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Interactive comment on "The MetNet vehicle: A lander to deploy environmental stations for local and global investigations of Mars" *by* A.-M. Harri et al.

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Author's esponse to the review (Reviewer #2) of the manuscript

Title: The MetNet vehicle: A lander to deploy environmental stations for local and global investigations of Mars Author(s): A.-M. Harri et al. MS No.: gi-2016-19

Dear Reviewer and the Associate Editor,

Thank you very much for your valuable comments in reviewing this manuscript. We have taken into account your comments and recommendations, and most of them have resulted in modified and/or added text in the manuscript. This response is structured such that we have firstly responded to the major comments and then to minor com-

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Discussion paper

ments. Our response treats all the reviewer's comments individually by introducing firstly the comment, then our response, and finally, the changes in manuscript are depicted in the end of this response as a supplemented file (in the form of a 'difference mansucript').

Thank you very much for your valuable review effort, A.-M. Harri et al.

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********************** RESPONSE ****************************

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Note: text in bold is our response. Text in bold and in quotes is text that can be found in the updated paper.

1. This paper is a useful and interesting summary of the MetNet vehicle design. With a few additional details and minor clarifications it should be suitable for publication. line 75 it would be appropriate to cite here Lorenz, R., Planetary Penetrators : Their Origin, History and Future, Advances in Space Research, 48, 403-431, 2011 which gives many pertinent details.

Added reference on page 3 line 82:

"Penetrators for a variety of Solar System destinations have progressed to the concept stage although only two designs have actually been launched (Lorenz, 2011)."

2. line 85 – since no real definition (g-threshold ?) of semi-hard landers is given, was Mars Pathfinder (which was after all, a Pathfinder for the MESUR mission, which was a network much as intended here) a 'semi-hard lander' ?

The Pathfinder reference has been added to the paragraph starting on page 4 line 91. The paragraph has also been rewritten.

"Semi-hard landers are vehicles that impact the surface at speeds, and experience subsequent decelerations, that are between those of a soft lander and a hard lander.

Such landers will experience a moderate deceleration of a few hundreds of gees over the time of some tens of milliseconds. Typically low-mass Martian semi-hard landers have thus far used a combination of heat shield, parachutes and airbags, e.g. see Harri et al. (1999); Linkin et al. (1998), for entry, descent and landing. Heavier semi-hard landers, eg. Golombek et al. (1999), have used additional retrorockets at the end of the descent phase to decelerate down to the required impact speed. Semi-hard landers provide a practical solution for deploying planetary surface payloads that include robust geophysical instruments and are especially suited for deploying lightweight sensor systems needed to perform atmospheric science experiments."

3. Table 1 – should identify where in this classification (if anywhere) the Mars-96 penetrators sits

Mars-96 penetrator EDLS is similar to the selected concept except MetNet has an inflatable rather than rigid heat shield. Added reference for Mars 96 to caption for table 1. See below.

"Table 1. The studied MNL EDLS concept candidates. In each concept the entry and descent phase braking devices are jettisoned to reduce decelerated mass. The concept A1 is as Mars-96 Small Stations (Linkin et al., 1998) and similar to the selected concept as the Mars-96 penetrators (Surkov and Kremnev, 1998) which used a rigid heat shield rather than an inflatable one. The column title 'Entry' refers to the hypersonic and supersonic portion of the flight. 'Descent' refers to the subsonic portion of the flight. A 'tension cone' refers to a type of inflatable decelerator shaped so as to contain tensile stresses, e.g. see Clark et al. (2009) for more information."

4. line 150 - what is the spin rate required for stability? How is it effected (spin carrier? spin-eject mechanism? post-separation spin rocket?)

Spring loaded mechanism that ejects the MetNet and at the same time creates the spin. Rewritten paragraph starting on page 7 line 160 to make this clear:

"Since the MNL itself does not have thrusters for trajectory or attitude changes, the carrier spacecraft may also need to carry out attitude change manoeuvers to release each MNL at the correct angle and at the correct time to reach its intended landing area. Stability is obtained from the aerodynamic properties of the vehicle and spinning of the the MNL. The MNL is ejected and given its spin of one revolution every six seconds by a spring loaded mechanism on the carrier spacecraft."

5. line 164 – seems to be a typo (+18 degrees would be flying away from Mars) – please check the range, and indicate for which altitude the flight path angle is defined .It would be nice here to indicate what the heat fluxes expected at this speed/angle might be.

Fixed, thanks.

6. line 210, 219 and following. I am not familiar with the alloy designations (Russian, perhaps). Can you indicate the composition or Western equivalents?

They are Russian GOST designations. Update text with a reference on page 10 line 226.

"The SAS is made of six metallic (AMg3M Aluminium-Magnesium alloy (GOST, 1977)) hollow tubes."

7. Fig 3. – please provide a list of components to go with the numbered labels.

Provided.

