

UAS (& Microlight)
Applications for
Environmental Monitoring
- What are others doing? -

Rolf Becker
Hochschule Rhein-Waal

Everything is Environment

Intention of this presentation:

Inspirations for our discussion about

- remote sensing business ideas,
- marketable products and services,
- and networking
- in the Euregio Rhein-Waal and beyond

What is the state of art?

Example: Pablo Zarco-Tejada – A European Pioneer in UAS



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Laboratory for Research Methods in Quantitative Remote Sensing (Quantalab IAS – CSIC)



The *Laboratory for Research Methods in Quantitative Remote Sensing (Quantalab)* is led by Dr. Zarco-Tejada, and belongs to the Instituto de Agricultura Sostenible (IAS), National Research Council of the Spanish Research Council (CSIC). The laboratory focuses on quantitative methods for remote sensing, with a particular emphasis on precision agriculture. QuantaLab's researchers have experience in using hyperspectral and thermal sensors to estimate biochemical and biophysical parameters, and the effects of chlorophyll fluorescence on leaf apparent reflectance. The **hyperspectral** and **thermal imagers** currently operated by QuantaLab are used to develop methods for successful estimation of vegetation pigment concentration,

Institute for Sustainable Agriculture,
National Research Council, Spain



JOINT RESEARCH CENTRE

Institute for Environment and Sustainability (IES)

European Commission » Joint Research Centre IES » Highlights archive

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print

Highlight June 2013 - Severe floods in Europe

An exceptionally wet May followed by several days of intense rainfall in June led to severe flooding in Central and Eastern Europe, in particular Germany, Austria and the Czech Republic, with the Danube and the Elbe swelling to near 100-year highs. High water levels were also reported in the Rhine. Up to 21 deaths were reported as a result of these floods, with thousands of residents being evacuated. Northern Spain and southwestern France were also hit by heavy rains towards the middle of June. These led to flash floods that killed three people, with hundreds evacuated from their homes. The IES contributed to the crisis management activities by monitoring and reporting on the current flood situation through the **European Flood Awareness System (EFAS)**.



EFAS was developed by the IES and other research institutes following the extreme flood events of 2002. EFAS, which is now part of the initial operations of the **Copernicus Emergency Management Service (EMS)**, provided the relevant national authorities and the European Commission's Emergency Response Centre (ERC) with EFAS information several days in advance. The JRC also provides the ERC with daily situation reports on the flood crises as they develop, integrating scientific information with impact information into products tailored for civil protection, thereby helping the authorities to coordinate action within the EU to mitigate potential damages across borders.

RSPSoc and NERC Technology Cluster UAV Workshop

July 7-8th, 2011

Imaging spectrometry instrumentation for vegetation monitoring

Pablo Zarco-Tejada (IAS-CSIC), Spain

Jose A.J. Berni (IAS-CSIC & CSIRO)

<http://quantalab.ias.csic.es>

pablo.zarco@csic.es

<http://www.nottingham.ac.uk/eotechcluster/documents/events/uav-sig/zarcointro.pdf>





