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Distribution:

International participants of the first SOLAR-C science definition meeting  
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CC:

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Prof. Masato Nakamura, chair, space science steering committee, ISAS/JAXA

In this letter, we report the current SOLAR-C status and propose a near-term development plan for your consideration.

The SOLAR-C Working Group (WG) has been continuing its activity since it was established in the ISAS/JAXA Space Sciences Steering Committee in December 2007. With a series of successful missions, Hinotori, Yohkoh and Hinode, space solar physics in Japan has broadened its observational frontier from flares and coronal activity, towards magnetic phenomena on the photosphere, and has provided many leading scientific results as well as new insights into the physics of the Sun with significant contributions from our international colleagues. In particular, Hinode has so far revealed that (1) the polar regions of the Sun, which had been considered weak in magnetic field strength and low in X-ray activity, show patches of magnetic field concentration exceeding 1 kG as well as frequent X-ray jets, and that (2) plasmas in the chromosphere, which is the interface layer between the photosphere and corona, show a rich variety of jet and wave phenomena, which may be a manifestation of yet-unknown but essential processes for energy transfer in the solar atmosphere and for chromospheric and coronal heating.

Based on these key Hinode results, the WG has been studying in parallel two possible mission plans for post-Hinode space solar physics, namely, polar-observing mission ("Plan A") and high resolution spectro-polarimetry mission whose observation target centered on the photosphere-chromosphere-transition region-corona coupling ("Plan B"). Since Plan A is to observe the polar region with an out-of-ecliptic orbit, a feasibility study on the spacecraft

system is a crucial issue in addition to the value of the mission science. In this regard, with the help of JAXA engineers, a very preliminary study on the spacecraft system was conducted, particularly in the area of orbit, ion engine, communications and power supply systems. Further study is necessary to identify the best approach to achieve the required spacecraft orbit.. We are now at the stage of initiating an in-depth study for assessing the feasibility of Plan A. As for Plan B, in addition to a study on science cases, a very preliminary study on the communication system, spacecraft orbit, data processing, and science operation has been conducted by WG members. Note that the data rate from the Plan B spacecraft is estimated to be an order of magnitude higher than that of Hinode. A feasibility study on (a) continuous observation of the Sun with continuous telemetry/commanding links from a geo-stationary orbit and (b) continuous observation with a massive data downlink from sun-synchronous orbit is in progress.

In addition to the above studies, the WG has made several SOLAR-C presentations and had discussions with participants in research meetings both inside and outside Japan. The WG participated in the following meetings held abroad in JFY (Japan Fiscal Year) 2008:

1. NASA Heliophysics Division town hall meeting (May; in Maryland, U.S.A.)
2. American Geophysical Union (AGU) spring meeting (May; in Miami, U.S.A.)
3. AGU fall meeting (December; in San Francisco, U.S.A.)
4. European Solar Physics meeting (September; in Freiburg, Germany)
5. Visits to space and astronomy institutions in Europe

Through these presentations and discussions we believe that there has been a significant growth of interest in SOLAR-C over the past year, both in the U.S. and in Europe.

The WG held a SOLAR-C Science Definition Meeting for four days, between 18-21 November 2008 at ISAS/JAXA. In the meeting, the science cases for two alternative missions, called Plan A and Plan B, were extensively reviewed with distinguished international researchers invited by the WG (22 from the U.S. and 12 from Europe). Strong support was expressed by the international meeting participants for the science objectives of both Plan A and Plan B, with each considered to have a strong scientific rationale to be pursued as a post-Hinode solar physics mission. Also, a common understanding was established among the participants that both plans needed to be further developed in order to clarify their scientific potential.

The WG came to the conclusion that we should not hastily choose either Plan A or Plan B

at this stage of the activity, but that we should further pursue the scientific and technical feasibilities of the two plans, hopefully, under an appropriate international framework. The WG will continue to study both plans in parallel for a time interval as described below. This conclusion arises from the following considerations:

1. A strong international consensus was formed in the SOLAR-C Science Definition Meeting that it is highly desirable to continue the study of both options.
2. Solar missions that are expected to have high scientific synergy with SOLAR-C, namely ESA Solar Orbiter and NASA Solar Probe Plus, have not entered the implementation phase.
3. Any decision to be made for SOLAR-C would have profound influence for the Japanese and international solar communities and related disciplines over a time scale of a decade.

