

"norsk elektro optikk..

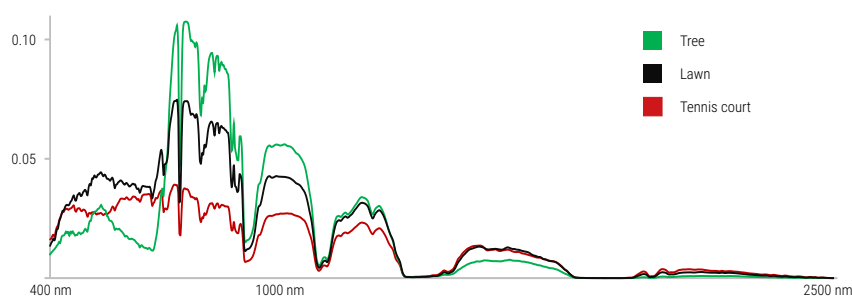
Norsk Elektro Optikk AS (NEO) was established in 1985 as a privately owned research company within the field of **electro optics**. The founders had their scientific and technical background from the Norwegian Defense Research Establishment, which for the last 30-40 years have been the leading research organization in electro optics in Norway. The company has grown to be the **largest independent research and development organization in electro optics** in Norway, and has established itself as a reputed manufacturer of advanced electro optical products. NEO is certified to the ISO 9001:2008 international quality standards.

The hyperspectral imaging activities at NEO started in 1995 with the **HISS (Hyperspectral Imager for Small Satellites) project for ESA**. The R&D activities in hyperspectral imaging have been internally funded through commercialization of the technology together with participation in **several EU projects**, as well as projects funded by the **Ministry of Defense**, the **Norwegian Research Council** etc.

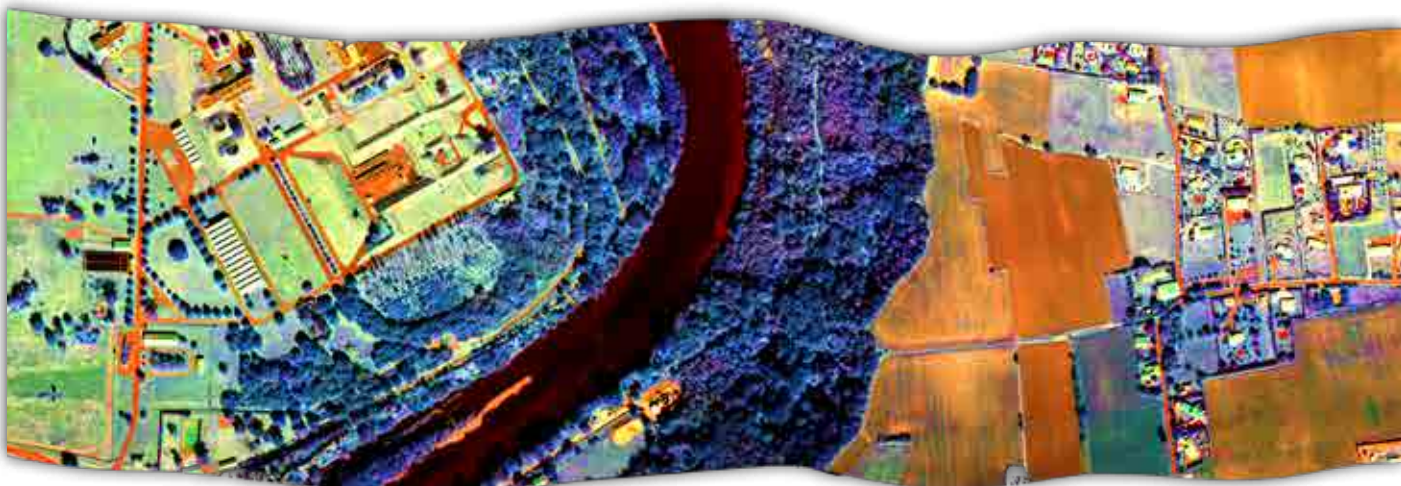


NEO and NEO Monitors are collocated at Prost Stabels Vei 22.

