

VENμS:
Joint Israeli – French Micro-
Spacecraft for Earth Observation
Mission

VENμS
Vegetation and Environment monitoring on a New Micro Satellite

The Venμs mission and products

<http://smc.cnes.fr/VENUS/index.htm>

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1 The Venus Mission

VEN μ S (Vegetation and Environment monitoring on a New Micro-Satellite) is the first cooperation between Israel and France for the Earth observation using a superspectral camera, dedicated to vegetation monitoring. The Memorandum of Understanding between CNES and ISA (Israeli Space Agency) was signed in April 2005. The satellite will be operational in 2016.

The VEN μ S satellite will use an IMPS micro-satellite platform (Improved Multi Purpose Satellite) of the IAI /MBT space division (Israeli Aerospace Industries).

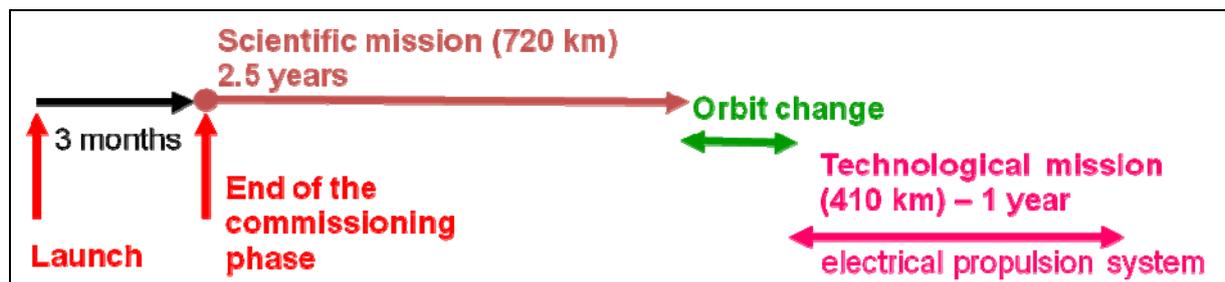
VEN μ S scientific objective is the provision of data for scientific studies dealing with the monitoring, analysis, and modeling of land surface functioning under the influences of environmental factors as well as human activities. To fulfill this objective, VEN μ S will acquire **every two days** high resolution and superspectral images of predefined sites of interest all around the world.

Scientific mission requirements have been defined by **CESBIO** (France), **Ben Gurion University of the Negev** (Israel) and CNES.

VEN μ S technological mission is aimed at validating the IHET (Israeli Hall Effect Thruster): qualification of the IHET thruster for low altitude station keeping and evaluation of the IHET performances in space.

CNES is responsible for supplying the superspectral camera and the science mission center. ISA is responsible for the spacecraft, for the launcher interface and for the satellite control center.

The scientific mission is expected to end about 33 months after launch (so-called VM1 period). At the end of this period, the Technological Mission will begin. The altitude of the spacecraft will be decreased from 720 km to about 410 km. The change of the orbit will take about six months (VM2 period). The 410 km orbit will then be kept during one year, from about 38th month to 50th month after launch (VM3 period). Imaging operation is expected to continue during the technological mission. Due to orbit change, the swath will be reduced to about 15 km, while the ground resolution will increase to about 3m.