As a part of a continuing investigation of the two plans, the WG will establish a set of international sub-Working Groups to carry out extensive studies for the next six months. The sub-WGs are formed for areas which are identified by the WG as being critically important from the scientific and technical viewpoints but where further investigation is needed to establish the technical feasibility of meeting the scientific requirements. There will be a total of five sub-WGs. They are:

(a) Engineering Investigation of Plan A Spacecraft

Chair: H. Hara (NAOJ)

Purpose: Investigate engineering feasibility of the Plan A spacecraft jointly with JSPEC (JAXA Space Exploration Center) as a part of a new "Out-of-Ecliptic Solar Explorer WG" at JSPEC (see below). This sub-WG will be a J-side-internal one.

(b) Plan A: Helioseismology and the SolarDynamo

Chair: T. Sekii (NAOJ) and Co-chair: T. Appourchaux (IAS)

Purpose: Establish science cases for the Plan-A mission in terms of seismology and the advancing our understanding of the solar dynamo through helioseismology measurements from out of the ecliptic.

(c) Plan B Measurement of the Chromospheric Magnetic Field

Chair: Y. Katsukawa (NAOJ) and Co-chair: B. Lites (HAO)

Purpose: Establish science cases for plan-B mission especially in terms of chromospheric and coronal magnetometry/extrapolation. This includes investigation of the scientific feasibility of magnetic field measurement in the chromosphere and in the corona, including requirements and specifications of the relevant instruments.

(d) UV/EUV high-throughput spectroscopy

Chair: T. Shimizu (ISAS/JAXA) and Co-chair: TBD

Purpose: Establish science cases for the UV/EUV range in terms of the plan-B and the plan-A mission purpose and develop plans for a model payload for high-resolution, high-throughput, and high-cadence spectroscopy.

(e) Next generation X-ray telescope

Chair: T. Sakao (ISAS/JAXA) and Co-chair E. DeLuca (SAO)

Purpose: Establish science cases and investigate technical feasibility for X-ray imaging observations with SOLAR-C, in particular with photon-counting spectroscopy.

The main charge to each sub-WG is to complete a mission proposal document for its relevant field in the next 6-8 months that will form the basis of a SOLAR-C mission proposal in a year from now. Our long-term and short-term roadmaps are shown in Figure 1 and Figure 2, respectively.

The action plans for the WG are, (1) extend the term for investigating both Plan A and B in the JFY2009, and prepare a mission proposal for both the plans with international sub-WGs, (2) select and propose a single SOLAR-C mission plan in JFY 2010 hopefully with trilateral coordination among ESA, NASA and JAXA, and (3) proceed to the initial review (MDR) in late JFY 2010 or in early JFY 2011. The target launch date is February 2017 (JFY 2016). This new strategy, including the new relationship with JSPEC/JAXA to be described below, was reported to and approved by the ISAS Space Sciences Steering Committee on 22 January 2009.

For the Plan A spacecraft, there are two major orbit options. The first is to perform the orbit maneuver with large ion engines while the second uses Jupiter and Earth swing-bys. The former requires the engineering development of a large propulsion and power supply system, while the second requires detailed engineering study on navigation and guidance, thermal control including hibernation, and radiation protection. Common engineering issues include high-rate data transfer and spacecraft system design for long term operability. The Engineering aspects of Plan A have strong relevance to ongoing JSPEC projects. There is lunar and planetary exploration heritage at JSPEC from the Hayabusa mission whose orbit maneuver was performed with ion engines, and also from the development of the large lunar orbiter Kaguya. The Jovian mission study performed at JSPEC is also relevant to the

SOLAR-C mission. Furthermore, the Plan A spacecraft has engineering relevance for the strategic roadmap of JAXA's lunar/planetary exploration under JSPEC initiatives. Considering the suitability and effectiveness of the development, establishing a WG preparation team was proposed to the JAXA's Space Exploration Committee at JSPEC on 23<sup>rd</sup> of this January leading to the "Out-of-Ecliptic Solar Explorer WG". This new WG is studying only the engineering aspects for Plan A. The proposal was approved and the preparation team is to start its activities including fundamental but preliminary design for the spacecraft. For both Plan A and Plan B, studies on science cases and model payloads are to be performed chiefly by solar physicists at both ISAS and NAOJ, with active participation from universities and research organizations in Japan. Table 1 summarizes task sharing among the three organizations, ISAS, JSPEC and NAOJ (including universities) for Plan A and Plan B.

This letter is intended to demonstrate our strong desire to proceed with SOLAR-C and to propose concrete steps to do so for your understanding and support. The JAXA SOLAR-C working groups are offering US and European scientists and their corresponding space agencies to participate in the JAXA SOLAR-C program, in order to continue the remarkable scientific accomplishments we have made together over the past 25 years.

Sincerely yours,

Saku Tsuneta

Chair, ISAS/JAXA SOLAR-C WG

Chair, preparation team for JAXA/JSPEC Out-of-Ecliptic Solar Explorer WG

Table 1: Task sharing between ISAS, JSPEC and NAOJ (including universities and research organizations in Japan) for Plan A and Plan B.

