the second week of January, it will be shipped back to Helsinki.

Petri Piironen from Helsinki University of Technology came here during the second week of December, overlapping his visit with the AOS testing. He came here mainly to help us with our beam measurements, and he brought along his phase locked 119GHz source which has a corrugated feedhorn. Using a feedhorn instead of something which looks like a point source adds a small complication in that one must de-convolve the source horn pattern from the receiver pattern. This is easily done using the well known pattern for the corrugated horn. We made measurements using the Finnish source, and were particularly scrupulous in placing absorbers around the measurement set up. The results showed a nearly perfectly circular beam. It seems clear that the problem with the elliptical beam was due to the test source and not the receiver. Some time ago, we had made measurements on our 119GHz source, and we did not detect ellipticity in it. So for the moment, the cause of the ellipticity remains a bit of a mystery. Nevertheless, the phase locked source with a corrugated horn is a much cleaner and more reliable test signal, so we are very confident of the results.

Another bit of very important information that Petri Piironen brought with him was the location of the far-field phase centre of the receiver feedhorn. In the original design for the optics which was done by Erik Ordell three years ago, the position for the horn phase centre that he used was 17mm inside the horn from the horn mouth. I have always used the same number in my calculations, and I must admit that it never occurred to me to verify the horn parameters used by Erik. The horn far-field phase centre is where we put the virtual origin of the Gaussian beam in the optics calculations. Petri told us that this position is closer to 3.9mm behind the horn mouth, and definitely not 17mm. I’m not sure where the value 17mm comes from in Erik’s paper, but I guess there was a misunderstanding about it perhaps four or five years ago.

I designed a new lens based on the correct horn parameters, and we tested it earlier this week. The result was extremely satisfying. The beam is circular to within 99.4% at the 3dB level, and we also now have quite a good agreement between the measured beam profile and the expected result. Thus we have cleared up the two main problems with the 119GHz optics. One was the beam ellipticity which was a
phantom problem, and the other was the incorrect beam size which was due to using the wrong position of the horn phase centre. It remains only to design, manufacture and test the second lens in the system which will take about a week and will be done after the Christmas break.

A couple of weeks ago, Omnisys delivered to Chalmers one of the Phase Lock Loop boxes with its controller electronics box. We have four Local Oscillator units here, and we have been testing them with the PLL. The phase lock we see is acceptably clean and we have performed the crucial test of mixing two locked LO's together and looking at the resulting signal in the IF. This is a direct measurement of the phase noise at the submillimeter frequencies, and we see a nice spike in the IF band which drops 20dB at 100kHz from the peak. When this test was performed on the prototype PLL which was delivered over a year ago, the result was not a spike but a very broad bump, so the EM PLL is a vast improvement.

The PLL is now acceptable with possibly one reservation, and that is the contamination just outside the IF band by the reference oscillator inside the lock box. This was a problem on the prototype PLL and we see again with this EM PLL. Last time, the reference oscillator was coming into the IF via the mixer bias because of poor shielding between the reference oscillator and the bias electronics. The new PLL design has adequate shielding, and the mixer bias electronics is entirely separate. The reference oscillator is coming in this time by the cross coupler after the Gunn in the LO chain, and it is modulating the 90GHz Gunn signal. This then propagates through the multipliers and gets into the mixer optically. That is, through its feedhorn. It is perhaps a faulty design to use a reference oscillator at 4.8GHz since it is so close to our IF band, however we are stuck with it. We are now testing to see what effect the 4.8GHz spike has on our system performance.

During testing of the PLL we have discovered a few problems with the Local Oscillator units. On one LO unit, the Gunn is unstable in part of the varactor tuning band. This means that when the bias on the varactor is set at some level within this band, the Gunn can oscillate with more than one frequency, and it becomes impossible to lock. The unuseable band for that Gunn is right in the middle, as one might expect. That LO unit is therefore unacceptable and will have to go back to Radiometer Physics for repair. A second LO unit has very low output power after the tripler (around 550GHz) so that one must also be repaired. The four LO's that we have here were already due to be returned to Radiometer Physics, so they will all go back as planned and Zimmerman will have to attend to these additional problems. I don’t think it is possible that he can do much about the cross-coupler after the Gunn to help with the spurious spike from the PLL. A directional coupler might help but it would have to be mechanically longer than the present component, and we simply have no space to add volume to the LO chains. Zimmerman will of course be
informed of the problem with the PLL and maybe he’ll have an alternative solution. Meanwhile, the other four LO units are on their way back to us from Radiometer Physics after having survived the vibration testing. We will use them in our future tests while Zimmerman works on the present ones.

I mentioned last month that Anders Emrich might deliver the correlator to Chalmers for some preliminary testing. I saw him myself while I was in the Netherlands for meetings at ESA for the FIRST satellite project. Sweden is hoping to provide the correlators for FIRST, but the rest of the FIRST community is waiting to see success with the Odin correlators before they accept the Swedish proposal. I asked Anders if he would be coming to Chalmers with the correlator and he still thought it was possible. In the end, however, he did not come which is perhaps not surprising but I was hopeful just the same. I know that the correlator has shown spectra of a synthesiser taken in the lab at Omnisys, but none of us will be satisfied until we see it working on the radiometer platform as part of the total system.

We have a personnel change in the Odin group here at Chalmers. One of our lab technicians, Christy Confrey, is leaving Chalmers to work in an electronics company in Gothenburg. This reduces the group to four, which includes the group leader Magne Hagstrom, the amplifier engineer Magnus Dahlgren, the mechanical craftsman Sven-Erik Ferm, and me. Christy was the only one of us who has been with the Odin project since the beginning so we are losing both a competent lab technician as well as a link to the early part of the project. Nevertheless, I think we have enough people working here to finish integrating the radiometer.

I will be spending the Christmas break over the next two weeks in France. The 6th of January is a holiday in Sweden so we will all be back at work on the 7th. I am planning to visit the lab in Toulouse possibly on the 5th or 6th before returning to Sweden. Isabelle Ristorcelli and her group are testing the reflectors now, as they did this past summer. This is in preparation for the tests we will eventually do with the fully integrated radiometer platform.
my very best wishes for the holidays and for a healthy and happy new year,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for January, 1998

Date: Mon, 2 Feb 1998 18:34:49 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle, David Kendall
Subject: Monthly Odin Report for January 98

Dear Sun,

Last Thursday, 30 January, the Autocorrelator finally made its appearance in our lab. Anders Emrich delivered the correlator and remained at Chalmers for the next two days to try and integrate it into the Odin system. Urban Frisk was also here. The correlator on-board software is not yet at a functional level. Anders spent his time trying to track down a problem with the communication of the correlator to the telemetry. We were not able to take any spectra. Nevertheless, it’s quite a boost to our confidence to actually have the unit here. It is still here and Anders intends to return this week. Meanwhile he is working on the problem at Omnisys. Urban will also return this week.

I began the month with a visit to the Toulouse lab on the 5th of January. This was just before returning to Sweden after the Christmas break. I had discussions with Isabelle Ristorcelli about the upcoming antenna tests which are now scheduled for September. This is a change from a date in February and comes about by a re-organisation of the testing procedure. As was mentioned at the Science Team meeting, we will now do the Telescope/Radiometer alignment, and the 119GHz hologram work in Linkoping in March while the Toulouse work is moved back to September.

The 119GHz receiver and the Cold-box was at ACR in Trossa (near Stockholm) over the holidays. This was for finalising the cabling within the box. Our intention was to continue work on the 119 optics right after Christmas, but the receiver did not return to Chalmers until the beginning of the third week of January. We subsequently spent a few days straightening out the optics. Since the problem of the elliptical beam was understood to be a product of our test set-up, which was cleared up before Christmas, we only needed a couple of days to make lenses and test them. We measured the beam from the first lens, and I designed the second lens based on the measured results of the first lens (ie, incorporating some compensation for the difference from the theoretically calculated beam). The result as I showed at the
Science Team meeting was very good agreement between the required beam profile and the measured beam profile.

The 119GHz receiver has since been returned to Ylinen Co in Finland where it must undergo a number of corrections. The mixer must be re-tuned to improve the poor noise performance. Also, there was a problem with a 100MHz ripple appearing across the IF band. This was apparently coming in from the PLL inside the 119GHz control part (sometimes referred to as the “warm part”). Note that this is not the PLL from Omnisys in Gothenburg. It’s part of the 119 system produced at Ylinen.

The problem in the submm system with the 4.8GHz spike appearing at the IF is difficult to understand. It seems to be coming in from the RF since we can suppress it when we cover the LO feedhorn. This is different than the problem we had with the prototype PLL which had the same symptoms but for a different reason. In that case, the 4.8GHz was coming in by the DC bias lines. This is not the case in the present system. At the moment, the spike at 4.8GHz seriously affects our dynamic range, and therefore our system noise temperature. We produced a short document showing the affect on the system with the AOS as a backend. We are affected by the 4.8GHz in the IF because the IF amplifiers still have some gain at that frequency which effectively lifts the noise floor of the amplifier. The result is a higher noise level in the IF even though the spike itself is outside the IF band. As Urban mentioned at the Science Team meeting, this problem will be tackled by adding filters into the system to take away the 4.8GHz. Therefore the total system performance will not be quite up to that expected in a system which doesn’t require filters.
The French teams from Toulouse and Marseille are here this week delivering the Qualification Model AOS. We will integrate it onto the platform and perform as many tests as possible. We are a bit limited in the tests we can perform. Since the 119 receiver is not here, we can’t verify the frequency switching mode, but there is no reason to think that the QM does not behave as the EM in this respect. Now that the correlator is here, we can finally test for system level interference between the two backends. Even if the correlator is not yet sending spectra to the telemetry, simply by being powered up and connected to the IF we can verify that the AOS is not affected by the correlator. We expect Anders Emrich to return this week to continue with the integration of the correlator. Next week, Alain Lecacheux will also be here to continue with AOS testing and help with the correlator integration.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for February, 1998

Dear Sun,

February began rather optimistically with the arrival of the correlator, but we have slowed down considerably since then for a number of reasons.

At the beginning of February, a French AOS team of five people arrived to deliver the Qualification Model AOS. They were three from the CESR in Toulouse, and two from LAS in Marseille. We spent the week checking out the functionality of the AOS including the synchronisation with the chopper, the internal frequency calibration system, and its long term stability. Everything seems to check out fine. There is a slight anomaly in the temperature of the laser diode in the form of a regular variation in the temperature which repeats itself over a period of 27 seconds. The amplitude of the variation is very small, only about one tenth of a degree Celsius, but the French team were still curious to know the cause. This variation only occurs when the AOS is working with our telemetry setup, and it doesn’t occur with the French simulator card (provided by SSC). The system performance is not affected by this.

We were unable to check the synchronisation with the 119GHz frequency switching mode since the 119GHz receiver is not here. However, since this was all verified with the EM AOS, we don’t expect anything different with the QM and FM.

When the correlator was here during that week, Anders Emrich and Urban Frisk were working to integrate it into the Odin telemetry system. It was not connected to the IF output from the radiometer, and finally, we did not receive any meaningful telemetry from the correlator. Anders must still complete the correlator control software and he returned to Omnisys with the correlator to continue working on it.

The following week, Alain Lecacheux, Carlo Rosolen and Vincent Clerc from Paris Observatory (Meudon) came here for more testing of the AOS. Alain wanted to verify the long term stability, the sensitivity after long integrations, and the frequency calibration of the AOS. The AOS is working very well, and when Anders Emrich
returned during that week with the correlator, we concentrated on working with that.

This time, the correlator was connected to the IF of the radiometer, and switched on while the AOS was also taking data. This is the main test that Alain has wanted to do for a very long time. All three backends are effectively connected at the input ports because they can each look at any of the five mixer IF outputs. The correlators can also take input from the signal combiner. Alain has been worried that there may be some interference from the correlator to the AOS. As it turns out, he has been perfectly correct all this time. When we switched on the correlator, we immediately saw an extremely strong signal at 4.2GHz in the AOS spectra.

At the time the spike appeared, the radiometer was chopping between the internal load and multiplied Gunn source, which however was not running. Just to be sure, we blocked the mixer feedhorn with absorber, but the spike in the AOS spectra was unaffected. It disappeared when we switched off the correlator.

The 4.2GHz signal in the correlator comes from an oscillator inside the box which is used to split the incoming IF band into four bands. There are four such oscillators, but the one at 4.2GHz was extremely strong. In fact, the signal coming from the correlator was so strong that we were able to see it simply by holding an open cable in the air a few centimeters above the box. The signal was perfectly clear on the spectrum analyser.

So the correlator was seriously affecting the rest of the radiometer system, and in addition the integration with the telemetry was still not complete. We never saw any spectra measured by the correlator.

I expected Anders Emrich and Urban Frisk to return to the radiometer lab the following week for more testing with the correlator, but they did not. Finally, I heard from Gunnar Florin that the correlator was sent directly to Stockholm for “official” delivery along with documentation. I sent a note to Urban pointing out the problem with the 4.2GHz. I hope that the correlator will undergo functional testing here before it is officially accepted. Once again I find the situation with the correlator quite frustrating because we don’t see what is happening with it. For the last two weeks we have had no information about it.

We now also have a delay due to a problem with a component delivery for the 4GHz Low Noise Amplifiers. Although we have five LNA’s accepted and flight tested, there was some question of their stability. Some time ago we decided to make a new set of amplifiers to replace the present set of five, which in turn would become flight spares. The new amplifiers were designed by Iltcho Angelov and Magnus Dahlgren. Iltcho is also responsible for the 119GHz pre-amplifier. The new amplifiers have a
better performance. The problem comes in with a new set of isolators ordered from a U.S. company called Pamtech. Pamtech delivered isolators which are one and a half times larger than what was specified. Moreover, they do not meet the electrical specifications. Mechanically, we have no leeway to allow for bigger components inside the cold box. The situation is being discussed now with Pamtech, but it's clear we are delayed by several weeks.

Meanwhile, Ylinen Co in Helsinki is waiting for the Chalmers LNA in order to complete their integration of the 119GHz receiver. In a report they mentioned that the problem with the ripple in the IF has been taken care of by using filters. Also, the mixer backshort has been retuned. They are only waiting for the new LNA to complete the receiver. Alternatively, we can continue to use the previous version of the LNA, but because of a repair it underwent recently, it will have to be requalified anyway.

Iltcho Angelov has now produced a 119GHz amplifier with a measured gain of around 14dB. He has not been able to measure its noise temperature because of the lack of a noise source and receiver at 119GHz. We will be able to measure it in the Odin 119GHz receiver as soon as it gets here. Clearly this problem with the delivery of the isolators for the LNA’s has had a chain reaction effect on our general progress.
With the problems we have seen this month, and especially with the correlator remaining as an unknown element, I don’t see how we can keep to the schedule presented at the last Odin Science Team meeting. It would be useful to us to know more realistic dates when components are to be delivered and when various testing must be done. The success oriented planning which we always see presented by SSC is unrealistic.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se (please note the change from EP to OSO)
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Dear Sun,

We have been very busy these last few weeks since the correlator was re-delivered on 12 March. Urban Frisk has been here much of the time to help out, usually three or four days per week. Mostly we were trying to get the correlator to respond to commands. The problem with the spike at 4.2GHz was cleared up, but the correlator would only work in its 8 band mode (i.e., minimum frequency resolution, widest bandwidth). Also, one of the A/D converters was faulty, so one of the 8 bands produced non-useful data.

The documentation on the correlator is quite sketchy, and Urban has been in regular contact with Anders Emrich at Omnisys. I’m happy to say that Anders has been very cooperative these past couple of weeks, and he’s been working hard to correct the control software and the telemetry communication of the correlator. This week, on Tuesday night around 8pm he delivered another EM correlator which was in fact the refurbished model we were testing in February. He remained for a while to help out with the testing and explained how the output is organized in the telemetry formats. Anders took back the other correlator so that we have one here while he repairs the one with the faulty A/D converter and reprograms the PROM. The correlator we have now seems to be functioning properly. It responds to commands and gives sensible output to the telemetry. We can make it work in single band mode (high resolution) as well as 2 band mode, 4 band mode, and 8 band mode. We will continue now with more in-depth testing of the correlator performance. We are extremely pleased and relieved that the correlator has reached this level of functionality, and I’m feeling much more optimistic about the project than I have in a long time.

With the testing of the correlator and the AOS we have been producing quite a bit of data. I have set up an archive of all the lab tests so far which can be accessed using the Odin project userid and password (the same we use on the SSC web pages). The address is ftp://rsspc7.rss.chalmers.se The server also gives you access to our
The Odin Chronicles - S.A. Torchinsky

TM saver which is stocking the telemetry files (ie level 0 data). This has been quite useful since a number of people can then participate in the data analysis; mainly Alain Lecacheux, Michael Olberg, and Urban Frisk (when he is not here).

Urban has been spending a lot of time here not only to help with the correlator, but also to lend a hand to our reduced group. During most of March our group leader Magne Hagstrom has been in hospital. Fortunately everything has gone smoothly with his operation and he is already back working full time. Magne is very important to the project because of his knowledge and skill with the mixers, LO and the receiver in general. Had he been absent for much longer, it would have had serious consequences to our progress.

At the end of next week, we will send the radiometer platform to Linkoping for alignment with the telescope. In preparation for this, we have been checking the alignment of the submillimetre system. The main problem is a displacement between the beam centres of the two pairs of submillimetre receivers (what we call the upper and lower side). We have located a couple of problem areas, one of which I’m afraid is probably due to an error on my part. It seems there was some confusion in the drawings for one of the mirrors and its mounting foot was made on the wrong side so that it is sitting upside down. We are making a new mirror and it should be ready by Tuesday. Another problem is a slight difference between the two sides of the chopper blade.

Outside Odin, I was occupied for a couple of days at the beginning of March doing an optical analysis for a fusion project at the University of Wisconsin. I have had quite a few emails over the past couple of years from people who have visited my Odin web pages. A the end of February I was contacted by Joseph Talmadge at the University of Wisconsin who wanted to know more about my Quasi-Optics for AutoCAD program. The program is not yet sufficiently user friendly or bug-free to make public, but I was able to help by doing a ray tracing of a design he had in mind. I incorporated his CAD drawings into my analysis program. He wanted to make a small modification to his plasma heating system, but unfortunately the rotation of the mirror causes too much aberration to be useful. Joseph Talmade was very appreciative of the work I did, and he hopes to be able to buy my software when I finally release it. The analysis I did can be viewed on my web pages at http://www.oso.chalmers.se/~steve/joe/

For the ESA satellite FIRST, there will be a meeting of the consortium building the Heterodyne Instrument (HIFI) on April 20-21 in Paris. I am planning to attend. The week after that, there is a meeting hosted by the CSA in Ottawa which will bring together Canadian industry representatives and University people interested in the FIRST/Planck mission. There will also be representation from ESA and some of the Principle Scientists of the various instruments will be there, including Thijs
de Graauw from the HIFI consortium. This is planned for April 28-29, and I have made arrangements to attend.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for April, 1998

Date: Sat, 25 Apr 1998 15:03:23 +0200
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle, David Kendall
Subject: Monthly Odin report for April ’98

Dear Sun,

I’m leaving for Canada tomorrow, so I’m writing this month’s report a few days early. The main activities in the Odin radiometer lab have been with the beam alignment measurements, and with the correlator. Sometimes these measurements require the same components on the radiometer platform, so correlator testing has slowed down while beam testing took the priority.

