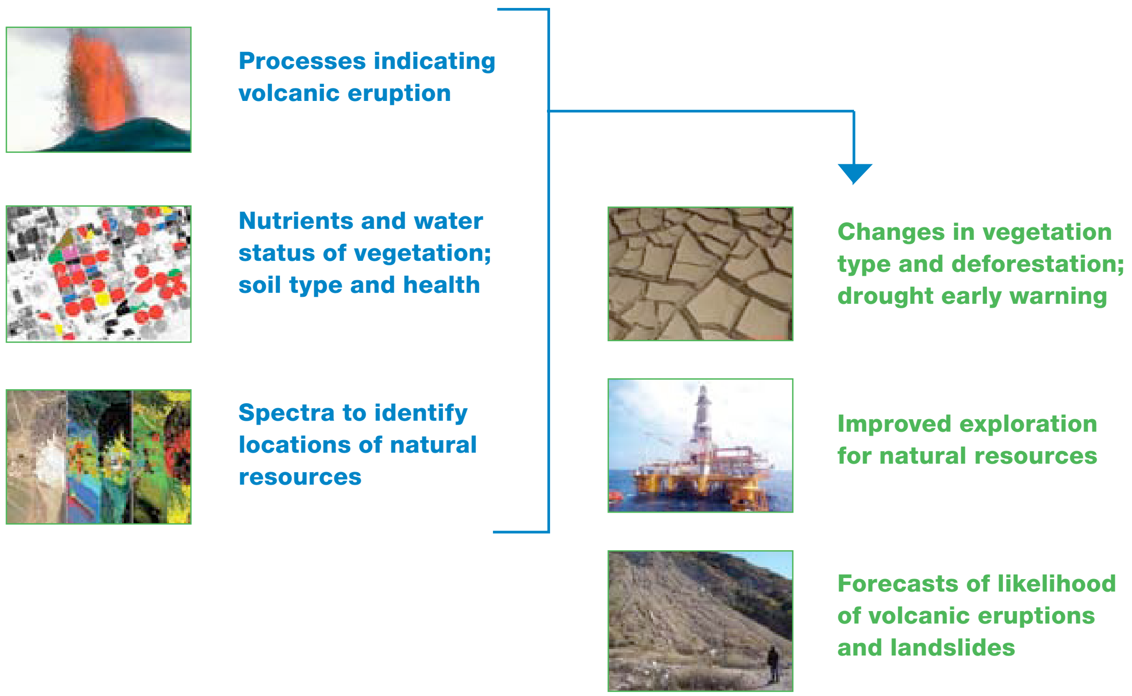
**HYPERSPECTRAL INFRARED IMAGER (HYSPIRI)**

**Launch: 2013-2016 Mission Size: Medium**




## HYPERSPECTRAL INFRARED IMAGER (HyspIRI) MISSION

Ecosystems respond to changes in land management and climate through altered nutrient and water status in vegetation and changes in species composition. A capability to detect such changes provides possibilities for early warning of detrimental ecosystem changes, such as drought, reduced agricultural yields, invasive species, reduced biodiversity, fire susceptibility, altered habitats of disease vectors, and changes in the health and extent of coral reefs. Through timely, spatially explicit information, the observing capability can provide input into decisions about management of agriculture and other ecosystems to mitigate negative effects. The observations would also underpin improved scientific understanding of ecosystem responses to climate change and management, which ultimately supports modeling and forecasting capabilities for ecosystems. Those, in turn, feed back into the understanding, prediction, and mitigation of factors that drive climate change.

Volcanos are a growing hazard to large populations. Key to an ability to make sensible decisions about preparation and evacuation is detection of the volcanic unrest that may precede eruptions, which is marked by noticeable changes in the visible and IR centered on craters. Assessment of soil type is an important component of predicting susceptibility to landslides. Remote sensing provides information critical for exploration for minerals and energy sources. In addition, such environmental problems as mine-waste drainage and unsuitability of soils for habitation, soil degradation, poorly known petroleum reservoir status, and oil-pipeline leakage in remote areas can be detected and analyzed with modern hyperspectral reflective and multispectral thermal sensors.