## Task Sharing Between Three Organizations (ISAS, JSPEC, NAOJ)

	Plan A (Out-of-Ecliptic Mission)		Plan B (Earth-Orbiting or Geostationary Mission)	
	Science	Engineering	Science	Engineering
<b>ISAS</b>	✓	–	✓	✓
<b>JSPEC</b>	–	✓	–	–
<b>NAOJ</b>	✓	–	✓	✓

N.B. Task sharing shown in this chart does not indicate share of cost expenses for the development.

## Calendar for Years 2009–2020

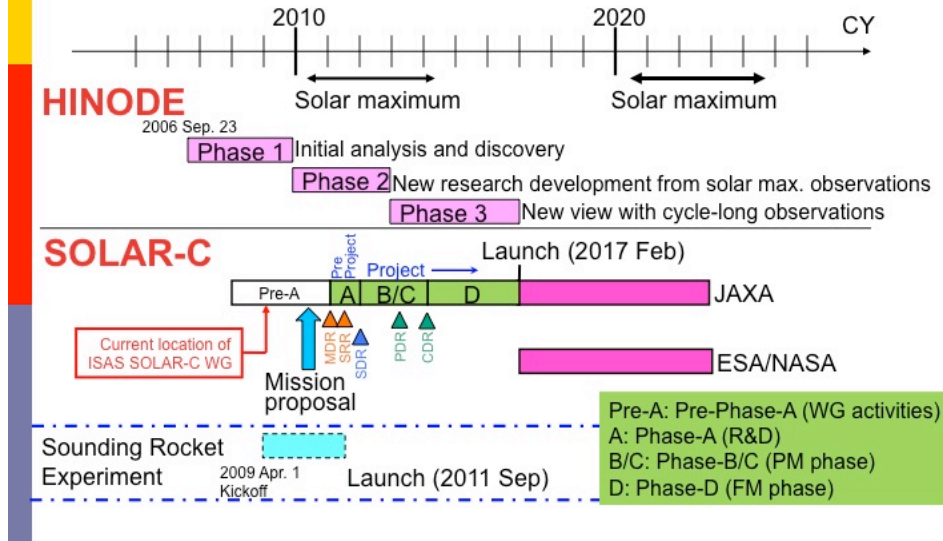


Figure 1: SOLAR-C schedule.

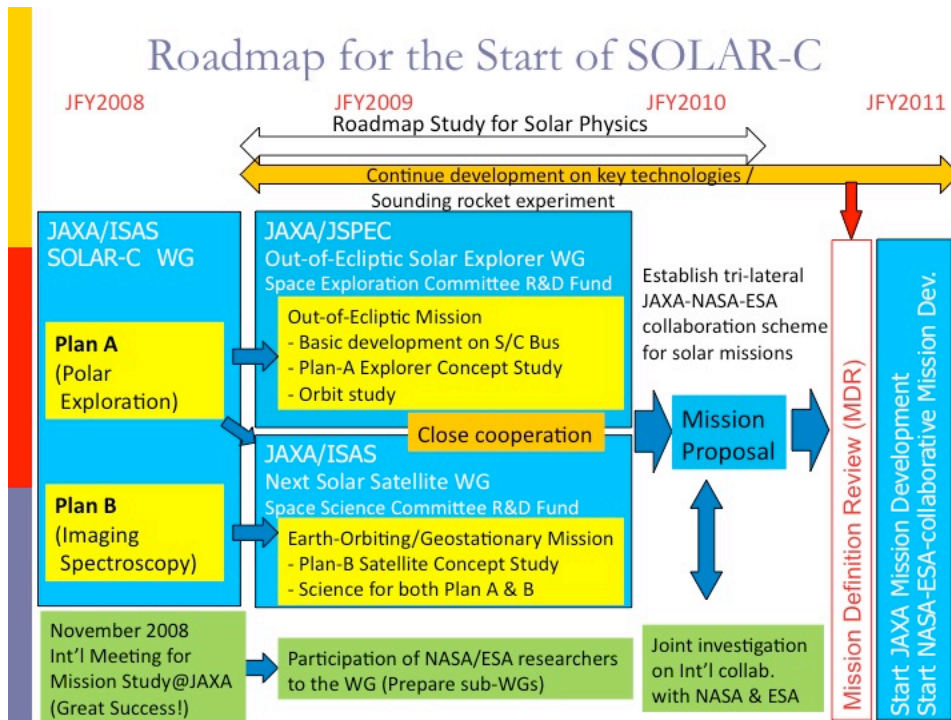


Figure 2: Roadmap for starting SOLAR-C.