2002



2011



HELICOPTER



MK-1



PILATUS



CROPSIGHT

Larger plane for longer endurance

- Longer endurance
- Larger payloads



1.5 h @ 3 kg payload
2.5 h @ 1 kg payload



Larger plane for longer endurance & payload

Thermal & hyperspectral imagery on board

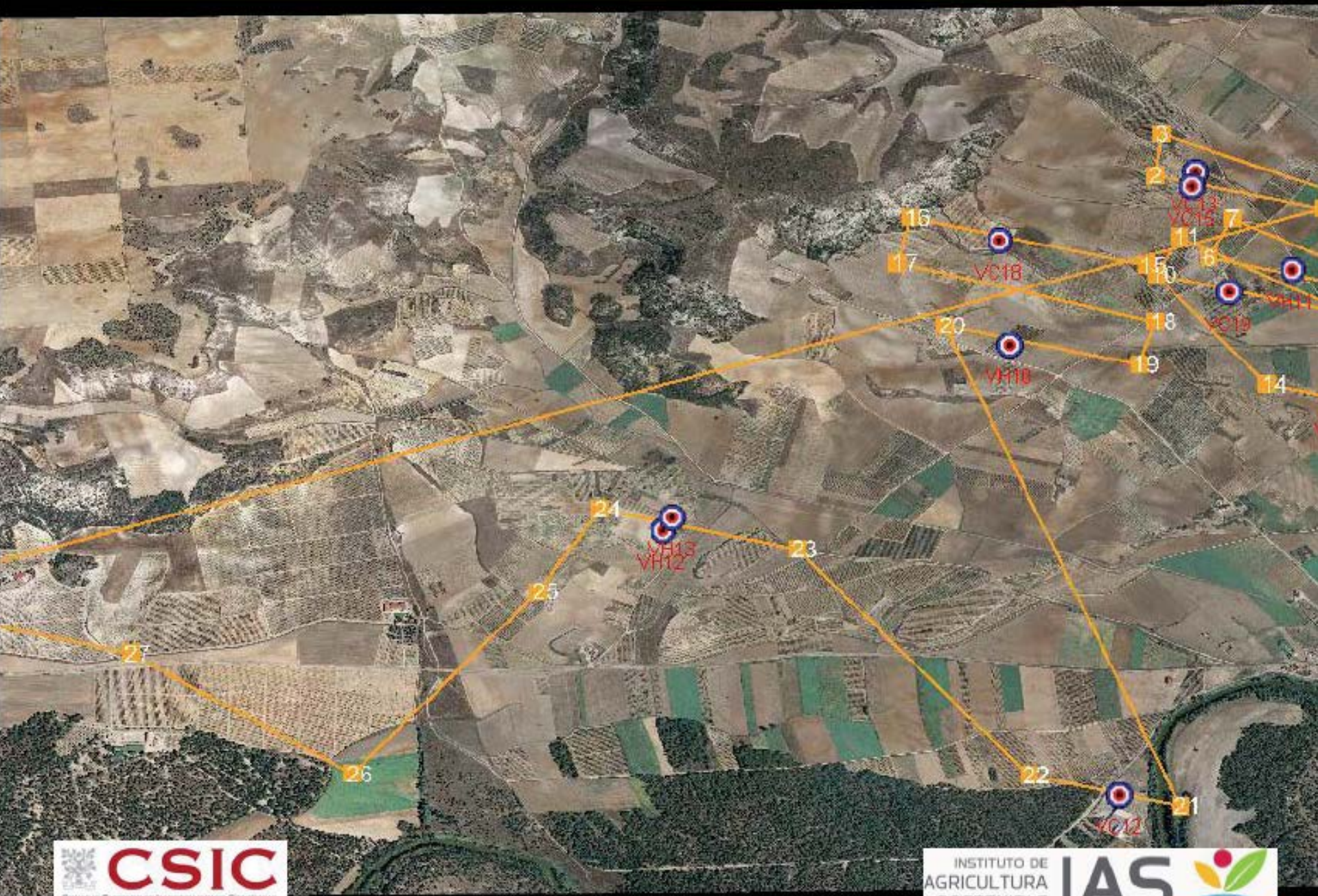


5 m wingspan

13.5 kg TOW

3 kg payload for 1.5 h flight

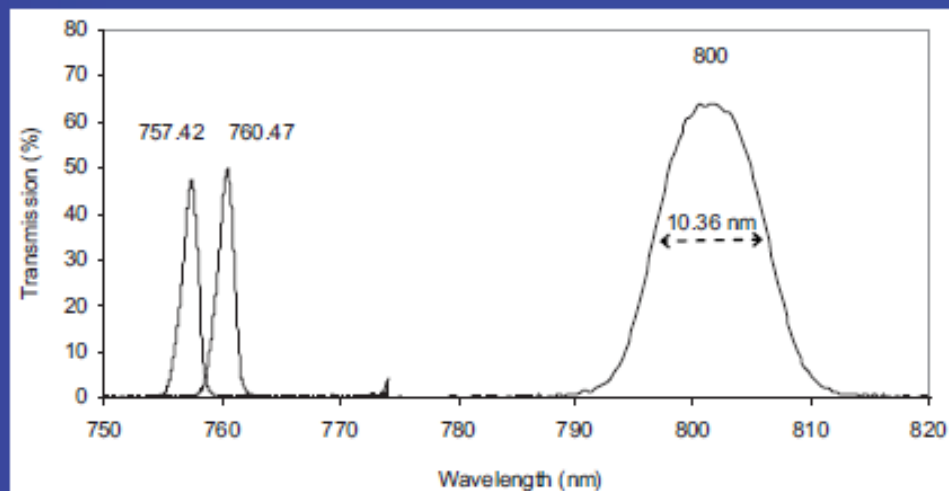
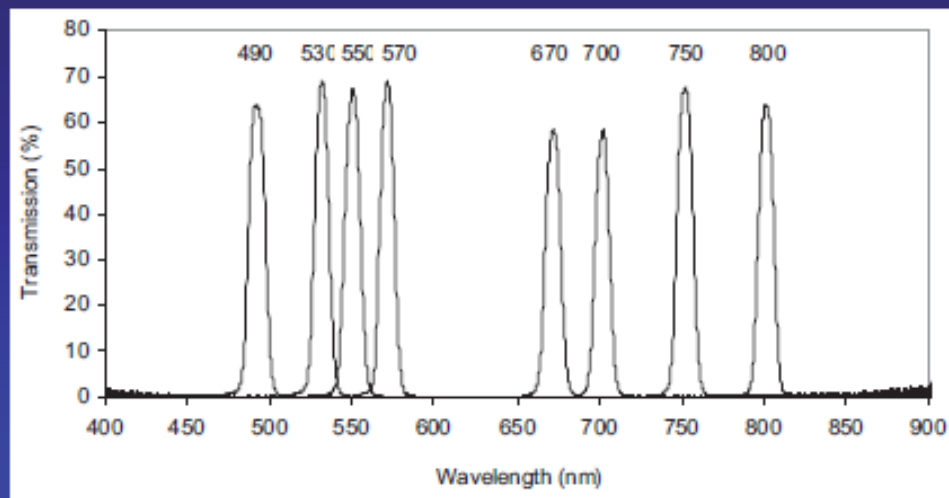
Flight Plan



