

EnMAP
Hyperspectral Imager



Spaceborne Imaging Spectroscopy Mission Compilation

Status: December, 2017

EnMAP Ground Segment Team
GSIS GRSS Technical Committee



Federal Ministry
of Economics
and Technology

Supported by the DLR Space Administration with funds of the German Federal Ministry of Economic Affairs and Technology on the basis of a decision by the German Bundestag (50 EE 0850).

Spaceborne imaging spectroscopy EO missions



Attention: This compilation of spaceborne imaging spectroscopy missions has been updated based on most up-to-date presentations on IGARSS 2017 invited session "International Spaceborne Imaging Spectroscopy Missions: Updates and News".

Note: If you find wrong or outdated facts or statements, we would be very happy to improve our compilation with your help. Please contact: uta.heiden@dlr.de.

Spaceborne imaging spectroscopy EO missions



Content:

- ❖ Running and terminated mission overview
- ❖ Future mission overview
- ❖ Fact sheets per EO mission

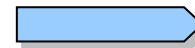
Legend



Running missions



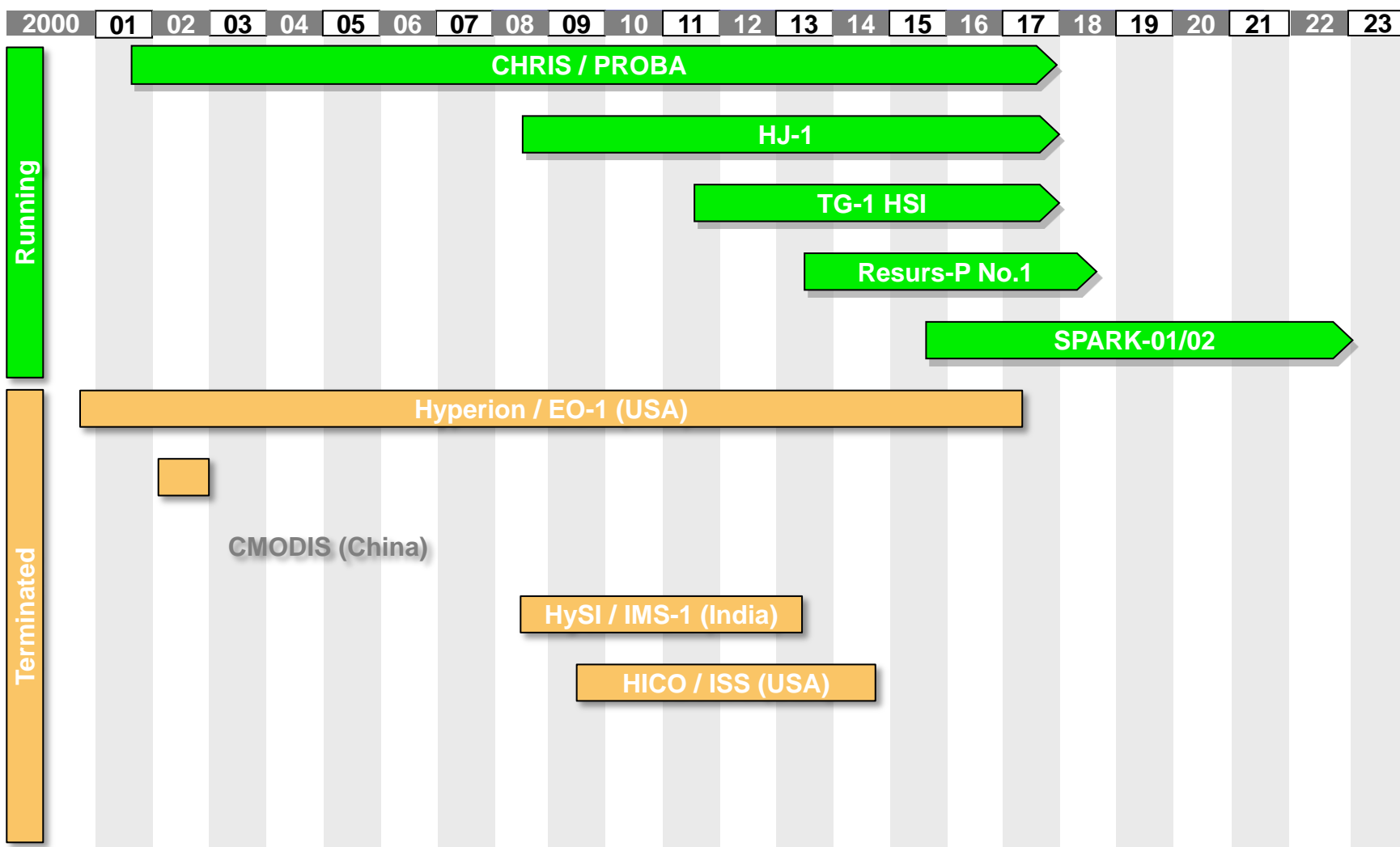
Terminated missions



Future missions

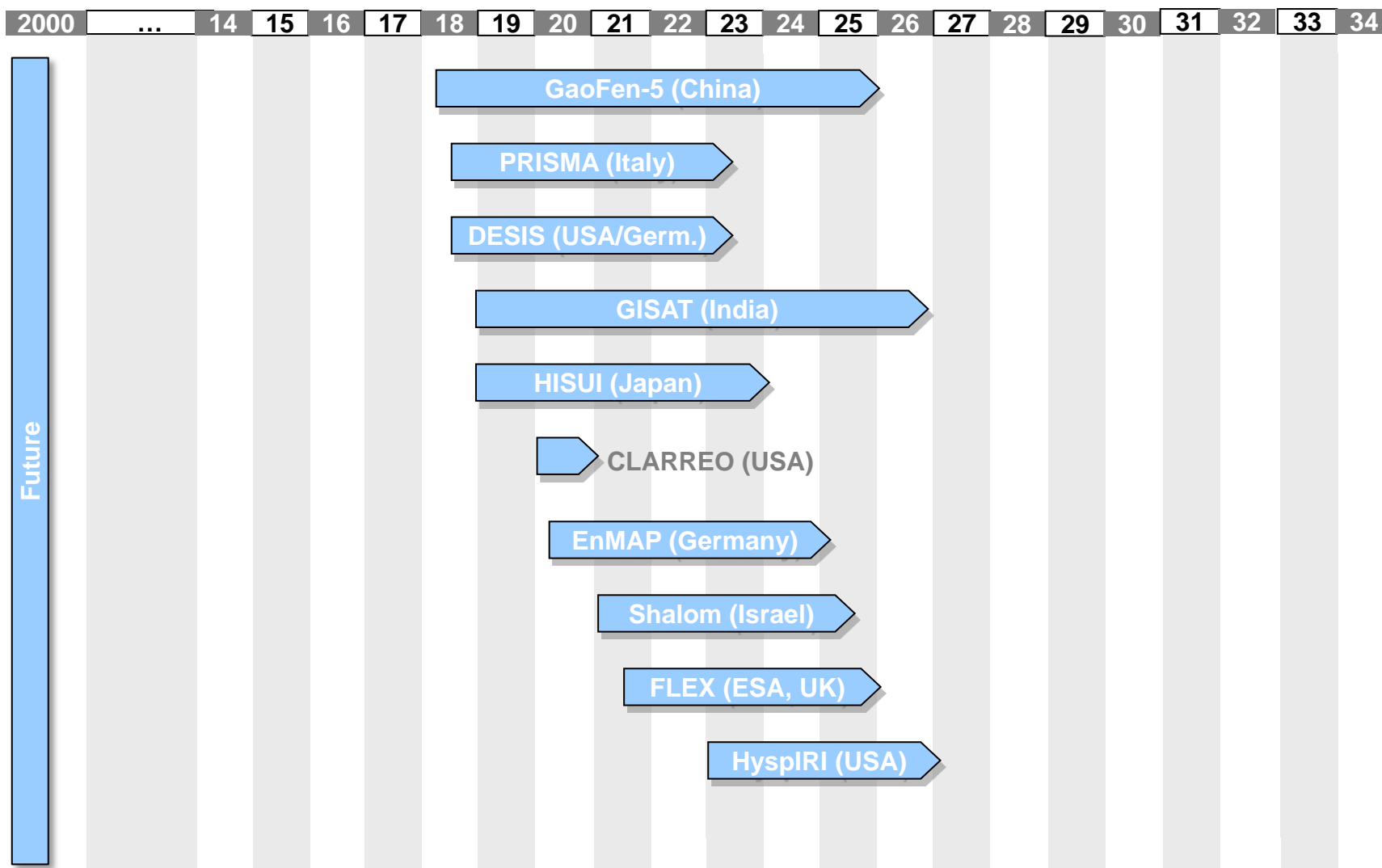
Running and terminated imaging spectroscopy missions

