International Spaceborne Imaging Spectroscopy (ISIS) Technical Committee

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1. Introduction

The International Spaceborne Imaging Spectroscopy (ISIS) Working Group was formed on November 16/17, 2007 in Hilo, Hawaii based on an initiative from Alex Held, CSIRO, by individuals (Figure 1) interested in the development of space-based imaging spectroscopy (hyperspectral) missions and their data utilization. In 2010, the ISIS Working Group was established as a Technical Committee of IEEE GRSS. The purpose of ISIS is as follows:

> *The ISIS TC provides a forum for technical and programmatic discussion and consultation among national space agencies, research institutions and other spaceborne imaging spectrometer data providers.*

Figure 1: Founding members of the Imaging Spaceborne Imaging Spectroscopy (ISIS) Working Group, Hilo, Hawaii.

The main goals of ISIS are listed below:

- Coordination among key space agencies to share information and establish data acquisition strategies involving a "virtual satellite constellation";

- Promote the need for more efficient data delivery to processing facilities (at key global centres or to in-country institutions);
- Support the establishment of common data analysis protocols and a small set of 'core products';
- Promote production of a small number of core public-good hyperspectral satellite data sets;
- Support coordinated vicarious calibration and product validation activities with linkages to airborne remote sensing community; and
- Promote the need for robust, underpinning R&D programs for continuous improvement.

The key issues are as follows:

- High-volume Data Downlink – upgrades to current satellite stations from basic X-band to Dual-pol X-band or Ka- band;
- Mass-data management, archiving and pre-processing;
- On-board and vicarious calibration standards and key sites;
- Data standards for delivery to users; and
- Data processing and key derived product definitions and algorithms for routine use.

The TC membership currently consists mostly of agencies involved in the development of spaceborne imaging spectroscopy missions or those interested in the data utilization. However, the membership is generally open to individuals interested in imaging spectroscopy and its application to today's challenges for better understanding the Earth system.

2. Activities

ISIS conducts regular meetings once a year at IGARSS and organizes sessions on topics relevant to spaceborne imaging spectroscopy missions, such as mission updates, sensor calibration and data management, at these symposia. The following list gives a broad overview of the TC's activities to reach its goals of improved coordination:

- Keep a 'watching brief' and sharing information among space agencies and users on status of current and proposed imaging spectroscopy (hyperspectral) satellite missions;
- Provide an open forum for dialogue at least once a year, among key space agencies, to establish data acquisition strategies involving a "virtual satellite constellation" philosophy;
- Raise awareness among agencies on the need for more efficient data delivery to processing facilities;
- Encourage data providers to make a small number of core hyperspectral satellite data sets publicly available for the development of algorithm and information products;
- Convene meetings to discuss common data analysis protocols and a small set of 'core products'; and
- Organize sessions on calibration and product validation activities.

So far, the focus of the ISIS TC was mostly on the mission status and strategies and to a lesser degree on data management issues, such as data policies, data delivery, and public data sets. Accordingly, a brief overview of current and future terrestrial space-based civilian imaging spectroscopy missions is given in the next section based on the ISIS session on 'Spaceborne Imaging Spectroscopy Missions: Updates, and Global Datasets and Products' held at IGARSS'12 in Munich, Germany.