Cameras for vegetation monitoring

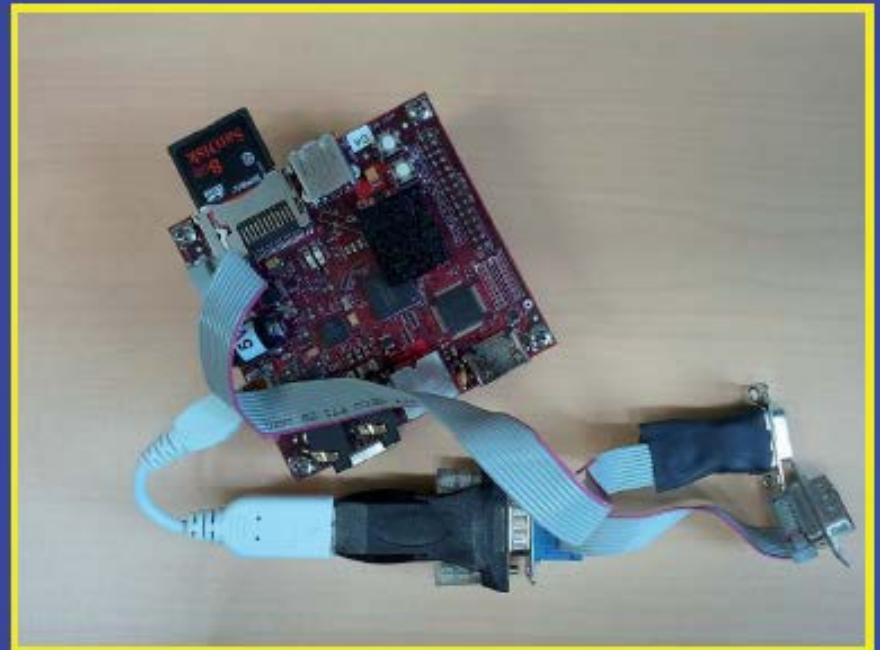
- RGB camera (NDVI work)
 - GOOD but we need multispectral !!!
- Multispectral camera (6 narrow bands FWHM 10 nm)
 - Nutrient stress detection (Cab, Car)
 - Physiological indices (PRI, F)
 - Water stress detection
- Thermal camera
 - Water stress detection / irrigation monitoring
- Hyperspectral imager VIS-NIR (5-7 nm FWHM)
 - All above + developing new indices / methods

