METIS INSTRUMENT PROPOSAL
for the Solar Orbiter Mission
Part 6: Instrument Financial Plan

Ester Antonucci (P.I.), S. Fineschi, G. Naletto, M. Romoli, D. Spadaro, S. Solanski, P. Lami and the Co-I’s Team

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METIS INSTRUMENT PCOPOSSAL
for the
Solar Orbiter Mission

Part VI
Instrument Financial Plan

Principal Investigator:  Ester Antonucci (1)
Co-Proposers:
S. Fineschi (1), G. Naletto (2), M. Comoli (3), D. Spadaro (4),
S. Solanki (5), P. Lamy (6), and the Co-I’s Team

(1) INAF – Astronomical Observatory of Turin, Torino, Italy
(2) University of Padua, Padova, Italy
(3) University of Florence, Firenze, Italy
(4) INAF - Astrophysical Observatory of Catania, Italy
(5) Max-Plank-Institute fuer Sonnensystemforschung, Germany
(6) Laboratoire d’Astrophysique de Marseille, France,

Leading Funding Agency:
ASI – Agenzia Spaziale Italiana
(Cef. S. Di Pippo – (simonetta.dipippo@asi.it) - Viale Liegi 26 – 00198 Coma Italy
Phone: +390685671 Fax: +39 06 8567267)

In cooperation with:
CNES – Centre National d’Etudes Spatiale
DLC – Detuches Zentrum fuer Luft und Kaumfahrt

prepared by  METIS Team

approved by  E. Antonucci
reference issue 1
total revision 0
date of issue 15 January 2008
Distribution

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<td>Marcello Coradini (*)</td>
<td>ESA/HQ (D/SCI) 8-10 rue Mario Nikis 75738 Paris Cedex 15 France</td>
</tr>
<tr>
<td>Richard Marsden</td>
<td>ESA/ESTEC (SCI-SM) + P.O. Box 299 1 (part VI) 2200 AG Noordwijk The Netherlands</td>
</tr>
<tr>
<td>Philippe Kletzkine</td>
<td>ESA/ESTEC (SCI-P) + P.O. Box 299 1 (part VI) 2200 AG Noordwijk The Netherlands</td>
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<tr>
<td>Simonetta Di Pippo</td>
<td>ASI – Osservazione dell’Universo Viale Liegi, 26 00198 Roma, Italia</td>
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<tr>
<td>Prof. Sergio De Julio</td>
<td>INAF Viale del Parco Mellini n.84 00136 Roma</td>
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(*) Hardcopy version only

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Table Of Contents

1 INTRODUCTION .................................................................................................................. 5

2 PROJECT FUNDING ........................................................................................................... 6

   2.1 Partner contributions....................................................................................................... 6

   2.2 Overall Cost.................................................................................................................... 6

   2.3 Technology development .............................................................................................. 7

3 ACRONYMS .......................................................................................................................... 10

ANNEX – 1 : LETTERS FROM THE FUNDING AGENCIES .................................................. 13
LIST OF FIGURES

Figure 1: METIS HW Tree .........................................................................................................................8
Figure 2: METIS WBS ...............................................................................................................................9

LIST OF TABLES

Table 1: Manpower (FTE man-year) allocated by the team consortium to the METIS investigation 6
Table 2.........................................................................................................................................................7
1 Introduction

This document provides the financial justification to the METIS investigation in terms of estimated resources, manpower, hardware and tech development.

The METIS investigation is proposed by an International Consortium under the responsibility of the Principal Investigator, Ester Antonucci, INAF-Osservatorio Astronomico di Torino. Experiment Manager of the METIS project is Giampiero Naletto, University of Padua and the METIS Investigation Scientist is Silvano Fineschi, INAF-Osservatorio Astronomico di Torino. The METIS elements are in turn under the leadership of the following Co-PIs: Marco Romoli, University of Florence (COR), Daniele Spadaro, INAF-Osservatorio Astrofisico di Catania (EUS) and Dan Moses, Naval Research Laboratory, US (SOCS).

The METIS proposal is endorsed by the Italian Space Agency (ASI) as Leading Funding Agency.