During the past two weeks the radiometer platform has been in Linkoping for its alignment with the Odin telescope. Prior to that, we were working on beam measurements of the submillimetre channels. There are a few problems that were found, some of which have already been sorted out. The main concern now is that there is an offset between the beam centres of the four channels.

The alignment is first checked with an optical laser, and we could see from this that there was already a problem with the alignment between the quasi-optics plate and the diplexer tower. Part of the problem had to do with a mirror which was mistakenly made upside down. As I explained last month, this turned out to be an error in one of my drawings. A new mirror was made in short time, but the alignment problem was not completely corrected. The rest of the error seems to come simply from machining imprecision in the quasi-optics mounting plate. This is disappointing since the integration philosophy was to rely in the precision of the machining to get the mirrors in the correct positions. I have already seen this idea used successfully in Edinburgh when they built the infrared spectrometer camera CGS4 for UKIRT. However, they were supervising the machining much more closely, I guess, and in our case the parts are coming from a number of shops, sometimes from outside contractors. Nevertheless, we have aligned the optics plate empirically, and we will have to keep in mind that the pinned positions of the mirrors may not be perfectly correct.

Another problem we saw was a slight ellipticity in one of the submillimetre beams.
Once again this turned out to be a problem with drawings from a couple of years ago. There was shift in mounting hole positions by 0.2mm in my mirror drawing compared to the mounting plate drawing. The first mirror next to the mixer is extremely sensitive to positional and rotational accuracy, so a small shift was enough to produce an aberrated beam. This problem has now been corrected.

The problem of the offset between the pairs of submillimetre mixers seems to be due to their mounting positions inside the cold box. We will continue to track down and correct the offset next week when the platform returns from Linkoping.

While we are making submillimetre beam measurements, the radiometer was unavailable for testing with the correlator. I was able to perform some testing using a noise diode and a synthesised Constant Wave signal at the IF frequency. With this set up I attempted to do a frequency calibration of the correlator by injecting a signal in incremental steps across the IF band. Sometimes phantom spikes appear, which is something which must be cleared up. Also, we still don’t have proper documentation explaining how the output data from the correlator is organised. In wide band mode, we get eight sub-bands which must be reshuffled and slightly overlapped to get the continuous spectrum. We don’t have all the information to reshuffle the bands into the correct order. I was hoping to see the frequency response of the bands with the test I described above, but the phantom spikes made this a bit difficult. There also is still a problem with the correlator not responding to commands properly. I think much of the correlator problems have to do with the on-board software. The correlator testing will by my priority when I return from Canada.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1806
fax. +46 31 16 45 13
Report for May, 1998

Dear Sun,

Lab work on the radiometer in May focussed entirely on the beam measurements of the submillimetre channels. We have been chasing up a problem with one of the four beams which was elliptical.

The main platform was returned to us from Linkoping two weeks ago, but we have not re-integrated the radiometer onto it. Instead, we have a smaller plate on which is mounted the diplexer tower and mixers. With this smaller set-up we can rotate the whole system and measure the beam from different ports of the diplexer tower. This has been very effective in tracking down problems. We started with this set up in order to find out where the beams from the different mixers diverge. I mentioned last month that the offset between the mixers appears to come from the way they are mounted in the cold box. In fact, this is not the case. The misalignment comes from very small angular deflections in the tuning mechanisms and corner mirrors of the diplexer tower. When the corner mirror or tuning mechanism is not mounted exactly flat against the diplexer tower, the beam is thrown up or down. The final beam position coming out of the diplexer is extremely sensitive to the mounting of the corner mirrors and tuning mechanisms.

By testing the beam at stages along the optical path, we can isolate the effect of each component mounted on the diplexer tower. This involved removing some components so that the beam goes straight out instead of through the rest of the diplexer. In this way we have been able to adjust with small shims the positions of the tuning mechanisms, corner mirrors, and folding mirrors. The largest shim required was a 40micron thick shim, but this makes an enormous difference to the position of the beam at the subreflector.

We have fine tuned the diplexer in this manner, and remained with one outstanding problem. One of the four submillimetre channels was showing a highly elliptical beam, which was completely unacceptable. It has taken us some time to track
down the problem due mainly to seemingly contradictory evidence. When the beam was measured with only the LO diplexer, (ie, with no SSB filtering) the beam looked acceptably circular. After the SSB part of the diplexer, the beam was highly elliptical. We concentrated on checking the positions of the grids, corner mirror, and tuning mechanism. It didn’t occur to us that the problem was at the mixer itself since the beam seemed okay after the LO diplexer. In hindsight, it seems the slight ellipticity in the double side-band beam was amplified in the SSB diplexer. Finally, we replaced the mixer with a prototype mixer of the same band, and the beam looked good. This prototype mixer is not flight qualified, and does not have as good a noise performance as the FM mixer. After discussion with Rudiger Zimmermann at Radiometer Physics (the supplier) we removed the feedhorn from the FM mixer and replaced it with the horn from the prototype mixer. Now the beam looks good.

Another activity for me this month has been the redesign of the internal calibration load. We have a load which will now have to be considered only qualification model and not flight. It occurred to me a while ago that the position of the load had not been cleared through Fredrik Sjoberg, the chief mechanical engineer for Odin at SSC. Sure enough, the load interferes with one of the star trackers. It’s hard to believe that this kind of space problem is still cropping up! The new load will be smaller, which is no problem for the submillimetre channels, but for the millimetre wave there is some difficulty making sure we have a black body source. The absorber we are using only takes 20dB at 119GHz so I need to have multiple reflections inside the load. The space restriction is making this difficult.
Work with the correlator did not advance at all this month. I did a brief testing session earlier this month, but the correlator does not respond properly to commands and can only be run in wide band mode. We have not had any input from Omnisys since early April so there is not much I can do with the correlator. The on board software must be upgraded, and the documentation must be much more detailed. We still don’t have sufficient housekeeping information coming from the correlator, and we don’t have any information on how to re-assemble to the sub-bands to form the continuous IF band. I wrote a mail to Anders Emrich on 14 May asking for input and never had a reply. I later wrote to Urban Frisk on 20 May pointing out the main problems with the correlator, and complaining about the lack of support from Omnisys, but I have had no response. I don’t know if this came up in the recent Science Team meeting (my mails were copied to people involved in the correlator, and also to the CSA).

best regards,

Steve

==================
Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Dear Sun,

The EM correlator is working again, thanks to help from Michael Olberg. A few weeks ago, Michael and I spent some time attacking the correlator, and finally Michael figured out why we could only get output in wide band mode. It had to do with the order that the commands are sent. In particular, there is a “config” command and a “calibrate” command. The calibrate command is to set the attenuators on the internal oscillators so that the sub-bands of the correlator come out at similar power levels. During calibrate, the correlator sets all the attenuators, regardless of how many bands are chosen for operation. Therefore we must send the config command after the calibrate command and not before, otherwise the correlator remains with all bands operating.

Another problem I had noticed in April was that there were spurious spikes on the output spectra. Looking back at the data from that time, I see that the signal I was putting into the correlator was much too strong, and the spurious spikes were probably due to harmonics. The spectra we see from the correlator is in fact an IF from mixing the 4GHz signal to 4 internal oscillators. We get eight bands when we look at both the upper and lower side bands of these oscillators. The strong signal I put in meant that harmonics were strong enough to be seen on the output. With a more reasonable level signal we don’t see this effect.

There is however a case when we do get spurious signal, and this is due to the internal oscillators of the correlator mixing with one another and the resulting beat signal comes out in the correlator sub-bands. We can avoid this effect by making sure the internal oscillators are tuned more than 112MHz apart. This makes it a bit tricky to create a set-up with continuous coverage in the radiometer IF, but by mixing up the upper and lower side bands of the correlator oscillators, we can come up with schemes which allow continuous coverage and also avoid the internal interference problem. Michael has in fact done this and produced a paper which is available on his server: ftp://nain.oso.chalmers.se/pub/ODIN/SSB.ps
Our main goal with the correlator testing has been to get its frequency response. We can now put together the correlator sub-bands in frequency ascending order. I have written some IDL routines to plot the correlator data, and Michael is working in parallel on his software which will eventually become the data reduction package. My routines are more for quick evaluation of the data for testing in the lab, but it’s useful to see the agreement between the two softwares.

The radiometer beam alignment work continues and is proving to be a difficult task. While the beam profiles are looking good for all the channels, we find that the beam centres are not perfectly co-aligned. Our test set up until last week was a smaller version of the radiometer platform which allowed us to see the beam from different ports of the diplexer without obstruction from the platform itself. We had the mixers mounted on their flight brackets, but not within the cold-box. When the alignment appeared satisfactory, we moved the mixers into the cold-box, and integrated all relevant components onto the flight platform. Now we find an offset between the submm channels on either side of the Dicke switch. Since the test set up showed good alignment, we suspected the trouble to be with the way the components are mounted within the cold-box. The receiver front end assembly is mounted up in a web of kevlar threads suspended inside the cold box, and is probably difficult to get high positional accuracy. In order to compensate for both pairs of submm channels, the cold-box must be adjusted in a complicated way since we can only change the feet of the cold box which is far from the beam position.

Today we made a mechanical measurement of the cold-box shell relative to the components within. It’s a bit puzzling to find that there seems to be quite good positional placement of the components, but with the beam tests we find we must move the cold box by up to 2mm, so it seems the cold box itself is not sitting at the correct position on the main platform.

At the moment we have lasers mounted inside the cold box at the two positions where the beam comes in to the two pairs of submm mixers. We are measuring optically whether the diplexer tower and the cold-box are in proper relative positions. Magne Hagstrom tells me just now that when we have our corrector pads on the cold box, the lasers come out at the correct positions. The 2mm positional shift is quite a large correction we’ve made.

Yesterday we had the 119GHz receiver mounted up, and we verified that the beam looks good. We have to have all five channels of the receiver co-aligned before sending the radiometer to Linkoping at the end of next week. The Helsinki group will be testing the 119GHz beam of the entire Odin system, including the telescope, using their hologram to generate a plane wave illumination of the entire telescope aperture. In order for this test to be representative, the receiver must be mounted up in the flight configuration, with no more adjusting to come afterwards. The
beam work is therefore taking the priority over other items. Cooling the receiver will probably be done only after the hologram work.

Beginning tomorrow the French AOS team will be here to do attitude control synchronisation testing of the AOS. This is the last stage of verification required for their on-board software. After this, they can finally burn the flight PROM and deliver the flight model AOS. We will be working with the AOS independent of the radiometer, so beam the alignment adjustments will continue unhindered. On Friday afternoon, we will integrate the AOS and correlator onto the radiometer platform and run a test overnight. This long integration will verify the chopper synchronisation of the correlator, and also the long term stability. The AOS has already undergone long term tests. Most importantly, we will finally have a representative set-up with both the AOS and correlator running simultaneously. The radiometer will have a submm channel operating with chopping between a signal and the internal load. If there is any interference between the backends, we should definitely see something after an overnight integration. We’ll be here on the weekend to check the results and set up another test for Saturday night. Working on the weekend lets us go ahead with these backend tests without interfering with the beam tests.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1806
fax. +46 31 16 45 13
Dear Sun,

The synchronisation testing of the AOS and correlator with the Attitude Control simulator showed up a limitation to the pointing error notification. When one of the star trackers detects a pointing error it sends the alarm through the onboard network. There is obviously a delay from the detection of the pointing error, the sending of the “epsilon” bits on the telemetry, and the reception of this information by the backends. For both the AOS and the correlator, there is integration of data on-board. By the time the command has been received to stop integrating because of pointing error, it may happen that some off-source data has already been included in the spectrum.

The ACDC simulator sends a signal to the backends whose frequency depends on the pointing status of the telescope. We can manually introduce a pointing error. When we do this, the spectra should never show a signal at 4.244GHz, which is what the simulator sends out when there is a pointing error. Although the AOS keeps a buffer of two spectra, this is not enough to ensure clean spectra given the time delay involved, and spectra with off-target data gets sent to the telemetry. Nevertheless, this is how the Attitude Control was defined by SSC, so the French have decided to go ahead with burning the PROM for the Flight Model AOS. They will deliver it to us during the last week of August.

For Astronomy, the pointing errors are defined as an inner circle and an outer circle of acceptance. It may be that by the time the backends stop integrating because of a pointing error, the telescope would in fact still be within the outer circle of acceptance. For Aeronomy, this may be more problematic since each Attitude error has equal significance and should result in a halt of data integration. It should be possible to reject spectra manually in post-processing, but will require throwing out some data which is possibly uncontaminated in order to be safe. I expect this problem must be the same for Osiris. If the detection of the pointing error had a time-stamp in the telemetry, then we could throw out only the bad data which is
taken after the event. I'm not sure what would be involved in changing the telemetry format to accommodate this, but I understand we are going ahead with the system as is.

The AOS performed perfectly well over the weekend of long integrations. With the radiometer platform mounted up in nearly flight configuration, there was almost no sign of cross talk between the correlator and the AOS even after a full night’s integration. The AOS also picked up a problem with the chopper by showing the difference in signal strengths between signal coming in from the two blades of the chopper. This is a problem we already knew about and has to do with the mounting of the chopper mechanism on the optics plate.

Alain Lecacheux and Roger Pons were able to help out quite a bit in running the correlator. We were able to set up the correlator in synchronous mode with the chopper, and both the AOS and correlator were integrating on the same signal. We used this set-up three times, and unfortunately, in each case the correlator stopped functioning after a relatively short time span. The best case was 42 minutes of continuous data gathering. Meanwhile, the AOS functioned continuously for 6 days. We never stopped it the whole time the French team were here. The data we have during those minutes of simultaneous functioning show good agreement between the AOS and the correlator.

Work on the optics alignment continued to be a struggle. While the four submillimetre beams were co-aligned, the adjustments made to achieve this necessarily meant the 119GHz receiver was offset compared to the submillimetre. We co-aligned the millimetre beam as much as possible, and we will see with the collimator in Toulouse whether the beams are acceptably co-aligned. The quality of the beam profiles are not much affected by these adjustments, and the main concern is that simultaneous observation of a source by any of the five receivers is possible.

Last week the radiometer platform was sent to Linkoping where the Helsinki group have set up their hologram. The hologram creates a plane wave at 119GHz which illuminates the entire aperature of the Odin telescope. I was in Linkoping on Monday to participate in the measurements. We have some difficulties due to the fact that the polarisation of the hologram’s plane wave is at 45 degrees to the receiver. We knew about this before we went to Toulouse last year, and our decision then was to filter out the unwanted polarisation with a grid mounted on the optics plate. This was considered an easier solution than rotating the entire satellite by 45 degrees. We used a grid which is a spare for the dichroic, and that was a bad decision. The wire spacings of the dichroic are relatively far apart in order to allow transmission of the submm beam. It is therefore also somewhat lossy at 119GHz and the hologram is then vulnerable to standing wave reflections.
The tests in Linkoping continued through today. During the most recent measurement, a 119GHz detector was substituted for the Odin receiver. This detector was using the same horn as the Odin receiver, and it was rotated by 45 degrees in order to match the polarisation of the hologram. All the measurements, including this last one, have been showing unsymmetric side lobes with one at a high level (-24dB from peak). It’s still not clear whether this has to do with the telescope and optics, or with the hologram test setup. In order to sort this out, we may try to measure the telescope beam with the receiver in the prime focus of the telescope. This is under discussion at the moment, but I’m afraid it would be a lot of work to make the new setup. It means designing and manufacturing some optics to allow the receiver to illuminate the telescope from the primary focus, and we will also need special brackets to hold the detector in place.

Most people are on holiday now in Sweden, including our workshop technicians, so we can’t make any special setup now. While the radiometer is in Linkoping until next week, it is a quiet time in the lab. I’ve decided to take advantage of this lull to go on holiday, so I’ll be away from today, 24 July until the 5th August.

best regards,

Steve

Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for August, 1998

Date: Thu, 3 Sep 1998 23:12:53 +0200
From: Steve Torchinsky
To: Sun Kwok
Cc: David Kendall, Victor Wehrle
Subject: Monthly Odin Report for August '98

Dear Sun,

Our efforts during August were mainly focused on the second round of beam testing at 119GHz using the Helsinki hologram.

The measurements in July were somewhat inconclusive due to the problem of cross polarisation between the hologram and Odin. The idea to filter out the cross polarisation did not work at the time because the grid did not sufficiently reject the unwanted polarisation. This grid is the one we use as a dichroic and so it is not optimised as a polariser.

Another method we tried was to match the polarisation of the receiver to the hologram by rotating the feedhorn through 45 degrees. It was not possible to rotate the receiver, so instead we replaced the receiver with a simple harmonic mixer whose IF (of 100MHz) was read by a spectrum analyser. It was then possible to rotate this assembly within the platform by 45 degrees. In the first measurement with this setup, it turned out that we had rotated the feedhorn in the wrong direction so we were completely cross-polarised and measured only the cross-pol “leakage” of Odin, which by the way is extremely low. Unfortunately, because of mechanical constraints on the set up, it was not possible to rotate the horn completely the 45 degrees required in the opposite direction. So we still had cross pol effects in the subsequent measurement.

The main worry after these measurements was a slight asymmetry in the beam, including a side lobe on one side coming up at around the -20dB level. Although this is probably acceptably low, it is quite far from the -30dB level calculated for Odin by Per-Simon Kildal (of the Chalmers Antenna Group). Also the slight ellipticity and asymmetry outside the main lobe were cause for concern. However, our measurements were unable to separate the contributions from the hologram and those from Odin itself.

After this experience, we went back to the lab to prepare for another series of tests

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in which the setup would be more flexible and allow more combinations to separate out the different factors. In particular, we wanted to remove the radiometer optics entirely. The idea was to illuminate the Odin antenna using just the feedhorn and a single lens in front of it. I had to design this lens, and we then measured the beam profile in this combination here at Chalmers before going back to Linkoping for more hologram testing. We also made a special bracket to hold the horn and lens at the correct position near the telescope focus.

From measurements here, we saw that my first lens was not giving exactly the correct output beam. The focal length required for this lens was so small that it became quite a thick lens and this means the beam does not behave as one expects theoretically since the path length through the lens is so much longer at the centre compared to the edges. I decided to design a somewhat more complicated, but much thinner “two-surface” lens, but it was already time to go back to Linkoping. Testing began last Tuesday using the first lens, and I arrived the next day with a new lens. As it turns out, both lenses approximated fairly well the radiometer beam.

Aside from these preparations for testing the telescope independent of the radiometer quasi-optics, we also had a new set up at Saab-Ericsson Space in Linkoping. Most importantly, we could now rotate the entire satellite by 45 degrees in order to match its polarisation with that of the hologram. With this set up we had a lot of flexibility to eliminate unknowns. We rotated the horn to match the hologram. We could rotate the horn and lens together, and independently. We rotated the entire satellite, and again the horn and lens, etc. The result was that the asymmetric features did not follow any of the rotations, which means that they could only be due to the hologram.