Over the years, HySpex has established itself as one of the **world's leading** brands for both airborne and ground based **hyperspectral imaging**. HySpex sensors are renowned for their **stability, flexibility and superior data quality**.



Sample radiance spectra from the image below.



HySpex false color RGB data preview (selected bands R:550nm, G:1620nm, B:1250nm).

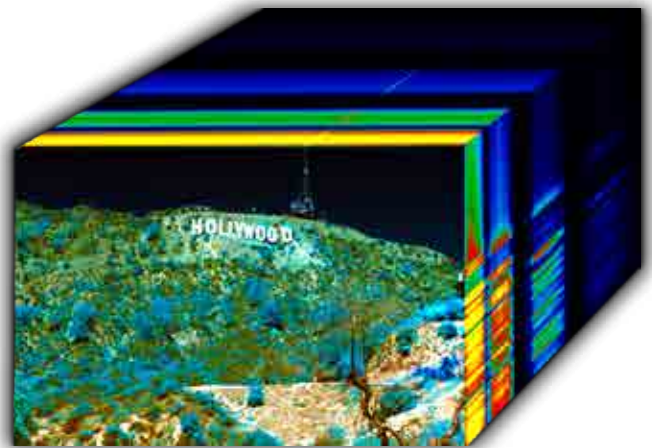
Pushbroom imagers

All HySpex cameras are pushbroom hyperspectral imagers. When acquiring data, the camera captures all **spectral information simultaneously** from a narrow line of the spatial scene. As the camera is scanned across the scene, or the scene in front of the camera, the spatial scene is captured and added to the hyperspectral cube.

The output data product thus contains both a spatial scene together with the contiguous spectral information from each pixel in the spatial scene.

HySpex cameras can be supplied as **turn-key** acquisition solutions, allowing the user to acquire **scientific grade quality data** immediately after delivery.

All classic HySpex cameras (i.e. HySpex VNIR-1024, VNIR-1800 and SWIR-384) can easily be equipped with custom **close-up lenses**, allowing the end user to utilize the same camera for applications where high spatial resolution is required (spatial resolution as high as 24µm is obtainable using the microscope lens for VNIR), as well as applications with a long working distance (airborne and field measurements). Universities and research institutes worldwide have chosen HySpex cameras for their **ground and airborne applications**, using the **same instruments** for airborne, field and laboratory measurements.



Depiction of hyperspectral cube, acquired with HySpex SWIR-384.

Data Quality

To ensure that HySpex cameras provide their users with scientific grade data, **all cameras** undergo **rigorous testing and characterization** during production. As a part of the environmental testing, the cameras are exposed to a vibration test, far exceeding normal operation conditions, to ensure **stability throughout the lifetime** of the instrument. The tests performed are documented in a **~20 page test report** for each individual camera, identifying both the test procedures and results.

Transparency in the calibration and testing procedures is key to provide the end user with an overview of performance parameters that are crucial to the quality of the system, but not necessarily communicable on a top level data sheet.



HySpex cameras used for airborne (left, courtesy DLR), field operations (middle, courtesy University of Alaska Fairbanks Hyperspectral Imaging Laboratory), and close range lab measurements (right, courtesy The National Gallery, Norway).

Airborne Applications

High resolution and **high speed**, combined with **low weight** and **power** consumption, make NEO's HySpex cameras very well suited for airborne data acquisition.

A typical airborne installation consists of the **HySpex cameras** coupled with an **airborne data acquisition unit**, a navigation system (**IMU/GPS**) and a **mounting platform**.

Both **actively stabilized** and **passively damped** mounting platforms can be supplied, as well as standard mounting plates with no damping.