Launch and life time



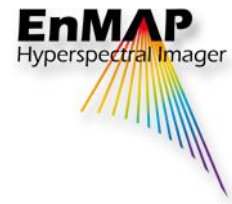
Future spaceborne imaging spectroscopy missions

Launch and life time



Running and terminated imaging spectroscopy missions

Spatial characteristics



CHRIS / PROBA

HJ-1A

TG-1

SPARK-01/02

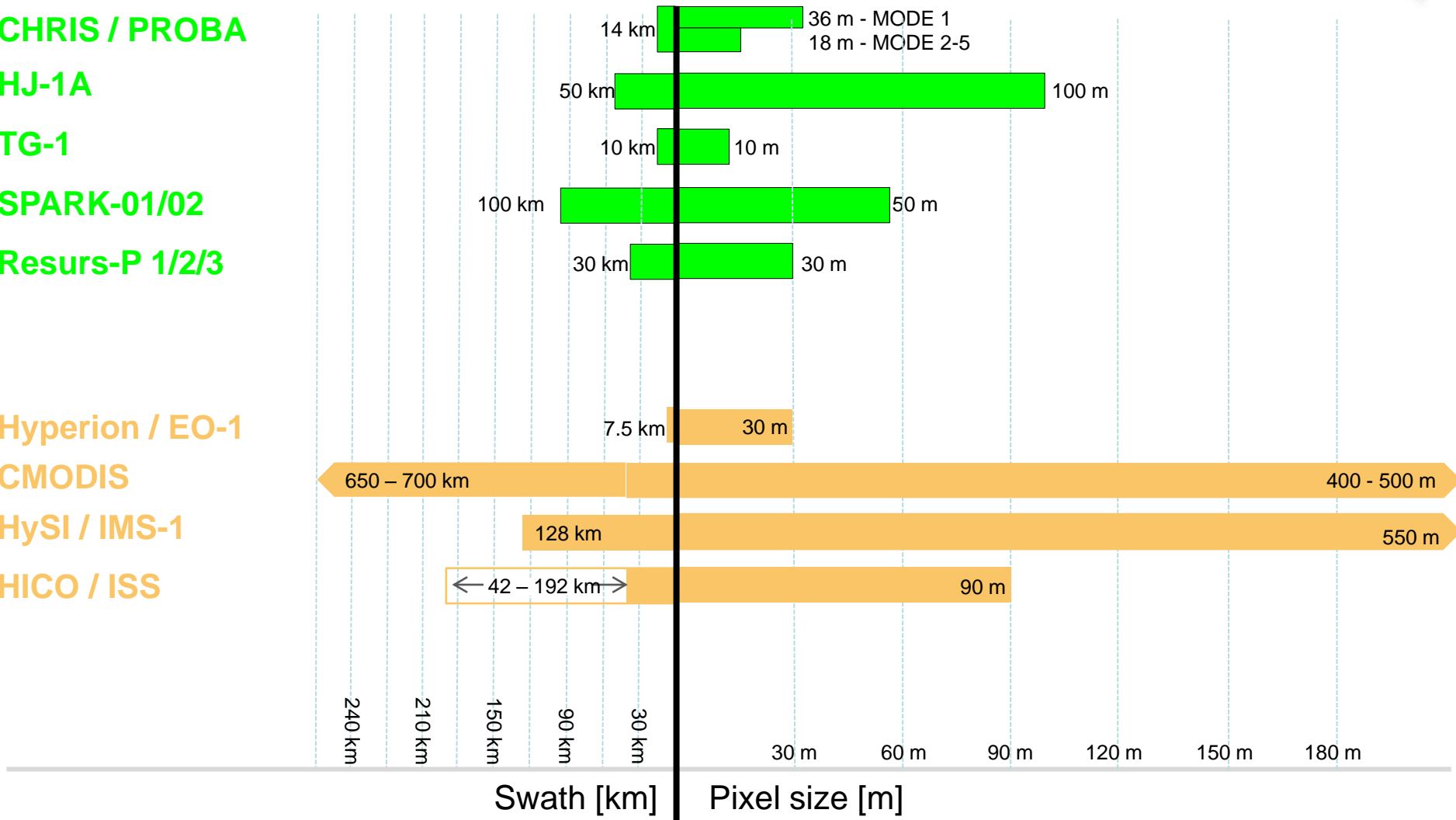
Resurs-P 1/2/3

Hyperion / EO-1

CMODIS

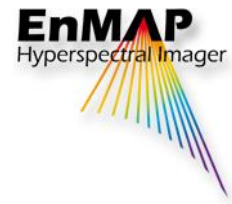
HySI / IMS-1

HICO / ISS



Future spaceborne imaging spectroscopy missions

Spatial characteristics



GaoFen-5

PRISMA

DESI

GISAT

HISUI

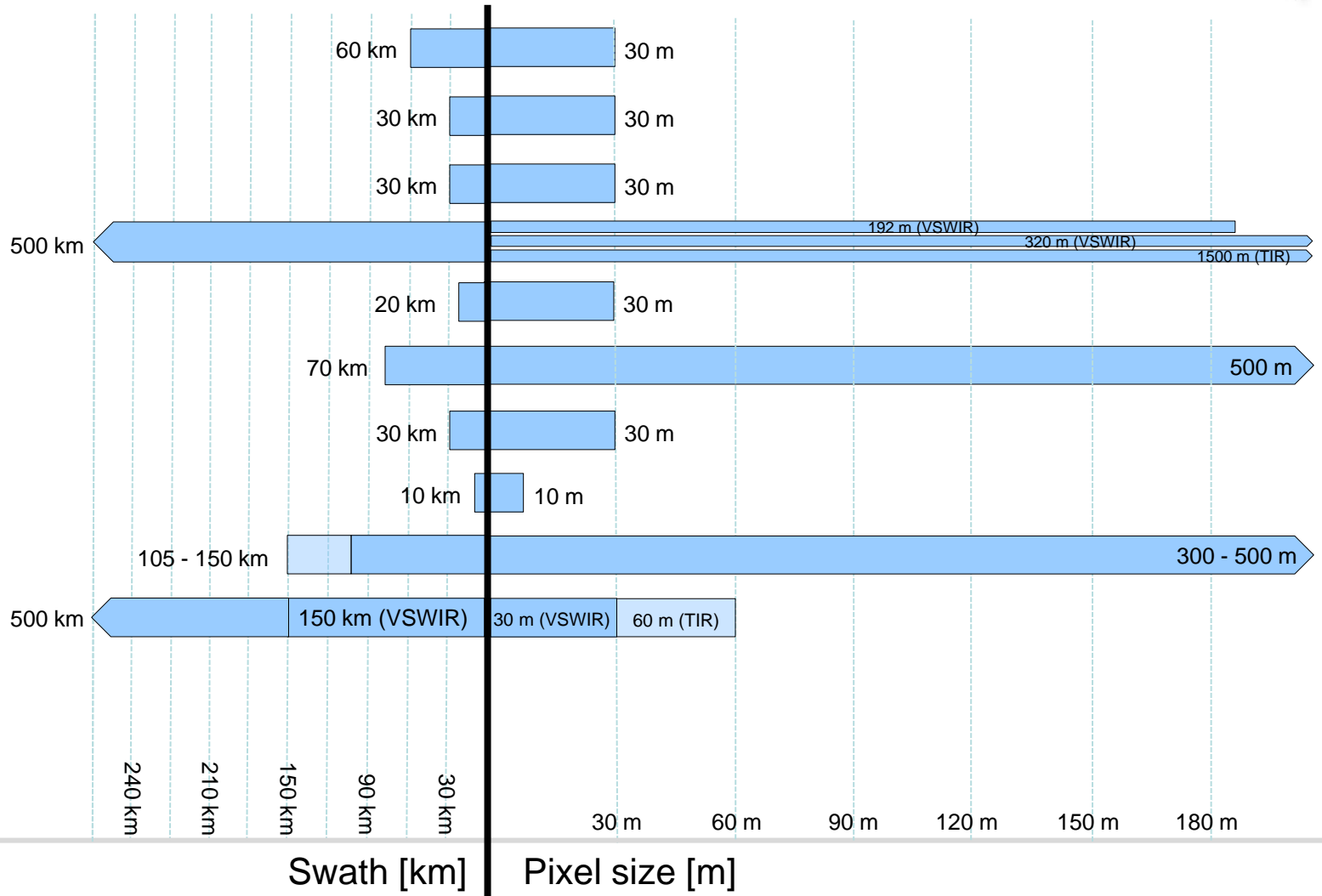
CLARREO

EnMAP

Shalom

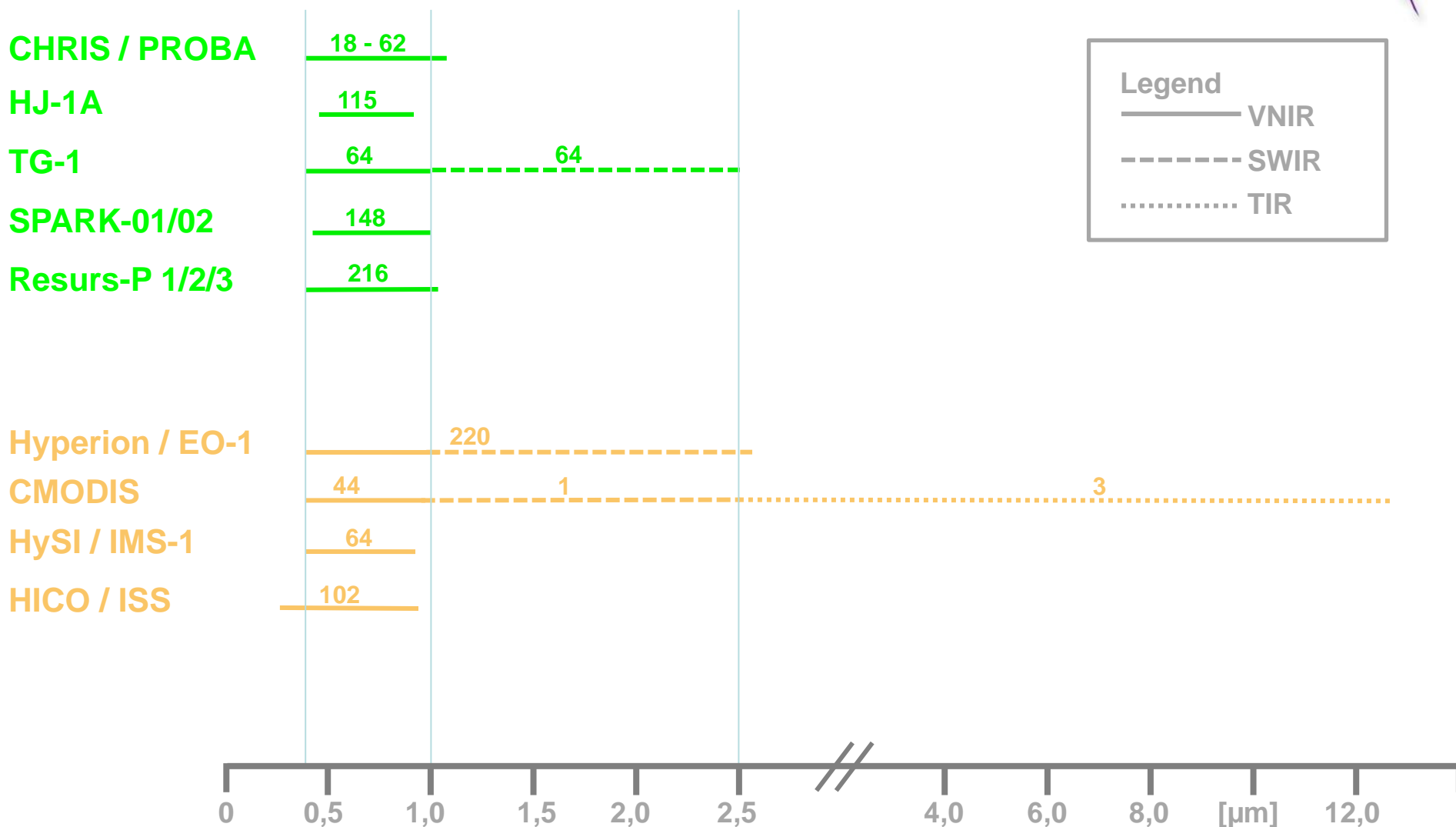
