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Interactive comment on "Mars sub-millimeter sensor on micro-satellite: sensor feasibility study" *by* Richard Larsson et al.

Richard Larsson et al.

ric.larsson@gmail.com

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1 General changes

The changes to the paper between this and previous version are substantial. The major changes are as listed

- The error analysis has been redone completely based on overarching comments from both reviewers. This has been done mainly to be able to discuss what both reviewers mentioned as important, namely the trade off between precision and resolution in an added subsection at the end of section 3. This discussion is not exhaustive but we think it addresses the reviewers' concerns about the the

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Discussion paper

aforementioned trade off.

- The forward simulations have been changed by using available GCM model atmospheres and updating the Zeeman effect spectroscopy. The former was done to better represent cases with a changed correlation distance (or scale length) in the a priori covariance matrix required to discuss mentioned trade off. The latter is a more recent development where the main author found a small (a few percent) error in the Zeeman splitting for the used molecular oxygen line.

Other smaller changes have also been incorporated in the current version.

Below in red are the reviewers' comments one-by-one as copy-pasted from the original response files provided by Copernicus. The one alteration that the main author has done to these comments is to add appropriate LaTeX-coding for references to variables in equations.

Before going over the detailed response, we wish to thank the reviewers because their suggestions have improved this work substantially.

Attached is the updated paper.

2 Respons to reviewer 2

The manuscript is about using sub-millimeter radiometry to measure Martian atmosphere. In my opinion this idea is a solid one and combining the sub-millimeter instrument with a micro satellite platform follows the current trend.

However, I find some problems with this feasibility study. I do see that the main emphasis of the manuscript is on the radiometer instrument and the measurements made with it. I would still like to see the space technology details discussed more.

There is a paper under preparation about the platform. We will therefore not discuss the platform in much more details in this work.

For example, the authors state that putting the satellite into Martian orbit has never been attempted before using atmospheric drag. The authors just assume that this can be done and assume a couple of potential orbits. But doesn't this mean that using micro satellite platform makes the mission harder to accomplish? Why not just put the instrument to a bigger platform and put it into orbit by more conventional means?

We wish to be clear, we state that using atmospheric drag as the only breaking mechanism has never been done before. The paper under preparation will discuss these points in more detail.

The reviewer is very much correct that our instrument can be placed on any other type of platform that wish to accept it as part of their payload, and that the small platform makes the mission much harder than if we could use a larger platform. To answer the second question a bit bluntly, we working on using the small scale approach because flying to Mars is expensive, we know of no one with an open call that would accept a sub-millimeter sensor on a Mars mission, and with a small platform we should be able to get this done ourselves.

None of these comments seem to fit in the paper, so the text has not been updated.

I also think that the description of the radiometer instrument is lacking. I did read the Kasai et al. 2012 paper and they describe the FIRE radiometer in detail. In what way the FIRE-mini differs from the FIRE instrument? Is it only size as the authors mention or the usage of two channels with different circular polarization? How about weight and power budget? Kasai et al. 2012 gives two options of FIRE radiometer; Limited science: 5 kg, 10 W & Full science: 16 kg, 40 W. If the micro satellite platform has max. weight of 100 kg then fitting in even the full science option of FIRE might do the job. So what is the advantage of FIRE-mini over FIRE?

The mass and power budget is smaller.

We update the start of subsection 2.2 to exemplify one limitation the platform has incurred on us that did not concern FIRE.

We have also changed the name working name internally to TEREX as an official name for the mission.

Solar power is available less in the Martian orbit than in Earth orbit. Is the 40W power feasible using solar panels? In my opinion the small satellite size could be a limitation in this case. How about the attitude control? A probable choice would be magnetic control which also uses electric power. So what is the actual advantage of using micro satellite platform? Is it the reduced costs?

Indeed, the power budget is very limited. The exact number we have is still a work in progress. The paper discussing the platform will go over these details. It is beyond this work.

I think the Reviewer #1 has good comments about the trade offs in accuracy, resolution and precision. The Reviewer #1 also points out that making the radiometer more sensitive reduces the errors in parameter retrieval. This could be difficult since the receiver is heterodyne receiver (because of sub-millimeter wavelengths) or at least depends much on the calibration of the instrument. I suppose the calibration of the FIRE-mini will be done using 2.7K background microwave radiation as with FIRE? Even though the orbit selection might no have a big effect on those the attitude control probably will have. Magnetic attitude control, however, is not that precise.

Yes, space is the background. The limb scanning mode we describe will not be as accurate as in figure 4, with perfect staring at each tangent altitude. Making it accurate either before making the measurements or as a reconstruction a posteriori is going to be a major challenge, and the exact limitation of this is going to have to be quantified once the measurements are available. Figure 4 and later figures should still fairly accu-

rately represent the error estimations if we can somehow reliably reconstruct pointing afterwards.

The authors describe the forward model in chapter 2.3 and then I suppose chapter 2.4 describes how the inversion of forward model is done. I think the description is more on the conceptual level and it is not that easy to see what is actually done in the paper.

Hopefully the update fixes most concerns about the inversions. We cite four papers describing some parts of the forward model, and one additional paper describing the spectroscopic parameters. The forward model is also available to read via provided hyper-links if even more in-depth details are necessary.

Please also note the supplement to this comment:
https://www.geosci-instrum-method-data-syst-discuss.net/gi-2017-50/gi-2017-50-AC2-supplement.pdf

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