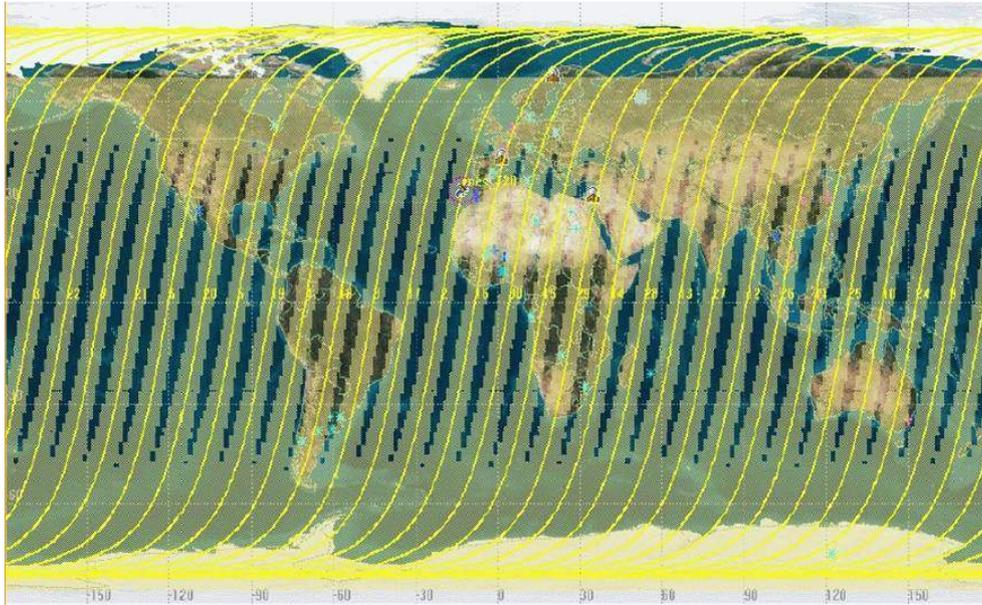


To fulfill its scientific objectives, VEN μ S will acquire frequent, high resolution, multi-spectral images of over 100 sites of interest all around the world, plus 10 sites for calibration purposes. The satellite will fly in a near polar **sun-synchronous** orbit at 720 km height, 98° inclination. The orbit will be controlled such as to maintain the local time of overpass at ± 5 minutes. The whole system will be able to be tilted up to 30 degree along and across track. This configuration will result in a 2-days revisit time, 27 km swath, a camera resolution of 5.3 m at nadir, and the capability to observe any site under a constant view angle. The system will cross the equator at around 10:30 AM.

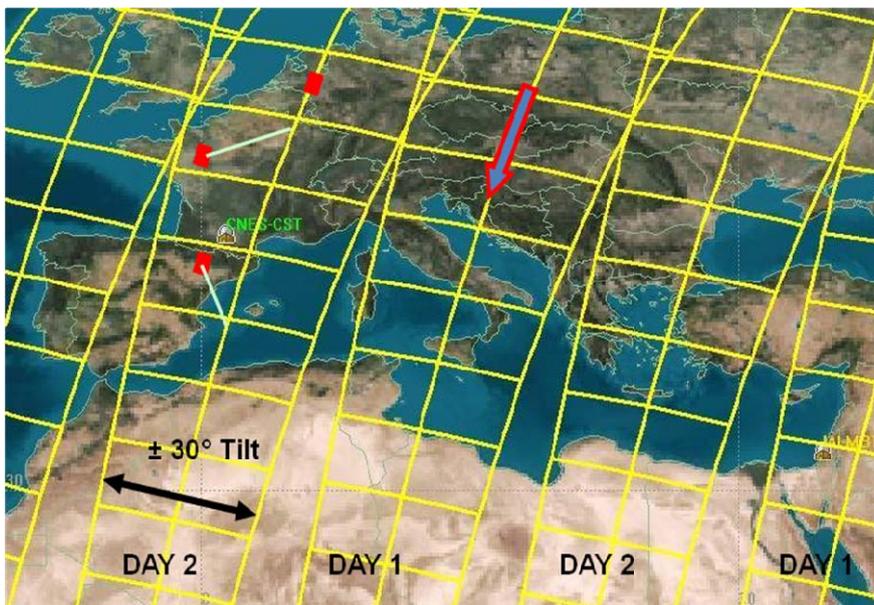
The satellite will carry a super-spectral camera characterized by 12 narrow spectral bands ranging from 415 nm to 910 nm. The band setting was designed to characterize vegetation status, including through red-edge bands, and to estimate the aerosol optical depth and the water vapour content of the atmosphere for accurate atmospheric corrections. The spectral band setting could also prove useful for coastal areas and inland waters studies.

The science mission center will deliver three levels of products, described in section 3.

Each site will be observed during the whole period of 2.5 years and will be imaged every second day, except under some circumstances such as during polar night.



Possible coverage of VENUS
Nadir in yellow, tilted viewing in grey



Closer view of possible coverage

2 CAMERA

The satellite will carry a super-spectral camera characterized by 12 narrow spectral bands (B1 – B12). The radiometric resolution for all bands is 10 bits.

At the camera level, each spectral line of an image is made of 5200 pixels. At nadir, the field of view is 27 km with a ground resolution of 5.3 m, but the SNR requirements are only met at 10.6 m. When an image is acquired with an oblique viewing, the native ground resolution decreases a little and the field of view increases.

The data will be acquired over existing or planned experimental sites with size ranging from 27 x 27 km² kilometers to 27 x 54 km² or more. All data for a given site will be acquired with the same observation angle in order to minimize directional effects.

Bands	Central Wavelength (μm)	Bandwidth (nm)	Main Driver
B1	0.420	40	Atmospheric correction
B2	0.443	40	Aerosols, clouds
B3	0.490	40	Atmospheric corrections
B4	0.555	40	Land
B5	0.620	40	Land
B6	0.620	40	DEM, image quality
B7	0.667	30	Land
B8	0.702	24	Land
B9	0.742	16	Land
B10	0.782	16	Land
B11	0.865	40	Land
B12	0.910	20	Water vapor

The set of bands includes 4 bands for atmospheric effects removal. The 638 nm band is duplicated with a difference in viewing angle of 1.5°. It is aimed at deriving Digital Elevation Models (DEMs) and image quality assessment. It will also be used to detect clouds using their altitude. Note that most Venus spectral bands (B1 to B9) are also suited for water colour applications, in situations which do not require a very high SNR.