**Background:** Global observations of multiple surface attributes are important for a wide array of Earth-system studies. Requirements for ecosystem studies include information on canopy water content, vegetation stress and nutrient content, primary productivity, ecosystem type, invasive species, fire fuel load and moisture content, and such disturbances as fire and insect damage. In coastal areas, measurements of the extent and health of coral reefs are important. Observations of surface characteristics are crucial to exploration for natural resources and for managing the environmental effects of their production and distribution. Forecasting of natural hazards, such as volcanic eruptions and landslides, is facilitated by observations of surface properties.

**Science Objectives:** The HyspIRI mission aims to detect responses of ecosystems to human land management and climate change and variability. For example, drought initially affects the magnitude and timing of water and carbon fluxes, causing plant water stress and death and possibly wildfires and changes in species composition. Disturbances and changes in the chemical climate, such as $O_3$ and acid deposition, cause changes in leaf chemistry and the possibility of vulnerability to invasive species. The HyspIRI mission can detect early signs of ecosystem change through altered physiology, including agricultural systems. Observations can also detect changes in the health and extent of coral reefs, a bellwether of climate change. Those capabilities have been demonstrated in space-borne imaging spectrometer observations but have not been possible globally with existing multispectral sensors.

Variations in mineralogical composition result in variations in the optical reflectance spectrum of the surface that indicate the distribution of geologic materials and the condition and types of vegetation on the surface. Gases from within Earth, such as $CO_2$ and $SO_2$, are sensitive indicators of volcanic hazards. They also have distinctive spectra in both the optical and near-IR regions. The HyspIRI mission would yield maps of surface rock and soil composition that in many cases provide equivalent information to what can be derived from laboratory x-ray diffraction analysis. The hyperspectral images would be a valuable aid in detecting the surface expression of buried mineral and petroleum deposits. In addition, environmental disturbances accompanying past and current resource exploitation would be mapped mineralogically to provide direction for economical remediation. Detection of surface alterations and changes in surface temperature are important precursors of volcanic eruptions and will provide information on volcanic hazards over areas of Earth that are not yet instrumented with seismometers. Variations in soil properties are also linked to landslide susceptibility.

**Mission and Payload:** The HyspIRI mission uses imaging spectroscopy (optical hyperspectral imaging at 400-2500 nm and multispectral IR at 8-12 μm) of the global land and coastal surface. The mission would obtain global coverage from LEO with a repeat frequency of 30 days at 45-m spatial resolution. A pointing capability is required for frequent and high-resolution imaging of critical events, such as volcanos, wildfires, and droughts.

The payload consists of a hyperspectral imager with a thermal multispectral scanner, both on the same platform and both pointable. Given recent advances in detectors, optics, and electronics, it is now feasible to acquire pushbroom images with 620 pixels cross-track and 210 spectral bands in the 400- to 2,500-nm region. If three spectrometers are used with the same telescope, a 90-km swath results when Earth's curvature is taken into account. A multispectral imager similar to ASTER is required in the thermal IR region. For the thermal channels (five bands in the 8- to 12-μm region), the requirements for volcano-eruption prediction are high thermal sensitivity of about 0.1 K and a pixel size of less than 90 m. An optomechanical scanner, as opposed to a pushbroom scanner, would provide a wide swath of as much as 400 km at the required sensitivity and pixel size.

The HyspIRI mission has its heritage in the imaging spectrometer Hyperion on EO-1 launched in 2000 and in ASTER, the Japanese multispectral SWIR and thermal IR instrument flown on Terra. The hyperspectral imager's design is the same as the design used by JPL for the Moon Mineralogy Mapper ($M^3$) instrument on the Indian Moon-orbiting mission, Chandrayaan-1, and so will be a proven technology.

**Cost:** About $300 million.

**Schedule:** Mid-2015. Both sensors, the hyperspectral imager and the thermal-IR multispectral scanner, have direct heritage from the $M^3$ and ASTER instruments, respectively. The technology is currently available, and so a 2015 launch is feasible.

**Further Discussion:** See in Chapter 7 the section "Ecosystem Function," and in Chapter 8 the section "Mission to Observe Surface Composition and Thermal Properties."

**Related Responses to Committee's RFI:** 6, 81, 89, and 97.

**Supporting Documents:**

NASA (National Aeronautics and Space Administration). 2002. *Living on a Restless Planet*. Solid Earth Science Working Group Report. Jet Propulsion Laboratory, Pasadena, Calif. Available at http://solidearth.jpl.nasa.gov/seswg.html.

NRC (National Research Council). 2004. *Review of NASA's Solid-Earth Science Strategy*. The National Academies Press, Washington, D.C.