Geosci. Instrum. Method. Data Syst. Discuss., 2, C233–C239, 2012
www.geosci-instrum-method-data-syst-discuss.net/2/C233/2012/

Geoscientific Instrumentation Methods and Data Systems Discussions

Interactive comment on "Electric solar wind sail mass budget model" *by* P. Janhunen et al.

Anonymous Referee #2

Received and published: 29 October 2012

Electric Solar Wind Sail Mass Budget Model Pekka Janhunen, Alessandro A. Quarta, and Giovanni Mengali

General remarks:

This paper proposes a detailed mass breakdown model of an E-Sail spacecraft. This model is proposed as a design tool for various types of missions that would use an E-Sail as its propulsive method.

The paper is written assuming that the reader is already familiar with the E-Sail concept. Two examples given below are illustrating this comment:

In the abstract, it refers to the "number of tethers" while the need for tethers is not obvious for the reader unfamiliar with the concept. In fact there are three parameters that control the propulsive acceleration: the number of tethers, their length and the

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

High-Voltage applied to the tether that defines the sheath size around each tether. The potential applied is always assumed throughout the paper to be 20 kV; it is not clear as to why this is not considered as a variable parameter in this study. This is regarded as one short-coming of the paper.

Except when noted in the comments below, all assumptions are reasonably defined. The outcome of the paper should be useful for those who intend to design a mission based on an E-sail propulsion technique when applicable.

Lots of parameters are defined throughout the paper and referred to by a symbol. I have spotted some that are either not defined or not defined the first time they are used. The authors are advised to verify very carefully that all parameters and their used symbol are well defined first time they are used.

This paper represents some progress in the understanding of the design parameters for an E-sail. The lack of using the High-Voltage value as a variable parameter is however a short-coming that should be corrected in the revised manuscript. The parametric variation of the HV value, may allow addressing the technology related to the High Voltage technology and identify critical aspects related to this feature of the E-sail.

An overall mass margin of 20% is assumed, which may be a rather low value for a new system that is based on a new concept. I would suggest to use a higher value.

A margin is not always used for each unit/element/subsystem. It should be a common practice in this study to use a certain margin (20-30 %?) for all elements

Detailed comments:

Details comments and questions are provided below. Note that in this ASCII text document, the Greek letters are spelled out.

Line 6: The term “scientific payload” may be mis-leading. Throughout the paper it should be understood as the mass of everything-else but the E-Sail system itself. With reference to an electric propulsion mission (Dawn, BepiColombo) it would then mean

GID

2, C233–C239, 2012

Interactive Comment

that all but the electric propulsion subsystem constitutes the scientific payload, which is not what the term scientific payload is meant to be. I would suggest to use an other term instead of “scientific payload”.

Line 25: It should be made clearer that a High Voltage power supply is required to polarise the tether at high voltage. The electron gun is only a support device to help expel the electron current collected by the tethers; hence to help maintain the spacecraft bus near zero volt; the phrasing “.. are kept in a (a) high positive potential by an on-board electron gun. . .” is misleading. It should be rephrased.

Line 29: I suggest to use the word Âń reference Âż instead of Âń baseline Âż

Line 32: How do you come to the value 960 W for the electron gun ?

Line 33: Provide a reference to previous work for this reference design, and explain in more detail the reasons behind the choice of this reference design. It should be verified that it does not bias the results of the parametric study.

Line 35: The reader may be confused with the use of the word Âń potential Âż it may be understood as an adjective while it is meant to the noun. The sentence should be rephrased.

The overlapping of the sheaths of nearby tethers is also a function of the High Voltage applied to the tethers. It should be said that the sheaths always overlap near the root of the tether as the spacing is small, and the overlapping breaks at a certain distance from the root of the tether (this distance being a function of the HV applied, and the Solar Wind condistions). Some numbers (distance at which the overlaps breaks vs HV value) should be given to illustrate concretely this point.

Line 36: Provide a reference to the fact that the trust varies with 1/r

Line 47: Delete Âń expectedly Âż

Line 49: Clarify that these numbers apply for the reference case. Provide a literature

GID

2, C233–C239, 2012

reference (the same as the one requested above) for the numbers provided.

Line 55: The technique behind the constant power strategy should be explained. Does it have an effect on the sizing of one of the subsystems?

Line 59: ".. The main tethers are spun. . .." should be rephrased. It's not the tethers which are spun, but the spacecraft bus that holds the tether deployment mechanisms.

Line 60: why is a factor of 5 so critical ?. Is there any latitude in this number?

Line 62: Clarify the unit Âń cN Âż

Line 64: Replace Âń along Âż by an other word

The micro-meteorid hazard is indeed addressed properly regarding the risk of a tether break due to a direct impact.