FLEX

HypSI



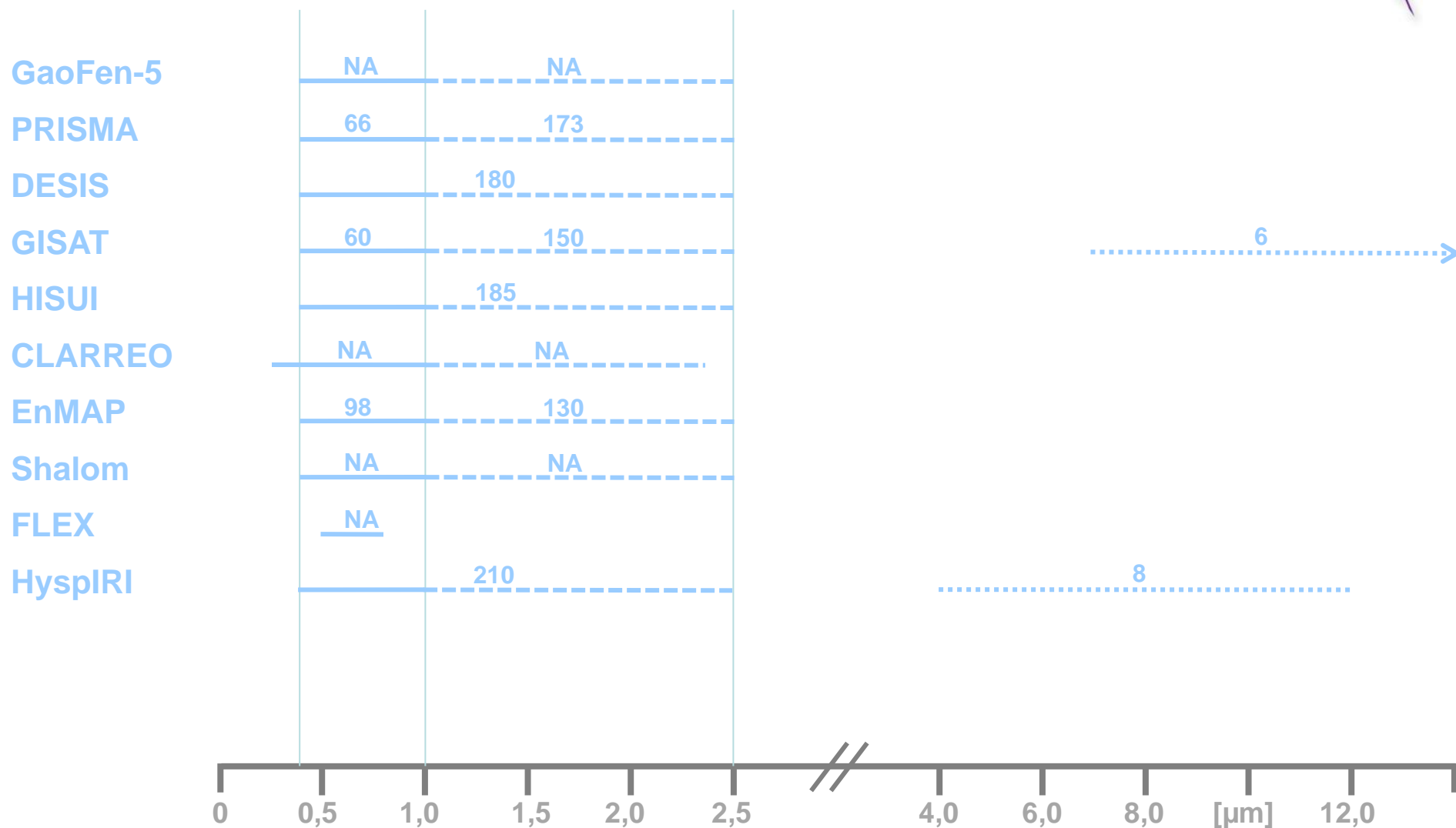
Running and terminated imaging spectroscopy missions

Spectral characteristics (no. of bands; spectral range)



Future spaceborne imaging spectroscopy missions

Spectral characteristics (no. of bands; spectral range)

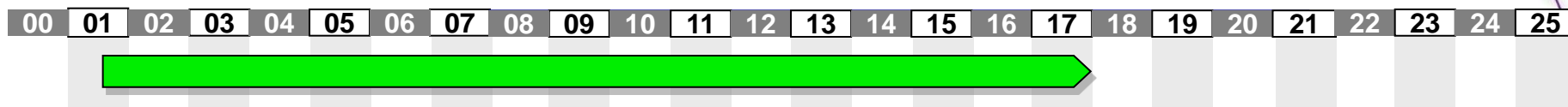


Fact sheets per EO mission



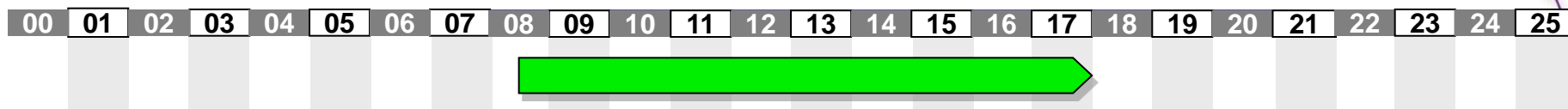
Source: <http://www.google.de/earth/explore/sesamestreet/images/animation/earth-eurafrica.jpg>

CHRIS / PROBA (ESA)



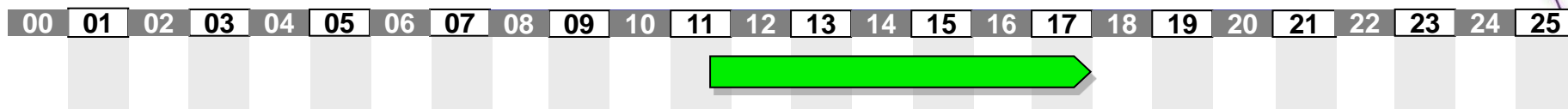
Parameter	Value
Mission	Technological demonstrator to collect BRDF data for better understanding of spectral reflectances
Spectral Range	400 nm – 1050 nm
Bandwidth	1.25nm at 400nm, 11nm at 1050nm
No of Bands	62 bands (MODE 1), 18 bands (MODE 2-5)
Spatial Resolution	36 m (MODE 1), 18 m (MODE 2-5), 5 viewing angles (along track)
Swath	14 km
Orbit	Sun-Synchronous at 615 km
Revisit	7 days
Special features	Lifetime exceeded, open data access, push-broom scanning
Links	https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/proba/instruments/chris
CEOS Database	http://database.eohandbook.com/database/missionssummary.aspx?missionID=403

HJ-1 (China)