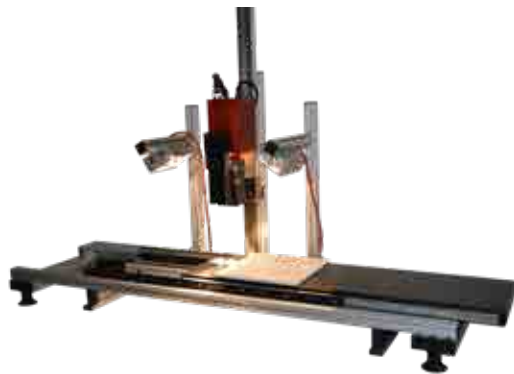
IMU/GPS solutions from **leading manufacturers** can be supplied and integrated with the cameras. Alternatively, HySpex systems can be interfaced with the customer's existing navigational hardware.



Laboratory Setup

For lab and field use, a scanning stage is needed to scan the cameras and build the hyperspectral data cube of the scene. A **user friendly table-top lab setup** with translation stage, VNIR-SWIR light sources and close-up lenses can also be supplied for scanning of samples of varying sizes.

The scanning speed is **automatically controlled** by the data acquisition unit, based on the selected lens option. The lab rack includes a camera adjustment platform, to facilitate camera **focus adjustment** when using different close-up lenses.



Field Setup

For **field operations**, NEO supplies a range of high precision rotation stages tailored to fit the number of cameras and the operational scheme. Long-life Li-ion **battery powered** solutions are available for increased **portability**

For **fast and precise scanning** of larger areas, such as a **mine face**, **outcrop** or **building**, NEO can supply an **automatic pan-tilt scanner**. By inputting the number of degrees and scan lines to scan in both the horizontal and vertical direction, the stage will automatically scan the **pre-programmed area**, ensuring the desired overlap between scan lines.

To ensure **stable and reliable acquisitions** in challenging field conditions, a **rugged, yet portable, tripod** is supplied. NEO supplies a variety of tripods with pan/tilt-heads that will accommodate the payload of the cameras and rotation stage used.

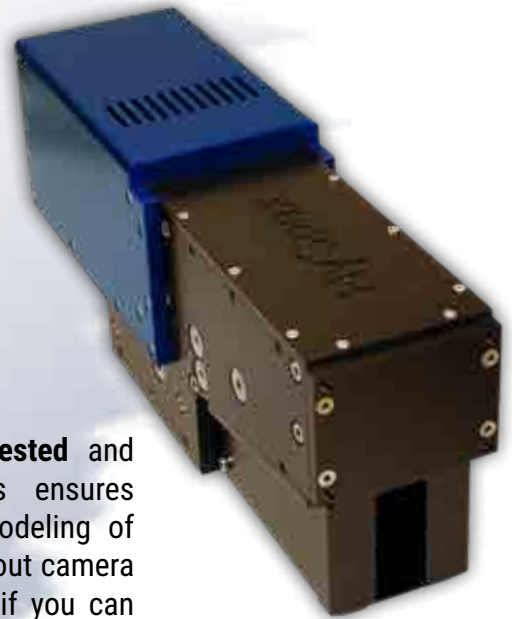


HySpex VNIR-1024

The HySpex VNIR-1024 **hyperspectral camera**, is developed for **field, laboratory, airborne** and **industrial** applications.

HySpex VNIR-1024 combines **extreme acquisition speeds** with no compromise on the data quality. The high frame rate makes VNIR-1024 an ideal camera for **industrial applications, low altitude flights** or other applications where high frame rates and **high radiometric accuracy** is required.

Like **all HySpex cameras**, HySpex VNIR-1024 is **rigorously tested** and **calibrated to traceable standards** during production. This ensures consistency in results between different cameras, allowing modeling of algorithms for deployment at e.g. different production points without camera specific adjustments. Inspired by Sinatra, NEO guarantees that if you can detect it "there", you can detect it anywhere.



HySpex VNIR-1024.

A wide range of **close-up lenses** allows the use of the camera at working distances ranging from a few cm **with a spatial resolution of 24 μm** , to infinity for e.g. **airborne remote sensing**.



Close range scanning of rucola seeds.