A brief summary of the interest of every band is given below.

B1, B2, and B3: These bands are sensitive to the scattering of light due to particles (aerosols) and molecules, those effects depend on the wavelength. They will allow estimating the turbidity (aerosols) of the atmosphere, which is then used to apply atmospheric correction. In addition, these bands are very efficient to detect clouds and cloud edges over land and water. This is important for automatic processing of image time series. Cloud screening and aerosol characterization do not require the use of full resolution data. Working with data averaged over 4x4 pixels or even more is sufficient. Therefore, the SNR (Signal to Noise Ratio) at full resolution can be lower than for the other bands.

B4: This band is located in the green peak of vegetation and is useful to characterize vegetation status (LAI, chlorophyll).

B5: Vegetation chlorophyll absorption. Used with B11 to compute vegetation indices

B6: this band is a duplication of B5, and is implemented in the camera focal plane such as the difference of viewing angle is 1.5 degree.

The interests of the duplicated B5 band are:

- From the small stereoscopic effect it will be possible i) to generate a coarse DEM ii) to help to detect clouds by their altitudes.
- Having a duplicated band has proved to be very useful with Polder mission for image quality purposes.

B7, B8, B9, and B10: these red-edge bands are designed for detecting the blue shift of the red edge when vegetation is stressed. They can be useful for computing the chlorophyll index.

B11: near infrared band, e.g. for NDVI and other vegetation indices computation

B12: water vapour absorption, to help correcting absorption effects on other bands

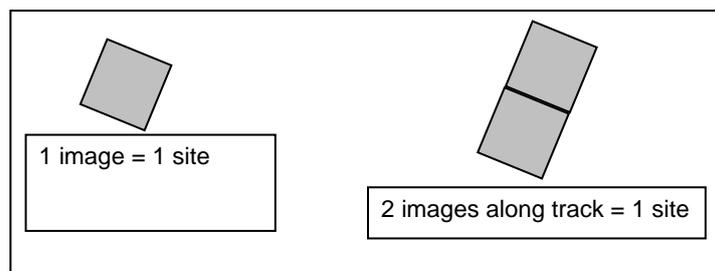
3 PRODUCTS

The Venus ground segment will deliver three levels of products. The products will be delivered within one month after the acquisition date. No near real time delivery is planned. Products will be available to the users through a web interface and ftp download.

At the camera level, each spectral line of an image is made of 5200 pixels. At nadir, the field of view is 27 km with a ground resolution of 5.3 m, but the SNR requirements are only met at 10.6 m. When an image is acquired with an oblique viewing, the native ground resolution decreases a little and the field of view increases.

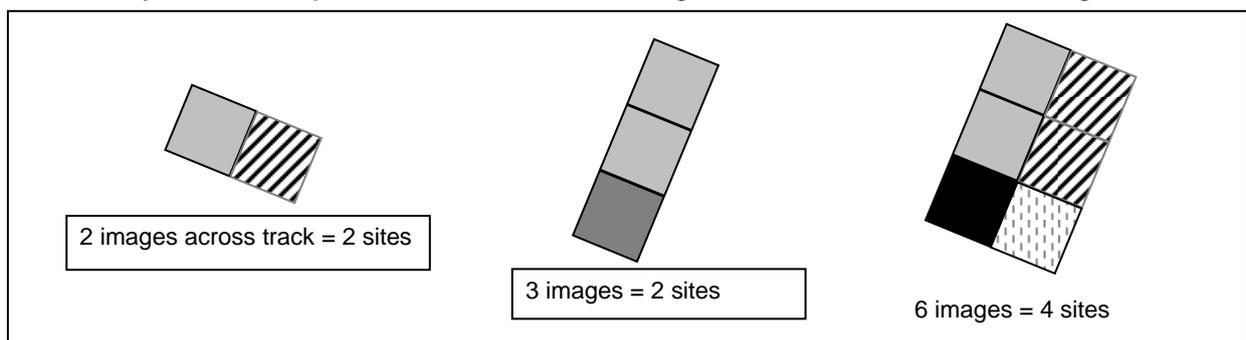
The following definitions apply in the rest of the text:

- An **image** corresponds to the acquisition of 5200 rows by 5200 pixels in the twelve spectral bands. At nadir, it corresponds to an area on ground of approximately 27x27km². This is the minimal product size which will be delivered to the users.
- The baseline definition of a **site** is: "an area on the Earth covered by one to two along track contiguous images". A site corresponds to 5200x5200 pixels (1 image) or 5200x10400 pixels (2 images) in the focal plane. Therefore, the minimum size of a site is 27x27 km², the maximum size being 27x54 km² at nadir.