The consortium is formed the following Italian institutions: Istituto Nazionale di Astrofisica (INAF), the Universities of Florence, Padua, Pavia, Catania, the Consiglio Nazionale delle Ricerche – Istituto di Fisica della Materia (CNR-INFM), the Politecnico of Torino, and the following foreign institutions: Naval Research Laboratory (NRL), US, Max-Planck-Institut für Sonnensystemforschung (MPS), Lindau, Germany, Laboratoire d’Astrophysique de Marseille (LAM), France, the Institute d’Astrophysique Spatiale (IAS), France, University of Athens, Greece, Royal Observatory of Belgium, Bruxelles, Belgium and Mullard Space Science Laboratory, UK. In terms of hardware contributions, NRL intends to provide the SOCS optical bench and sensors MCP, and is submitting to NASA a proposal in response to the NASA Focused Opportunity for Solar Orbiter, FOSO (deadline 31 January 2008), MPS intends to provide the two detectors of the COR element, LAM intends to provide the mirrors and mountings for COR.
2 Project Funding

As stated by ASI, METIS leading funding agency, the investigation cost details will not herein be provided. These will be part of a later issue of this document after the instrument selection and consequence of a direct contact between ESA and the Leading Funding Agency.

The overall manpower estimation is reported in table 1. The FTE manpower effort is expressed in man-year.

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<td>83.8</td>
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(*) Excluded Italy
(**) SOCS not included

Table 1: Manpower (FTE man-year) allocated by the team consortium to the METIS investigation

For reference in Figure 1 and Figure 2 are shown the METIS HW tree and a preliminary WBS respectively.

2.1 Partner contributions

NRL will submit at end of January their proposal to NASA in order to contribute to METIS with the SOCS sensor.
Max-Plank-Institute Lindau will provide the COR detectors.
LAM will provide COR mirrors blank and mounts.
Further hardware contributions (e.g. from the Greece Space Office) have not yet been finalized.

2.2 Overall Cost

The overall ROM funding requirements estimation of METIS, inclusive of Manpower, Hardware, Tech Dev, is about 67M€, based on a cost estimation made by Thales Alenia Space, Galileo Avionica and the contributing partners.

The detailed cost plan will be part of direct contact between ESA and the Leading Funding Agency.
2.3 Technology development

A preliminary estimation for the activities related to technology development within the METIS project is shown in Table 2

<table>
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<td>Multilayers</td>
<td>250k€</td>
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<td>Liquid Crystal Variable Retarder</td>
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<td>Detectors</td>
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The backup technologies do not require a space development or qualification program.

Funding Agencies

ASI is the leading funding agency of METIS. Annex 1 includes:

- the Letter of Commitment of ASI
- Letters of Endorsement to ASI from DLR and CNES
- Letter of Endorsement for CO-I participation from BELSPO and MSSL.
Figure 1: METIS HW Tree
Figure 2: METIS WBS
3 Acronyms

ADC  Analog to Digital Converter
AFT  Abbreviated Functional Test
AIT  Assembly, Integration and Test
AOCS Attitude and Orbit Control System
APS  Active Pixel Sensor
BB   Breadboard
BBM  Bread-Board Model
BELSPO Belgian Space Policy
CCD  Charge Couple Device
CFRP Carbon Fiber Reinforced Plastic
CME  Coronal Mass Ejections
CNR  Consiglio Nazionale delle Ricerche
CNRS Centre National de la Recherche Scientifique
CoI  Co-Investigator
CoM  Center of Mass
CoPI Co-Principal Investigator
COR METIS Visible and EUV Coronagraphic imager
CTE Coefficient of Thermal Expansion
DMS Data Management System
ECSS European Cooperation for Space Standardization
EEO Extended External Occulter
EEOM EEO Mechanism
EM  Electrical Model
EM  Experiment Manager
EO  External occulter
EOM External occulter Mechanism
EQM Electrical Qualification Model
ESA European Space Agency
EUI EUV Imager
EUS METIS EUV disk Spectrometer
EUV Extreme UltraViolet
EUV C EUV Channel
FEE Front End Electronics
FEM Filter Exchange Mechanism
FFT Full Functional Test
FM  Flight Model
FOV Field Of View
FS  Flight Spare
FWHM Full Width at Half Maximum
GSE Ground Support Equipment
H/W Hardware
HeF Aluminum low-pass filter of the coronagraph
HELEX Heliophysical Explorers
HERSCHEL Helium Resonance Scattering in the Corona and Heliosphere
HF  Narrow-band multilayer filter of the coronagraph
ANNEX – 1 : Letters from the funding Agencies