Main specifications

Spectral range	400 – 1000 nm
Spatial pixels	1024
Spectral channels	108
Spectral sampling	5.4 nm
FOV*	16.1°
Pixel FOV across/along*	0.28/0.56 mrad
Bit resolution	14 bit
Noise floor	11 e ⁻
Dynamic range	3400
Peak SNR (at full resolution)	> 330
Max speed (at full resolution)	690 fps
Power consumption	6 W
Dimensions (l-w-h)	30.5 – 9.9 – 15 cm
Weight	4.2 kg

**Can be doubled with FOV expander*

HySpex VNIR-1800

The HySpex VNIR-1800 **hyperspectral camera**, is developed for **field, laboratory, airborne** and **industrial** applications.

HySpex VNIR-1800 utilize a cutting edge **actively cooled and stabilized scientific CMOS** detector. This makes VNIR-1800 the ideal camera for high-end data acquisitions where **high radiometric accuracy** is required.

The dynamic range of 20 000 ensures **outstanding SNR levels** even in darker areas of an image of highly dynamic scenes. With a max frame rate of **260 fps**, combined with **aberration corrected optics** and **high optical throughput** (f/2.5), HySpex VNIR-1800 offers a unique combination of data quality, high speed and sensitivity.

A wide range of **close-up lenses** allows the use of the camera at working distances ranging from a few cm with a **spatial resolution of 24 µm**, to infinity for e.g. **airborne remote sensing**.



HySpex VNIR-1800.



Flight line with vegetation enhanced in red to the right.

Main specifications

Spectral range	400 – 1000 nm
Spatial pixels	1800
Spectral channels	186
Spectral sampling	3.26 nm
FOV*	17°
Pixel FOV across/along*	0.16/0.32 mrad
Bit resolution	16 bit
Noise floor	2.4 e ⁻
Dynamic range	20000
Peak SNR (at full resolution)	> 255
Max speed (at full resolution)	260 fps
Power consumption	30 W
Dimensions (l-w-h)	39 – 9.9 – 15 cm
Weight	5.0 kg

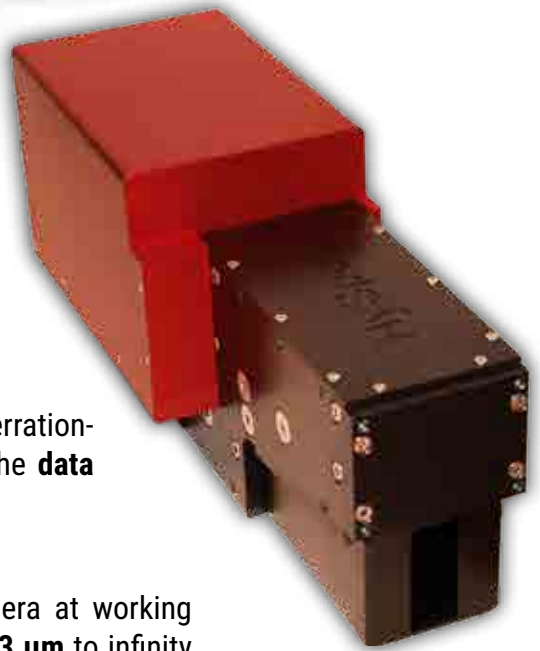
**Can be doubled with FOV expander*

HySpex SWIR-384

The HySpex SWIR-384 hyperspectral camera, is developed for **field, laboratory, airborne and industrial applications**. The state of the art MCT sensor with cooling down to 150K yields low background noise, high dynamic range and **exceptional SNR levels**.

With a max frame rate of **400 fps**, combined with an aberration-corrected optical system with high optical throughput (f/2), the **data quality, speed** and **sensitivity** is truly **state of the art**.

A wide range of **close-up lenses** allows the use of the camera at working distances ranging from a few cm with a spatial resolution of **53 μm** to infinity for e.g. airborne remote sensing.



HySpex SWIR-384.



Kaolinite abundance map (courtesy: CSIRO, Minerals Down Under Flagship Minerals Down Under Flagship).