I have some beam plots in postscript files showing the most important results. In particular, the measurement #011 is the satellite in true flight configuration: The radiometer with all the quasi-optics, and no extra grids to filter out cross polarisation since the satellite was oriented to match the hologram. The files are available for download by anonymous ftp at ftp://rsspc20.rss.chalmers.se/pub/hologram.zip

I have some photos from the July session at Linkoping on my web pages: http://www.oso.chalmers.se/~steve/Odin/photos/hologram

Soon I will have my pictures developed from last week’s testing in Linkoping. The satellite mounted at 45 degrees was an impressive sight.

In other areas, the new isolators for the IF amplifiers have finally arrived from PamTech. The new IF amplifiers have been assembled and tested with these isolators. They give similar performance to the previous set of amplifiers, which are also flight qualified, but the new amplifiers have better stability so we will probably use
the new amplifiers, and the earlier ones will become flight spares.

The 119GHz receiver is not functioning perfectly and it is now in Helsinki where the unreliable phase lock is being refurbished.

Delivery of the flight AOS was delayed because of the antenna testing. We have rescheduled it for the 21st of September.

I understand the correlator is delayed because of problems with the control software. I have not done much on the EM correlator during the past month, except to clean up my analysis programs a bit. We can’t do much more with it until the on-board software is upgraded. According to Urban, the problem I mentioned about the correlator freezing up after less than an hour of work most likely has to do with memory overflow. I suppose this is what is holding up the FM correlator.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for September, 1998

Dear Sun,

Early last week we began system noise temperature measurements of the submillimetre radiometer. On Monday we started with the system on the bench, but not in vacuum. It’s the first time we’re measuring the entire system in nearly flight configuration. We use the AOS which is synchronised with the Dicke switch to get spectra on a cold load of liquid nitrogen and then switched to the internal calibration load sitting at 300K. This way we get the noise behaviour of the radiometer right across the IF band. Our results so far approximately agree with what we expect, given that the receiver is not cooled.

Trouble began on Tuesday afternoon when we put the radiometer in vacuum for the first time. Except for the cooler and the correlator, every electronics component was powered up, and most were running. These include the mixers, amplifiers, LO’s, PLL, PLL controller, AOS, mechanisms and mechanism electronics: In total, some 50Watts of power. Things heated up pretty soon after testing began, but unfortunately we weren’t paying proper attention to physical temperatures within the vacuum box. After about 45 minutes, as we were searching for the reason the receiver performance was degrading, we realised our mistake, and began switching off components.

Almost all components were running at high temperatures by the time we switched off. The QM-AOS had been operating well above its recommended temperature, and for about a quarter of an hour, it was three degrees above its qualification level. Anyway, it’s well qualified now because it still appears to be operating properly. The amplifiers were above 50C, and the hottest component was the PLL controller at 70C. After a further week of testing, we don’t see any problems that relate directly to this incident. Nevertheless, Urban Frisk and Gunnar Florin were here yesterday and today for a “debriefing” meeting. Mathias Fredrixon in our group is now working on an automated temperature monitoring program which will include visual and audible alarms to warn us when we approach high temperatures.
At the moment, the main concern is that the thermal design for the satellite should not be in error, but we have identified a number of factors which contributed to the overheating. A couple of the components were not properly screwed down onto the platform, and the main problem was the platform itself which was sitting at 30C. The satellite design expects the platform to be at around 15C. We have an enclosed water cooling system with Peltier elements, but the heat transfer from the copper base plate to the radiometer platform is insufficient. We are also considering inserting thermally conductive material between the platform and each of the electronics components. As it is now, the components are sitting on slightly raised feet on the platform, so there is relatively little thermal conduction to the platform. Most heat must be expelled by radiation only.

There are a number of difficulties before us, unrelated to the over-heating from last week. We appear to have a mismatch between the Low Noise Amplifiers and the mixers resulting in a ripple in the IF output. We have tested a number of variations in the set up, including differing cable lengths, and repositioning of the isolator. The results are best when the isolator is closest to the mixer rather than the amplifier but there is no way to arrange for this in the cold box. We must also consider the fact that the system is designed to perform optimally at cold temperatures and we have been measuring at room temperature.

The components from Omnisys are giving us a hard time. The PLL controller has been back at their lab several times during September for refurbishment. This is previous to the heating incident. The mixer bias box also has an anomaly. As well as the mixers, this box runs the thermistors which are positioned in a number of locations around the platform. When a thermistor is missing then this controller box does not provide the correct bias levels to the mixers. Therefore we have the possible situation in which a malfunctioning thermometer anywhere on the platform will directly affect the mixers. I don’t think this is acceptable, but I’m not sure if the bias box will be corrected. We will have to compensate for the incorrect bias readout if a thermistor dies.

I believe the correlator will eventually again be the item on the critical path, although it isn’t at the moment. I don’t have any detailed news about the FM correlators except that there are “software problems”. I’ve been told that the PROM does not properly take the on-board program. I find this hard to believe since this technology is very well understood. It seems much more likely that there are bugs in the on-board software itself, but I don’t have the FM correlator here to see for myself. I know there are definitely incompatibilities with the EM correlator and the OSU.

It is still the case that none of the Omnisys components are fully integrated into the Odin System Unit. The PLL, mixer bias and LO controller are all controlled independently by direct communication with a PC. Only the correlator goes through
the OSU, but imperfectly.

Although the noise temperature testing has been dominating our activities lately, in fact we spent most of September with beam alignment work. The four submillimetre receivers are now co-aligned to within a tenth of a beam diameter (FWHM). This was achieved after many minor adjustments on mirrors and mounting brackets using shims and small rotations about the mirror centre points. I’m quite disappointed that the radiometer could not be “hardwired” in place as we had hoped. The original plan was to have extremely high precision machining which would enable us to mount all the components into pinned positions. As it turned out, there were many small, and sometimes not so small, imprecisions in the manufacture of various mounting plates. The cold box mounting scheme with the web of kevlar threads is inherently imprecise, and this caused the greatest difficulty. Finally we had to shift the entire cold box by a couple of millimetres. This change has now been approved by SSC.

The 119GHz receiver is still in Helsinki. There was a problem with the phase lock, and we haven’t had any news about it since the beam testing in Linkoping in August. Once we receive it, we will have to co-align the 119 beam with the four submm beams. That will be a two to three day job to be fit into the cooling schedule of the radiometer.
The FM AOS delivery was delayed on our request. With beam alignment work still to be done, we thought it best to wait with the FM AOS integration. We didn’t want to install and then un-install it, which may be required if we need better access to the receiver. As it turns out, this was a good decision because otherwise it would have been the FM unit in the vacuum box last week instead of the QM. We will probably take delivery of the AOS at the end of November when I return from Canada.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for October, 1998

Dear Sun,

We spent a couple of weeks this month making changes to the thermal system of our vacuum box. The platform was completely de-integrated and remained so while we made changes. We now have five Peltier coolers on the underside of the platform to take the heat away. The main difficulty however was with the thermal contact between the platform and the Peltier elements. We couldn’t bolt them onto the platform since this would require making new holes in the bottom of the flight platform. We could not simply let the platform sit on the Peltier elements because the platform is not perfectly flat and there would be gaps. Finally, we made a spring loaded sandwich with a second plate and the Peltier elements in between. This way each Peltier element is independently loaded onto the bottom of the platform. Some thermal paste was also required to fill gaps.

In a first test, we did not re-integrate the platform. Instead, a number of resistors were placed on the platform in the positions of the electronic components. We tried to maintain the platform at a temperature below 15°C while heating it with 120 Watts of power through the resistors. The amount of heating power was determined by adding up the power we have already measured each component takes (eg 14W for the correlator, 18W for the AOS). We were able to keep the platform well below 15°C, so the platform has been re-integrated.

All the work on the thermal setup has brought us to this week. In testing the other day, everything was operating well, with no overheating. The AOS stayed at its regulated temperature of 30°C throughout the day yesterday while it was running in the vacuum box. We have not yet integrated the EM correlator on the platform so we don’t know if will not over heat in the vacuum. All components mounted on the platform sit on slightly raised feet, so in fact there is relatively little conductive heat transfer to the platform. The AOS handles most of its heat dissipation by radiating to cool space and to the cool platform (at 15°C). It is working fine in these conditions. The correlator probably generates more heat than the AOS and we think it may not
be able to radiate away its heat. If this turns out to be the case, we will fill the gap between the correlator and the platform with a special space qualified thermal conducting material that we have already bought.

Initial testing of the submillimetre part of the radiometer was done while in vacuum, but not cooled to 120K. The receiver physical temperature in this case is around 30C, and we measure a noise temperature of 5000K at 575GHz. This is a Single Side Band temperature. It should improve by a factor of two or more when the receiver is cooled. At the moment we see a frequency dependence on the noise temperature across the IF band. This has to do with a slight mismatch between the mixer and the LNA. The LNA has been designed for optimum performance at 120K, so we hope that most of this non-flatness in the system noise temperature will be suppressed when we cool the receiver.

We are waiting for two key components before we begin cooling the receiver. One is the cooler itself, which Gunnar Florin will bring next week. The other component is the second PLL controller from Omnisys. This is also expected to be delivered next week.

The delivery of the 119GHz receiver has been delayed another week. I don’t have any information as to why it has taken so long to repair the Phase Lock on the millimetre receiver. Hopefully they haven’t come across further problems.

We require probably two weeks with the 119GHz receiver in order to integrate it in the system, and verify the beam alignment. We want to take delivery of the FM AOS only after we are sure that there will be no more de-integration of the main platform. With this in mind, I have asked the French team to hold off on delivery of the AOS yet again at least until 7 December.

The noise measurements we perform are done entirely with the Odin system. We use the AOS to read the IF and the data is taken from the telemetry coming from the Odin System Unit. I have a number of programs (written in IDL) to read the telemetry and extract data from the AOS, the correlator, and also to get the physical temperatures of the AOS sub-components. Since I will be away for the next two weeks, I needed to create a more sophisticated program which would allow Magne and the others to easily plot noise temperatures. I spent some time on this, and now we can compute system noise temperatures almost in real time. The program reads the most recent data, verifies the operating mode of the AOS and the correlator, and computes the noise temperature using data from each in turn. Normally, we use the system in synchronisation with the chopper giving us hot and cold load measurements in two second intervals. It is also possible to do a “manual” measurement in which we we place a warm and cold load in turn in front of the vacuum box window. My program will detect this type of measurement also. I
think this program might prove useful during the commissioning phase to allow us to do a quick check on system performance.

We haven’t yet had a chance to measure noise temperature using the correlator. I’m sure it will not match what we see with the AOS. We already saw this in July when we ran tests on the QM AOS and the correlator running in parallel. The EM correlator has a much higher peak to peak noise level than the AOS. Also, there appears to be a staircasing problem with the correlator, at least in the case of wide band mode. However, this is testing that was done with the EM correlator. The FM is supposed to be fully compatible with the OSU, and it should not have any performance problems, but we will test it out thoroughly.

I have set up some of the Odin computers to be reachable over the internet, so I will be able to see the latest measurement when I’m in Calgary. I’m looking forward to the visit.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1838
fax. +46 31 16 45 13
Report for November, 1998

Date: Wed, 2 Dec 1998 23:27:50 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle, David Kendall
Subject: Monthly Odin Report for November ’98

Dear Sun,

Since the Science Team meeting was only last week, you’ll probably be up-to-date with the general status of the project. The main problems in November have been with the 119GHz receiver, and with outgassing in our vacuum system.

The problem with the 119GHz receiver was due to a mix-up with the pre-amplifier from TRW. Apparently the documentation incorrectly labeled the bias port, with the result that the amplifier was reverse-biassed during testing at Ylinen in Finland. It’s not clear whether the amplifier was damaged since it still produces gain on the signal. As I understand it, there are two models of the amplifier, one of which was sent back to TRW for re-evaluation. Meanwhile, the 119GHz receiver is being environment tested, and we expect delivery here next week.

Here in the radiometer lab, an outgassing problem was discovered a couple of weeks ago. This was almost certainly due to some cables which were not properly vacuum safe. Insulation material evaporated from the wires, and redeposited on the coolest parts within the vacuum box. The components within the cold box were not affected. Mostly the material (a sticky film) was found on the main platform and also on one of the mirrors (a calibration mirror which sits directly on the platform). A chemist from SAAB aerospace came here last week to take samples. One of the materials he found may have been from a sealant we’re using in the vacuum box. As a precaution, this sealant was scraped off the inside of the box, and vacuum safe epoxy was placed there instead. We did a vacuum test yesterday, and it looks like we’re okay now.

People from Omnisys have been in and out of the radiometer lab during the last few weeks. You may have heard a report that the correlator is working perfectly, but I must admit that I am not convinced that this is the case. There were a number of problems with the EM correlator that I don’t think have been fixed, but we’ll soon see for sure when we run the system again on Friday. Anders Emrich explains the frequent hanging up of the correlator on bad data over the telemetry. According
to him there is interference on the wire from the running mechanisms. We are now replacing the TM cables with properly shielded cables. It is worth noting that we never had any such troubles with the AOS which was delivered right at the beginning with the necessary cables. I don’t know why Omnisys provided us with the cables that they did, except that they have a long tradition of not using shielding (recall the first version of the PLL).

During testing in the summer, I noticed staircasing in the correlator data. This occurred with a rather strong input signal, but it was only 5σ (2 sec integration) and it posed no problem whatever to the AOS. Another problem was a higher peak-to-peak noise level on the correlator than on the AOS. I will be checking these things first of all, hopefully on Friday.

At the same time, Omnisys are also working to properly integrate the rest of their components into the Odin system. Beginning with our next series of tests we should have for the first time all components running through the Odin System Unit, as it should while in flight. Until now a number of components have been controlled by direct communication, including all the bias levels for the mixers, LO’s and the amplifiers. I expect some time will be spent with troubleshooting.

We have finally set a date for the delivery of the flight model AOS. This will take place on 6 January. We want to be finished with the alignment of the 119GHz receiver, and at a stage when no more changes to the platform will take place. This is highly dependent on the 119GHz delivery. Next week we’ll know if we’re on schedule, but the French team are making their travel plans, so I think we’ll take delivery of the AOS on 6 January no matter what. Hopefully everything else will be in place.

FIRST:

Regarding FIRST, I can report about the HIFI meeting I went to on 16-18 November. There was a lot of questions about the Canadian involvement, and unfortunately I could only say that we won’t have a commitment before February. On the other hand, most other countries are in a similar situation so we’re not unique in that respect. What is different however, is the amount of man power already dedicated to HIFI. People are already working on designs of the various components, but for us this is a bit difficult since our intended contribution will come from industry. We can’t ask them to start on design work until there is definitely money for the project.

We need to make a preliminary design of the LO frequency synthesiser. The idea is to use power amplifiers to allow multiplication of a reference oscillator all the way up to the RF. This is not a PLL in the same way we use on Odin. That is, where a high frequency oscillator (a Gunn) is mixed down and referenced to a phase stable...
source at a lower frequency. For FIRST, we will not lock one oscillator to another but we will simply use the lower frequency oscillator and multiply it all the way up. As a result, the phase noise requirements on this frequency synthesiser are extremely difficult. This is definitely a development project.

On the subject of science with the heterodyne instrument on FIRST (called HIFI) I suggested to Thijs de Graauw that we organise a workshop, much like we have had for Odin. I don’t think we’ve ever had people get together to discuss the science of HIFI in particular. Thijs seemed to think this was a good idea. Hopefully we can organise something next year. Maybe we can offer a Canadian location?

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1833
lab. +46 31 772 1806
fax. +46 31 16 45 13
Report for December, 1998

Dear Sun,

We’re slowly progressing to final delivery of the radiometer, though not at the rate envisioned by SSC. There are a few problem items, and the correlator remains somewhat of an unknown.

The main setback this month was a problem with the cooler electronics. During the cool tests in November, we were using a laboratory electronics box to control the cooler. There was an incident which damaged this electronics box: Two legs of a table collapsed, and the electronics box fell to the floor. There was some internal damage, and it was decided that we should continue work using the Flight electronics box which was immediately sent to us from Stockholm. The Flight electronics for the cooler was integrated on the platform, and an initial test was made before going into vacuum. As soon as the unit was switched on, the compressor made a horrible sound, as if it was being driven past its limit, or perhaps in the wrong direction. We were instructed not to use the cooler, and it has since been sent back to England for evaluation. They will not be able to look at it until the new year. It’s a bit of a mystery why this problem was not picked up and corrected much earlier. Apparently, this screeching of the compressor occurred once before during testing at SSC, but I guess it didn’t repeat, so they perhaps thought that they had commanded the electronics incorrectly.

The 119GHz receiver is scheduled for delivery here on 22 December, which is much later than we had hoped. As a result, there will not be time to do a proper integration, including optical alignment, of the 119GHz receiver before we take delivery of the FM AOS on 6 January. The good news is that TRW have confirmed that the 119GHz HEMT amplifier was not damaged by the reverse biasing and they have shipped it back to Sweden.

While a few important items are missing from the radiometer platform, we will still go ahead with the AOS FM delivery on 6 January. This will be a scaled down session
instead, in which the hardware will be delivered and installed by the Marseille and Toulouse groups. Probably a month later, Alain Lecacheux will come for a full scale testing under more representative conditions. We will repeat the testing that we did in the QM this past summer, but this time with a cooled receiver, and all the flight controllers and correlators in place.

I’m happy to say that the front end controllers are finally integrated in the telemetry system. This means that we are finally in a state where all components on the platform are controlled through the telemetry system. The work has been going on throughout the past few weeks by Omnisys engineers, and I believe the rate of progress has been normal. Of course, the controllers did not work at all at first, and there were a series of programming bugs that had to be worked out. As usual, I find it frustrating when SSC expects that we can simply plug these things in and they’ll work immediately. The timetable depends on this type of bad assumption with the result that the planning is useless and only serves to give the scientific community unrealistic hopes for an early launch date.

One side effect of the control software debugging has been the requirement to replace one of the LO control boxes. In order to reprogram the on board software, the PROM chip had to be physically removed from the controller box, and placed in a special re-programming module. With the many solderings, and un-solderings, the circuit board connections lost integrity. We are using a spare controller box, which is now considered the flight model. It has been removed from the platform for environmental acceptance testing.

The correlator is going through similar treatment as the front end controllers. The QM correlator that has been here off and on over the past few weeks, has been re-soldered so many times that the input ports are no longer reliable, according to Anders Emrich. When the unit finally seemed to be responding properly to telemetry, we couldn’t feed the IF signal into it. The FM correlator then made its brief appearance yesterday, and when powered up, it wouldn’t boot up. A half hour later, the unit was packed up and back at Omnisys. The FM correlator is meant to be reprogrammable on the fly, which means that the on board software can be updated, even after Odin is in orbit. This obviously depends on the correlator starting up to begin with.