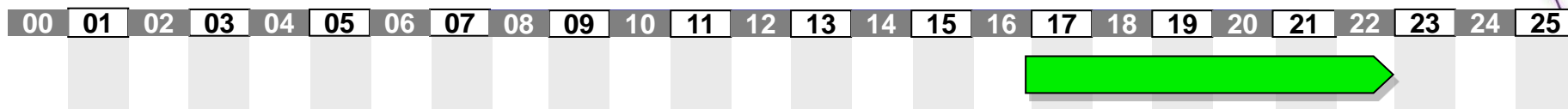
Parameter	Value
Mission	Disaster and environment monitoring and forecasting, Small Multi-Mission Satellite (SMMS) of Asia Pacific Space Cooperation Organization (APSCO)
Spectral Range	450 nm – 950 nm
Bandwidth	~ 5 nm
No of Bands	115 bands
Spatial Resolution	100 m
Swath	50 km
Orbit	Sun-Synchronous at 649 km, pointing capabilities of up to $\pm 30^\circ$
Revisit	4 – 31 days
Special features	No data access, constellation of small satellites HJ-1A/B (launch 2008), equipped with CCD camera and Hyper-Spectral Imager (HSI)
Link	https://directory.eoportal.org/web/eoportal/satellite-missions/h/hj-1 http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6565416&tag=1 http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/02_2.%20IGARSS2017-Zhang%20Lifu.pdf
CEOS Database	http://database.eohandbook.com/database/missionssummary.aspx?missionID=463

TG-1 HSI (China)



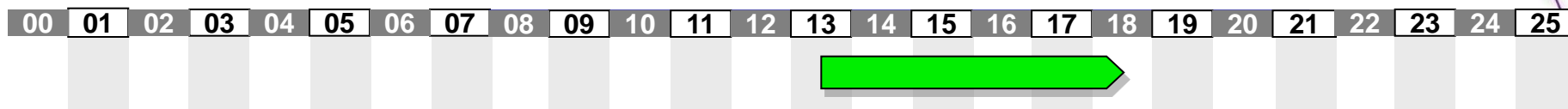
Parameter	Value
Mission	Chinese Tiangong-1 (TG-1) experimental space laboratory, for land use monitoring
Spectral Range	400 nm – 2500 nm
Bandwidth	10 nm (400 nm – 1000 nm), 23 nm (1000 nm – 2500 nm)
No of Bands	64 bands (0.4 – 1.0 μm), 64 bands (1.0 – 2.5 μm)
Spatial Resolution	
Swath	10 km
Orbit	Inclined orbit of 42.4° with altitude ranging from 363 to 381 km, Chinese space station module
Revisit	
Special features	SNR 180@1600nm, on Chinese manned low Earth orbit platforms
Link	http://www.grss-ieee.org/wp-content/uploads/2014/12/2014_07_ISIS_Session1_Mission/1030_zhanlf-IGARSS-20140716.pdf (2014) https://www.grss-ieee.org/wp-content/uploads/2015/08/TU4.B1.2.Lifu_Zhang.pdf (2015) http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/02_2.%20IGARSS2017-Zhang%20Lifu.pdf (2017) http://www.sciencedirect.com/science/article/pii/S0924271615002543 http://www.n2yo.com/satellite/?s=37820
CEOS Database	-

SPARK-01/02 (China)



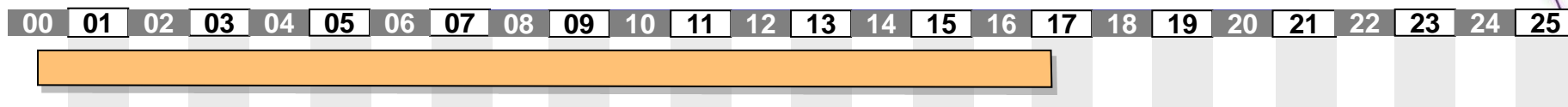
Parameter	Value
Mission	China's first commercial hyperspectral nano-satellites SPARK-01 and SPARK 02
Spectral Range	420 ~ 1000 nm
Bandwidth	4 nm
No of Bands	148 bands
Spatial Resolution	50m@700km
Swath	100km@700km
Orbit	
Revisit	16 days
Special features	Weight: 42kg
Link	http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/02_2.%20IGARSS2017-Zhang%20Lifu.pdf http://space.skyrocket.de/doc_sdat/spark-01.htm
CEOS Database	-

Resurs-P1/2/3 (Russia)



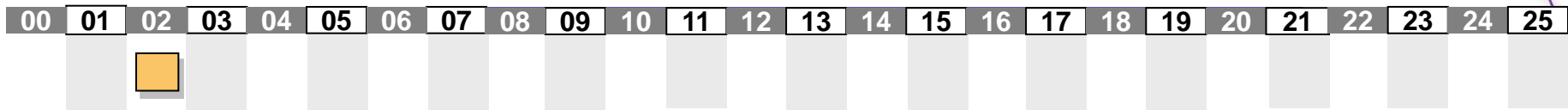
Parameter	Value
Mission	Resurs-P (Resurs-Prospective) Remote Sensing Mission Constellation for environmental and ecological monitoring, oil, gas and other natural resources deposits survey, ice condition, natural and man-caused emergency situations monitoring, water security, reserved areas control
Spectral Range	400 nm – 1100 nm
Bandwidth	5 nm – 10 nm
No of Bands	216 bands
Spatial Resolution	25 - 30 m
Swath	30 km
Orbit	Sun-synchronous near circular orbit, altitude = 475 km, inclination = 97.3°. The repeat cycle is 3 days. LTDN (Local Time on Descending Node) = 10:30 hours, period = 94 minutes
Revisit	3 – 4 days
Special features	Additionally high resolution (better than 1 meter) optical sensor, wide capture multispectral optical sensors (with high – 12 meters and medium – 60 meters resolution); data freely available: http://www.gptl.ru/
Link	http://www.unoosa.org/pdf/pres/stsc2015/tech-57E.pdf http://www.gptl.ru/ http://eng.ntsomz.ru/for_clients/standart_ip/standart_ip_resurs_p#gsa https://directory.eoportal.org/web/eoportal/satellite-missions/r/resurs-p http://www.russianspaceweb.com/resurs_p.html
CEOS Database	http://database.eohandbook.com/database/missionssummary.aspx?missionID=624

Hyperion / EO-1 (USA)



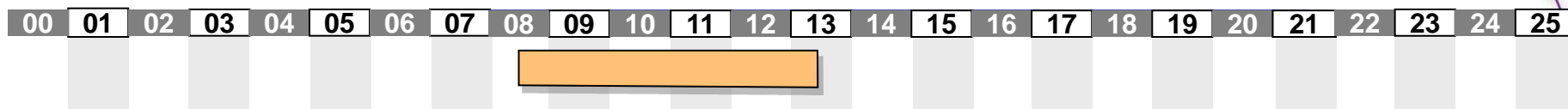
Parameter	Value
Mission	Technology validation / demonstration mission
Spectral Range	400 nm – 2500 nm
Bandwidth	~ 10 nm
No of Bands	220
Spatial Resolution	30 m
Swath	7.5 km
Orbit	Sun-Synchronous at 705 km (LEO), 1 minute behind Landsat-7
Revisit	16 days
Special features	Planned for 1 year life time, free and open data access: , shut down in March 2017
Link	https://eo1.usgs.gov/sensors/hyperion https://eo1.gsfc.nasa.gov/new/validationReport/Technology/TRW_EO1%20Papers_Presentations/10.pdf
CEOS Database	http://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=627