Main specifications

Spectral range	930-2500 nm
Spatial pixels	384
Spectral channels	288
Spectral sampling	5.45 nm
FOV*	16°
Pixel FOV across/along*	0.73/0.73 mrad
Bit resolution	16 bit
Noise floor	150 e ⁻
Dynamic range	7500
Peak SNR (at full resolution)	> 1100
Max speed (at full resolution)	400 fps
Power consumption	30 W
Dimensions (l-w-h)	38 – 12– 17.5 cm
Weight	5.7 kg

**Can be doubled with FOV expander*

HySpex VS-725

HySpex VS-725 is a hyperspectral imaging system consisting of HySpex VNIR-1800 and HySpex SWIR-725. Designed to provide **high resolution airborne data** in the full spectral range from **400-2500 nm**, HySpex VS-725 offers a **compact** and cost efficient solution.

The novel HySpex SWIR-725 configuration provides a **high resolution** SWIR imaging system of unique optical performance with **exceptionally low smile and keystone**. HySpex SWIR-725 consists of two HySpex SWIR-384HR (High Resolution) systems, overlapping with one degree in the central FOV, in a **common sensor head** configuration.



HySpex VS-725.

The Data Acquisition Unit provides full control and real time previews from all sensors, and ensures **accurate synchronization** between the sensors and the INS to achieve **high precision georeferencing**.

Main specifications

HySpex VS-725		
	VNIR-1800	SWIR-725
Spectral range	400 – 1000 nm	955 – 2510 nm
Combined spectral range	400 – 2510 nm	
Spatial pixels	1800	725
Combined spatial pixels	725	
Spectral channels	186	288
Combined spectral channels	453	
Spectral sampling	3.26 nm	5.45 nm
FOV	17°	17°
Combined FOV	17°	
Pixel FOV across/along	0.16/0.32 mrad	0.41/0.41 mrad
Combined Pixel FOV across/along	0.41/0.41 mrad	
Bit resolution	16 bit	
Noise floor	2.4 e ⁻	150 e ⁻
Dynamic range	20000	7500
Peak SNR (at full resolution)	> 255	> 1100
Max speed (at full resolution)	260 fps	400 fps
Power consumption	30 W	60 W
Combined Power consumption	90 W	
Dimensions (l-w-h) [cm]	39 – 9.9 – 15	38 – 36 – 17.5
Combined Dimensions (l-w-h) [cm]*	50 – 50 – 40	
Weight	5.0 kg	12 kg
Combined Weight*	22 kg	

*Includes interface plate for GSM4000



HySpex Mjolnir V-1240 carried by CamFlight FX8HL. NEO offer full integration with CamFlight's robots.

The Viking Era: ODIN and Mjolnir

In 2009, NEO was contracted by the Norwegian and French military to design a **high-end airborne hyperspectral sensor**. The project resulted in **HySpex ODIN VS-1024**, with an optical architecture different from the classic cameras and with a **common slit**, ensuring perfect co-registration for all 1024 spatial pixels in the VNIR and SWIR range.

Upon completion of the project, NEO used the optical architecture of ODIN to develop **Mjolnir** ['mjɔl:nir] – a **very compact camera** designed specifically for UAV use.



HySpex ODIN VS-1024.

Different approaches to high-end data

Typically, the optics in high end hyperspectral imagers, such as the classic HySpex cameras, are designed to **minimize optical artifacts** such as smile and keystone (hardware corrected cameras). Industry-leading hardware corrected cameras, (e.g. HySpex SWIR-384) can document smile and keystone down to **10% of a pixel** over the full spectral and spatial range covered by the camera. An alternative to hardware correction of these artifacts is to characterize them precisely and resample the data. It is crucial that the effects are **stable over time, temperature and pressure**.

Research conducted by the R&D team at NEO demonstrated how the remaining error in a resampling camera corresponded to 10-15% keystone. Thus, a **resampling camera** will have the same optical performance as an industry-leading hardware corrected camera, with the added benefit of allowing up to **4 times higher** light throughput than a hardware corrected camera.

The technologies are combined in **HySpex ODIN VS-1024**, where the SWIR portion is hardware corrected while the VNIR data are resampled and binned from 2560 to 1024 spatial pixels and the spectral channels from 591 to 197 bands. In **HySpex Mjolnir V-1240**, the data are resampled from 1392 pixels and 480 spectral bands to a data output of 1240 pixels and 200 bands.