Miniaturized multispectral camera (10 nm FWHM, 6 bands, configurable) – 300 gr

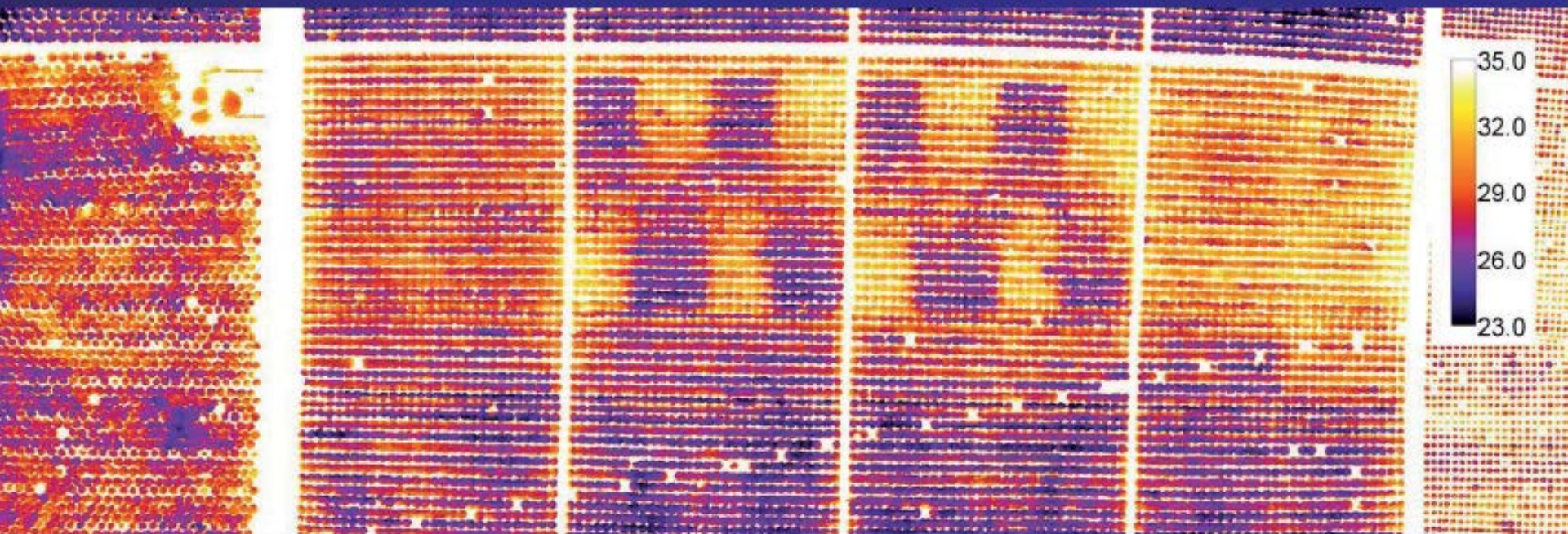


Thermal camera

- Thermal camera
 - ARM® Cortex™-A8 based TI system-on-chip
 - USB2 LVDS data transfer
 - 640 x 480 resolution



Thermal mosaic generation ranging 500-1000 ha per flight



(40 cm resolution)

A micro-hyperspectral imager onboard an UAV

New objective: micro-hyperspectral imager



- An old dream
- Challenging
- 3 kg weight in total
- Reliability / Endurance / Stability
- Large data volumes stored during flight

