OVERVIEW OF TERRESTRIAL IMAGING SPECTROSCOPY MISSIONS

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ABSTRACT

This paper provides a brief overview of current civilian imaging spectroscopy (hyperspectral) missions currently operating in space or ready for launch for imaging the Earth. This overview is followed by a list of missions currently under development, and the paper concludes with a survey of missions in a planning stage. The latter is probably not a complete list of missions, but provides a good cross-section of sensors, which might be in space around the 2020 time frame.

Index Terms— Imaging spectroscopy, hyperspectral, current and future sensors, spectral and spatial sensor characteristics

1. INTRODUCTION

With the development of the imaging spectroscopy concept in the early 1980s, the development of imaging systems was first focused on airborne instruments. Based on the expertise in the development of such systems, many terrestrial spaceborne missions have been under study, such as NASA's High Resolution Imaging Spectrometer (HIRIS) [1], the Australian Resource Information and Environment Satellite (ARIES) [2], and ESA's Ecosystem Changes Through Response Analysis (SPECTRA) [3], to list just a few initiatives. Unfortunately, only a few, such as Hyperion [4], made it into space the last decade. These civilian missions together with those under development, such as the Hyperspectral Precursor of the Application Mission (PRISMA) [5] and Environmental Mapping Program (EnMAP) [6] will be briefly discussed in this paper. In addition, a brief overview of new initiatives, which are currently in a planning stage and will be operating around 2020, will be given.

2. MISSIONS CURRENTLY IN OPERATIONS OR READY FOR LAUNCH

In the beginning of the last decade, the first spaceborne imaging spectrometers, NASA's Hyperion on EO-1 and ESA's Compact High Resolution Imaging Spectrometer (CHRIS) [7] on PROBA, were successfully launched, which were followed by the Chinese HJ-1A [8], the Indian HySI on IMS-1[9] and NASA/Office of Naval Research's (ONR's) Hyperspectral Imager for the Coastal Ocean (HICO) [10] towards the end of the last decade. These sensors cover the visible and near-infrared (VNIR) portion of the electromagnetic spectrum, with the exception of Hyperion, which in addition covers also the short-wave infrared (SWIR). The spectral resolution is ≤ 10 nm. A deviation is CHRIS with varying bandwidths between 5.6 nm to 32.9 nm depending on the data acquisition mode. With a ground sampling distance (GSD) of 17 m (CHRIS) to 500 m (HySI), the swath width varies accordingly from 7.65 km (Hyperion) to 129.5 km (HySI). Most of these missions' purpose was to demonstrate the hyperspectral capability and, therefore, have a limited data acquisition capacity. The spectral and spatial characteristics of these missions, currently operating in space, are summarized in Table 1. Also listed is a VNIR hyperspectral sensor, the Hyperspectral Equipment (HSE), on the Russian Resurs-P platform, which incorporates also two multispectral sensors and is currently ready for launch [11].

3. MISSIONS CURRENTLY UNDER DEVELOPMENT

New initiatives have led to missions, which are currently under development and include the Indian Geostationary Hyperspectral Imager Satellite (GISAT) [12], the Italian PRISMA, the Japanese Hyperspectral Imager Suite (HISUI) [1], and the German EnMAP (Table 2). The latter three are targeting missions with a 30-m GSD resulting in a swath width of 15 – 30 km and a 10-nm spectral resolution covering the VNIR and SWIR. As the next generation of sensors replacing the existing sensors currently in space in the 2014 to 2017 time frame, they will have an increased data acquisition capacity and provide data with a superior data quality compared to the technology demonstrators Hyperion and CHRIS. In order to increase the capabilities of these missions, they will include, with the exception of EnMAP, other sensor payloads (i.e., PRISMA - a panchromatic instrument, HSUI on ALOS-3 – a high-spatial

Table 1: Spectral and spatial characteristics of missions currently operating in space or ready for launch (GSD = ground sampling distance, FWHM = full-width half-maximum).