HySpex ODIN VS-1024

HySpex ODIN VS-1024 is a **next generation** state-of-the-art airborne hyperspectral imager, covering the spectral range from **400 to 2500 nm**.

Perfect co-registration between 1024 spatial pixels for VNIR and SWIR is achieved by employing a novel **common fore-optics** design.

In addition to the **extreme resolution**, the unique design provides high sensitivity and low noise, low spatial and spectral misregistration (smile and keystone).

In addition to its supreme data quality, HySpex ODIN VS-1024 includes **real-time data processing** functionalities such as **real-time georeferencing** of acquired images. It also features built-in **on-board calibration** system to monitor the stability of the instrument.



HySpex ODIN VS-1024.



False color VNIR and SWIR representation of flight line acquired during ODIN test flight.

Main specifications

	VNIR	SWIR
Spectral range	0.4 - 1.0 μm	0.95 - 2.5 μm
Spatial pixels	1024	
Spectral channels	427	
Spectral sampling	3.0 nm	6.1 nm
FOV	15°	
Pixel FOV across/along	0.25/0.25 mrad	
Bit resolution	16 bit	
Noise floor	2.4 e ⁻	150 e ⁻
Dynamic range	37000	7500
Peak SNR (at full resolution)	>500	>1300
Max speed (at full resolution)	180 fps	450 fps
Power consumption	60 W	
Dimensions (l-w-h)	113.4 – 42.3 – 72.6 cm	
Weight	90 kg	

HySpex MJOLNIR V-1240

The **HySpex Mjolnir V-1240** hyperspectral imaging system for UAVs provides a unique combination of small form factor and low mass, combined with high performance specifications and **scientific grade** data quality.

HySpex Mjolnir V-1240 covers the VNIR spectral range, **400 - 1000 nm**, and is built with an optical architecture based on the high-end HySpex ODIN system.

With a weight of **less than 4 kg** and less than **50 W** power consumption, **HySpex Mjolnir V-1240** is very well suited for a wide range of UAVs.

The UAV bundle offered by NEO integrates a hyperspectral camera with a powerful **PicoITX i7** computer and an **Applanix APX-15 UAV** navigation system, all fitted into a self-contained module mounted on a passive damping platform. The system is also compatible with several off-the-shelf gimbals.

NEO offers high-performance unmanned aerial vehicles, fully integrated with the **HySpex Mjolnir V-1240**. The UAV is fitted with a standard battery package allowing up to 30 minutes flight time. **All HySpex Mjolnir** systems can also be mounted on a **tripod and rotation stage for ground use**.



HySpex Mjolnir V-1240.



False color RGB image from HySpex Mjolnir data acquired at 120 m altitude.

Main specifications

Spectral range	400 – 1000 nm
Spatial pixels	1240
Spectral channels and sampling	200 bands @ 3 nm
F-number	F1.8
FOV	20°
Pixel FOV across/along	0.27/0.27 mrad
Bit resolution	12 bit
Noise floor	2.3 e ⁻
Dynamic range	4400
Peak SNR (at full resolution)	> 180
Max speed (at full resolution)	285 fps
Power consumption*	50 W
Dimensions (l-w-h)*	250 – 175 – 170 mm
Weight*	< 4 kg

**Includes IMU/GPS and DAU – <4.5 kg including standard battery*

HySpex MJOLNIR S-620

The **HySpex Mjolnir S-620** hyperspectral imaging system for UAVs is the SWIR version of the Mjolnir camera series. Similar to the VNIR version, it provides a unique combination of small form factor and low mass, combined with high performance specifications and **scientific grade** data quality.

With a weight of **less than 4.5 kg** and less than **50 W** power consumption, **HySpex Mjolnir S-620** is very well suited for a wide range of UAVs.

HySpex Mjolnir S-620, covers the SWIR spectral range, **1000 - 2500 nm**, and is built with an optical architecture based on the high-end HySpex ODIN system.