As I mentioned last month, I expect that quite some time will be spent getting the correlator running, even after the basic problems of start up and telemetry have been overcome. Looking again at data from the EM, I see that in wide band mode, the correlator spectrum shows spikes at the internal oscillator frequencies. If the FM behaves in the same way, then this would mean that the correlator can not be used in wide band mode (800MHz bandwidth). There is also the possibility of finding staircasing. Hopefully after the holidays when the AOS is delivered we will also have
the correlator and we can repeat our testing session that we did last summer.

I will be away from the lab for the holidays starting tomorrow (Saturday 19th) through until January 6th, in time to help with the AOS integration. I have left contact information with my colleagues here.

wishing you the best for the holidays and a healthy and happy new year,

Steve

Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1806
fax. +46 31 16 45 13
Dear Sun,

The FM AOS was delivered on the 6th of January as planned. As it turned out, this was mainly a formality. The AOS was unpacked and verified that it had survived the transportation, and that is was functional. Gunnar Florin of SSC officially accepted the AOS, and afterwards it was repacked in its travel case. We decided to continue with the original plan which was to integrate the FM AOS on the platform only when radiometer was nearly fully integrated. In particular, we want the full FM frontend (all submm mixers and LO’s and the mm receiver) as well as the cooler. At that point the French team will return to install the AOS on the platform and stay on to perform in-depth functional testing. Until then, we are continuing to use the QM AOS which is essentially identical to the FM. The French team remained here for four days, and we took the opportunity on Friday, 8 January to visit Saab-Ericsson Space in Linkoping where compatibility tests are in progress using the EM AOS.

During January the diplexer tower had all its screws locked down. This is the structure with all the grids, tuning mechanisms, corner mirrors and LO’s. We were confident that it was the final assembling of the diplexer, but it was not to be. The diplexer tower had to be dis-assembled again for two reasons. The first had to do with the fact that the bias circuit boards for the LO’s had not yet been made flight-ready by locking down the screws. We had been under the impression that the FM LO units had been accepted as the final delivery, which is why we went ahead and locked down the diplexer tower. There is also a question about shavings from screw threads inside the bias/mounting plates so the LO units have been sent back to Omnisys for cleaning and locking down. We expect them back this week.

More importantly, however, was the loss of a doubler on the 572GHz LO chain. The doubler diode has gone open circuit, and we don’t know how it happened. There is no obvious event that happened in the lab which could be related to the failure. This is somewhat worrying, but it’s the first incident with an LO for more than two
years. They have otherwise proven themselves to be extremely robust. The LO has been sent back to Zimmerman in Germany. I'm not sure when we will get it back, but we will continue with the flight spare.

We have the cooler here at Chalmers again. In fact, it was never sent back to England. In December, Gunnar Florin took the cooler with him to SSC in Stockholm. He continued testing it, but couldn't reproduce the screeching sound the compressor had been making while here. It was to be sent to British Aerospace, but their engineers would not have time to look at it before the end of January. Finally, Gunnar decided to return here with the cooler, and to have the British Aerospace engineers come here to look at it, instead of sending it back to England. We mounted accelerometers on the compressor to measure the vibrations, and switched it on. It was working normally. Afterwards we operated the cooler under vacuum, and the vibrations continued to appear nominal. Now, apparently Gunnar has decided we should continue as normal with the cooler. The British Aerospace engineers will not come to check out the system. I find this decision rather curious. I will ask Urban about it when he’s here on Thursday. Meanwhile, the cooler has been in continuous operation since last Thursday. There has been no breakdown, but the mixers have only cooled to 145K, and we’re hoping for 120K.

The 119GHz receiver was delivered last week. It has not yet been integrated on the platform. This will be done next week when we install the flight submm mixers, and rebuild the diplexer tower for the last time. This will be followed by perhaps two weeks of beam testing during which we will verify the optical alignment of the four submm receivers, and co-align the 119GHz receiver to the four submm beams.

An important activity going on now is the compilation of Look Up Tables for the radiometer configuration in each of the foreseen observing modes. There are twenty-five modes, and for each mode, we have to specify a large number of settings. Each LO chain must have the bias levels set for the two multipliers and the Gunn diode, as well as tuning the frequency settings for the lock loop. We must also set the positions of the eight tuning mechanisms, and set the mixer bias levels. There is also the question of determining whether a given setting interferes with the settings of another receiver, mainly due to the reference oscillator setting in the Phase Lock Loop.

Finally, I will end this month’s report with the correlator. In fact, there has been good progress in this area. The correlator returned at the beginning of January. We were hoping to do compatibility testing with the AOS, but the correlator was not fully debugged in time. The problem of hanging-up after 40 minutes of operation was the exact same as it had been last summer. Anders Emrich was much more open-minded about discussing the correlator this time around. He acknowledged that is was probably a software problem, and went ahead and debugged the on-
board control program. It turns out a memory buffer was overflowing because a counter was not being reset. Over the next couple of weeks Anders, and one of his employees, Johan Lassing, worked quite diligently to fix this and other software issues.

We now have the two FM correlators integrated on the radiometer platform. All the basic functionality has been shown to work. We are now at the level of testing the data quality in depth. Michael Olberg is participating in this phase of radiometer integration, and he is quite often in the lab. Alain Lecacheux is also helping from Meudon by accessing the radiometer data through the internet. The two correlators and the AOS have been running continuously since last Wednesday until this afternoon. Over Wednesday night we ran the radiometer at room temperature with the mixer looking at a thermal load. There is over twelve hours of data with which we can verify the final peak-to-peak noise level of each of the backends. Since Thursday, the cooler has been operating, and radiometer was also functioning the whole time, including the chopper with all backends in synchronisation mode. We have a couple of gigabytes of radiometer data to sort through!

The basic operation of the system seems to be fine. In particular, Alain says he does not see any compatibility issues between the AOS and the correlators. That is, there are no signals coming from the correlators into the AOS. Recall, this was a big problem last summer. We still have some difficulty with the scaling of the spectra from the correlators. For example, noise temperatures of the radiometer using the correlators don’t give sensible results, and certainly don’t match the AOS. It also remains to prove that there is no staircasing in the wide band modes of the correlator, and that adjacent bands can be put together sensibly. I hope Anders Emrich will continue his active participation in this part of the correlator work when he returns from FIRST meetings in California.
best regards,

Steve

Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1806
fax. +46 31 16 45 13
Report for February, 1999

Dear Sun,

My apologies for the lateness of this report.

The beam alignment for the 119GHz seemed to go quite smoothly. This work is not quite finished yet because we have to do the final measurements on the fully integrated platform, and re-check the co-alignment with the submm beams.

The platform integration is still held up by the flight refurbishment of the LO bias/mounting plates. I mentioned last month that we expected to have them back during the first week of February, but they are still not here. Apparently a decision was taken to go for an extremely flight-safe process. The LO bias board components and screws are being glued down. I believe much of the time we are waiting for the glue to dry. The bias boxes are still to be shipped to England for a special over-coating of the bias boards. This will prevent any accidental short-circuit in case a metal particle falls across the circuit board. The PLL boxes and the Cold Box Bias (the bias for submm mixers and amplifiers) are all undergoing the same process. We are promised the CBB back tomorrow, and the LO’s are expected next week (which, I’m sorry to admit, is the same statement I made last month).

Another missing item is the 119GHz electronics box. This has been sent back to Finland where they are replacing a crystal oscillator used in the PLL for the 119GHz. This oscillator had failed vibration testing, which is a problem we already experienced with the submm PLL from Omnisys. I’m not sure when we can expect the 119GHz electronics box back here, but we were relieved yesterday when Ylinen confirmed its receipt, despite a strike by DHL employees (the pilots, I believe).

Regarding the failure of the doubler in the LO chain, we have determined the cause. Under normal operation when the LO is shutdown, the bias voltage on the multipliers is returned to zero in steps. It is not simply cut directly to zero. The incident with the doubler happened when the LabView control program sent a default value of zero to a running doubler. The diode in the doubler then failed and became on open
circuit. Peter Zimmermann at Radiometer Physics was surprised that such a thing could happen, and when he received the unit, he repointed the diode, and repeated the experiment. The diode failed when he cut the bias to zero which confirmed our guess of the cause of the failure. Zimmermann replaced the Schottky diode with a new one. The LO chain has been re-qualified, and is on its way back. I assume that he re-tested the diode’s sensitivity to zero biasing. It should be impossible to kill a component by a software command.

Further investigations have been done on the cooler. We have found a poor thermal connection between the compressor and the main platform. We are now modifying the copper braids connecting these components together, and hopefully this will give us better heat dissipation away from the compressor. This in turn will allow the cooler to extract more heat from the cold-box and maybe we’ll be able to get down to the goal of 120K. There is still the question of the efficiency of the drive electronics. British Aerospace have received copies of the measurements we’ve been making, and they claim the drive electronics are functioning properly. Perhaps the poor thermal coupling between the compressor and the main platform is the primary problem. We will know more in a couple of days.

Once all components are back at Chalmers and integrated on the platform, we have estimated that we need four weeks of system testing. This includes a number of tests for all channels including: making final, high quality beam maps, measuring the side band suppression through the diplexer, and measuring noise temperatures at a representative number of frequencies. We must also compile tuning tables for all LO settings (doublers, triplers, Gunns, PLL frequencies), mixer bias, and tuning mechanism positions. There is also the performance of the correlators to be confirmed, as well as the cooler.

We are coming up against a hard deadline in mid April when a time slot has been reserved for magnetic field testing of the integrated satellite. It’s difficult to see how we can have the radiometer complete and tested, shipped to Linkoping and integrated with the rest of the satellite all in time for mid April. I’m not sure how SSC will deal with this situation, but Fredrik von Scheele has already requested that we work weekends. I’m afraid they also might simply cut into our testing schedule for the radiometer.
best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1806
fax. +46 31 16 45 13

Date: Mon, 8 Mar 1999 10:12:22 +0100
From: Steve Torchinsky
To: Sun Kwok
Cc: David Kendall, Victor Wehrle
Subject: correction to Odin Report Feb’99

Dear All,

I apologize for an erroneous statement in last month’s report. The request to work on weekends came from Fredrik Sjoberg (Chief Mechanical Engineer), and not from Fredrik von Scheele. I guess this makes a bit of a difference politically, but not practically.

regards,

Steve
Report for March, 1999

Date: Thu, 01 Apr 1999 18:34:12 +0200
From: Steve Torchinsky
To: Sun Kwok, David Kendall, Victor Wehrle
Subject: Monthly Odin Report for March '99

Dear Sun,

The last of the refurbished LO blocks as well as the Front End Controller boxes were returned to Chalmers from Omnisys on March 17th. At this point, we began what was to be the final integration of the radiometer. We now are working on a very tight timetable, which is imposed on us by the timeslot reserved for magnetic field testing of the full Odin system.

On May 4th, Odin must be in Munich where it will undergo testing to determine its magnetic characteristics. This is essential information required to de-tumble the satellite once it achieves orbit. Odin should be in complete flight configuration during these tests, including all electrical systems running. After the Odin tests, the same lab will be used for Cluster. If we miss our timeslot in May, it would probably mean at least two months before the facilities would be free again. Therefore, Urban has decided that the Munich tests will go ahead regardless of the current status of the system.

As it happens, we encountered a serious problem soon after the March 17th delivery of the LO’s. One of the LO blocks had soft diodes in the multipliers. This LO (for the 572GHz channel) was not delivering enough output power. It was exchanged for the spare, which meant dis-assembling the diplexer tower (two days work, to dis-assemble and then re-integrate). The submm system is working well now, but the show-stopper regarding final delivery of the radiometer on April 19th, is the fact that this replacement LO is not flyable. The spare LO’s have not yet undergone the flight refurbishment from which the FM LO’s have recently returned.

We are continuing with the planned timetable, and will deliver the radiometer to Linkoping on April 19th. The radiometer will have to be returned to Chalmers afterwards in order to install the flight 572GHz LO. This will probably be in June after the magnetic field testing in Munich and then Electro-Magnetic compatibility testing in Linkoping after that.

In any case, given the amount of work remaining for radiometer system configuration
tests, it was probably unrealistic that we could complete it all before April 19th. There still remains all the tuning look-up tables to compile for all observation modes (LO frequency settings, PLL settings, mechanical tuner settings, mixer bias).

We must also take care of the co-alignment of the beams. Related to this, one of the tuning mechanisms had to be replaced because it was unstable in servo mode. There is imprecision in the mechanics of these units and in this case, the tuning mirror does not sit exactly flat relative to the diplexer tower. We have adjusted these imprecisions with shims, and it was required to determine the correct shim for the replacement unit. Another difficulty with the beam alignment comes in from the placement of the three main units: the cold-box, the diplexer tower, and the quasi-optics plate. Although the mirrors are all pinned in place within each of these units, the units themselves do not have a precision mounting setup on the main platform. As a result, each time the radiometer is taken apart, and put back together, we have to go through the full process of beam alignment. This will be repeated in June when the 572GHz flight LO is re-installed.

Today we discovered a ripple in the IF of the 119 system. This type of problem comes from standing waves in the system due to a mismatch between components. In this case, we believe it to be something in the second stage amplifier contained within the 119GHz electronics box. After we complete our series of tests with the cooled receiver, Petri Jukkala from Ylinen will come here to investigate the problem with the 119GHz system.

We have made some progress with the correlator. Michael Olberg has written a very useful document describing how to apply the quantisation correction for the correlators. He has also spent a lot of time trying to get information from Omnisys regarding the Odin correlators in particular. Recently, Michael was able to reproduce with correlator data the system noise temperature measurements we have been doing using the AOS. The correlator has a much higher peak to peak noise amplitude than does the AOS, but otherwise, the spectra from the different backends seemed to fit together nicely. We discovered also that the IF signal level is too high for the correlator. The specified level to the backends was -25dBm. We measured this independently to be -27dBm (which is less than -25dBm). For the AOS, the IF level is perfect (as required!) For the correlators, we have been forced to add attenuators onto the input ports.
I will be in touch soon regarding my upcoming travel plans.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1806
fax. +46 31 16 45 13
Report for April, 1999

Date: Tue, 27 Apr 1999 21:01:29 +0200
From: Steve Torchinsky
To: Sun Kwok, Victor Wehrle, David Kendall
Subject: Monthly Odin Report for April '99

Dear Sun,

The month of April has been particularly busy. Our goal was the full integration of the radiometer by 19 April. As I mentioned last month, it became clear early on that we wouldn’t be able to make a final delivery of the radiometer on the 19th. However, we continued working towards this delivery date in order to reduce as much as possible the amount of testing to be done when the radiometer returns to Chalmers.

Amongst the items to clear up with the radiometer is a problem with the 119GHz receiver. We found a ripple in the IF of the 119GHz receiver which is due to reflections between the second stage amplifier and the backend multiplexer. All the spectrometers measured the same ripple. The 119GHz system was returned to Finland, and it will be reintegrated on the radiometer platform next week on Monday.

We haven’t yet finished with a complete characterisation of the correlators. In particular, there may be an anomaly with the frequency calibration. This is to be confirmed. In addition, the Filter Bank does not return data to the telemetry stream. The Filter Bank is to be used for aeronomy, and simply divides the 119GHz IF band into three. That is, it is a very low resolution spectrometer (300MHz resolution). The malfunction is almost certainly due to an oversight in the on-board software of Correlator-2 which controls the Filter Bank. This will be debugged by Omnisys Instruments, and I don’t expect it to take long to find and fix the problem.

During April we had the radiometer cooled, and measured noise temperatures. We had two serious problems. One mixer diode went open circuit upon being cooled. This could happen by contraction of the whisker diode which then loses contact with the diode. When the receiver was warmed up, this mixer had a soft Current-Voltage (I-V) characteristic, indicating that it had recontacted itself, though imperfectly, upon re-warming.

Another mixer seems also to have gone open-circuit, but this is not clear. The mixer worked fine for a couple of weeks, and was open circuit towards the end our
run of testing. After warming, the mixer had exactly the same I-V characteristic as before cooling. This indicates that the mixer was never damaged, but something else caused the mixer current to drop to zero (lack of LO power, for example). I extracted housekeeping data from the telemetry files, but they indicate that the mixer had no current across it even when the LO power was on. So two mixers have been sent back to Radiometer Physics in Germany, and meanwhile we have remounted the FM spares, which we had been using up until this last series of tests.

The most exciting event this month was a gas cell measurement of the water line at 557GHz. We mounted a pressure chamber in front of the radiometer window which was pumped down to low pressure. The air inside was simply excited by the ambient temperature of the lab and we were looking through it to a cold load of liquid nitrogen. We chopped against our internal calibration load and very easily saw the water line at 557GHz. All three backends were running: One correlator in high resolution mode and the other in wide band mode. Correlator-1 in high resolution mode measured the line 30MHz off-set from the other two backends, so we have to check the frequency calibration of the correlators. Urban has put these measurements on the SSC Odin web pages:

http://home.ssc.se/odin/pw/Odin

Follow the links to “Tsys” and “Raw H2O spectra” under the Instruments section to see the radiometer system noise temperature and the water line measurements.

Last week the radiometer was delivered to Linköping. There were a few minor problems to overcome, as expected with the first full integration of the satellite. For example, a telemetry cable had to be replaced and the telemetry format running on the Odin System Unit did not include changes we made back in December. On Friday last week, many parts of Odin were working together that had never been together before. The radiometer and Osiris were both running, and neither experienced any interference from the other. At least this is true for short integration times. We will continue to look at the data.

The integration and test plan has been altered. Needless to say, the “unmoveable” date for magnetic field testing has been moved. It will take place during the week of June 7th instead of May 4th. This change is unfortunate for us in the Radiometer group because we have already planned our travel/holidays to coincide with the May date. We are not needed during the magnetic field testing. Nevertheless, I am leaving for Canada tomorrow. I was in Linköping today, mainly to show Urban how to use the data plotting routines that I wrote. I’ve given him contact information in case he needs me over the next few weeks. Michael Olberg will also be here to help out with radiometer data during the EMC testing.
The present plan has the radiometer back at Chalmers in July. We will then need about a month to complete our series of tests.

best regards,

Steve

Steve Torchinsky
Odin Instrumentation Scientist (Canada)
Dept of Physics and Astronomy, University of Calgary, Canada
posted to Onsala Space Observatory, Gothenburg, Sweden
by the Canadian Space Agency
for The Odin Satellite Project
http://www.oso.chalmers.se/~steve/
email: steve@oso.chalmers.se
ph. +46 31 772 1806
fax. +46 31 16 45 13
Report for May, 1999

Date: Thu, 03 Jun 1999 21:52:28 +0200
From: Steve Torchinsky
To: Sun Kwok, David Kendall, Victor Wehrle
Subject: Monthly Odin Report for May ’99

Dear Sun,

Since I was in Canada throughout the month of May, this month’s Odin report is more brief than usual, and is based mainly on updates I’ve had from my colleagues here at Chalmers.

The radiometer lab remained quiet during the past few weeks, with members of the radiometer team taking turns going to Linköping to help with the EMC testing. This is still going on and there is data waiting to be analysed from a few different days. I haven’t had a chance to look at them yet.

At the beginning of May, the 119GHz receiver was installed onto the radiometer platform as planned. At the same time, one of the correlators was also exchanged. I believe this was to replace a QM version for the FM, but I am waiting for Urban to confirm this. There is still one correlator at Omnisys Instruments undergoing refurbishment, and the Filter Bank is still to be made operational.