CMODIS (China)



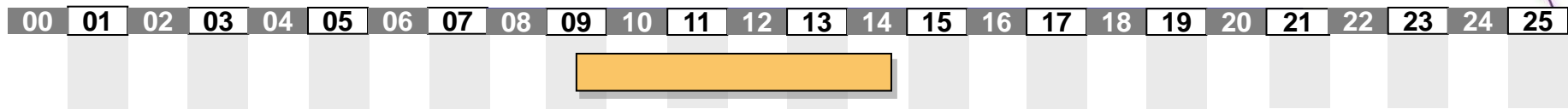
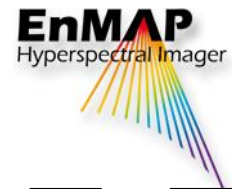
Parameter	Value
Mission	Mainly for remote sensing of ocean and water color
Spectral Range	403 nm – 12500 nm
Bandwidth	20 nm (VNIR), 100 nm (SWIR), 500 nm (TIR)
No of Bands	34 bands (20 bands (VIS), 10 bands (NIR), 1 band (SWIR), 3 bands (TIR))
Spatial Resolution	400 m – 500 m
Swath	650 km – 700km
Orbit	200 km – 351 km
Revisit	
Special features	Lifetime: 200 days in orbit, more than 2000 cycles around the Earth during its operation time
Link	http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6565416 http://www.grss-ieee.org/wp-content/uploads/2014/12/2014_07_ISIS_Session1_Mission/1030_zhanlf-IGARSS-20140716.pdf
CEOS Database	-

HySI / IMS-1 (India)



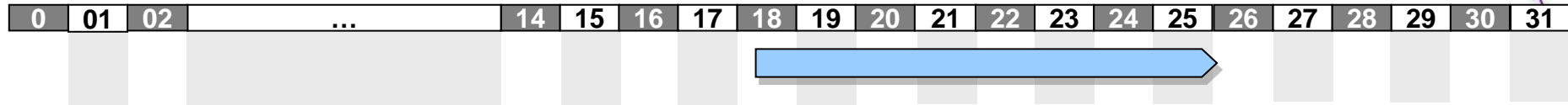
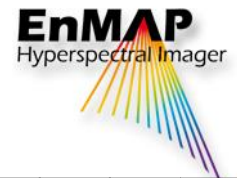
Parameter	Value
Mission	The HySI is being used on an experimental basis to obtain experience of such a payload and also of handling the hyperspectral data and generating the application models.
Spectral Range	400 nm – 950 nm
Bandwidth	15 nm (8nm sampling interval)
No of Bands	64 bands
Spatial Resolution	550 m
Swath	128 km
Orbit	Sun-Synchronous at 632 km
Revisit	22 days
Special features	Lifetime exceeded, additional Multispectral Camera (MX), only one sensor can be operated at a time. HySi data is provided to all Global Users as free downloads: http://bhuvan.nrsc.gov.in/data/download/index.php
Link	https://www.nrsc.gov.in/Remote_Sensing_Data_Policy?q=IMS-1 https://directory.eoportal.org/web/eoportal/satellite-missions/i/ims-1
CEOS Database	http://database.eohandbook.com/database/missionssummary.aspx?missionID=570

HICO (USA)



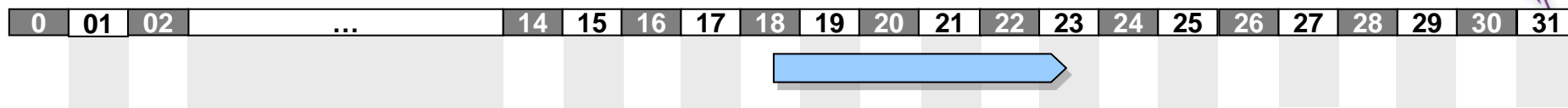
Parameter	Value
Mission	Observing coastal ocean
Spectral Range	380 nm – 960 nm
Bandwidth	5.7 nm (FWHM: 10 nm (400 - 745 nm); 20 nm (746 - 900 nm))
No of Bands	102 bands
Spatial Resolution	90 m (vary depending on the altitude and angle)
Swath	42 km – 192 km (varies depending on the orbit path)
Orbit	On-board the ISS, 330 km – 435 km altitude
Revisit	~ 3 days
Special features	Free and open data access for scientists, end of operations in September 2014
Link	http://hico.coas.oregonstate.edu/ http://hico.coas.oregonstate.edu/datasets/datacharacteristics.shtml http://www.ioccg.org/sensors/Davis_HICO_IOCCG-15.pdf
CEOS Database	http://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1737

GaoFen-5 (China)



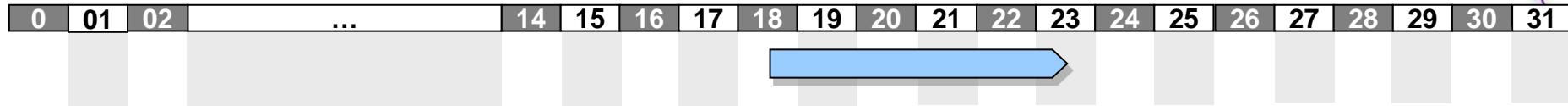
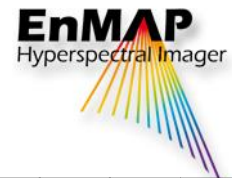
Parameter	Value
Mission	GF-5 contains six types of payload, one of them is hyperspectral, belongs to China's high-resolution civilian satellite program
Spectral Range	400 nm – 2500 nm
Bandwidth	5 nm (VNIR), 10 nm (SWIR)
No of Bands	
Spatial Resolution	30 m
Swath	60 km
Orbit	
Revisit	
Special features	SNR features: VNIR:≥200, SWIR1:≥150, SWIR2:≥100; 8 year lifetime
Link	http://space.skyrocket.de/doc_sdat/gf-5.htm https://directory.eoportal.org/web/eoportal/satellite-missions/g/gaofen-1 http://ceos.org/document_management/Virtual_Constellations/ACC/Meetings/AC-VC-12/Day%201/5.%20Linagfu%20Chen%20-%20Gaofeng-5%201013.pdf https://chinaspacereport.com/spacecraft/gaofen/#launch-history
CEOS Database	-

PRISMA (Italy)