Baseline definition of a site and standard Venus image acquisitions

However, this definition has to be extended to more complex situations since the same area can also be observed with different view angles, for example nadir, forward and backward viewing from the same orbit and/or from different orbits. In that case, the area of interest is covered by several **acquisitions** of one to two images each with different view angles.



Site definitions for non standard Venus image acquisitions

When a project requires images which depart from the baseline definition of a site, several sites of one to two images have to be defined. This could occur in the following situations:

- More than two along track contiguous images are needed to cover the area of interest
- Two or more across track images are needed. In that case, the images are acquired with different viewing angles, possibly from different orbits.
- Two or three images of the same area are acquired from different viewing angles. Each viewing direction corresponds to one site (e.g. 3 viewing directions = 3 sites)

Since the Venus ground segment will only manage and deliver sites of one or two images, the mosaicking of several sites to cover the project area of interest will have to be done by the proponents.

Each site will be observed during the whole period of 2.5 years and will be imaged every second day, except under some circumstances such as during polar night.

The three levels of products which will be made available to the users are summarized in the table below.

Product level	Temporal characteristic	Content	Ground resolution
Level 1	single date and single viewing angle acquisition	Top of the Atmosphere reflectances, map projected (orthorectified image)	5 m
Level 2	single date and single viewing angle acquisition	Surface reflectances, map projected (orthorectified image)	10 m
Level 3	10 days time composites of single viewing angle acquisition	Surface reflectances, map projected (orthorectified image)	10 m

There is one set of products per site, namely levels 1, 2 and 3. Therefore a product is made of 1 (5200x5200 pixels) or 2 images (5200*10400 pixels).

3.1 Level 1

The Venus level 1 will provide:

- Geolocated top of atmosphere reflectances (possibility to use a different geographic projection for each site, but only one per site), with a subpixel (objective 3m) multi-date registration.

The level 1 geometric ground resolution is 5 m. Level 1 is used as input to Level 2 processors.



Level 1: Top of the Atmosphere reflectances calibrated & geocoded (orthoimage). Formosat-2 data, 8m ground resolution.

3.2 Level 2

The Venus level 2 products will provide:

- a fine cloud and cloud shadow mask, and a water mask
- surface reflectance after atmospheric corrections for all spectral bands (still geolocated)

The level 2 geometric resolution is 10 m.



Level 2: Single date surface reflectances after cloud masking and atmospheric correction on Level 1 product. Formosat-2 data, 8m ground resolution.

References:

Hagolle, O., G. Dedieu, B. Mougenot, V. Debaecker, B. Duchemin and A. Meygret, 2008, Correction of aerosol effects on multi-temporal images acquired with constant viewing angles: Application to Formosat-2 images. *Remote Sensing of Environment*, Vol. 112, n°4, 1689-1701.

Hagolle O., M. Huc, D.Villa Pascual, and G. Dedieu, "A multi-temporal method for cloud detection, applied to FORMOSAT-2, VEN μ S, LANDSAT and SENTINEL-2 images," *Remote Sensing of Environment*, vol. 114, Aug. 2010, pp. 1747-1755.

3.3 Level 3

The Venus level 3 will provide the same variables as Level 2, every week, maximising the number of cloud free pixels. Level 3 will be based on L2 data acquired under the same viewing angle.

The level 3 geometric resolution is 10 m.



Level 3: 10 days time composite of level 2. *Formosat-2 data, 8m ground resolution.*

3.4 In-situ data

For operational reasons, it is not possible to incorporate in-situ data, such as local aerosol measurements, in the operational level 2 and 3 processing.

3.5 Data available before Venus Launch

In the framework of the preparation of the Sentinel-2 and Venus projects, CNES decided to launch the SPOT-4 (Take 5) experiment to simulate the repetitivity of Sentinel-2 satellite, using SPOT4, from February to end of may 2013. During this experiment, images have been acquired every 5th day over 42 sites located in different regions of the Earth and processed by the Theia Land Data Centre. The data are available for free download using the following URL:

<http://www.theia-land.fr/en/products/spot4-take5>

More information on the algorithms, products and uses can be found on the dedicated blog:

<http://www.cesbio.ups-tlse.fr/multitemp/>

For instance, we suggest you to visit the following pages :

http://www.cesbio.ups-tlse.fr/multitemp/?page_id=1015

<http://www.cesbio.ups-tlse.fr/multitemp/?cat=43>

A new version of the experiment with SPOT5 will also happen from April to August 2015.

3.6 Data distribution after Venus Launch

It is expected that data distribution will start after the end of the commissioning phase, which is scheduled 3 months after launch. The distribution of Venus products is not quasi real time, though best efforts will be done to shorten delays.