Michael Olberg has analysed the data from our water measurement of April. He discovered that the correlator which was running in high resolution mode can be made to agree with the AOS data. He did this by assuming the IF signal was being put through on the Lower Side Band of the correlator’s internal receiver. The correlator was documented to operate in the opposite way. We have to investigate this further. In addition, there still remains a small but significant discrepancy between the second correlator and the other two backends. Michael’s results can be seen on his web pages: http://nain.oso.chalmers.se/ODIN/water.html

Urban has posted my version of the same results on the Odin project pages at http://home.ssc.se/odin/pw/Odin_frameset.htm

It looks like the schedule remains unchanged from what we expected a month ago. That is, the radiometer will return to our lab in July. We will then have four weeks to complete our integration and testing. This includes re-integrating the flight correlators, checking out the Filter Bank, and verifying all the receiver modes. We will also test the correlators independently using a signal generator to verify the
frequency calibration. We will re-do the water measurement.

According to this schedule, we would be in Toulouse in August. I think this is problematic because of the summer vacations in France at that time. Intespace and CESR staff will be on holiday, and the labs could well be entirely closed for most of August. Perhaps we can better use that time here at CTH for further radiometer testing, and go to Toulouse for the beginning of September.

I will be spending some time on FIRST in June. There is a HIFI meeting 16-18 June, which includes the Science meeting, as well as an Optics Working Group meeting. Thijs de Graauw has informed me that the optics design is ready, and he’s asked me to have a look at it. I will devote some time to that this month while the Odin radiometer lab is quiet.

best regards,

Steve

—

Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
Dear Sun,

The radiometer lab at Chalmers has been very quiet during June, as expected. Odin has recently returned to Sweden from Munich after the completion of the magnetic field tests. The satellite is in Linköping now.

I heard from Gunnar Florin that the Munich work went relatively smoothly. There were no surprises for the magnetic field of the system, however apparently there are still some control-software issues. There is software debugging work to be done for the attitude control system.

I spent some time this month creating a help facility for my radiometer plotting routines. The routines were being used in Linköping for the EMC tests, and since I am no longer the only person running these radiometer routines, I thought I’d write some documentation to help other people plot the AOS and correlator data, as well as to extract some housekeeping data. The help is written in HTML, so it’s quick to find out how to run a particular routine.

I was at Omnisys a couple of times last week and this week. They are working on the problem they have had with their on-board control software which is incompatible with the Odin System Unit. At the moment they are working on the correlator, but this problem also exists for the Front End Controller. In the case of the Front End Controller, it entirely fails to boot up. To help Omnisys, we have moved a part of the Chalmers set-up to their lab. This includes a couple of computers and our Telemetry/Telecommand simulator (ie. basically our entire Ground Station simulator set-up). We had to make a few new cables because we didn’t want to take apart our vacuum box set-up. Some time was also spent debugging the new set-up at Omnisys, but as of yesterday it is up and running, so now it’s up to Omnisys to clear up the problems with their units.

The current plan has the radiometer platform back at Chalmers sometime during the week of the 12th. It will probably not have the Front End Controllers and the correlators at that time, but we can use some time to set up our optical alignment.
tests. We will also have to get the Ground Station set-up back from Omnisys.

I was occupied with FIRST work for a good part of June. The HIFI meeting was during the week of 14 June, and there was also an Optics meeting on the 16th. SRON has come up with a draft “work package” for the optics verification, and I am responsible for part of this work in collaboration with Anthony Murphy of the University of Ireland, and Neil Trappe, Anthony’s PhD student.

I will be in Ottawa next week to help put together a work package for the LO Frequency Synthesiser design study. I have already written a draft of this which I have circulated to my HIFI colleagues. I hope to have some comments from them before I take it to CSA for further modifications. I expect to be in Ottawa from the 6th to the 16th. I will either remain available at CSA during the week of 12 July, or else I will use that time to meet with the companies involved in HIFI, if that will be useful.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
Dear Sun,

The radiometer has been back at Chalmers for two weeks now. Much of that time has been spent setting up the system again, but we have been able to get started on some testing.

While the satellite was still in Linkoping, the correlators and Front End Controllers were at Omnisys for debugging. The telemetry simulator at Omnisys was not showing any problems with the correlators and FEC, but when they were run in the Odin System Unit, there was some incompatibility. Omnisys was therefore using our setup during June and the first part of July to fix their on-board software problems.

The return of the radiometer was simultaneous with the return of our telemetry set-up (computers and simulator boxes) from Omnisys. It took about a week to get everything up and running again.

Last week we began working with the correlators. In particular, we’ve been checking the frequency calibration by injecting a synthesised signal. Working with Michael Olberg, I was able to find two errors in my data processing routines for the correlators. One was something we had noticed a while ago. In high resolution mode, the correlator is using the Upper Side Band of its internal oscillator, and I had been plotting the results assuming it was the Lower Side Band. This accounts for the large displacement of the water line we measured in the lab in April, for one of the correlators. The second correction to be made in my program had to do with channel spacing.

We are now trying to understand a 2MHz offset that remains in the other correlator (or possibly both). This appears to be related to the internal side band which is active in the correlator. In wide band mode, all side bands are used, and there is some overlapping between these sub bands, which is as required. We find that in the overlapping region, a generated input signal does not appear at exactly the same frequency in each band. There is an offset of 2MHz. I believe this is simply a question of understanding the peculiarities of this correlator (ie. a constant frequency
shift, for example) and we should have this basic functionality sorted out soon. It remains to test the long term stability of the correlators, and to repeat the water experiment.

There are still a few problem components to deal with. The 119GHz receiver had its mixer replaced during the past couple of weeks, and it should return to Chalmers this week. One of the Front End Controllers does not boot up. The FEC, as with the correlators, are re-programmable, even in flight. However, this makes them extra sensitive at power-up since it is then that the unit takes re-programming instructions. A stray signal will put garbage in the operating system, and the unit then simply does not start up. We already had this problem with one of the correlators and it was corrected, and this problem with the FEC was meant to have been fixed during June. For the moment, we are using the spare Front End Controller, and the flight unit is back at Omnisys.

The most important problem now is with the cooler. Today we had an engineer from British Aerospace to look at the system. The cooler emits a piercing sound when it starts up, which is apparently coming from a number of springs in the compressor. The problem has to do with the way the electronics controls the cooler, but we were unable to determine exactly how. It looks like the cooler will have to go back to England for repairs. This is further complicated by the fact that lay-offs since the merger with Matra means that virtually no one who originally worked with our cooler is still with the company.

Other activities: FIRST and CloudSat

From July 7th to 16th I was at the CSA in Ottawa. I was there to help put together the “Request for Proposal” for a design study to look at the Frequency Synthesiser for the Heterodyne Instrument on FIRST. I had already written a draft version, and this served as a basis for writing the RFP. This should be out soon, and we hope work can begin on the design study by October. I am planning to return to Ottawa at the end of September to help with the evaluation of the bids.
While I was in Ottawa, Bob Hum asked me to look at a design proposal for CloudSat. CloudSat is a joint NASA/CSA mission to image clouds from above using a 94GHz radar. The Frequency Synthesiser on FIRST and the Cloud Profiling Radar on CloudSat use some similar techniques: For example, highly stable oscillators, multipliers, Low Noise Amplifiers. The RFP we wrote for FIRST was used as a template for a similar design study for CloudSat. Both design studies will run roughly concurrently. Before returning to Sweden, I stopped by MPB Technologies in Montreal, and they were able to give me some more background information on cloud radar technology. CloudSat looks like an interesting mission and I hope to continue to be involved.

best regards,

Steve

Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
Report for August, 1999

Date: Thu, 02 Sep 1999 20:18:17 +0200
From: Steve Torchinsky
To: Sun Kwok, David Kendall, Victor Wehrle
Subject: Monthly Odin Report for August 1999

Dear Sun,

The radiometer lab continues to be very busy as we work in parallel with beam alignment and with testing the correlators. There are still a number of outstanding issues.

The Front End Controllers continue to give is difficulty. There are three main problems with these units. One is the loss of memory upon powering on the unit. This is the behaviour I described last month. Basically, the FEC reprograms itself with garbage when it is powered up. This happens irregularly, but roughly every third or fourth time the unit is switched on. The FEC can be reprogrammed through the telemetry, but it is somewhat time consuming.

The Front End Controller is also responsible for communicating and commanding the Phase Lock Loop units for the Local Oscillators. The system can lock the LO’s to the desired frequency by generating a voltage ramp on the varactor (which controls the frequency of the Gunn diode). When voltages match up, the loop locks-in. The FEC is sending an anomalous lock sweep (the voltage ramp) which makes locking the LO’s difficult. The lock sweep has a sudden dip in it, instead of being a gently sloping voltage ramp.

The third problem with the Front End Controller is a factor of 2 in the commanded values compared to the actual voltages found at the LO’s. There is also coincidentally (or perhaps related) the behaviour that the FEC does not send a useful lock sweep on every other attempt.

While part of the problem with the FEC has to do with the on-board control software, there may also be hardware problems, so the Front End Controllers will be returned to Omnisys.

The testing of the correlator continues and we have moved on to long term stability tests. We observed some time ago that the peak-to-peak noise of the correlators seemed very high. In a more controlled experiment, which involved an overnight
integration, we co-added over 28000 spectra and found that the correlator is a factor of 1000 more noisy than the AOS. We were using the correlators with 2-second onboard integration time. According to Anders Emrich, it may be problematic to use this short integration time, so we re-did the experiment with a 10 second integration time. The correlator noise level was improved, so it seems part of the problem was with counter under-flow with short integration times (ie, not enough data is taken to get a reasonable autocorrelation function). This is a correlator control software problem which should be corrected.

However, the high noise level is also due to degraded performance near the sub-band edges, in particular, near the internal oscillator frequencies. Ultimately, we may have to clip some data in post-processing in order to get clean spectra, but this would leave small gaps in the IF band (eg, a few MHz in wide band mode).

We have identified the cause of the 2MHz offset in Correlator-2. It turns out that the sampling clock frequency is 223.06MHz instead of 224MHz. Therefore, each sub-band is less than 112MHz. This is a problem that we can cope with, although it does make data processing and comparison somewhat awkward. Similarly, the offset in the correlator when it is running in high resolution mode is due to an offset in the internal Single-Side-Band oscillators of around 100kHz compared to the commanded value. This is a bit more difficult to deal with because the offset is different for different settings of the SSB oscillator, whereas the sampling clock is something which never changes.

More worrying from the point of view of hardware, is an irregularity in the input level of one of the sub-bands of Correlator-1. The correlator does a self-calibration and then sets internal attenuators to get the 8 sub-bands at roughly the same levels. We have seen that the first sub-band will spontaneously drop after some time. This behaviour might indicate an impending failure. The input level for this sub-band is very low, which can be caused either by a problem with the attenuator, or with the mixer (that is, internal to the correlator, not the submm mixers).

We would like the correlator to go back to Omnisys for verification and repair. It would also be nice if they would replace the slow sampling clock in Correlator-2. Urban Frisk will have to make the final decision about whether to send them back or not.

The measurements of the correlator internal oscillators prompted a complete survey of all the oscillators on the radiometer platform. This includes the Harmonic Reference Oscillator in the Phase Lock Loop, as well as the Phase Reference Oscillator. First, our measurement set up was calibrated against the Onsala maser which is used for Very Long Baseline Interferometry. This gives us an accuracy of 1Hz, which is a factor of 100 better than the highest resolution on the radiometer. One
The oscillator which concerns us is the Harmonic Reference Oscillator which determines the frequency of the Local Oscillator. It has a frequency drift with temperature of several tens of kHz per degree, which is too high, especially because this drift value is multiplied all the way up to the submm frequencies where it translates to a few MHz. The HRO is found in the Phase Lock box supplied by Omnisys.

As you have seen in the message from Victor Wehrle a few days ago, it looks like the problem with the cooler electronics has been identified. The cooler was sent back to England earlier in August, and apparently we now can expect it back at Chalmers by mid September. This will probably coincide well with our test plan. By that time we should be finished with beam alignment verification, and we can begin noise temperature testing with the cooled system.

The 119GHz receiver arrived at Chalmers yesterday, so we can use it to check the co-alignment of the five radiometer channels. Unfortunately, the HEMT pre-amplifier is not currently mounted on the receiver. Some weeks ago at Ylinen in Finland, they discovered that the amplifier gain was much lower than expected, only 7dB instead of 15dB. The amplifier was sent here and we verified the gain to be only 7dB. At this point, TRW has been notified, and I suppose the amplifier will be sent back for repair. I haven’t heard that there was any particular incident associated with the amplifier failure. The worst case would be that this soft behaviour occurs after some period of time, which makes it a lifetime issue.

I have just begun evaluating the filter bank. The filter bank is in a way a fourth backend on the radiometer, but it only operates with the 119GHz receiver, and is intended for aeronomy. It provides three 40MHz wide channels within the IF. They are spaced near the centre of the band, but they are not adjacent. Initial results seem to show some cross talk between the channels, but this is still very preliminary.

Just to summarise, here are the items which are outstanding on the radiometer:

- the cooler (to be returned in two weeks)
- the 119GHz pre-amplifier (to be returned to TRW)
- the correlators (high probability that they will be sent back to Omnisys)
- the Front End Controllers (to be sent back to Omnisys)
best regards,

Steve

–

Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
e-mail: sat@iras.ucalgary.ca

Date: Mon, 06 Sep 1999 11:10:17 +0200
From: Steve Torchinsky
To: Sun Kwok, Victor Wehrle, David Kendall
Subject: Re: Monthly Odin Report for August 1999

Dear all,

I’m just looking over my last monthly report, and I noticed an error regarding the frequency measurement precision we have:

1Hz is a factor of 100000 (ie. $10^5$) better than the best resolution we use on the Odin radiometer (not 100 as I mentioned in my report).

regards Steve

–

Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
e-mail: sat@iras.ucalgary.ca
Dear Sun,

During September, the main effort has been directed at the beam co-alignment of the submillimetre channels. Since two of the mixers had been returned to Germany for repair, they have been reintegrated in the system. Despite carefully noting the position of the mixers, including the shim placement that was necessary, the beams did not come out at the same position as they had before. As a result, we have been forced to go through the alignment process again. This means many beam measurements and subsequent adjustments of mixer positions, and sometimes mirrors as well.

The main difficulty is the requirement that all receiver channels should be within a tenth of a beam width of one another. This corresponds to the requirement that the beam centres at the focal plane should be within 0.3mm of one another. This offset is extremely difficult to measure. We now have three independent methods for verifying the beam positions at the focal plane. The original method was to place a small aperture at the focal plane, and move it with micrometers until we had maximum throughput. We now have a setup which re-images the focal plane to a position outside the radiometer platform where it can be probed with our computer controlled beam measuring system. The third method involves transforming the beam with a short focal length mirror (we used a spare LO mirror). The result is to amplify beam offsets by a significant factor making it easier to measure. We are now making good progress towards the beam co-alignment.

The correlator with the faulty input has been repaired at Omnisys instruments. This now appears to behave properly. The other correlator with the slow sampling clock will remain as is. The large factor of difference in noise performance between the correlator and AOS was due to the on-board software of the correlator. With short integration times, the correlator did not have enough samples to make a proper autocorrelation function. This was because the control program was bit-shifting the register in order to prevent overflow. A new autocorrelator control software has been written which allows us to specify a prescale value. With a proper choice
of prescaler, we can prevent the underflow. This control software is not yet fully debugged. In particular, it does not return the prescale value on the housekeeping, which is essential now for building the spectra from the autocorrelation function. Nevertheless, in preliminary testing, the correlator appears to behave well. We also see less noise peakiness at the band edges as we did before. More detailed testing is required and will continue in parallel with the beam measurements.

The Front End Controllers continue to have problems. There has been a number of adjustments to these units, but we consistently have unreliable behaviour. It very often will not function when powered up, and then the control software must be uploaded to it, which takes about 20 minutes. We have fitted our setup with solid state power switches in order to avoid the momentary fluctuations inherent in mechanical switches. A mechanical switch will vibrate causing the voltage supplied to fluctuate before settling to the final level. This happens over a period of about one millisecond. None of the other units have been bothered by this, but we put in the solid state switches to see if it helped the Front End Controller. The FEC continues to show the same unreliable behaviour.

The filter bank was indeed faulty. The filter band passes were far too large. It turns out there is an oscillator in this unit, which came as a surprise to all of us in the radiometer lab. The oscillator wasn’t properly locked, which resulted in the large band pass. The filter bank was replaced with the flight spare which looks okay. The three bandpasses are correct but we should still test the long term performance.

The 119GHz HEMT pre-amplifier is still in California (TRW) for repairs. We have been told to continue without it. We will do the 119GHz beam alignment without the HEMT. In place of the HEMT we have a simple waveguide in a block with the same outer dimensions as the HEMT. In principle we should be able to replace the dummy block with the HEMT without changing the beam alignment. In practice, we have seen that this may not work out so simply, as was the case with the reintegration of the submm mixers.

I must also report that one of the submillimetre mixers has gone soft. This was almost certainly due to handling. All the usual precautions against Electro Static Discharge have been taken, but clearly something happened to the mixer between the time it was tested on the bench, and then again after it was mounted in the cold-box. The mixer will have to go back to Germany for the Schottky diode to be re-pointed.

The cooler is still in England, having undergone repairs and tests. There is some question of reliability since the fault was due to a broken connection on a transistor, and other components had been mounted in the same way. I understand there is some discussion going on now between SSC and Matra/British Aerospace. SSC
don’t want to pay for the repairs, and neither does Matra since it has been four years since the original delivery of the cooler. We are told to expect the cooler back at Chalmers in two weeks.

The schedule for the coming months is roughly as follows. We should finish the beam alignment work in the next two weeks. Afterwards, we have six weeks for the cold receiver testing, including noise temperatures, and stability tests. The radiometer should be transferred to Linkoping in January for integration with the rest of the satellite. Thereafter, Odin will be sent to Toulouse for the system environment and beam testing.

Today was my last day as a “permanent guest” at Chalmers and I was very sorry to say good bye to my colleagues here. However, I am looking forward to the move back to Calgary and will remain in close contact with the radiometer lab. The radiometer data is available over the internet and I will be able to download the telemetry files, and the beam measurement files from Calgary. Also, I decided to get a return ticket back to Gothenburg, since it’s the same price as a single, and I’m planning to come back here in December to help with the full system testing. I’d like to be here when we re-do the water measurement.

I’m looking forward to joining the Calgary group next week,

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
Dear Victor and David,

I didn’t like the idea of dropping the Odin reports entirely, as long as Odin is still on the ground. I thought I would send a report to flesh out some of the details you’ve had from Ake in his recent mail.

I’ve been in touch with the Chalmers radiometer lab by phone once a week to keep up with the activities there. This is in addition to viewing data files over the internet.