Hyperspectral Image Orthorectification

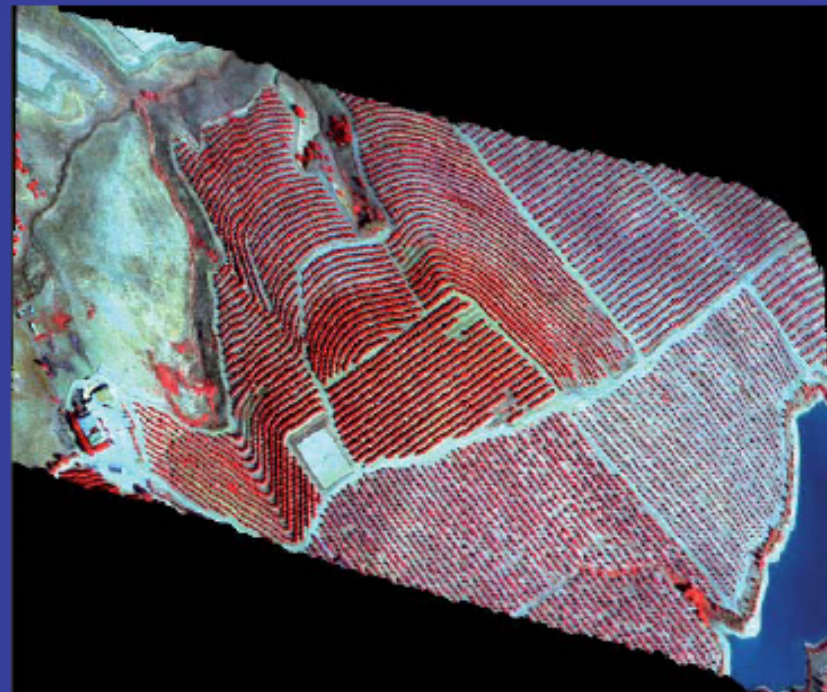
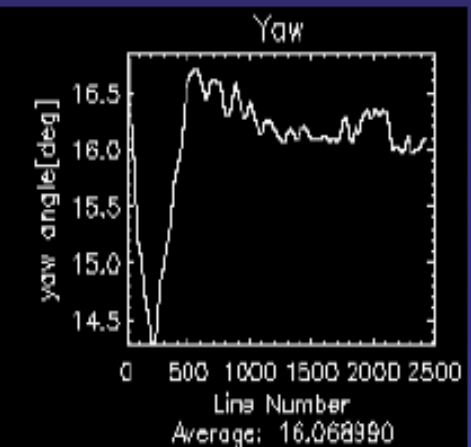
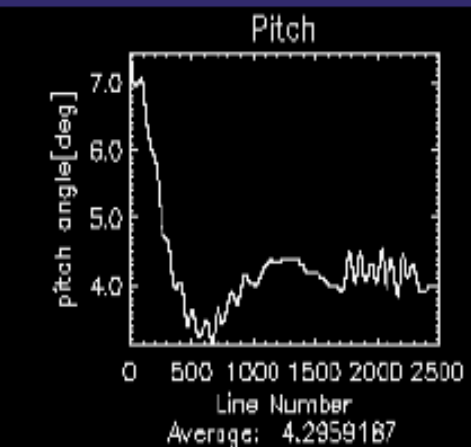