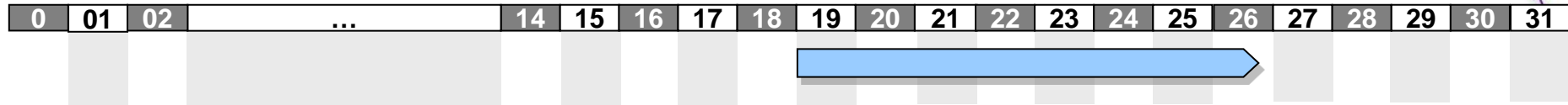
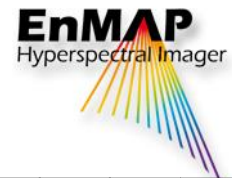
Parameter	Value
Mission	The PRISMA mission is conceived with technology demonstration purpose, and pre-operative characteristics, main objective of the mission is to deliver hyperspectral and panchromatic images of the Earth (up to level 2d)
Spectral Range	400 nm – 1010 nm (VNIR-Hyp), 920 nm – 2500 nm (SWIR-Hyp), 0.4 μm – 0.7 μm (PAN)
Bandwidth	Spectral Sampling Interval: ≤ 10 nm; Spectral Width (FWHM): ≤ 10 nm
No of Bands	66 bands (VNIR-Hyp), 173 bands (SWIR-Hyp)
Spatial Resolution	30 m (VNIR-Hyp/SWIR-Hyp), 5 m (PAN)
Swath	30 km
Orbit	Sun-Synchronous at 615 km
Revisit	~ 15 days
Special features	Push-broom imager, lossless compression with compression factor 1.6, near lossless compression
Link	http://prisma-i.it http://prisma-i.it/index.php/en/events/conferences-and-workshops http://prisma-i.it/images/Eventi/20170301_Workshop_ASI/Abstract_book.pdf http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/03_PRISMA-IGARSS2017_Scopa_7_24.pdf
CEOS Database	http://database.eohandbook.com/database/missionsummary.aspx?missionID=396

DESIS (Germany / USA)



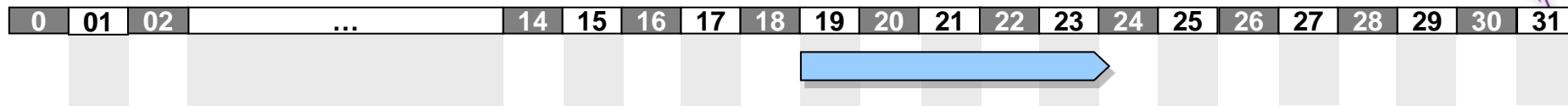
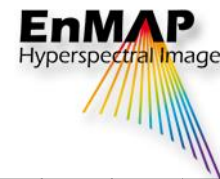
Parameter	Value
Mission	Atmospheric science, vegetation and crops monitoring, BRDF studies of earth surfaces
Spectral Range	400 nm – 1000 nm
Bandwidth	Measured: 235 @ 2.55 nm; programmable binning factor (1 to 4)
No of Bands	180 bands
Spatial Resolution	24.7 m – 32.6 m (depending on altitude, nominal: 30 m)
Swath	25.3 km – 33.4 km (depending on altitude, nominal: 30.7 km)
Orbit	Installed at ISS at 330 km – 435 km altitude
Revisit	~ 9 days (mid-latitudes with a 30 km swath)
Special features	Onboard the ISS; cannot access latitudes over 52 N and below 52S and subject to changes of illumination, pointing unit $\pm 15^\circ$ along track (3 measurements possible)
Link	http://www.dlr.de/os/en/desktopdefault.aspx/tabid-9294/16011_read-39367/ http://www.teledyne.com/news/tdy_05202014.asp https://coast.noaa.gov/data/docs/geotools/2017/presentations/Perkins.pdf
CEOS Database	http://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1734

GISAT (ISRO, India)



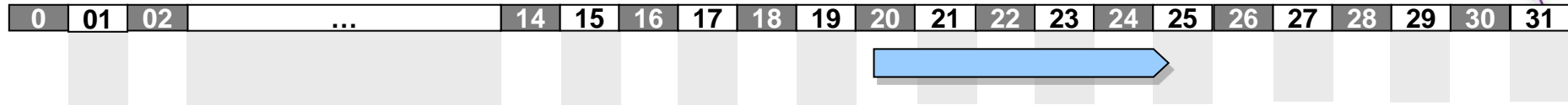
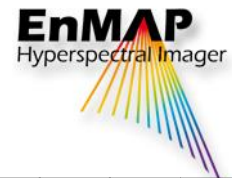
Parameter	Value
Mission	Geostationary Hyperspectral Imager Satellite - Observation of ocean colour, vegetation processes and aerosol, vegetation processes, surface temperatures
Spectral Range	400 nm – 870 nm (VNIR), 900 – 2500 nm (SWIR), 7.1 μm – 13.5 μm (TIR)
Bandwidth	< 10 nm (VNIR(/SWIR sensor)
No of Bands	60 bands (VNIR), 150 bands (SWIR), 6 bands (TIR)
Spatial Resolution	320 m (VNIR), 192 m (SWIR), 1.5 km (TIR)
Swath	< 500 km
Orbit	Geostationary (35.786 km) at 93.5° E
Revisit	For India multiple times per day
Special features	
Link	http://www.wmo-sat.info/oscar/satellites/view/526 http://space.skyrocket.de/doc_sdat/gisat-1.htm
CEOS Database	http://database.eohandbook.com/database/missionssummary.aspx?missionID=693

HISUI (Japan)



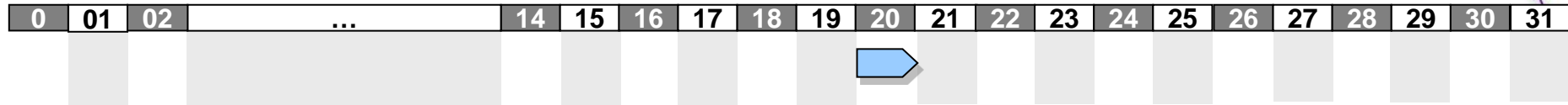
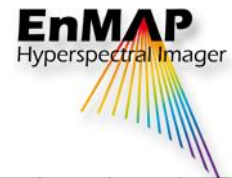
Parameter	Value
Mission	HISUI is a future spaceborne hyperspectral imager being developed by Japanese Ministry of Economy, Trade, and Industry (METI) as its 4th spaceborne optical imager mission, for oil/gas/mineral resource exploration and other fields such as agriculture, forestry, and coastal issues
Spectral Range	440 nm – 970 nm (VNIR), 900 nm – 2500 nm (SWIR)
Bandwidth	10 nm (VNIR), 12.5 nm (SWIR)
No of Bands	185
Spatial Resolution	20 m (cross track) x 30 m (across track)
Swath	20 km
Orbit	Onboard the ISS
Revisit	
Special features	HISUI data sent from EF device are recorded on the removable media in MDR-PM. (≈300 GB/day). After recording, the media are planned to be shipped from ISS to the ground 3 or 4 times per year (TBD). In addition, the limited amount of HISUI data are transmitted from ISS to the ground station in near-real time; pushbroom/grating, SNR: ≥ 450 @620 nm ≥ 300 @2100 nm; HISUI data policy is under consideration (for scientific purposes free with priority of domestic users)
Link	http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/06_1705_IGARSS_HISUI_Matsunaga_07b.pdf
CEOS Database	http://database.eohandbook.com/database/instrumentsummary.aspx?instrumentID=1634