Virtually all the work during October was on the beam alignment. This is meticulous work, and very time consuming. The difficulty is getting all five radiometer beams co-aligned in the focal plane, as well as maintaining proper illumination of the subreflector. Two main setups are in use at the moment. One is to re-image the focal plane which is found at the chopper position, to a position outside the vacuum box which can be probed by the computer controlled beam measuring system. This is done by a couple of mirrors mounted on a plate which is suspended above the radiometer platform. The second setup is to verify the subreflector illumination which is more simple since it only requires a beam measurement at the distance from the radiometer to the subreflector. Any adjustment to the radiometer optics is followed by a number of beam measurements with both these setups. There has been a lot of tweaking to get things right, but it looks like the beams are well aligned now.

As of Tuesday this week, the cooler had still not been delivered to Chalmers. This is another reason why so much time has been spent getting the last few percent precision on the beam alignment. There was simply not much else to work on, until the vacuum/cool tests could get under way.

Last month I reported that a mixer had gone soft. Magne Hagstrom now tells me that he doubts the mixer is faulty. The Current-Voltage characteristic of the diode is okay, but the mixer current level is too low. This could come about from misalignment with the LO, or also from attenuation in the air of the LO signal. Magne wants to test the mixer in vacuum and cold before deciding that the mixer must be repaired. His feeling is that it is okay, which makes sense since the most reliable indicator is the Current-Voltage characteristic.
It seems the problem with the Front End Controller losing memory has finally been solved. This behaviour was traced to a non-grounded pin in the FEC. With a floating voltage, the FEC sometimes expected itself to be reprogrammed. Another problem has also been fixed in the FEC with respect to the algorithm used to find a lock setting in the Phase Lock Loop. This was a software bug.

The correlator has remained pretty much inactive in October, except for a brief session on the 14th. It is functional except that a couple of important parameters are not being passed back in the housekeeping telemetry. We won’t go ahead with performance testing until a new version of the on-board control software is ready. We also want to do the next long term tests with the radiometer in vacuum in order to better control the environment for stability.

The main holdup with the correlator now has to do with an unfortunate accident. While on holiday in Greece, Anders Emrich had an accident on a motorbike, and hit his head giving himself a bad concussion. He was in hospital for a couple of weeks, but is now recovering. His responsibilities with the correlator control software are being taken over by his partner at Omnisys, Stefan Andersson. Stefan had a priority to deal with the FEC, but can now begin to look at the correlator control software.

Since relocating to Calgary, I have spent much of my time with the Design Study of the FIRST Local Oscillator Source Unit, which is well underway now at MPB. I was also at a meeting last week at U. Mass in Amherst for the HIFI LO subsystem. I do try to spend a good portion of my time on Odin, and I am already planning my return to Sweden for two weeks in December, which should coincide with the cooled radiometer testing.

best regards,

Steve

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Steve Torchinsky
Odin Instrumentation Scientist
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
Dear David and Victor,

The cooler was re-delivered to Chalmers on the 7th of November. After some initial verification on the bench, it was mounted on the platform. Beam alignment work had been completed by that time, and cooling of the receiver began on the 19th. As of today, the temperature at the mixers is 129.5K, which is the coolest we’ve ever had them. It seems the cooler and the cooler control electronics are functioning properly.

The 119GHz receiver is not integrated in the system, and remains in storage waiting for the 119GHz pre-amplifier (HEMT). The amplifier is expected back at Chalmers in two weeks, which is something to keep in mind for the Integration Readiness Review. When the amplifier is delivered, the 119GHz system must be re-integrated into the cold box. Related to this, a new protection circuit has been manufactured by Omnisys which will sit alongside the 119GHz pre-amplifier. Omnisys built the protection box for the mixers, so we don’t expect any problems. However, this is a new component being integrated into the system for the first time, and I expect there will be at least some initial difficulties. Already it is clear that the radiometer can not be considered ready for Odin system integration in two weeks time, coinciding with the IRR.

Omnisys Instruments has hired a new engineer, Johan Dahlberg, who has taken over the correlator control software work. There have been many changes to the correlator software since the beginning of the month. The data and housekeeping formats in the telemetry for the correlator has been re-organised, and I will have to rewrite my correlator data extraction routine. Michael Olberg has been following this work, and has provided me with the necessary details. The correlator seems to be making progress since Johan Dahlberg took over the control software work, but there is still some problems with the self-calibration mode. Apparently, the problem is understood and a new version of the software should correct it.

During November I my time has been divided between three projects. The FIRST-HIFI design study continued to occupy much of my time. I also began working on a
receiver design proposal for the Atacama Large Millimeter Array (ALMA) project. This is being done in collaboration with Victor Belitsky from Chalmers.

At the end of October I received a mail from Dave Walker who is chairman of the Quasi-Optics special session at next year’s IEEE Microwave Theory and Techniques conference. I’ve attached his email. I was recommended to him by Paul Goldsmith (Director of Arecibo) to present my Quasi-Optics design software. As a result I have finally begun writing the Odin optics paper. The four-page summary version was submitted today, and I will make it available on my web pages.

I am going to Sweden on Monday, and will spend a week in the radiometer lab before the IRR.

looking forward to seeing you in Stockholm,

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Dear David and Victor,

First of all, please accept my sincere apologies for the lateness of this report, and a very happy new year to you! The change to the new year had no effect on the Odin computers whatsoever. In fact, even a few old 486 PC’s marched boldly into 2000 without complaint.

At the IRR meeting in December, it was reported that the radiometer is on track for delivery to Linkoping for the end of January. We are currently running somewhat on this schedule, but there are still a number of outstanding issues that we should watch.

Before Christmas, the radiometer was warmed up so that the refurbished 119GHz receiver could be reinstalled. It was last week that Petri Jukkala from Ylinen in Helsinki went to Chalmers to help with the installation. As expected, there were a few teething troubles with the new protection circuit box. Some changes were required to the protection box layout in order to make it fit mechanically into the cold box. This was done successfully and now the 119GHz receiver is integrated in the radiometer system.

Initial tests of the 119GHz receiver at room temperature show a noise temperature which is perhaps too high. However, since the amplifier and the protection circuit are both optimized to operate at cool temperatures, it is not straightforward to extrapolate from the warm receiver performance to the expected performance when it is cooled. In particular, there is current leakage from the 119GHz amplifier to the protection circuit. When the system is cooled, the amplifier diode characteristic will move into a regime in which it is no longer perturbed by the protection circuit. The only way to be sure of the 119GHz system performance, is to cool it and measure the noise behaviour. Cooling of the radiometer began this week.

All being well, the cold box has been integrated for the last time. We are planning two more cool down sessions, including the current one. The first uses the noise temperature measurement setup, and the second will be for a final beam measure-
ment series, as well as a repeat of the water cell measurement which was done last April. I think the second series of tests might be in danger of elimination, in the interests of time, which would be a shame. The water measurement is a good test of complete system performance, since it is a true measurement of a natural process (not a synthesised signal).

During the first half of December, I was working at Chalmers. I spent most of that time bringing my correlator software up to date. The correlator on-board control software underwent a number of changes in a short time, but it looks like we now have a stable version. It was not shown at the IRR meeting, but noise temperature measurements of the radiometer using the correlators as the backends agree quite well with the AOS measurements. We still want to verify the long term stability of the correlators.

There is one important failure to report regarding the radiometer, which has to do with the mechanism control electronics. Last week, the control box ceased to operate properly and the problem was tracked down to a faulty transistor. The transistor has been replaced and the controller works properly again, but we have to ensure that the failure is not repeated. The engineer from ACR, who supplied the mechanisms and controller, believes that the transistor failure could have been caused by disconnecting cables while the control box was powered up. Such an event happened quite some time ago. A few years ago, this was responsible for the failure of one of the tuning mechanisms. The transistor could have been damaged at that time, with total failure not occurring until much later. With this in mind, it seems we will have to replace all the transistors in the mechanism control electronics box. The plan is to do this when the radiometer gets shipped to Linkoping in February.

I am currently expecting to return to Sweden in February/March to help with the Comprehensive Electric Performance Tests. I will plan this trip closer to the date.

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Dear Victor and David,

I created some confusion here on two issues. Firstly, that the second series of tests might be by-passed: I must say that this is entirely my feeling based on the pressure we’ve been under to deliver by February. I don’t have any direct statement from Urban saying that we would forego the water cell measurement. Indeed, he mentioned at the IRR that it is part of the plan, so I think it’s premature to lean on the Swedes.

The second point is regarding the beam measurements. The final beam measurements are to take place in Toulouse at the CESR facilities, at a time to be determined, but to me, it looks like it would be in May. These are definitely not to be scrapped. I unfortunately wrote “final”, when what I meant was the last beam tests at Chalmers. One might argue that there is not very much to be gained by another series of beam measurements at Chalmers, but I would like to verify that the cooled receiver has the same profile and alignment as the room temperature measurements. Since nearly all the optics are in an environment of 300K under normal operation, there’s little reason to believe things would change when the receiver is cooled. There is however the possibility of some movement of the mixers and the first mirrors by thermal contraction. Also, the 119GHz system has a lens at the window to the cold box.

We also want to check the side-band suppression of the Martin-Puplett diplexer. There was some degradation of performance which has been linked to vibrations from the cooler. These vibrations are modulating the tuning mechanisms. It is possible to measure the SSB performance in the current setup, but there is a question of scattered radiation since in this setup our synthesised signal is not coupled efficiently to the receiver beam.

As long as we do the water cell experiment, another series of beam maps would only amount to an additional couple of days. The changeover from beam measurement to water cell can be done quickly, without warming up the receiver.

Our current setup is for noise measurements and we have a cold load in the vacuum box in the main beam path. To change from this setup to the water cell setup, we have to warm up the receiver, remove the cold load and replace it with a window.
After that, pumping out the box, and cooling the receiver takes about a week. I don’t see how this can fit in with a February delivery to Linkoping. We have always worked against the SSC schedule in this way, so I guess there’s no reason to think it would be different this time, but there does seem to be a feeling of urgency now that hasn’t been there before. Nevertheless, until I hear something to the contrary from Urban, I think we can expect to do the water cell experiment regardless of the time frame.

I hope I’ve explained things more clearly this time! I think it’s too early to bring this up with SSC.

best regards,

Steve

Date: Wed, 12 Jan 2000 15:42:26 -0700
From: Steve Torchinsky
To: “Wehrle, Victor”
Cc: “Kwok_Sun”, “Kendall, Dave” Subject: Re: Thanks for Clarifications

Victor,

I spoke to Magne Hagstrom this morning to further clarify our test schedule. He’s the leader of the Odin radiometer group at Chalmers. We are definitely going ahead with the water experiment, however this will be done with the SMR at room temperature. There are no further beam measurements planned at Chalmers.

The current cool-down of the receiver should be the last before flight. It will be warmed up after this series of noise temperature measurements, which are focussing on the 119GHz performance. Afterwards, the setup will be changed for the water experiment. The SMR will be operated in vacuum, but it will not be cooled down for the water-cell measurement.

I opened up the discussion about possible changes to the alignment due to cooling. Magne is considering this issue, and we’ll also discuss it with Urban. I expect we will not do beam measurements with the cooled receiver. The cooling process takes a week, in addition to the time required to do the measurements. There will be great resistance to taking this time. We also have to think about the temperature cycling of the flight mixers, which must be minimized.

Regarding the 119GHz system, the SMR has been cooling since yesterday, and the 119GHz is showing vastly improved performance. At a physical temperature of ~210K, the 119GHz noise temperature is ~1000K. As was hoped, the leakage
current to the protection box has vanished with cooling. It looks good for the 119GHz receiver to reach the goal performance once it has cooled to 140K.

best regards,
Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for January, 2000

Date: Tue, 01 Feb 2000 15:56:11 +0000
From: Steve Torchinsky
To: Victor Wehrle, David Kendall
Cc: Sun Kwok
Subject: Monthly Odin Report for January 2000

Dear Victor and David,

The main topic of last month’s report was whether or not we would do beam testing with the cooled receiver. The decision finally was in favour of doing another cool-down, not only for beam testing, but also for a few other measurements which cannot be done properly in the current setup. In particular, it is important to test the Single Side Band filter with the cooled receiver because we want to verify that the vibrations from the cooler have been properly eliminated. The water-cell experiment will also be performed with the cold radiometer.

The radiometer has been running pretty much continuously throughout January. In fact, except for a warm-up/cool-down break at the end of December, the radiometer has been going for a couple of months or more. Lately, there has been much progress in the automation of the system. The radiometer can be initiated in a number of different observing modes, and a new setup can be started as desired on a timetable. For example, a recent overnight test had the radiometer in all the different modes, spending about ten minutes in each. An observing mode implies configuring the front-end (the mixers, the tuning mechanisms, the bias supplies, the LO frequency settings...) and also the backend spectrometers (input selection, attenuation setting, wide-band or high resolution, split band or full band...) There are 27 such modes.

There is still some fine tuning to be done on the radiometer system configuration. A new algorithm is being implemented in the submm Phase Lock Loop electronics which should make the circuit find the lock more reliably. Once all the front-end settings have been tied down, we will go through the startup scripts to make sure they are efficient (ie, no redundant commands) and that all commands are executed in the correct order. We should have all the scripts ready before the LEPT/HEPT/CEPT series of tests in Linkoping.

The 119GHz HEMT pre-amplifier is functioning well, but the 119GHz system as a whole is giving us trouble. The system noise temperature was measured at 520K, which is very good. Later on, there was a full heat load on the cooler when all
five mixers were running, and the physical temperature inside the box rose by 16K.
The 119GHz system noise temperature then also rose to 650K, so it looks like we
should not overstress the system by running all five receivers at the same time.
Subsequently, the cold box was re-cooled when the heat load was reduced, but the
119GHz system did not return to the original $T_{sys}=520K$. Instead, it is now showing
only 605K, and this is not yet understood.

A more serious problem with the 119GHz receiver is something which has showed
up before. The phase lock system does not lock properly on one side. The system is
meant to lock on either side of the oxygen line at 118.75GHz, which permits us to
use a frequency switching observation mode. At the moment, only one side works,
and it is noisier than expected. It looks like the 119GHz system will have to return
to Finland for repairs again.

I am beginning to plan a return visit to Sweden. My original intention was to be
there for the CEPT testing in Linkoping in March. I believe the radiometer may
still be in Chalmers in March, however I think it will be useful to go anyway. I can
help with the water-cell experiment, and the final beam testing at Chalmers before
going with the radiometer to Linkoping for the CEPT. I will finalise my plans in the
coming weeks.

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Dear Victor and David,

The trouble with the 119GHz receiver turns out to be an over sensitivity to temperature changes. The electronics for the 119GHz receiver sit on the radiometer platform just next to the cold box. This is not an actively cooled location when Odin is in flight, but we have Peltier cooling elements on the platform during lab tests in order to prevent overheating of the radiometer. This is meant to simulate the environment we expect when Odin is flying.

The 119GHz electronics box operates fine at a temperature of around 20C. During testing with the cooler running, the temperature drops below 20C to around 18C. At this point, there is a failure of the 119GHz phase lock loop system. In fact, this box only operates properly within a very narrow temperature range of about 3C, which is unacceptable. The specifications were for an operating environment between 0C and 40C. That is quite a bit overspecified, but what we have now is unacceptable. The 119GHz electronics box was returned to Finland where it has been for the past three weeks.

The problem looks to be somewhat complicated to fix. Since oscillators are temperature sensitive, the lock loop must be built in such a way that it can lock down the oscillator frequency even if it has a tendency to drift. It’s possible that the oscillator frequency can drift too far and go out of range of the lock loop. This is what I understand to be happening. Magne Hagstrom of Chalmers tells me it’s possible to build the lock circuit so that it is not sensitive to this drift, by using thermal compensating resistors, for example. Another possibility is to put a heater on the 119GHz electronics box, and control the temperature, but this would require changes in other systems as well, including the 119GHz on-board control software, the OSU, and the radiometer harness. There was a meeting yesterday at Ylinen Inc. in Helsinki, but I haven’t heard yet what was the outcome.

As an aside, I should point out that Ylinen is a company which is currently involved in CloudSat through a collaboration with MPB Tech. It may well be that the two
projects are competing for the time of the same engineers. In addition, part of the long duration of the 119GHz electronics in Finland was due to the absence of the lead engineer there, Petri Jukkala, who was on holiday for one week. We’re all quite frustrated with how things have turned out with the 119GHz system. I understand Urban Frisk was particularly upset, which is why he insisted on yesterday’s meeting. Magne has also gone to Finland for this meeting, since he has a lot of experience with RF circuits. You may remember that Magne was essential to the redesign of the submillimetre phase lock loop electronics a few years ago.

Meanwhile, the Chalmers group are continuing with the test and configuration of the submillimeter receivers. Current tests are being done at room temperature, with the radiometer in vacuum. Last week they re-did the water vapour measurement that we had done last year in April. I was surprised they had done this already as I was thinking of going to Chalmers to help with that test. I have copied over the data files, and will look at them here in Calgary. Michael Olberg has already completed an analysis and the system looks good. You can see his results on the Onsala-Odin web server:

http://odin.oso.chalmers.se/water2.html

One more cool down is planned for the radiometer, and they are going to use the noise temperature set-up, so there will not be beam tests with the cooled receiver. The philosophy being that we will have to accept the performance we get when the system is cooled. If there is an alignment shift due to mechanical contraction, then the performance would degrade in a couple of ways. It’s possible that the four submillimetre beams would no longer be perfectly co-aligned. We could have a loss in beam efficiency with the beams moving out of the optimal position on the subreflector. These are performance issues, and not failure issues. On the other hand, if we measure the beams with the cold receiver and find that they are not optimal, then to fix it would require a number of cool-downs as we make adjustments with shims and remeasure the result. All in all, the balance between optimal performance and the difficulty to adjust the beams, weighs heavily in favour of not going ahead with cooled receiver beam testing.

With the test plan changing on-the-fly as it has been doing, I am once again re-thinking the appropriate time for my return to Sweden. I believe I will go back to my original plan, which was to join the Chalmers group for the integration in Linkoping and the CEPT. Given the uncertainty of the 119GHz receiver, there’s no way to tell when that would be.
best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for March, 2000

Date: Fri, 31 Mar 2000 18:18:36 +0200
From: Steve Torchinsky
To: Sun Kwok
Cc: Victor Wehrle, David Kendall
Subject: Monthly Odin Report for March 2000

Dear Sun,

We’ve been keeping to the timetable that I mentioned in my mail to Victor two weeks ago. The radiometer has been behaving well, and I think there’s good reason to remain optimistic.

The radiometer is warmed up now, and is sitting in its packing case waiting to go. Early Monday morning we will drive to Linkoping with the radiometer, computers, and test equipment, and set everything up at Saab-Ericsson Space laboratory. Over here, Johan Lassing has done an excellent job with the radiometer control software, and we can generate complete scripts for commanding the radiometer in any of the 25 modes. These scripts still have to be verified manually before we upload them to the radiometer, but it looks like we’re ready for the CEPT next week.

We will not test every mode, but we will probably get through several of them and verify that the radiometer operates properly. In fact, when you include the calculation for Doppler shift, an individual observing mode is different each time it will be sent up to the satellite. This is because the LO frequency setting will change according to the Doppler shift, and so the phase lock setting has to be recalculated. When Odin is flying, the phase lock calculation will be done on the ground, and the scripts will be generated at that time before being sent up to the satellite. We will operate in this manner in Linkoping next week, sending up a few typical observing modes.