3. Overview of Spaceborne Imaging Spectroscopy Missions

With the development of the imaging spectroscopy concept in the early 1980s by American and Canadian researchers, many 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], ESA's Process Research by an Imaging Space Mission (PRISM) and Surface Process and Ecosystem Changes Through Response Analysis (SPECTRA) [3] and the Canadian Space Agency's Hyperspectral Environment and Resource Observer (HERO) [4], to list just a few initiatives. However, only a few made it into space within the last decade. NASA and ESA sucessfully launched Hyperion on EO-1 and CHRIS on PROBA, respectively in 2000 and 2001 [5,6]. These were followed by the Chinese HJ-1A [7] and the Indian HySI on IMS-1[8] in 2008, respectively. A year later, NASA/Office of Naval Research's (ONR's) Hyperspectral Imager for the Coastal Ocean (HICO) started operating from the International Space Station [9]. With the exception of HJ-1A and HICO, these systems were launched to demonstrate the hyperspectral technology and, therefore, have limited data acquisition capabilities. On the other hand, HICO has its own unique orbit (space station), which restricts imaging areas up to mid-latitudes (e.g., up to 53° north). The spectral and spatial characteristics of these missions, currently operating in space, are listed in Table 1. It can be seen that all these sensors cover the visible near-infrared (VNIR) portion of the electromagnetic spectrum with the exception of Hyperion, which in addition acquires data in the shortwave infrared (SWIR). The ground sampling distance (GSD) varies from 17 m (CHRIS) to 500 m (HySI), which also results in a variation of the swath width from 7.65 km (Hyperion) to 129.5 km (HySI). The spectral resolution of these sensors is $\leq$ 10 nm with the exception of CHRIS whose bands vary from 5.6 nm to 32.9 nm. The latter is capable to acquire image data from the same area on the ground under five different viewing angles (-55°, -36°, 0°, 36°, 55°), a unique feature which no other spaceborne imaging spectrometer exhibits.

Future missions under construction as shown in Table 1 include the Indian Geostationary Hyperspectral Imager Satellite (GISAT) [10], the Italian Hyperspectral Precursor of the Application Mission (PRISMA)[11], the Japanese Hyperspectral Imager SUIte (HISUI) [12], and the German Environmental MAPping and Analysis Program (EnMAP) [13]. The latter three missions are very similar to Hyperion with respect to the spatial and spectral characteristics with a 30-m GSD, 15-30 km swath width, approximately 10-nm spectral resolution, and VNIR and SWIR wavelength coverage. As the next generation of sensors operating in space from 2014/16 and beyond, they have an increased data acquisition capacity and provide data with a superior data quality compared to the technology demonstrators Hyperion and CHRIS. HSUI on ALOS-3 has in addition to the hyperspectral sensor a four-band multispectral instrument on board, while the PRISMA payload includes a panchromatic instrument. An additional sensor, a three-band thermal infrared (TIR) imager, is also included in GISAT, which provides with a 500-km swath width (1500 km for the TIR sensor) a synoptic coverage compared to the other targeting sensors currently under construction.

Table 1: Spectral and spatial characteristics of missions currently in operation, under construction, and in a planning stage (GSD = ground sampling distance, FWHM = full-width half-maximum, Res. = resolution, VNIR = visible and near infra-red; SWIR = short-wave infra-red, NA = not available, TBD = to be determined).

Sensor	**Organization (Country)**	**GSD (m)**	**Swath at Nadir (km)**	**Wavelength Coverage (nm)**	**Number of Bands**	**Spectral Res. (nm @ FWHM)**	**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	110-128	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
GISAT	ISRO (India)	500	NA	NA	210	NA	≥ 2013
PRISMA	ASI (Italy)	30	30	400-2500	237	~ 12	2014/15
HISUI	METI (Japan)	30	15	400-2500	185	10 (VNIR) 12.5 (SWIR)	≥ 2015
EnMAP	DLR/GFZ (Germany)	30	30	420-2450	218	5/10 (VNIR) 10 SWIR	2016
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	145	380-2500	> 200	10	~ 2020
SHALOM	ISA/ASI (Israel/Italy)	10	10	400-2500	200	10	TBD

■ Missions currently in operation, ▨ Missions under construction, □ Missions in a planning stage

Several new spaceborne imaging spectroscopy initiatives are currently on various levels of planning stages by agencies in different countries, and only a selection of missions, the HYperSPectral Inra-Red Imager (HyspIRI) [14], HYPXIM-P [15], FLuorescence EXplorer (FLEX)[16], and Spaceborne Hyperspectral Applicative Land and Ocean Mission (SHALOM) [17], are listed in Table 1. One of the features of the HyspIRI mission, which is listed in the NASA Tier-2 Decadal Survey, is to provide global coverage. It also includes a thermal imager with eight bands located between 4 to 12 µm and a 60-m GSD resulting in a swath width of 600 km. A thermal instrument (8 – 12 µm) is also planned for the French

HYPXIM-P together with a panchromatic camera (2-m GSD) in addition to the hyperspectral instrument. The Italian/Israeli SHALOM mission includes also a panchromatic camera with a 2.5-m GSD. Both, HYPXIM's and SHALOM's VNIR/SWIR imaging spectrometers have a 8-m and 10-m GSD, respectively, which are the best GSDs of all the listed hyperspectral instruments in Table 1. Another hyperspectral sensor in planning stage is the FLuORescence Imaging Spectrometer (FLORIS) on board the FLEX mission. With its narrow spectral resolution (0.3 to 3.0 nm) in the 500-nm to 780-nm wavelength range, its main goal is to provide global data of chlorophyll fluorescence of vegetation canopies. Other future missions considered are EnMAP-2 and KOMPSAT-6.