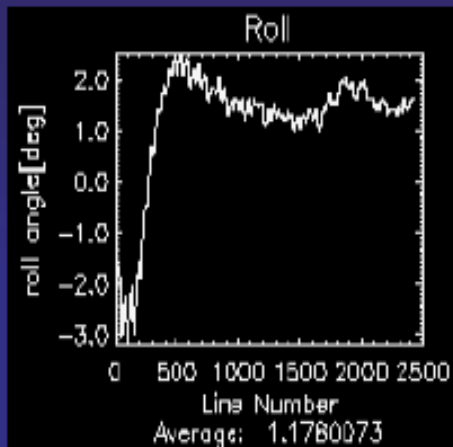
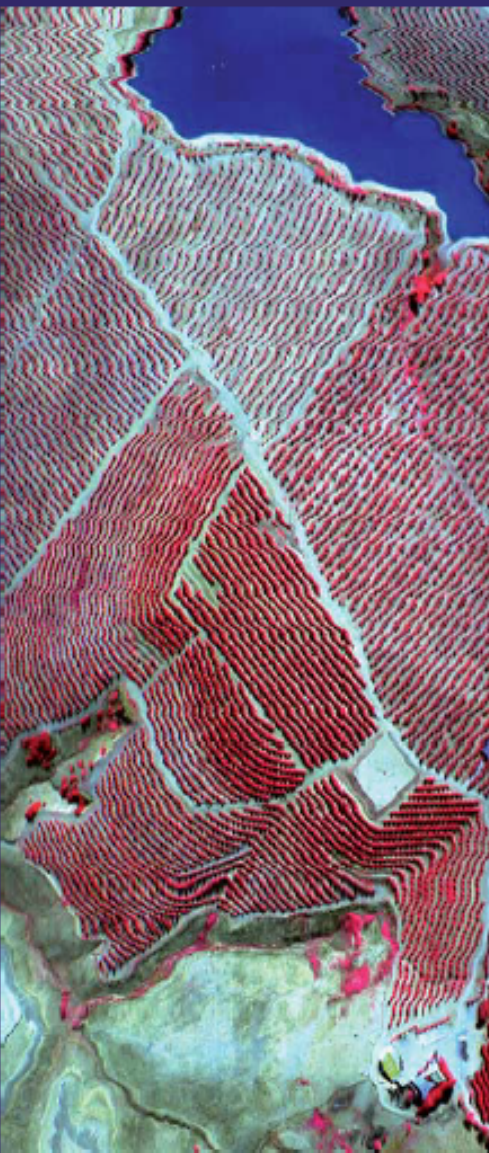
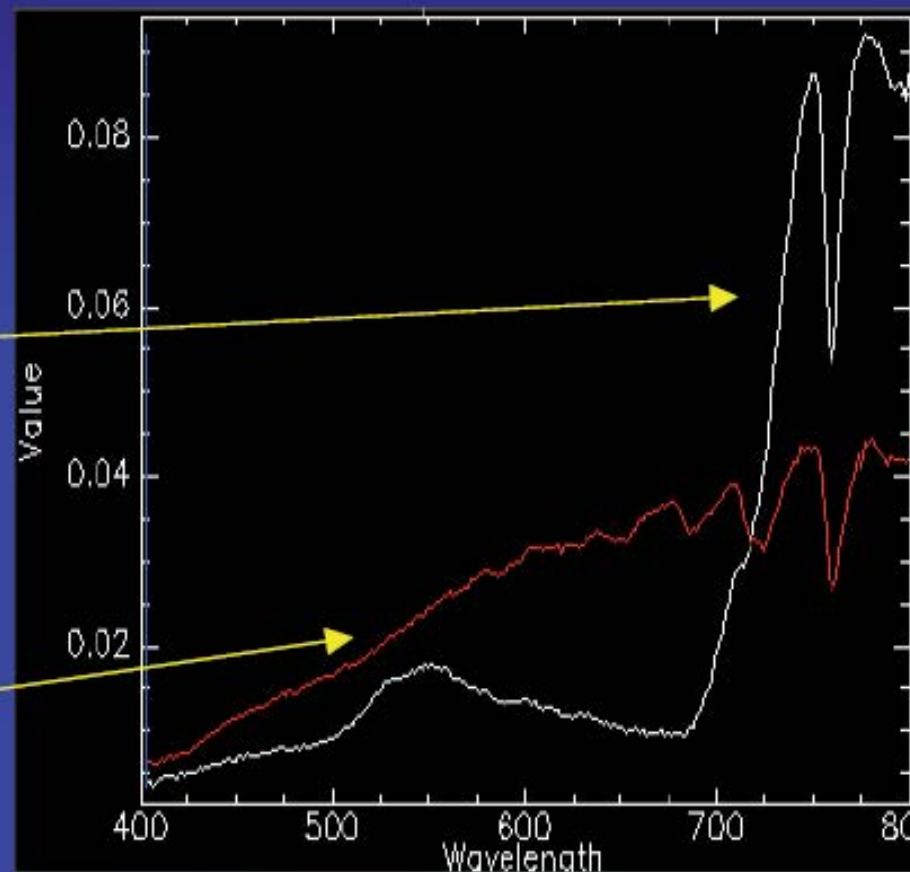
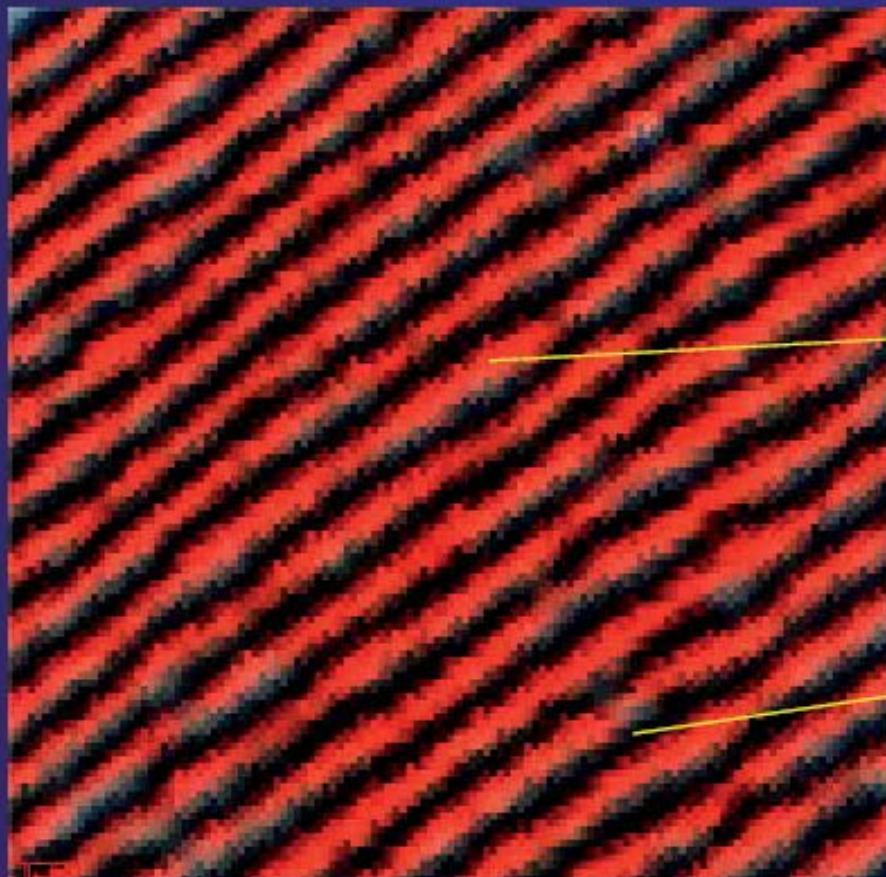