The 119GHz phase lock loop is still an open issue. Yesterday, Mathias Fredrixon was sent to Finland to deliver the 119 electronics box back to Yliinen (it wasn’t trusted to a courier). I don’t have any news on progress there, but it sounds like there’s at least a week’s work, perhaps more. It looks like the 119 electronics box will not be re-integrated while we’re in Linkoping, and we will have to do it in Toulouse.

There are couple of issues with the radiometer that I think are important to consider because it may affect the scheduling. We have had some difficulty with cross-talk
between channels in two of the observing modes. These are the Astro 4 and Astro 7 modes, and the trouble comes about when trying to set two LO’s to 572.498GHz and 556.936GHz respectively. There is interference between the reference oscillators of the two lock boxes when we try to do this. We are still working on finding a setting which will work. There is some freedom with the tuning ranges, so these two modes are not ruled out. Still, I think it might be useful to have a plan in the case that these lines cannot be observed simultaneously.

Another possibility I see looming is a problem with heat dissipation. Here in the lab we have been cooling the main platform with Peltier elements, and we’ve probably provided more cooling than will be available to the satellite by radiative cooling when it is in flight. We will know better after the solar simulation tests in Toulouse. It may be that running all five channels simultaneously is not viable because of overheating. In particular, the AOS must not be allowed to operate above 35C, but other units are also susceptible to high temperatures. It’s possible that we will only run two channels simultaneously at any given time. We already know that the 119GHz will have to be operated completely on its own, if we want it to have maximum sensitivity.

I will be in Linkoping for the next two weeks and can be reached in the lab at +46 13 18 64 10. The fax number at Saab-Ericsson is +46 13 18 64 12. I won’t be checking my email until April 17th.

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Dear Victor and David,

In general, things are going very well with Odin. As it turns out, I spent three weeks in Linkoping for the CEPT, and in fact, it has continued through the end of April, and will go on into the first week of May. People have been working very hard to complete the testing, not only the radiometer team, but also the Saab employees, and of course Nick for Osiris. Despite the pressure to complete testing within the two week allotted period, no corners have been cut in the procedure. I think this is a good thing, but the result is obviously that the CEPT continues, probably right through the end of next week. The attitude in the lab is basically to get all the work done properly, even if it takes more time than planned by SSC. This is best for Odin, but I don’t see how it is compatible with a November launch.

The delivery of the radiometer to Linkoping went smoothly, and the two components to be refurbished were completed, and re-integrated on the first day there. These were the Front-End Controller, which had a protective coating applied to the circuit board, and the Mechanism Control electronics box which had one circuit-board replaced.

The trouble with the 119GHz receiver was not so simply overcome, and in fact there are still some worries today. Petri Jukkalla of Ylinen came to Linkoping with the 119GHz electronics box which contains the repaired Local Oscillator. He had tested it in Finland at a number of temperatures from 0C to 50C, and the Phase Lock Loop remained in lock. When we ran it in Linkoping, the PLL would not lock at all. The suspected cause was a potentiometer which regulated the bias voltage to the Gunn oscillator, but this potentiometer screw was locked down, so it’s still not confirmed if this had anything to do with the problem.

The main culprit with the 119GHz system was a mismatch between the output waveguide, and the input to the receiver inside the cold box. Magne Hagstrom went back to Finland with Petri Jukkalla, and helped devise a solution. The result is an additional component just outside the 119GHz electronics box. It is a waveguide isolator which removes reflected signal coming back from the input waveguide at
the receiver. Since that time, the 119GHz system had been behaving well, until a couple of days ago when it was discovered that the PLL becomes noisy when the temperature of the box rises above 32°C. Probably, the 119GHz electronics box will have to be taken off the platform again. It will be retuned to be optimal at higher temperatures, and a heater will be used if necessary to maintain the best temperature. At the same time, the potentiometer regulating the bias supply will probably be replaced with a fixed resistor.

Otherwise, work with the radiometer went very well. We managed to produce a CEPT super script which ran a full check of the radiometer. We did a dry-run while I was there last week, mainly to test the script. This week, they ran the script, and Urban tells me it took four hours to complete. The radiometer performed well. Currently, they are doing noise temperature tests using a liquid nitrogen cooled load in front of the telescope. Urban thinks the work in Linkoping will continue through the end of next week.

In other news, we had a bit of a scare when Urban became very ill on Friday, April 14th. This was a serious stomach infection, possibly food poisoning. He was in the hospital over the weekend, and it took him a week before he was recovered. We’re glad he’s back in good health!

Urban mentioned to me yesterday that the solar simulation can happen as late as June 12th. I’m going to book flights for Toulouse for the second week of June, and I’ll stay throughout June and July. August is holiday season in France, so if we slip the timetable too much, it will be impossible to work at that time. They actually shut down the buildings, so there is no access to the laboratories at that time.

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
e-mail: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for May, 2000

Dear Victor and David,

Odin is in Toulouse now. The CEPT continued through the first week of May and then Odin was prepared for transportion and shipped to Toulouse. Magne Hagstrom is already in Toulouse since the beginning of this week. He is re-installing the 119GHz electronics box onto the radiometer platform. As I understand it, the problem with the narrow tuning range of the 119GHz phase lock system should now be fixed. I will join the team on Monday in Toulouse. We should have a preliminary checkout of the radiometer before starting with the mass properties and system vibration testing, so we’ll be able to verify the 119GHz system.

During May I spent some time updating our Odin web pages. These now have a consistent look with the rest of the Space Astronomy Laboratory web pages. In addition to my Quasi-Optics pages, there are also pages on the Astronomy science overview by Sun and Kevin, and some screenshots and text showing Kevin’s scheduling software. There are many photos of Odin hardware on these pages. Maybe you would like to include a link in the CSA Space Astronomy Odin page to our Odin pages. Here’s the url: http://www.iras.ucalgary/~sat/Odin

One of the main areas I worked on during the CEPT was a program to generate, in a semi-automatic way, a complete command sequence for the radiometer to put it into a desired observing mode. I want other people to be able to run this program, so I wrote up some documentation explaining how to run it. I sent this over to SSC and the radiometer team on May 2nd.

Last week I went to Vancouver for the JSSA meeting followed by CASCA. At JSSA I gave an Odin report. I was also there to answer questions regarding the FIRST/HIFI proposal. The JSSA gave approval for development of the HIFI Local Oscillator synthesiser prototype. I have revised my proposal of March and will be sending it in later today.

At CASCA we had an Odin poster on display. The poster gives an overview of
the Canadian contributions to the Astronomy part of the mission and includes a brief description of the quasi-optics along with a couple of photos of the radiometer. Kevin’s scheduling software is also featured on the poster. All the information on the poster can be found on our web pages as well.

We noticed in the new CSA Space Astronomy pamphlet that there is no mention of Odin. Maybe before the next printing of these pamphlets we can have something on Odin in there. I hope in year’s time that Odin will be the big news in Astronomy, especially if we finally get a detection of molecular oxygen!

I’m am off to Toulouse tomorrow and I’ll join everyone at Intespace on Monday morning. I’ll be in France throughout these series of tests with a return scheduled for August 9th. I’ll be staying with my parents-in-law in Agen which is 100km from Toulouse, and I have rented a car for commuting, rather than stay at a hotel in Toulouse. Here is the contact information:

M. & Mme COMBES  
xxxxxxxxxxxxxxxxxx  
47000 Agen  
FRANCE  
ph +33 xx xx xx xx

best regards,

Steve

–

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
e-mail: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Dear Victor, David, Sun,

Three important events have slowed us down here in Toulouse during the past month. For a while, we were doing a good job keeping to the schedule, due mainly to the big effort on the part of the Saab engineers, and to the tight ship being run by our chief engineer, Fredrik Sjoberg.

The most significant set-back occurred during random vibration along the x-axis (the telescope beam axis). There was a complete failure of a bolt which sheered in two. This was one of the three bolts holding the telescope structure to the satellite frame. Aside from the bolt itself, we did not detect any damage to the telescope or the rest of the system. We did notice some metal filings on the radiometer platform afterwards. The broken bolt is unfortunately right above the diplexer tower. I was worried that some pieces could have lodged in the grids, but as far as we can see, the grids are clear.

The telescope had already undergone qualification level vibrations four years ago, so it was not expected to see a failure at only acceptance levels. The bolts which were submitted to qualification levels are not the ones currently mounting the telescope. One possibility is that the bolts were not of the correct grade of steel, and so not as tough as the bolts used in qualification. Apparently the flight bolts came from a different supplier than the qualification bolts.

The second important failure was the dichroic in the radiometer optics. This is a 50mm diameter grid. A few of the wires in the centre have broken and the dichroic must be replaced. This means that the quasi-optics plate must be removed from the radiometer platform. I’m a bit worried at what this will do to our alignment, but since the individual components on the optics plate will not be touched, including the dichroic bracket, the optics plate as a whole will maintain its alignment integrity as a unit. Our relative alignment between the five channels should not be affected. The absolute alignment is not as important since we pay only a small price in beam efficiency for a relatively large mechanical offset. The mechanical mounting of the quasi-optics plate on the radiometer platform should be good enough. In any case,
this will be verified during the beam testing at CESR at the end of August/beginning September.

It’s not exactly clear how the dichroic suffered damage. It was either during work which was done nearby for mounting thermal sensors in preparation for the solar simulation test, or it happened during vibration. If it was a vibration failure, the most likely candidate is the protective shell surrounding the pyro which cuts the wire fastening the cooler compressor platform. There was no note of the broken dichroic during visual inspection after each vibration run.

Finally, our current problem is with a worker strike going on here at Intespace. We were scheduled to go on a 3-shift/24hr schedule on Saturday. The engineers are still negotiating with management, so there has been no real work done since Saturday evening. I think a one or two day break was welcome to most people on the team. In fact, I’m worried that a few people are working too many hours and are getting tired. It’s when people are tired that mistakes occur, and this could cost us more than a couple of days. But now it will be three days off, so I hope the dispute will be resolved and we can get back on track.

The schedule is currently modified as follows. We are ready to start the solar simulation testing now which will continue for six days including pump-down and cooling. After that, we will return to the vibration lab to continue where we left off, including the random x-axis vibrations which caused the failure. This depends on the results of the analysis on the sheered bolt, and on whatever course of action is to be taken to fix the problem. Hopefully this will not involve a redesign of the bolt which has a bearing integrated in it, and is not a completely simple item to redesign.

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for July, 2000

Date: Tue, 1 Aug 2000 07:09:38 -0600 (MDT)
From: Steve Torchinsky
To: Dave Kendall, Sun Kwok, Victor Wehrle
Subject: Odin Monthly Report for July 2000

Dear Victor,

Thanks for forwarding the report from Fredrik von Scheele, I hadn’t seen it yet. He has covered pretty well most areas, and I’ll just try to fill in some gaps for my July monthly.

The main event of July was of course the Solar Simulation session during 6-11 July. There was a lot of preparation leading up to this, and I’d like to mention again how impressed I have been with the dedication we’ve seen from all the people involved, including all the engineers from Saab-Ericsson Space, and our people from Routes, as well as the SSC engineers, and of course the Chalmers radiometer team. There have been quite a few long days.

As Fredric v.S. mentioned, the radiometer components on the platform at the end opposite to the AOS experienced over heating. The main problem was the LO block at 572GHz which is buried in the dense corner of the the radiometer platform. This end also happens to be the sunward edge, making it even more susceptible to overheating. In addition, there is a shunt situated just on the other side of the radiometer platform at exactly this location. The shunt is a power dump from the solar panels in order to maintain a constant load on the solar panels during normal operation. It is basically a resistor which heats up when it takes the excess power from the solar panels. This shunt will be moved, which is one of the “simple adjustments” mentioned by Fredrik in his letter.

During Solar Sim, the 572GHz LO block exceeded a temperature of 43C, at which point Magne Hagstrom shut it off. That was at UTC3:35 on July 9th (5.35AM local time). This was the last time that LO block functioned properly, until it was removed from the system. After Solar Sim, we went through a lot of detective work to try and find the exact moment that the failure happened, but it was only possible to pin-point the last time the system worked. The next time it was powered up, it did not work, and that was a day and half later.

We were sure that the component which failed was the frequency doubler in the LO chain. There are a number of reasons for this, the main one being that it
would normally be the first thing to go. One of our suspicions was that a dropped command was responsible. The frequency doubler must be biased before it receives power from the Gunn oscillator, otherwise the doubler diode will be zapped. If the command to bias the doubler is omitted, and the Gunn is switched on, the doubler will be destroyed. Unfortunately, one thing which we are missing in the telemetry is a command read-back from the LO unit. We have this from the spectrometers (correlators and AOS), but not from the LO. So we couldn’t say definitively that a command was not received. The OSU simply reports that it received the commands, but we don’t have an independent way to confirm that the LO unit, in turn, received the commands from the OSU.

After Solar Sim, the radiometer was disassembled, and we tested the frequency doubler diode in a curve tracer. It was fine! We then tested every diode in the chain, and they were all okay. There seemed to be no reason why the LO chain was not supplying power to the mixer, and yet it wasn’t. The mixer itself was also checked and is okay. The next idea was that the bias circuit integrated in the LO-block was faulty. To check this, we used the prototype LO-block for comparison. We were able to put RF power on the mixer using the prototype LO, and the same setup produced nothing with the flight LO. Next we biased the flight LO using the prototype electronics, and there was no power. We did the opposite, and biased the prototype LO with the flight electronics, and there was power. So it seemed that something was wrong with the LO block itself, but we couldn’t see what. After this, we decided to verify our setup again, and using only the prototype with its own electronics, we produced power on the mixer. We did the same again with the flight LO, and here’s where we threw up our hands in submission; the flight LO now produced power on the mixer! So at this point, we had a perfectly working system. We never found the fault, and it didn’t exist anymore. Nevertheless, the LO was replaced by the flight spare, and the flight unit was sent back to RPG. It will be temperature cycled to see if the failure can be reproduced.

As Fredrik mentioned, The LO’s have had their thermal characteristics improved, which means that they were painted black. In my view, there have been significant changes to the thermal setup of the system. The shunt is to be moved, the 572GHz LO is replaced, and the 555/572 LO’s have been painted black. Also, the mechanism electronics box has been pretty much entirely refurbished. I have quietly suggested that we should redo the Solar Sim, but this is not a popular idea, as you can imagine. Many of us are still concerned about the OSU. As you mentioned, there has been the occasional dropout of TM seen by OSIRIS. The Radiometer has also had these kinds of events. Mainly we see spurious, non-physical, housekeeping data from time to time. For example, the AOS temperature will suddenly read 5°C for one second, when it is stable at 20°C. Anders Mortsell of SSC looked into this, and he noticed that
the spurious HK arrive when we are commanding the satellite from the on-board mass memory at the same time that we are also sending up TM commands from the ground. In general, it has been difficult getting detailed documentation on the OSU, which has been frustrating while we look into these kinds of problems. Stefan Lundin of SSC is responsible for the OSU.

The preparations for vibrations are scheduled to restart today. The radiometer team will return to France in the first week of September for the beam alignment verification at CESR. I am returning to Calgary on the 9th, and will be back here in September. It wasn’t possible to change my flight for an earlier departure because no seats are available. Instead, I will spend the week here on holiday, unless someone from the radiometer team is needed at Intespace. They have my phone number (+33 5 53 96 15 14)

best regards,

Steve
Dear Victor and David,

I thought I would delay writing my August monthly until arriving here in Toulouse last Monday, so that I could give a more up-to-date report about current activities. This was a bad strategy. Of course the activity level has been very high here, so I haven’t been able to write my report!

In August I took the first week off. Afterwards, I spent time on optimising the flight scripts for the radiometer. I managed to reduce the number of backend scripts since many of the observing modes call the same backend modes. The backends are how we refer to the AOS and correlators. We currently have 23 modes which means 23 scripts for front-end configuration, and 15 for backend configuration because of overlap. This number is doubled to create scripts for the cooled radiometer which has slightly different parameters for the front end. And the number of scripts is doubled again to have A-control, and B-control versions. Ultimately, there will be more scripts because the front-end is dependent on the Doppler shift of the satellite orbit. The intention is to generate scripts throughout the lifetime of the mission, although in principal we can generate everything now.

There’s still some confusion about what exactly is expected from us for the OSU. After some discussion with Urban, it’s clear that we have to modify our scripts. Stefan Lundin seems to be asking for something different than what Urban explains. We need to get together on this. I’m returning to Linkoping on the 24th for two weeks, and we’ll spend the whole time on the radiometer scripts.

When I arrived here last Monday, Odin was setup and running in the CESR lab in front of the collimator. They had already done some preliminary beam maps. The alignment work progressed very rapidly. We have excellent co-alignment between the five radiometer channels. It looks even better than what we measured at Chalmers. The CESR setup is a much more precise method to determine the co-alignment, and we think the small quantitative disagreement between the two measurements is due mostly to our measurement uncertainty at Chalmers. Anyway, the beams are well within the required 1/10 of a beam diameter. Our biggest separation is between
the centres of the 119GHz and the 572GHz channels, and it’s about 15 arc seconds. The submillimetre channels are together within 10 arc seconds. The 119GHz beam diameter is about 270 arc seconds, and the submillimetre channels have about 120 arc second beam diameters.

We also managed to measure the radiometer beam positions for three of the submillimetre channels using the mercury lamp instead of our Gunn sources. This is useful because it gives us a direct reference to the measurements being done with Osiris. Osiris measurements continued Friday and Saturday, but we’re not quite at the point yet where we can make the comparison between Osiris and the radiometer positions.

This week we will continue with Osiris on Monday and Tuesday, possibly finishing off with one more radiometer measurement to confirm our beam position both before and after the Osiris measurements. Wednesday is packing day and Thursday Odin is transported back up to Sweden. It should be in Linkoping by Friday. I’m leaving Toulouse Tuesday afternoon. I have a meeting for FIRST on Wednesday, and then I’ll be back in Calgary for a week before returning to Sweden. Odin looks well on track for the launch, but I understand there’s some possibility of a delay from the Russian end, for once!

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for September, 2000

Date: Tue, 17 Oct 2000 12:08:35 -0600
From: Steve Torchinsky
To: Victor Wehrle, David Kendall
Cc: Sun Kwok
Subject: Monthly Odin Report for September 2000

Dear Victor and David,

My apologies once again for a very late Monthly report. We haven’t slowed down on Odin, with lots of activity during September, and continuing.

After the beam alignment work in Toulouse, I was able to come home for a week before heading back to Linkoping for the Comprehensive Electrical Performance Testing. I mentioned last month that the radiometer alignment went very well during the first week of September. After that, the co-alignment with Osiris took a bit longer than I expected. We had the advantage in the radiometer team of having used the facility at CESR before, but it wasn’t long before Nick et al had the system figured out. I guess you’ve already heard from him about the Osiris portion of that test campaign. It looks like all the receivers on Odin are all lined up and ready to go.