EnMAP (Germany)



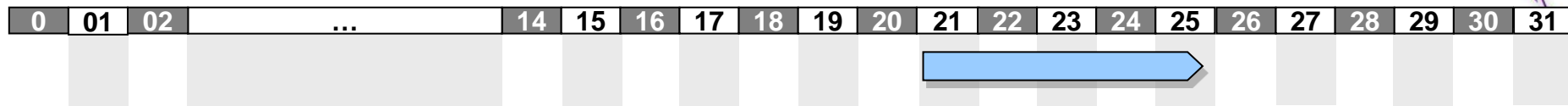
Parameter	Value
Mission	Germany's first hyperspectral Earth observing satellite mission, scientific path finder mission for later operational services, for environmental monitoring, process understanding
Spectral Range	420 nm – 1000 nm (VNIR), 900 nm – 2450 nm (SWIR)
Bandwidth	6.5 nm \pm 1.25 nm (VNIR), 10 nm \pm 2.50 nm (SWIR)
No of Bands	98 bands (VNIR), 130 bands (SWIR)
Spatial Resolution	30 m
Swath	30 km
Orbit	Sun-Synchronous at 653 km
Revisit	\leq 4 days (\pm 30° off-nadir tilt) and \leq 21 days (\pm 5° off-nadir tilt)
Special features	Mission fully funded
Link	www.enmap.org http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/05_2017-07-24_IGARSS17_EnMAP_FINAL.pdf
CEOS Database	http://database.eohandbook.com/database/missionsummary.aspx?missionID=600

CLARREO (USA)



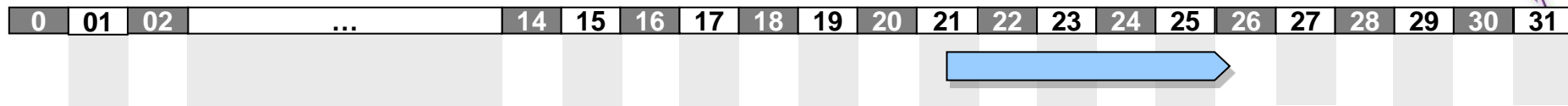
Parameter	Value
Mission	CLARREO Pathfinder is a directed mission through the NASA Science Mission Directorate – Earth Science Division, demonstrates high accuracy SI-Traceable Calibration, demonstrate Inter-Calibration
Spectral Range	350 nm – 2300 nm
Bandwidth	350 to 2300 nm at 4-nm sampling interval with 8-nm resolution.
No of Bands	
Spatial Resolution	500 m
Swath	70 km
Orbit	
Revisit	
Special features	Onboard the ISS, CLARREO Pathfinder (CPF) will have a Reflected Solar spectrometer on the International Space Station (ISS) starting in 2021 that will detect the complete spectrum of radiation from the Sun reflected by Earth
Link	https://clarreo.larc.nasa.gov/about-pathfinder.html https://clarreo.larc.nasa.gov/pdf/CLARREO_Pathfinder_Factsheet-Generic.pdf http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/05_1707_thome_igarss_talk.pdf
CEOS Database	http://database.eohandbook.com/database/missionsummary.aspx?missionID=778

Shalom (Italy / Israel)



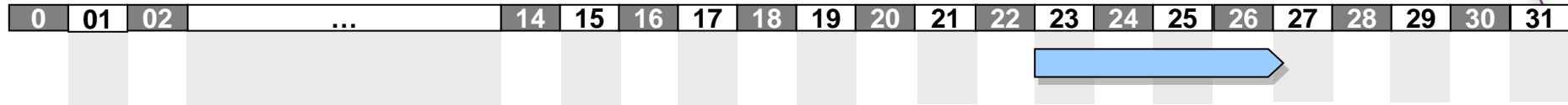
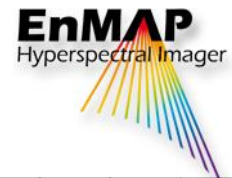
Parameter	Value
Mission	Environmental quality, crisis monitoring, search for mineral and natural resources, monitoring water bodies, assisting precision agriculture activity
Spectral Range	400 nm – 700 nm (PAN), 400 nm – 1010 nm (VNIR), 920 nm – 2500 nm (SWIR)
Bandwidth	~ 10 nm
No of Bands	
Spatial Resolution	10 m (VNIR-SWIR)
Swath	10 km
Orbit	Sun-Synchronous at 600 km, combined with panchromatic imager
Revisit	2 days
Special features	High SNR at typical radiance (>530@550nm; <430@1245 nm) thanks to the possibility to perform with the satellite manouvers of Ground Motion Compensation (GMC)
Link	http://prisma-i.it/images/Eventi/20170301_Workshop_ASI/Sessione%204/Labate.pdf http://www.grss-ieee.org/wp-content/uploads/2014/12/2014_07_ISIS_Session1_Mission/shalom_IGARSS_2014_2.pdf
CEOS Database	-

FLORIS / FLEX (ESA, UK)



Parameter	Value
Mission	Quantitative global mapping of actual photosynthetic activity of terrestrial ecosystems, as a function of variable vegetation health status and environmental stress conditions
Spectral Range	500 nm – 780 nm
Bandwidth	0.3 nm – 3 nm
No of Bands	
Spatial Resolution	300 m (500 m to enhance SNR)
Swath	105 km – 150 km
Orbit	Sun-Synchronous at ~ 815 km
Revisit	19 days
Specialities	Planned, tandem mission with Sentinel-3
Link	http://www.esa.int/esaLP/SEMD9AGMTGG_index_0.html http://www.congrexprojects.com/custom/icso/2012/papers/FP_ICSO-081.pdf http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/04_FLEX_Moreno_IGARSS17.pdf
CEOS Database	http://database.eohandbook.com/database/missionssummary.aspx?missionID=836

HyspIRI (USA)



Parameter	Value
Mission	Global investigation of ecosystems and natural disasters
Spectral Range	380 nm – 2510 nm (VSWIR), 4 μm – 12 μm (TIR)
Bandwidth	7 nm (VSWIR), 0.084 μm – 0.54 μm (TIR)
No of Bands	210 bands (VSWIR), 8 bands (TIR)
Spatial Resolution	30 m (VSWIR), 60 m (TIR)
Swath	150 km (VSWIR), 600 km (TIR)
Orbit	Sun-Synchronous at 626 km
Revisit	16 days (VSWIR), 5 days (TIR)
Specialities	Proposed as a NASA Decadal Survey mission, three options for implementation: full combined mission, ISS option, separate platform
Link	http://www.grss-ieee.org/wp-content/uploads/2017/hyperspectral_igarss_sessions/01_pres_Global_Imaging_Spectroscopy_Overview_170724d.pdf https://hyspiri.jpl.nasa.gov/
CEOS Database	http://database.eohandbook.com/database/missionsummary.aspx?missionID=644