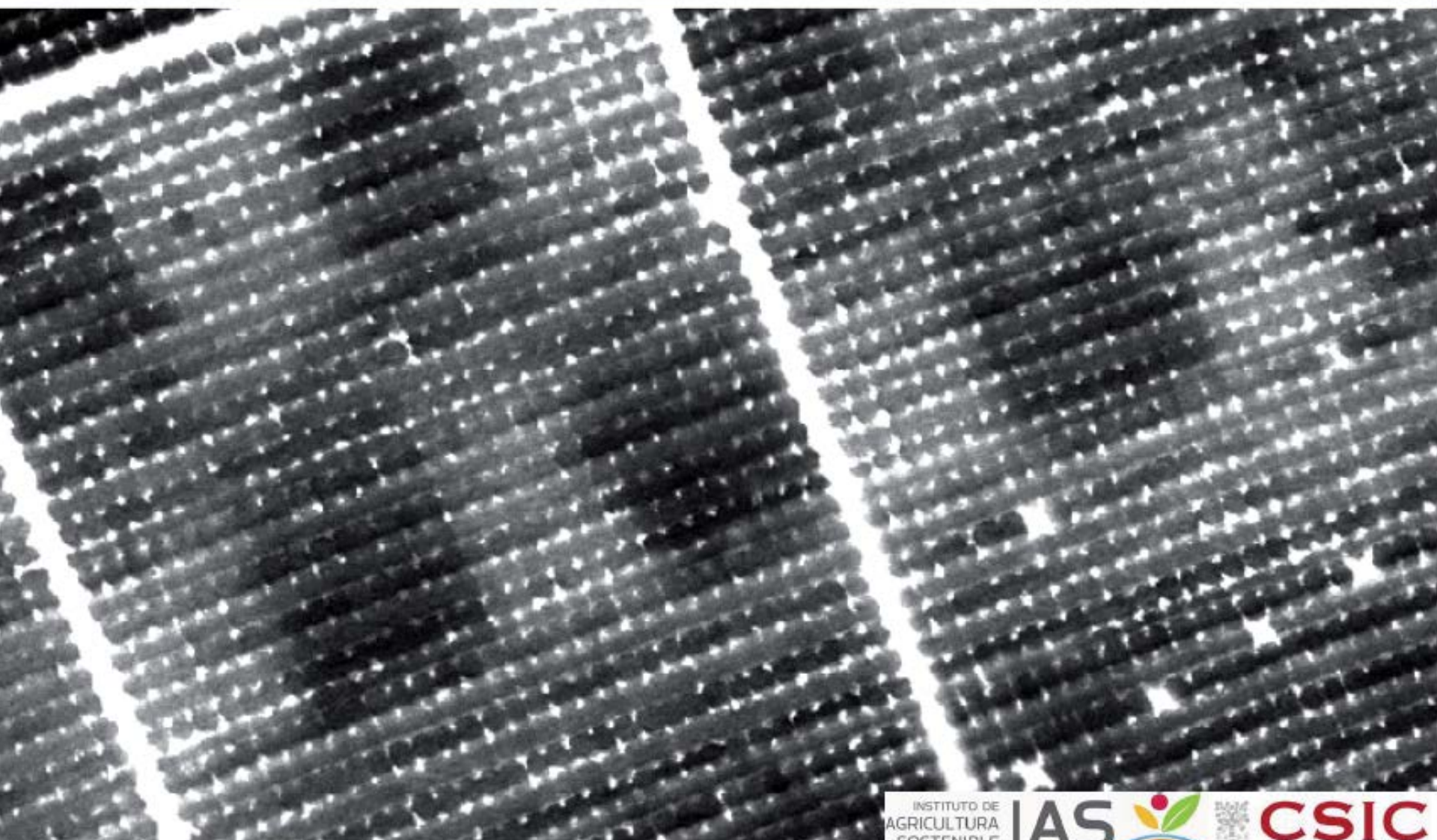
Image orthorectification is conducted using attitude data acquired with an AHRS instrument synchronized with the hyperspectral imager. Commercial software and IAS-CSIC algorithms are applied in the laboratory after each flight campaign.