Is there not also a potential risk associated with an impact on the spacecraft bus itself as it would induce a plasma cloud around the spacecraft that may be a disturbing environment for the HV involved. It is recommended to address this point.

Line 71: Is it reasonable to assume full trust for 10 years of flight at 1N ? At what distance from the Sun would the trust remain at 1N ?

Line 72: Remove the Âń s Âż in Âń MNs Âż

Line 77: For a full comparison, would it not be appropriate to address what is limiting the efficiency of an electric thruster? Am I correct in assuming that, if the ejection velocity of the ions could be increased (by increasing their acceleration voltage) the efficiency of the electric thruster would be increased, hence less propellant would be required. Would it be relevant to consider, for comparison, the performance of an electric thruster that works with the same HV as the one used for the E-Sail (25 kV)?

Line 86-87: Explain what is meant by Âń near-term technology data Âż

Line 91: Replace Âń constituted by Âż by Âń consisting of Âż

GID

2, C233–C239, 2012

Line 92: add a Âń a Âż in Âń having a length Âż

The numbering of the lines is not correct for a while in the manuscript.

The parameter Âń m str Âż 2 lines above formula (1) and Âń eta str Âż in the formula do not seem to be defined

The fact that new parameters used in equation (2) are only defined in the next subsection makes it difficult for the reader to understand the equation (2)

3rd line in section 2.1 : What is the reference for "gamma eg = 1.0 kg/kW". Is this applicable to the required parameters for the electron gun in this application?

Line 113: Here it is mentioned that a ". . .simple strategy of varying the tether voltage..", while later, line 143, it is written that each tether can have its own high voltage source.." If each tether has it own voltage source, does it require that all voltages are synchronised or can each high voltage source be adjusted independently from the others ? It is not clear how the Peg is controlled if there is a power source for each tether.

Line 147: I was not able to find information on the Ultravolt voltage source model 35A24-P30. A proper reference should be given. What is the output voltage? if it is below the value needed for the envisaged application, can the same technology be used for the required HV value ? The availability of the HV technology for the envisaged application should be further discussed, as it is a critical item. It would be useful to make reference to already flown HV subsystem and discuss applicability of the used technology to the E-Sail.

Line 155-160: is the parameter Âń Rho Al Âż defined ?

Line 160-165 : Provide a reference for the description of the two test missions mentioned: ESTCube-1 and Aalto-1

Section on Remote Units:

I am missing a description of this unit. What is the power supply for it ? How are they

GID

2, C233–C239, 2012

controlled ?

In several places, remove the Âń s Âż from Âń Ns Âż

Formula (8): is Rho Ka defined somewhere ? Section 2.6

The performance of the camera (operating under day light conditions) are not assessed

Line 199: What are the pointing requirements for the optical beacon ; where is the receiver ? under which conditions are the pointing requirements met ?

Line 202: an allocated mass of mgc = 1kg seems to be a low number for a guidance computer ; what level of radiation shielding is assumed ?

Line 219: A power consumption of 0.1 W/kg seems to be very low.

Line 230: Please clarify the value 1W/kg. Does it mean that a 1000 kg Power subsystem is required to provide electrical power to the electron gun(s) ? It seems to be the right assumption when I refer to table 1.

Line 234: the parameter Âń gamma sa Âż does not seem to be defined

Line 241: the parameter Âń eta sa Âż does not seem to be defined

Line 242: clarify " . . ..the power system produced. . ."

Line 250: Please clarify how pointing to the sun is maintained

In the two-line text between formula (10) and (11), in the review version the meaning of the greek letter "Delta" above the sign Âń = Âż is not understood. This symbol is used in other places.

Line 276-277: The reader should be referred to Table 1 earlier in the manuscript, when undefined symbols are used.

Line 285: remove the Âń s Âż of Âń accelerations Âż ; the meaning of a 3 value vector is not obvious (although it can be deduced as meaning three different values by reading

GID

2, C233–C239, 2012

table 2 ,3,4)

Line 365: Same remark as for line 285 for the 4-value vector

Line 385: It is understood that such an E-Sail may be used to get close to a NEA; does the concept allow to arrive at zero-velocity at the asteroid or does the mass budget include the mass required to slow to low velocity at the asteroid ?

As noted above, the value of the high voltage is a variable parameter. The reason for the choice in this parametric study should be explained.

Line 405: The wording Âń .. but is wanting in . . . Âż is not understood

Line 411 and in several other places in the text/ it should be clarified that Âń scientific payload Âż is meant as the payload carried by the E-Sail, not only the scientific payload as is commonly understood in a science mission.

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., 2, 429, 2012.