LOC-ASI-Metis.pdf

DLR_METIS_COR LoE-1.pdf

CNES_SOLAR_ORBITER_METIS.pdf

LoE_BELSPO-ASI_EUS.pdf

MSCL_METIS.pdf

NASA_SOCS_NOI.pdf

The Italian Space Agency hereby endorses the proposed participation by the Multi-Element Telescope for Imaging and Spectroscopy (METIS) experiment for the ESA Solar Orbiter mission. The METIS investigation Team is lead by the P.I. Prof. Ester Antonucci of Osservatorio Astronomico di Torino – INAF.

Should the METIS experiment be selected, ASI will manage all the industrial and scientific contracts in Italy as well the agreements, based on non exchange of funds, with the hardware contributors belonging to the other National Funding Agencies or Institutions. The project will include a contribution by Co-Principal Investigators and Co-Investigators from Naval Research Laboratory-NRL, USA, Max-Plank-Institute für Sonnensystemforschung, Deutschland and Centre National d'Etudes Spatiales- CNES. Therefore, NASA, DLR and CNES are expected to guarantee the funding of the respective Co-PI contributions by formal interagency agreements with ASI as the Lead Funding Agency.

The letters of endorsement for the hardware contribution from the NRL and MPI are in annex to this letter.

In case of selection of the METIS instrument ASI will make its best effort to support the full development and the exploitation of this experiment, in coordination with the other National Funding Agencies who will contribute to the realization of the experiment.

The level of this support will be subjected to the availability of funds within the global Italian budget allocation for the Solar Orbiter mission payload.

Dr. Simonetta Di Pippo
Director, Observation of the Universe
Italian Space Agency

Cc. M. Coradini ESA/HQ (D/SCI), R. Marsden ESA/ESTEC (SCI-SM), Ph. Kletzkine ESA/ESTEC (SCI-PS), E. Antonucci (INAF OAT), E. Flamini (ASI- UOU)
ESA ANNOUNCEMENT OF OPPORTUNITY FOR SOLAR ORBITER PAYLOAD

Letter of endorsement for the participation of Prof. S. K. Solanki and Dr. L. Teriaca in the Solar Orbiter proposal METIS (which includes COR and EUS).

Dear Prof. Antonucci,

Prof. S. K. Solanki and Dr. L. Teriaca, Max-Planck-Institut für Sonnensystemforschung, Katlenburg-Lindau, intend to participate in the proposal "METIS: Spectro-Coronograph and EUV disk-spectrometer" for Solar Orbiter to be submitted by you as the Principal Investigator.

They intend to develop the detector units (without covers) for the COR segment of the METIS instrument.

We welcome and endorse their participation in this proposal.

It is understood that this endorsement is subject to the relevant DLR funding procedures.

Therefore, at present time this endorsement does not constitute any obligation to provide financial support.

Sincerely

i. V. Dr. W. Klinkmann

i. A. Dr. W. Frings
Directorate for Strategy, Programmes and International Relations

Prof. Dr. Ester ANTONUCCI
Astronomical Observatory of Turin
STRADA OSSERVATORIO 20
10025 PINO TORINESE
antonucci@cato.inaf.it

Paris, January 8, 2008
CNES/DSP/EU-2008/0171

Dear Dr Antonucci,

The present letter is to confirm that the Centre National d'Etudes Spatiales (CNES) is aware that you are currently coordinating a proposal concerning a Multi Element Telescope for Imaging and Spectroscopy (METIS) instrument for the Solar Orbiter mission.

CNES is also aware that the Laboratoire d'Astrophysique de Marseille (LAM) is participating to this proposal with specific commitments regarding the procurement of hardware sub-systems and that Philippe Lamy from this institute is involved as Co Investigator.

CNES is committed to support the participation of French scientists for the Solar Orbiter Definition Phase in accordance to the above mentioned proposal.

