Imaging/Radiometry White Paper

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This paper is provided as input in response to the open call for interdisciplinary science for consideration in the upcoming research announcement of the Science Mission Directorate at NASA HQ. The specific recommendation is made that an Earth-Sun System Instrument Development Program (ESSIDP) be established with an emphasis on remote sensing. The context for exploring the Earth-Sun System using imaging is presented in the next three paragraphs. A table identifying needed technologies is provided at the end.

It has become increasingly clear that our local region in the universe we call the Solar System, is comprised of a collection of coupled systems. In fact it is one large system-of-systems with our star, the Sun, as the primary source of energy and center of organization. Earth, as our home, is the planet we know most about. We have ventured quite successfully into Earth's low orbit region and it's immediate surrounding, called Geospace. We have learned some things about how Geospace is intrinsically connected over diverse scales of space and time to the dynamic plasma and energy emanating from the Sun. Over time a sizeable armada of spacecraft probing various regions and aspects of the Earth-Solar System has been assembled. Their collective observations have given us a glimpse into the extent of the coupled nature of the Solar System.

We are now poised to venture beyond our immediate surrounding, driven by the vision to extend and find life beyond Earth as we explore the Solar System and the universe beyond, while improving, understanding and protecting life here. In our quest to explore the Solar System, tools must be available and a level of understanding must be achieved that allow wise decisions to be made throughout this epoch of exploration. The investment of national resources and public expectations for future generations demands this. Considering the complexity and coupled nature of the Sun-Earth-Solar System, a well fashioned strategy is required. By the very nature of coupled systems, observation of system components and their relationships is critical to effectively understand and characterize the collective behavior. Imaging is the tool that most effectively meets this need. Understanding of the complex interrelationships is impossible without global imaging of Geospace and the Sun-Heliospheric system. Imaging provides more information than any practical number of distributed single-point measurements and therefore is indispensable for system level exploration.

An effective strategy to explore the Solar System will be based on the recognition that probing all regions of space is not possible and that understanding of the environment that is encountered during exploration is vital to the safety of our explorers and technological assets. Therefore reliance on models that predict environments and explain observations is required for exploration. The development of these models necessarily depends on understanding the mechanisms and coupling processes that are at work in the regions being explored. The knowledge required for this understanding is often most effectively gained by exploring analogous systems that are more easily accessible, such as in Geospace, or readily observable, such as at the Sun. Imaging plays a unique and necessary role in providing observations of system level interactions and processes that are not possible otherwise. Imaging constrains theories and models used to describe mechanisms operating throughout the Solar System.

The specific recommendation is made that an Earth-Sun System Instrument Development Program (ESSIDP) be established with an emphasis on remote sensing that includes radiometers for all spectral wavelengths and neutral atom imagers, and 3 dimensional detectors where each spatial pixel contains its spectral information. Below is a list of technologies that was compiled during an imaging workshop held in Huntsville, AL on November 9-10, 2004. More information on the workshop and science questions that these technologies will address can be found at the following URL: http://science.nasa.gov/spaldo/ImagingWorkshop/.

Component	Observation	Description
Detectors	particle	Low energy solid state particle detectors
	particle	MEMS technology, high speed choppers
	particle	Thin foil – thinner stronger for particle detectors
	particle & photon	Calorimeter detectors – large arrays, small pixels, large count rates. X-ray spectroscopy, can't be windowless
	particle & photon	MCP with low intrinsic noise
	particle & photon	Image intensifiers greater resolution (40 line pairs/mm)
	photon	Active pixel sensors – low power, CMOS technology
	photon	High QE for solar blind FUV detectors
	photon	Multi channel CSA
	particle & photon	Calorimeter detectors – large arrays, small pixels, large count rates. X-ray spectroscopy, can't be windowless
	particle & photon	MCP with low intrinsic noise
	particle & photon	Radiation hardening of parts
	particle	LENA type detector (surface conversion)
Instrument	photon	Ultra-sensitive diffuse EUV spectrometers
	photon	Multiple spectral detectors – VIS/UV hyper-spectral detectors
	photon & particle	Low power DPU
Optics	particle & photon	UV suppression technology
	photon	Diffraction grating – higher performance
	photon	Focusing hard x-ray optics - Nano tubes?
	photon	EUV/UV mirrors – performance
	photon	Adaptive/adjustable optics mirrors
	photon	Light weight optical mirrors (10 - 100 cm)
	photon	Free standing diffraction grating
System	System	Solar Sails
	System	High altitude long duration balloon
	System	Spacecraft location requirements knowledge
	System	Morphing instruments – on command zoom optics/detectors and wavelength tuning