Sensor	Organization (Country)	GSD (m)	Swath at Nadir (km)	Wavelength Coverage (nm)	Number of Bands	Spectral Resolution @ FWHM (nm)	Launch Date
Hyperion	NASA (USA)	30	7.65	357 - 2576	242	10	2000
CHRIS	ESA (UK)	17/34	13 (nominal)	400 - 1050	6/18/37	5.6-32.9	2001
HJ-1A	CAST (China)	100	50	450 - 950	128	5	2008
HySI	ISRO (India)	506	129.5	400 - 950	64	~ 10	2008
HICO	NASA/ONR (USA)	90	42	353 - 1081	128	5.7	2009
HSE Resurs-P*	ROSCOSMOS (Russia)	30	30	400 - 960	192	5 - 10	2013

* ready for launch

Table 2: Spectral and spatial characteristics of missions currently under development (GSD = ground sampling distance, FWHM = full-width half-maximum).

Sensor	Organization (Country)	GSD (m)	Swath at Nadir (km)	Wavelength Coverage (nm)	Number of Bands	Spectral Resolution @ FWHM (nm)	Launch Date
GISAT	ISRO (India)	500	NA	NA	210	NA	≥ 2013
PRISMA	ASI (Italy)	30	30	400 - 2500	237	~ 12	2014/15
HISUI	METI (Japan)	30	30	400 - 2500	185	10 (VNIR) 12.5 (SWIR)	≥ 2015
EnMAP	DLR/GFZ (Germany)	30	30	420 - 2450	218	5/10 (VNIR) 10 SWIR	2017

resolution four-band multispectral imager, and GISAT – a three-band thermal imager).

4. MISSIONS IN A PLANNING STAGE

Various agencies are currently looking into spaceborne imaging spectroscopy payloads/missions, such as the Hyperspectral Infra-Red Imager (HyspIRI) [14], HYPXIM-P [15], Fluorescence Explorer (FLEX) [16], and Spaceborne Hyperspectral Applicative Land and Ocean Mission (SHALOM) [17] (Table 3). These latest missions have some improved features, such as global coverage (HyspIRI), spatial resolution of ≤ 10 m (HYPXIM and SHALOM), narrow spectral resolution Fluorescence Imaging Spectrometer (FLORIS) on board the FLEX mission, and additional payloads, such as an eight-band thermal imager covering 4 μm – 12 μm (HyspIRI mission). In addition, the Canadian Space Agency is currently looking into a hyperspectral VNIR sensor to fit on a micro-satellite platform [18]. Currently a 30-m GSD is considered with a 10-nm spectral resolution. Other potential future missions are EnMAP-2 and KOMPSAT-6.

5. OUTLOOK

With the expected launch of the HSE on the Resurs-P spacecraft in 2013, the next generation of imaging spectroscopy sensors will emerge. This will be followed by PRISMA, HISUI, and EnMAP, which will have similar spectral and spatial characteristics (Table 2). In addition, India should have launched an imaging spectroscopy mission by 2017 as a result of its current five-year hyperspectral program. Also China, which pursues an active hyperspectral program, might have a second hyperspectral mission in space by that time frame as well as Canada. As a result, there could be several missions in space by 2017.

Despite the fact that several imaging spectroscopy missions, such as HYPXIM, HyspIRI, FLEX, and SHALOM as listed in Table 3, are in a planning stage for a launch around 2020 or beyond, it is difficult to predict which

Table 3: Spectral and spatial characteristics of missions currently in a planning stage (GSD = ground sampling distance, FWHM = full-width half-maximum).

Sensor	Organization (Country)	GSD (m)	Swath at Nadir (km)	Wavelength Coverage (nm)	Number of Bands	Spectral Resolution @ FWHM (nm)	Launch Date
FLORIS/ FLEX	ESA	300	100 - 150	500 - 780	NA	0.3 – 3.0	~ 2018
HYPXIM- P	CNES (France)	8	16	400 - 2500	> 200	10	~ 2019
HyspIRI	NASA (USA)	60	150	380 - 2500	> 200	10	≥ 2020
SHALOM	ISA/ASI (Israel/Italy)	10	10	400 - 2500	200	10	TBD

of these sensors are eventually built and put in space. However, if the next generation of spaceborne spectrometers of which several are currently under construction is successful, it is expected that the development of missions will continue and become more operational.

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