Once the instrument consortia are selected by ESA (by fall 2008), CNES will assess the level of resources that would be required for a full support of the French contribution to Solar Orbiter.

Should priorities be necessary, after consulting its advisory committee (CPS), CNES will enter a discussion phase with ESA and the concerned partners in order to seek a share of contributions within this consortium that is compatible with our expected level of resources and then settle the required frame of Inter Agency agreements.

Best regards,

F. Casoli
Fabienne CASOLI
Head, Space Science and Exploration Office

Copies:
Marcello Coradini
Philippe Kletzkin, Richard Marsden
Philippe Lamy

ESA/HQ
ESTEC
LAM
Dr. Simonetta Di Pippo  
Agenzia Spaziale Italiana  
Viale Liegi 26  
00198 Roma  
Italy

Subject: SOLAR ORBITER AO – EUS Instrument - Letter of Endorsement

Dear Dr. Di Pippo,

In response to the Announcement of Opportunity for the payload of the SOLAR ORBITER mission, a proposal for the Extreme Ultraviolet Spectrograph (EUS) instrument is submitted by Dr. Ester Antonucci as PI (INAF, Italy).

The Belgian Science Policy Office (BELSPO) hereby endorses the participation of Dr. Susanna Parenti (Royal Observatory of Belgium) to this proposal. We understand that this participation will be in the form of science support activities.

The provision of funding (via the PRODEX Programme) for the Belgian participation to the EUS instrument is subject to definitive selection of the proposal by ESA and subject to the availability of the necessary funds at Belgian level within the relevant years.

Yours Sincerely,

Dr. Werner Verschueren  
Belgian ESA Delegation – Space Sciences and Exploration
Ester Antonucci
INAF-Astronomical Observatory of Turin, Torino, Italy

10 January 2008

Dear Dr. Antonucci,

The UCL Mullard Space Science Laboratory is aware of your Solar Orbiter METIS proposal for a combined imaging coronagraph and ultraviolet spectrometer, to be submitted by Dr. E. Antonucci (Principal Investigator), and is fully supportive of the role of Dr. Giulio Del Zanna (Co-Investigator) in this effort.

If METIS is selected for Solar Orbiter, the UCL Mullard Space Science Laboratory commits approximately 0.1 Full Time Equivalent (FTE) per year of Dr. Del Zanna’s time for he instrument development, science operation and scientific analysis phases of METIS, which is in part subject to the availability of funds from the UK Science and Technology Facilities Council (STFC). Dr. Del Zanna currently holds a STFC advanced fellowship which covers his research activities until 2012.

Sincerely,

Prof. A. Smith
**PROPRIETARY INFORMATION**

This Notice of Intent may contain proprietary information, and shall only be used in a manner consistent with NASA policies. A copy of this notice shall be applied to any reproduction of this Notice of Intent.

**SECTION I - NOI Information**

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<td>John Moses</td>
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**NOI Title:** Investigation of Solar Wind Energetics and the Origins and Acceleration of Solar Energetic Particles

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For Consideration By NASA Organization (the soliciting organization, or the organization to which an unsolicited proposal is submitted)

NASA, Headquarters, Science Mission Directorate, Cross Division

**Date Submitted:** 11 / 16 / 2007

**Submission Method:** Electronic Submission Only

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**SECTION IV - Project Point of Contact Information**

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<th>Name</th>
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<td>202-404-8108</td>
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**SECTION V - Authorization**

A Notice of Intent (NOI) to Propose, and the information contained therein, is not binding on the submitter, and the signature of an Authorized Organization Representative is not required. Although an NOI is not binding, it should be as accurate and complete as possible, and submitted by its due date.
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<td>Dennis Socker</td>
<td><a href="mailto:dennis.socker@nrl.navy.mil">dennis.socker@nrl.navy.mil</a></td>
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<td>202-767-0244</td>
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<td>Allan Tylka</td>
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<td>Clarence Korendyke</td>
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<td>202-767-3144</td>
<td>Department of the Navy</td>
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SECTION VII - Project Summary

The coronal processes determining solar wind energetics and the generation of solar energetic particles (SEPs) are predominantly non-thermal. Spectroscopy of UV and EUV radiation either emitted or scattered by ions in the corona can measure the generation and evolution of non-thermal populations in the critical coronal region linking the Sun to the inner heliosphere. The proposed HELEX mission Solar Orbiter Coronal Spectrometer (SOCS) sensor will obtain the breakthrough first measurements of these processes that can be directly traced to inner Heliospheric phenomena observed in situ by complementary components of the HELEX mission.