The UAV bundle offered by NEO integrates a hyperspectral camera with a powerful **PicoITX i7** computer and an **Applanix APX-15 UAV** navigation system, all fitted into a self-contained module mounted on a passive damping platform. The system is also compatible with several off-the-shelf gimbals.

NEO offers high-performance unmanned aerial vehicles, fully integrated with the **HySpex Mjolnir S-620**. The UAV is fitted with a standard battery package allowing up to 30 minutes flight time. **All HySpex Mjolnir** systems can also be mounted on a **tripod and rotation stage for ground use**.



HySpex Mjolnir S-620.



HySpex Mjolnir on Camflight FX8HL.

Main specifications

Spectral range	970 – 2500 nm
Spatial pixels	620
Spectral channels and sampling	300 bands @ 5.1 nm
F-number	F1.9
FOV	20°
Pixel FOV across/along	0.54/0.54 mrad
Bit resolution	16 bit
Noise floor	80 e ⁻
Dynamic range	10000
Peak SNR (at full resolution)	> 900
Max speed (at full resolution)	100 fps
Power consumption*	50 W
Dimensions (l-w-h)*	254 – 175 – 170 mm
Weight*	< 4.5 kg

**Includes IMU/GPS and DAU – <5 kg including standard battery*

HySpex MJOLNIR VS-620

Combining HySpex Mjolnir V-1240 and HySpex Mjolnir S-620 into a common housing, **HySpex Mjolnir VS-620** provides **620 coregistered pixels** in the VNIR and SWIR spectral range, 400 - 2500 nm.

For applications requiring low mass, combined with high performance specifications and **scientific grade** data quality on the full VNIR-SWIR range, HySpex Mjolnir VS-620 is an ideal solution. Sharing the on-board data acquisition unit and navigation system, HySpex Mjolnir VS-620 is both space efficient and cost effective.



HySpex Mjolnir VS-620

In addition to the high quality hyperspectral data cube, covering the spectral range from 400 - 2500 nm, with 490 bands, **double resolution** data in the VNIR range is always readily available. With smile and keystone less than 0.1 pixel for each spectral range, the merged Mjolnir VS-620 data product will have co-registration/keystone **better than 0.2 pixel** for the full VNIR-SWIR range.

The UAV bundle offered by NEO integrates a hyperspectral camera with a powerful **PicoITX i7** computer and an **Applanix APX-15 UAV** navigation system, all fitted into a self-contained module. All HySpex Mjolnir systems can also be mounted on a tripod and rotation stage for ground use.

Main specifications

	HySpex Mjolnir VS-620	
	V-1240	S-620
Spectral range	400 – 1000 nm	970 – 2500 nm
Combined spectral range	400 – 2500	
Spatial pixels	1240	620
Combined spatial pixels	620	
Spectral channels and sampling	200 bands @ 3.0 nm	300 bands @ 5.1 nm
Combined spectral channels	490	
F-number	F1.8	F1.9
FOV	20°	20°
Combined FOV	20°	
Pixel FOV across/along	0.27/0.54 mrad	0.54/0.54 mrad
Combined pixel FOV across/along	0.54/0.54 mrad	
Bit resolution (raw data)	12 bit	16 bit
Noise floor	2.3 e ⁻	80 e ⁻
Dynamic range	4400	10000
Peak SNR (at full resolution)	> 180	> 900
Max speed (at full resolution)	285 fps	100 fps
Power consumption*	50 W	
Dimensions (l-w-h)*	374 – 202 – 178 mm	
Weight*	~ 6 kg	

**Includes IMU/GPS and DAU – <6.5 kg including standard battery*

Gremsy gStabi H16

The advanced 3-axis digital stabilizer, **gStabi H16**, weighs only 2.2 kg (4.85 lbs). NEO delivers the gStabi H16 with a circular quick release, allowing it to be seamlessly fit on a wide range of multirotors. Capable of handling payloads up to 7 kg (15.43 lbs), the gimbal can support **all HySpex Mjolnir models**.