I spent two weeks in Linkoping, but I suppose they could have used me there a bit longer. We spent a big portion of those two weeks testing the phase lock system for all four submillimetre receivers. The phase lock loop electronics work fine, but there is a complication because of interference between the lock electronics of the receivers. The reference oscillator frequencies have to be carefully chosen so that they don’t disrupt the lock loop of the adjacent system. This has to be done for each observing mode, and each frequency tuning within each mode. The Doppler shift due to the Earth’s orbit, and also due to the source velocity, means that we have a large number of settings. We produced spectra showing the locked Phase Reference Oscillator for all modes and Doppler shifts. The result is a reference of some 1500 plots!

Much of the work on the submillimetre configuration had already been done at Chalmers a year ago, but since we replaced the Local Oscillator unit for the 572GHz channel, we had to re-do all the settings for that LO, and then make sure it didn’t interfere with the 555GHz channel, and vice-versa. Essentially, this meant going through all the modes for all the channels again. You can see why we were so
reluctant to change the LO after Solar Sim!

At the same time, we were preparing the scripts for the flight modes. This is an ongoing process, as observation modes are being redefined (or, refined) during Science meetings. We also tried to optimise the scripts to reduce the amount of waiting time, and to reduce the number of commands where possible. Since we have new flight scripts, we decided to use them in the CEPT, so this took some debugging work. We had a dry run with the radiometer CEPT on October 4th, and the CEPT itself began officially the next day. I was there for the first day, but I had to return to Calgary for the 6th.

The CEPT continued the next week with satellite systems, and this week we are testing the radiometer flight scripts. I’m in regular contact with Mathias Fredrixon of Chalmers, who is in Linkoping testing all the modes for the radiometer.

Radiometer modes are generated in a two-step process, which is a bit unwieldly. The Front-End configuration is generated by a program written by Johan Lassing which calculates all the Front-End settings (LO frequencies, bias levels, tuning mechanism positions). Johan’s program produces script files which are compatible with OCOM (the Odin commanding program run on the EGSE). Johan’s program is written in LabView and runs on Windows.

I then produce all the backend settings (AOS, correlators, chopper mode, calibration), and I also produce a script which runs a check on the radiometer to make sure the commands have been received (current levels, mechanism positions, attenuator settings ...) My program is a “bash” script which uses a bunch of Unix utility programs. Fortunately, these utilities are also available for Windows, so now my program will also run under Windows (though much more slowly, for some reason). Mathias will try it today to see if he can produce the whole set of radiometer scripts using one machine.

Meanwhile, we are still discovering some bugs here and there in the flight scripts. When we optimised the scripts to remove redundant commands and unnecessary wait states, we of course over-did it in some places. In one case, the AOS didn’t return any data because we had removed a command which set the number of internal integrations. In another case, the calibration selection mirror was still searching for its home position while we ran the calibration. There were also a couple of incompatible front-end settings which slipped through into the flight scripts. So the flight scripts are still evolving, but they should be clean before the end of this month.

I’ll be in Ottawa next week for a meeting on the 24th about FIRST/HIFI. I look forward to seeing you next week!
best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for October, 2000

Dear Victor and Dave,

It’s only a couple of weeks since my last report, so here is a short report for October.

Odin is in Linkoping and will remain there right up until it is shipped to Russia early in the new year. The CEPT is still the current activity, and this will be followed by a flight simulation. So far, I have only heard of minor difficulties. Some troubleshooting was required on the power control software. I’m not sure of the exact nature of the problem, but I understand that it is under control.

The radiometer is not currently the prime subsystem under test, although it is powered up in order to have a realistic load on the power system. This is a quiet time for the radiometer team, but starting next week the flight simulation will get under way. Flight simulation will be similar to the Solar Simulation campaign in Toulouse, but the ambient environment will not be flight conditions. This is a test of flight functionality, and will verify the command scripts, as well as giving the ground crew a chance to work with the satellite before it flies.

The work on the radiometer command scripts is the main task for the radiometer team. I believe this will be a living process which continues into the life of the mission, or at least during the commissioning period. Fortunately, we have developed a reliable and repeatable method for generating new command scripts. Beginning from templates, we can globally change parameters for all observing modes. It is also possible to tweak commands for individual modes.

For example, I recently had to change all the scripts to remove some housekeeping checks for the backend spectrometers. With the Odin Commander software (OCOM) it is possible to check some parameters, such as temperatures, voltage levels, etc. During flybys when the satellite is in orbit, it will downlink using the High Telemetry Format. In this mode, the scientific data is not directly available. It has to be extracted afterward from the mass memory dump. I had to remove all the real-time checks of the correlator and AOS attenuator settings, since these come in with the scientific data.
Another item to keep in mind is the Attitude Control System. Currently, the scripts do not mask for pointing error. This is because the ACS was not running, and the satellite was in a perpetual state of pointing error. Eventually, we have to put the ACS mask back into the scripts. This is the type of thing which is easy to forget!

In other areas, I’ve spent much of the past two weeks on FIRST business, with the meeting in Ottawa last week, followed by a day at MPB technologies on the following Friday. Most of that day was spent working with the X-band synthesiser in the lab, and it was nice to finally work with some hardware for FIRST.

best regards,

Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Dear Victor and Dave,

In November, my main activity for Odin was probably the Toulouse beam testing report. The measurements were done in September, and we had produced many beam maps, but putting it all together was a bit more time consuming than I expected. I finally produced a document about a week before the Flight Acceptance Review, and it was immediately made available on the SSC Odin project pages. I understand some of the results were presented at the FAR.

You can find the document at the SSC project pages by going to the SSC Odin project pages at http://home.ssc.se/odin/pw/Odin_frameset.htm and select “FAR documentation and agenda” and then scroll down the menu on the left to “Telescope Test Report” and “CESR beams”.

I spoke to Alain Lecacheux on Friday to ask about the AOS problem with the laser diode. For a while, they were worried that the diode was showing signs of aging. It turns out however, that the problem was one of temperature stability. We have to be careful that the laser diode has reached it’s operating temperature before we do the frequency comb calibration. The laser diode is temperature sensitive in a non-linear way, such that at certain temperatures, its frequency dependence jumps, with the result that the spectrum of the laser through the Bragg cell is shifted on the AOS CCD detector. That means that the AOS would give erroneous frequency information on the spectrum.

At Alain’s suggestion, I have modified the radiometer command scripts so that the AOS laser diode is never switched off. That way, it will remain at a stable temperature. At times when the AOS is powered off, there will be a heater functioning to keep the laser diode temperature above 0C. When the AOS is powered on, we will wait 30 seconds (or maybe more) to make sure the laser diode temperature is stabilized before we continue.

I will forward to you a report that Alain Lecacheux and Nicolas Biver have written about AOS laser diode.
Right now, the SMR team are hard at work in Linkoping. They are going through every observing mode, and allowing it to run for 10 minutes each. I just got off the phone with them, and they were still working at 10pm! While running the radiometer modes, a signal is injected at the frequency of the water line. The frequency calibration of the backends is then verified by looking at the science data.

FIRST/Planck:

I have been quite active this month on FIRST and Planck. As you know, I was in Ottawa for a meeting about HIFI. Thijs de Graauw from the Netherlands attended, as well as Mike Fich. We have prepared a first draft of a Request for Proposal to build the Ka-band synthesiser for HIFI. I hope this can be issued very soon. MPB Technologies have decided they are no longer interested in pursuing space projects, but it looks like COMDEV are very interested in this project. I’m still quite hopeful that we can build the synthesiser in Canada. I also spent a day with MPB Technologies, and together we visited the PolyGRAMES institute at Ecole Polytechnique in Montreal. I was very impressed with the microwave facilities and know-how at Montreal.

Recently, Douglas Scott at UBC asked me to help out with the effort to find a hardware contribution to the Planck mission, in particular for the Low Frequency Instrument. I’ve looked at a few of the open possibilities, and one thing which stands out is the idea that Canada builds the control electronics for the Sorption Cooler. In fact, the Sorption Cooler is part of both the Low Frequency Instrument, and the High Frequency Instrument. The temperature stability required is measured in microKelvin, so this looks like an interesting project for one of our space electronics companies. COMDEV is a possibility, and perhaps Routes. I’m expecting to get more details on the requirements, and then maybe we can look into the possibility of an RFP for this hardware.

I’m very pleased that Douglas asked me to help with Planck. I hope now that we are finally cooperating, we can make progress on all the FIRST and Planck projects.

best regards,
Steve

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for December, 2000

Date: Thu, 11 Jan 2001 15:47:47 -0700
From: Steve Torchinsky
To: Victor Wehrle, David Kendall
Cc: Sun Kwok
Subject: Monthly Odin Report for December 2000

Dear Victor and David,

My Odin activities in December concentrated mainly on the scripting for the radiometer that was done at the beginning of the month and which I mentioned in my November report. Otherwise, December was occupied mainly with FIRST.

I spoke to Mathias Fredrixon of the Odin radiometer group this week, and also to Urban Frisk to have an idea of the coming schedule. Two members of the radiometer group are going to Russia a week from Sunday, the 24th of January. Magne Hagström and Mathias Fredrixon will be there throughout the preparations leading to the launch. Later on, Michael Olberg will join them during the CEPT that will take place in a few weeks time. Urban will also go to Russia, but he is returning to Sweden before the launch in order to be in Kiruna.

Launch is currently scheduled for February 20th, and the radiometer is scheduled to be switched on within a few days afterwards, so we will be getting housekeeping information from the radiometer very soon after launch. The cooler will be activated approximately two weeks later, and it takes about a week for the radiometer to reach its final operating temperature. Urban says he expects to do a test observation lasting about two days as early in the schedule as possible, and it looks like this could be done roughly a month after launch. This will be before pointing is stabilised, but it will still be within 40 arc seconds precision, so we can easily observe Jupiter, for example, and probably Orion.

I would like to go to Kiruna before the launch and be there even when the first housekeeping data comes in. At the moment, I’m looking at leaving Calgary during the week of 12 February, and stopping by at Chalmers on the way up to Kiruna. I expect to stay there for a couple of months, and I especially want to be there during the first test observation, which could happen by mid-March. The regular observing programme will begin in May according to the current schedule.
FIRST/Planck

I traveled to Toledo, Spain, in December for the symposium “The Promise of FIRST”. This was a scientific meeting which was very well attended. There were nearly 200 astronomers, many of whom gave talks, or had poster presentations. There were many interesting talks covering a wide range of topics, and Canada was well represented, thanks to generous funding from the CSA! We had poster papers from Erik Gregersen and Brenda Matthews of McMaster, and from Nick Tothill of St Mary’s, as well as from Mike Fich of Waterloo, and Douglas Johnstone of U. Toronto gave a talk.

There were two afternoon sessions in which scientists split into a number of groups in order to discuss a plan for the Key Projects on FIRST. The groups were essentially divided by the instrumentation, with people interested in astrochemistry, the interstellar medium, and star formation generally going to the HIFI discussion. Cosmology and galaxy formation are better addressed by the other two instruments on FIRST: the bolometer array called SPIRE, and the photoconductor array called PACS. It was interesting to note that the three groups had roughly the same number of people, indicating that FIRST is well balanced in terms of the scientific instrumentation.

I attended the session on “FIRST/Planck Synergy”. Planck will do an all-sky survey in order to measure the anisotropy in the cosmic microwave background. As a result, the entire galactic plane will be mapped which will give an unbiased complete survey of star formation regions in the galaxy at wavelengths which probe into the cores of star forming regions.

While in Toledo, I took the opportunity to talk with people about Planck, and the possibility that Canada could participate. In particular, Douglas Scott and I had a meeting with Jean-Loup Puget, the PI for the High Frequency Instrument on Planck. From the European side, Canadian participation is most welcome and encouraged, and in fact they are greatly relieved by the possibility that Canada can do the Control Electronics for the cooler system. This would be a contribution to both scientific instruments on board Planck since the cooler is used by both of them. I think this is a good way forward for participation in Planck, and we will present more details during the meeting in Ottawa on the 26th.

One other outcome of the Toledo conference is that FIRST has officially been renamed by ESA in honour of William Herschel, who discovered infrared radiation in 1800. It is now called the Herschel Space Observatory, but I expect documentation will continue to carry the name FIRST, in addition to Herschel.
I look forward to seeing you again in two weeks time,

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for January, 2001

Date: Thu, 01 Feb 2001 22:05:06 -0700
From: Steve Torchinsky
To: Victor Wehrle
Cc: David Kendall, Sun Kwok
Subject: Monthly Odin Report for January 2001

Dear Victor and David,

With Odin at the launch site in Svobodny, I no longer have direct contact with the radiometer team. I understood that they would have computers linked to the internet, but I imagine the access is limited. However, there is a diary at SSC which is updated almost daily, including new photos. It looks like everything is going well. Here’s the link:
http://www.ssc.se/ssd
and follow the links to “Odin Diary”

Kevin is very busy with Odin these days since Urban asked him to take care of scheduling for the commissioning period, as well as for the regular programme. He’ll be going to Sweden in two weeks.

I wrote to Stefan Lundin to ask him when I should go to Esrange. As Victor mentioned, they want to keep the numbers down as much as possible. Stefan says that the radiometer will be switched on a few days after launch, but it won’t operate for a full orbit until about a week later. He’d like to have one radiometer person on site for that first switch-on, but it will most probably be Urban himself. Stefan asked me to be “on-call” starting from the 27th. I’m planning to travel to Gothenburg on the 25th and I’ll stay at Chalmers/Onsala until it’s time to go up to Esrange. Mathias Fredrixon and I will go together from Gothenburg.

Here in Calgary we’re planning a press conference on the 20th. I’m going to participate in that, and we’d like to do a French segment as well. Meanwhile, we’re working on updating our web pages. I’ve added more photos to the “hardware” section, mainly from the Solar Simulation last year. We’ll also have a special page ready for the press conference, which will be more targeted to the general public.

On Saturday the 28th, I gave the Odin report at JSSA, and I want to thank David once again for his kind words.
FIRST/Planck:

We’re now preparing to start the next Design Study for the HIFI source unit, this time it will be done at COMDEV. MPB Technologies have agreed to act as consultants, so we’ll maintain some continuity. Once COMDEV have completed their study, I hope we can move on straightaway to building hardware.

For Planck, we seem to have settled on the Sorption Cooler Control-Electronics as the Canadian contribution to flight hardware. This will be done in collaboration with the Institut des Sciences Nucleaires in Grenoble. They have already produced a design, and are working on the bread-board version. We’d like to have a study here in Canada to evaluate the design and to see how we can collaborate with the French.

For my next monthly report I’ll have news of Odin in orbit!

best regards,

Steve

P.S. Victor, I’m sorry I missed you on Friday. I didn’t get away from the Planck meeting in time to drop by for a visit.

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Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Part II

In Flight Commissioning
Dear Sun, Victor, David,

This is my 72nd monthly report for Odin with March 1st marking my sixth year on the project. We all know the most important news for the month of February 2001, but I can’t resist including it in one of my monthly reports: Odin was successfully launched on February 20th!

I’ve been told that the START-1 launcher has placed Odin into orbit with such accuracy, that the deviations from the pre-calculated orbit are too small to measure. The Russians have had a perfect record with this launch vehicle, and thankfully it continued with us!

The radiometer was switched on for preliminary testing on Monday, Feb 26th. You may already have received some emails from Michael Olberg with “first light” data from the SMR. If not, you can see the spectra at the following web addresses (the usual username and password are required).

http://odin.oso.chalmers.se/astro-1.html

http://odin.oso.chalmers.se/water-1.html

Odin does not yet have active pointing, so the telescope is following the field lines of the Earth’s magnetic field. As a result, we are looking at the stratosphere in a sort of uncontrolled aeronomy experiment. You can see the oxygen detection with the Finnish 119GHz receiver. Note the split lines, this is apparently Zeeman splitting.

We have a problem with one of our submm LO’s. The 572GHz channel did not lock during Astro-1 mode. This is the same LO that was replaced after the solar simulation in Toulouse last summer. The problem is the cross-talk with the 555GHz channel which uses the same Phase Lock Loop Box. We have seen this before, and spent a lot of time coming up with compatible settings, but it’s turned out to be quite tempermental. We’re confident that we can come up with a solution. One
possibility is that reflections in the diplexer tower are inhibiting the lock. We will try detuning the diplexer, and then locking the LO. Afterwards, we have found that once the lock is in place, it is robust, so we can then tune the diplexer properly for LO coupling.

Otherwise the system is checking out well. All mixers are alive. There Current-Voltage characteristics (I-V curves) were measured on Monday. The LO's are all producing power. The cooler will we switched on towards the end of next week.

I have been concentrating on basic housekeeping while Michael works with the spectra. It’s interesting to see the temperature fluctuations following the orbit period. This weekend the radiometer will be switched on again. We have to keep an eye on the temperatures because the cooler is not running yet, and we mustn’t let the mixers get too hot. So far they have remained at around 300K, and it looks like the temperature levelled off at that point.

Some of my plots are available on my web pages (not for public consumption):

http://www.iras.ucalgary.ca/~sat/Odin/project

best regards,

Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
email: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
Report for March, 2001

Dear Victor and David,

You’ve had quite a few emails during this month from me as well as from others here in Sweden, so I’ll just summarise a bit for this month’s report.

Regarding the cooler, you’ve just heard from Urban and again from Lennart that it is working nominally. As of this morning, the mixer temperatures were down to 136K and still dropping, with signs of leveling off. When we do the radiometer commissioning in about a week’s time, we’ll be testing the stability of the system. I think we have every reason to be optimistic.

During the pointing exercise recently, you heard from Nick Lloyd that OSIRIS detected Jupiter early on in the campaign. The radiometer also detected Jupiter a few orbits later, agreeing with the OSIRIS position. It looks like we’re all well aligned. We still have to check the “A” side of the radiometer compared to the “B” side. During the last few days, when the cooler was working intermittently, our sensitivity changed with temperature. This basically destroyed our baseline reference during the last two days before Jupiter was out of view. We can verify the A/B co-alignment on other objects during the radiometer commissioning.

I’m attaching a few plots which may be of interest. The first is the 557GHz water channel detection of Jupiter. The AOS is the spectrometer in that case. Plotted together with that is the 572GHz channel, with Correlator-2 as the backend. It is noisier, but still shows clearly a detection at the same time. When the spectra of the Correlator are co-added into bins, the detection comes up more clearly (second plot attached).

Finally, I’m attaching a spectrum from the AOS tuned to the 557GHz water line, which was taken while Odin was looking at the Earth’s atmosphere. At the time, we were chopping between the telescope and one of the calibration sky positions. When the sky position is no longer looking into cold space, but is also looking at the atmosphere we get this split effect which looks like frequency switching. The
different angles of view between the two positions results in a different line of sight velocity, and the Doppler shift difference between the two creates the double line shown here. The negative peak is the one that is in the reference beam, while the positive peak is the one in the signal (telescope) beam.

best regards,
Steve

Steve Torchinsky
Dept of Physics and Astronomy, University of Calgary, Canada
www.iras.ucalgary.ca/~sat
e-mail: sat@iras.ucalgary.ca
ph. +1 403 220 6059
fax. +1 403 289 3331
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