"Fig. 3. The Rigid Aerodynamic Shielding (RAS) includes a blunt front shield plate, a toroidal pressure vessel (which stores the H-IBU inflating gas under pressure) as well as supporting structures for both the Surface Module and the entry and descent systems. The labels are as follows: (1) front shield (FS) with TPC; (2) body of FS; (3) H-IBD filling system; (4) H-IBD; (5) lander body; (6) telescopic cone; (7) telescopic cone drive; (8) T-IBD; (9) shock absorber; (10) cover; (11) instrument container."

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8. line 228 what is TPM-8 fabric (polyimide? polyester?) What is the inflation gas?

TPM-8 fabric and inflation gas are classified items specified by the Russian Space Agency.

9. Fig 5 – what does label E indicate?

The label E is not important and has been removed.

10. line 304 – please indicate what microcontroller is used, or at least give some specifications (e.g. clock rate, instruction set, memory etc.)

Added text on page 16 line 330:

"The micro controller type used is a freescale micro controller MC9S12XEP100. The micro controller has 1 MByte Flash PROM for program, 64 kByte RAM for data, 4 kByte EEPROM and 32 kByte D-Flash. External memory used in the MetNet DPU: 2 x 128 Mbit serial flash memory. The same type of micro controller is used for DREAMS aboard ExoMars 2016. "

11. line 311 – please follow your own instructions and define JTAG

Defined: JTAG (Joint Test Action Group)

12. line 382 – indicate how accurately Phobos eclipse timings need to be to refine location (e.g. timing to 1 second is a constraint to 1 km??). What kind of on-board clock is used, and how accurate is it (assuming temperature history is known, since most quartz oscillators are strongly temperature-dependent)

Added text after page 21 line 426:

"The sampling frequency is 1 Hz as a compromise between precision and generated amount of data inside the needed measurement window. This leads to a resolution of approximately 3 km depending somewhat on the latitude of the actual landing side. The clock precision and stability is 5 orders of magnitude better than this, so can be ignored. The 1 Hz sampling rate is hardcoded in the software outside the cyclogram control system to allow absolute time scheduling."

13. 406 – what kind of material is KT-11 cloth?

KT-11 fabric material that is a glass-cloth-based laminate. Updated text on page 22 line 444.

"Section I is constructed of a double layer of KT-11 cloth, a glass-cloth-based laminate (Shalin, 1995), that can survive temperatures up to 1500 K."

14. 414 'radiolucent' – not sure if this is a word. 'radio-transparent' is clear.

Changed to radio-transparent.

15. 420 et seq. The shape of the inflatable entry system is novel, so any additional details on aerodynamic coefficients (especially stability derivatives) would be welcome additions to the paper.

This is work in progress using numerical simulations to calculate the aerodynamic coefficients.

16. 435 – the planetary protection section is very important, but not very explicit. The considerations given here are worthwhile, but if (as one might hope) the MetNet vehicle and/or some of its components have been qualified for specific planetary protection procedures (e.g. ethylene oxide, DHMR, etc.) that would be well worth stating in detail here – presumably part of the goal of this paper is to indicate mission-readiness!

Added some details on page 24 line 497.

"The MNL decontamination will most likely be performed via a combination of dry heating and hydrogen peroxide treatment. Dry heating is applied for humidity sensor devices."

17. line 505 - the Lorenz paper mentioned above discusses the 'N of M' survival prob-

lem in the context of hard landers and network missions. Some of the considerations there might usefully be raised in this section.

A reference has been added here to the penetrator paper. Page 28 line 543.

"Although correlated and combined observations are qualitatively a leap forward from previous types of observations, the potentially larger numbers of deployable MNLs and acceptance of higher risk of the failure of a single vehicle, e.g. see Harri et al. (2012); Lorenz (2011), would permit clear advantages for studies in microscale meteorology and atmosphere-surface interactions (e.g., momentum and thermal fluxes):"

18. line 545 et seq. The payload mass fraction really needs to be defined better – for small vehicles the level of integration is very high (one reason the DS-2 number is not really given in the literature – the instruments were not boxes that were weighed and bolted on, but integral parts of the vehicle). This confusion is evident from the fact that the numbers in the text ('17%' – including thermal insulation and container) are discrepant with Table 4 immediately above (does this include these other items?) Clarify/check, please.

Added text to explain payload mass fraction page 29 line 596:

"Table 4 compares the MNL to other soft and semi-hard Mars landers and their resources. The science payload fraction is listed here rather than the landed payload fraction. It should be noted that for older spacecraft like the Viking lander the level of integration of the instruments is low, i.e. each instrument may be self-contained rather than sharing resources, with an apparently higher payload ratio for newer spacecraft. Also small landers will tend to have a higher level of integration."

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Modified Manuscript with changes tracked

provided as a supplement file

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Please also note the supplement to this comment:
http://www.geosci-instrum-method-data-syst-discuss.net/gi-2016-19/gi-2016-19-AC2-supplement.pdf

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