- Gimbal and Mjolnir payload powered by same battery
- Encoder with resolution up to 0.005°
- Ultra accurate IMU sensor with temperature compensation
- Simple 5 minutes setup & balance with Auto Tuning Feature
- gMotion Controller based on a 32 bit ARM high speed microprocessor providing super fast response and accurate calculation



HySpex Mjolnir and Gremsy gStabi H16.



Camflight FX8HL.

Camflight FX8HL Robot

- 8S 44 000 mAh batteries providing ~30 min. flight endurance for coverage of large areas, with Mjolnir payload
- Lockheed Martin Autopilot for high precision flights
- Virtual cockpit ground control SW for advanced flight plans
- High stability in wind

Applanix APX-15 UAV

- Advanced Applanix IN-Fusion™ GNSS-Inertial integration technology
- 100 Hz real-time position, roll, pitch and heading output for direct georeferencing of sensor data
- IMU data rate 200 Hz
- 336 Channels (GPS, GLONASS, BeiDou, Galileo, QZSS, SBAS)
- Solid-state MEMS inertial sensors w/Applanix SmartCal™ compensation technology
- Unfiltered, unsmoothed pseudo range measurements data for low noise, low multipath error, low time domain correlation and high dynamic response



Applanix APX-15 UAV.



HySpex Mjolnir field solution

Field applications

All Mjolnir systems can easily be deployed for field work by mounting it on a tripod with a rotation stage.

- Light weight, robust, compact and self contained design
- Working distances: 20 m – ∞
- Fully LiPo battery operated for long endurance
- Quick mounting and easy operation with scan speed fully synchronized with camera frame rate
- Easy wireless operation from tablet or laptop

HySpex models overview

All HySpex cameras (except ODIN) can be used for both ground based and airborne applications. The classic cameras can be delivered with a wide range of close-up lenses, making them very versatile and ideal for a wide range of applications requiring different spatial resolutions without compromising the optical performance of the system. The HySpex Mjolnir series, designed for UAVs, is also an outstanding, and very portable solution for ground applications with working distances greater than 20 m.



HySpex VNIR-1800.



HySpex SWIR-384.



HySpex Mjolnir V-1240.



HySpex ODIN VS-1024.

Classic HySpex

	VNIR-1024	VNIR-1800	SWIR-384	VS-725	Mjolnir				ODIN
					V-1240	S-620	VS-620	VS-1024	
Spectral range [nm]	400-1000	400-1000	930-2500	400-2500	400-1000	970-2500	400 - 2500	400 - 2500	
Spatial pixels	1024	1800	384	725	1240	620	620	1024	
Spectral channels	108	186	288	453	200	300	490	427	
Spectral sampling [nm]	5.4	3.26	5.45	5.45	3.0	5.1	3.0	6.1	
FOV	16.1°	17°	16°	17°	20°	20°	20°	15°	
Pixel FOV across/along [mrad]	0.28/0.56	0.16/0.32	0.73/0.73	0.41/0.41	0.27/0.27	0.54/0.54	0.54/0.54	0.25/0.25	
Bit resolution (raw data)	14 bit	16 bit	16 bit	16 bit	12 bit	16 bit	16 bit	16 bit	
Noise floor [e⁻]	11	2.4	150	2.4	2.3	80	2.3	2.4	
Dynamic range	3400	20000	7500	20000	4400	10000	4400	37000	
Peak SNR (at full resolution)	> 330	> 255	> 1100	>255	>180	>900	>180	>500	
Max speed (at full resolution)	690 fps	260 fps	400 fps	260 fps	285 fps	100 fps	100 fps	180 fps	
Power consumption	6 W	30 W	30 W	90 W	50 W	50 W	50 W	60 W	
Dimensions (l-w-h) [cm]	30.5-9.9-15	39-9.9-15	38-12-17.5	50-50-40	25-17.5-17	25.4-17.5-17	37.4-20-17.8	113.4-43-73	
Weight [kg]	4.2	5.0	5.7	22	< 4.0*	< 4.5*	< 6.0*	90	
				VNIR SWIR		VNIR SWIR		VNIR SWIR	

*includes IMU/GPS & DAU