There are now five terrestrial imaging spectroscopy missions in space as shown in Figure 2. These missions will be replaced in the 2015/16 time frame by several missions, such as GISAT, PRISMA, HSUI and EnMAP. Accordingly, there could be a virtual constellation of about four satellites within a three- to four-year time span. The number of satellites could even increase, especially if China, which has an active hyperspectral program, will launch its second imaging spectroscopy mission towards 2015/16. With about a five-year lifetime of the missions currently under construction, it is important that the missions, such as HyspIRI, HYPXIM-P, SHALOM, FLEX, and EnMAP-2, currently in various levels of planning stages have to be realized in the future in order to guarantee hyperspectral data continuity in 2020 and beyond.

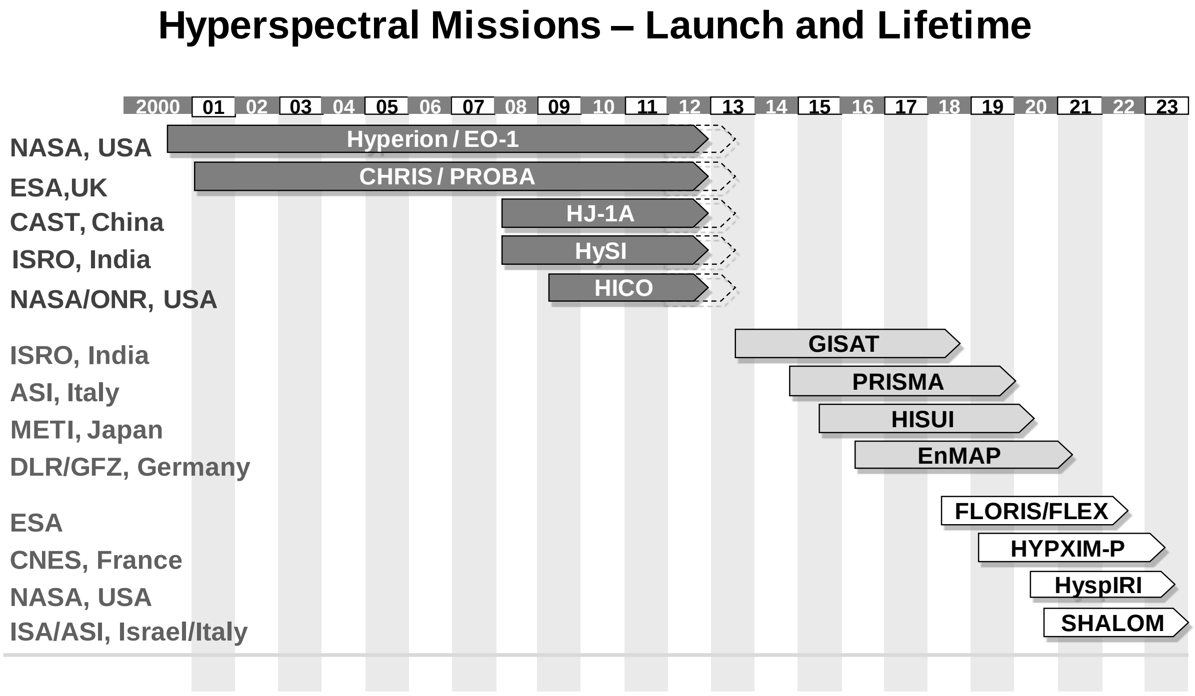
Hyperspectral Missions – Launch and Lifetime

Figure 2: Spaceborne imaging spectroscopy mission launch dates and lifetimes (■ missions currently in operation, ▒ missions under construction, □ missions in a planning stage).

4. References

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