The SOCS observations uniquely enable an investigation of the sources, acceleration, and transport of Solar Energetic Particles (SEPs). The SOCS sensor will detect the generation of suprathermal particle populations above the threshold necessary for efficient acceleration by shocks associated with high speed coronal mass ejections (CMEs). SOCS will observe the evolution of the non-thermal characteristics of the coronal plasma as CME shocks traverse the corona and inner heliosphere. This investigation will demonstrate the site of SEP acceleration can be identified and parameters determining the magnitude and the energy distribution of an SEP event can be measured in pre- and post-shock coronal plasmas - thus fulfilling the NASA HELEX mission and providing information about the solar sources of space weather that affect our home planet.
PI Name : John Moses
Organization Name : NAVAL RESEARCH LAB

NOI Title : Investigation of Solar Wind Energetics and the Origins and Acceleration of Solar Energetic Particles

SECTION VIII - Other Project Information

Proprietary Information

Is proprietary/privileged information included in this application?
Yes

International Collaboration

Does this project involve activities outside the U.S. or partnership with International Collaborators?
Yes

Principal Investigator Co-Investigator Collaborator Equipment Facilities
No Yes No No No

Explanation :
The proposed investigation is achieved through the development of a sensor to be integrated into an instrument suite led by an ESA member state institution.

NASA Civil Servant Project Personnel

Are NASA civil servant personnel participating as team members on this project (include funded and unfunded)?
No

Fiscal Year Fiscal Year Fiscal Year Fiscal Year Fiscal Year

Number of FTEs Number of FTEs Number of FTEs Number of FTEs Number of FTEs

FORM NRESS-300 Version 2.0 Apr-06-05
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</thead>
<tbody>
<tr>
<td><strong>Does this project have an actual or potential impact on the environment?</strong></td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

Environmental Impact Explanation:

Exemption/EA/EIS Explanation:
<table>
<thead>
<tr>
<th>Historical Site/Object Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does this project have the potential to affect historic, archeological, or traditional cultural sites (such as Native American burial or ceremonial grounds) or historic objects (such as an historic aircraft or spacecraft)?</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

Explanation:
**SECTION IX - Program Specific Data**

1. **Question 1 : Short Title:**
   
   **Answer:** Solar Orbiter Coronal Spectrograph (SOCS) Sensor

2. **Question 2 : Team Members Missing From Cover Page:**
   
   **Answer:**

   Steven Myers, Naval Research Laboratory, Program Manager

   At this time, review of information on the international collaboration anticipated for the proposal described in this NOI has not been completed by the Naval Research Laboratory Office of Legal Counsel. Thus, specific information on this collaboration does not appear in the NOI.

3. **Question 3 :** In order to handle FOSO proposals with SMEX proposals, in spite of the later due date, NASA requires that the team members (Co-Is, collaborators, industry partners, etc.) be finalized by the SMEX due date of January 15, 2008, and that the final team member list be entered into the unsubmitted FOSO proposal cover page in NSPIRES. I acknowledge that the final team member list for my FOSO proposal will be entered into the unsubmitted proposal cover page in NSPIRES by January 15, 2008.

   **Answer:** Yes

4. **Question 4 :** I give NASA permission to view the team member list on my unsubmitted proposal cover page in order to plan for the peer review of my FOSO proposal. I give NASA permission to view my unsubmitted proposal cover page at any time after January 15, 2008, but before my proposal is submitted by an authorized representative of my organization.

   **Answer:** Yes
**PI Name:**

**Organization Name:** NAVAL RESEARCH LAB

**NOI Title:** Investigation of Solar Wind Energetics and the Origins and Acceleration of Solar Energetic Particles

**SECTION X - Budget**

**Total Budget:** No budget required