Vineyard fields imaged

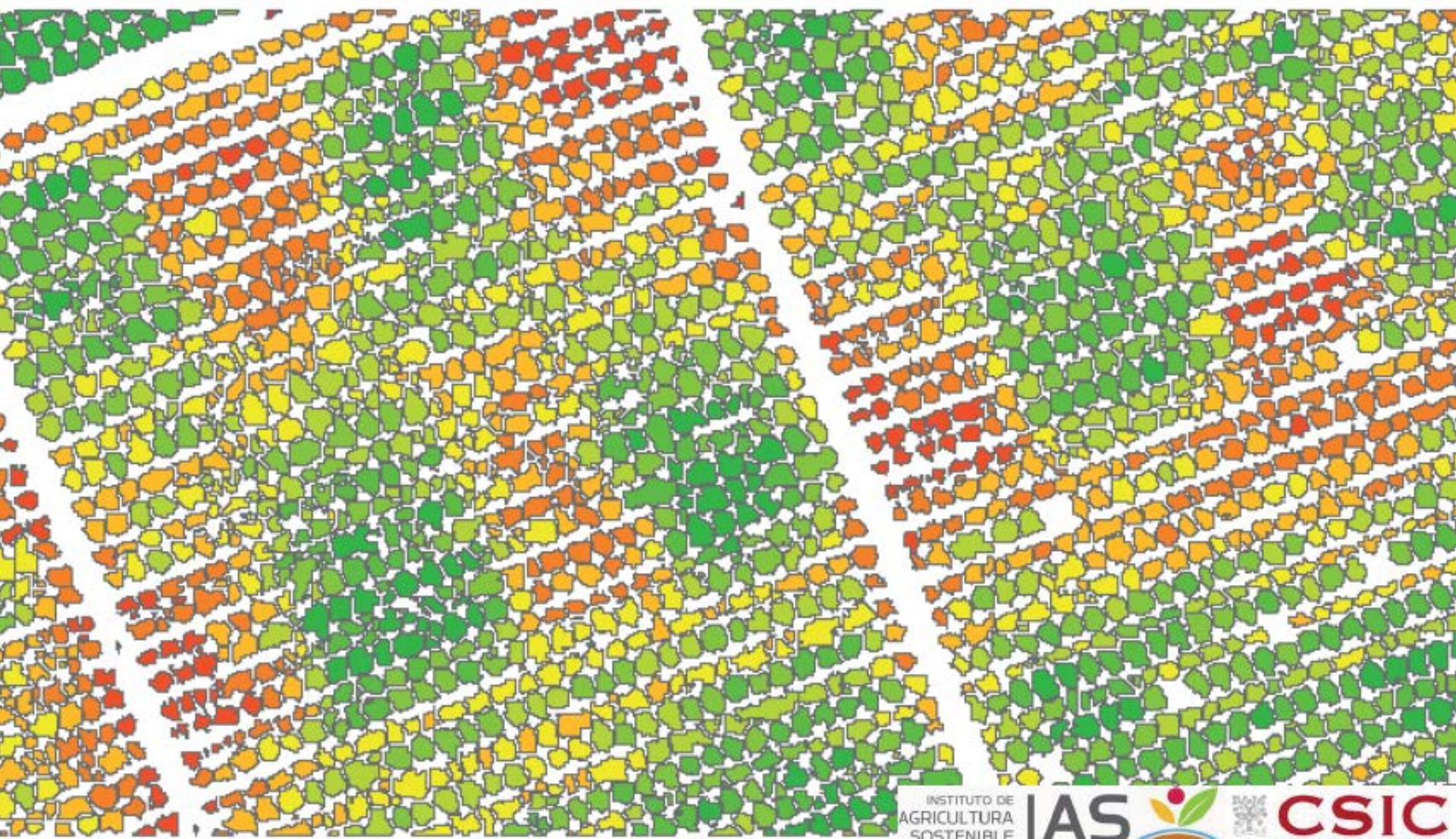
Pure vine vegetation radiance spectra



Automatic tree identification



Automatic tree identification



A quick and simple method for
submitting the products to the
end user after a flight is
conducted

(in 1 day !)

The person in charge of the farm irrigation may / may not
have experience on GIS software tools

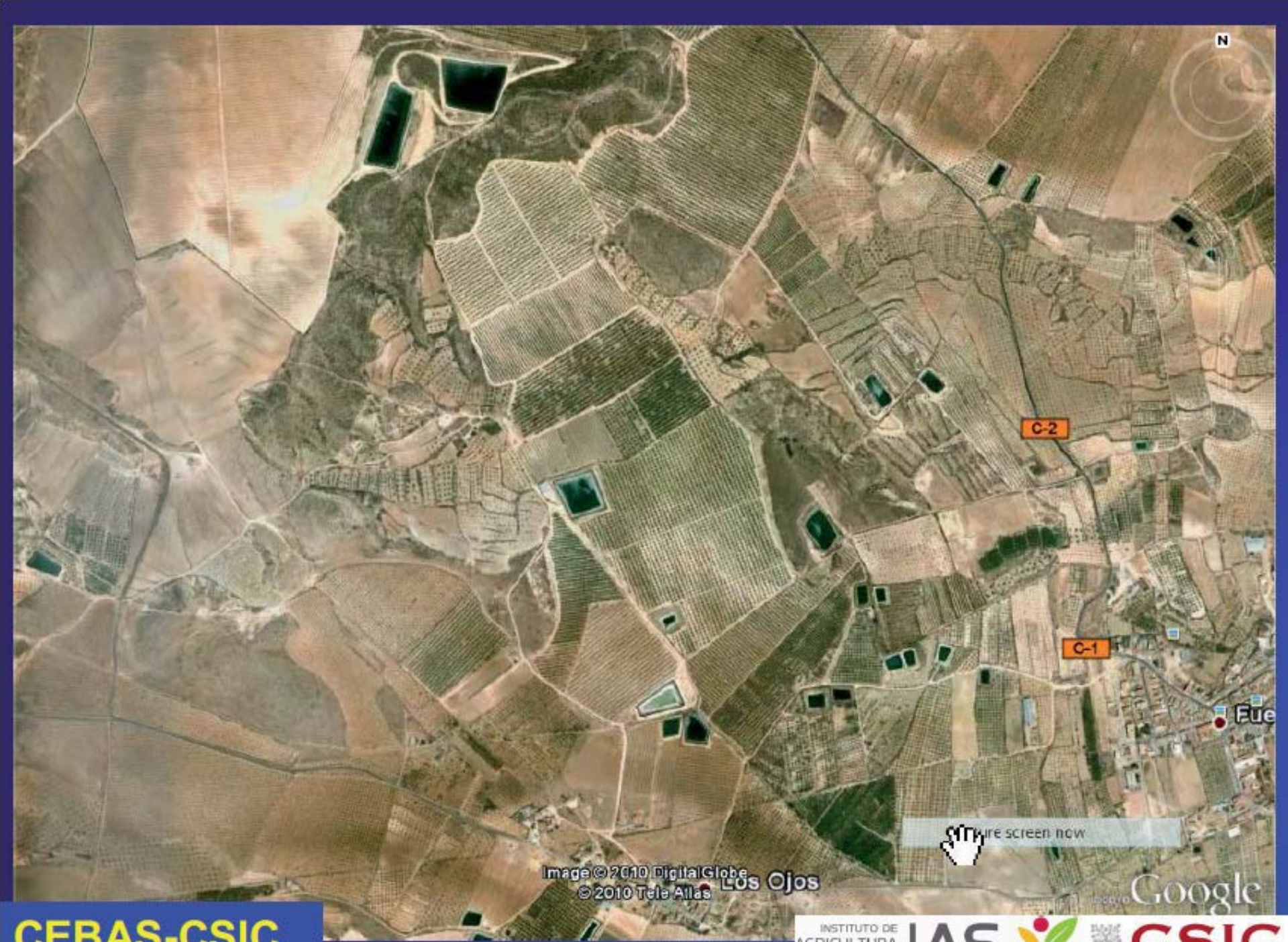


Image © 2010 DigitalGlobe
© 2010 Tele Atlas Los Ojos

Google

CEBAS-CSIC

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Irrigation block level

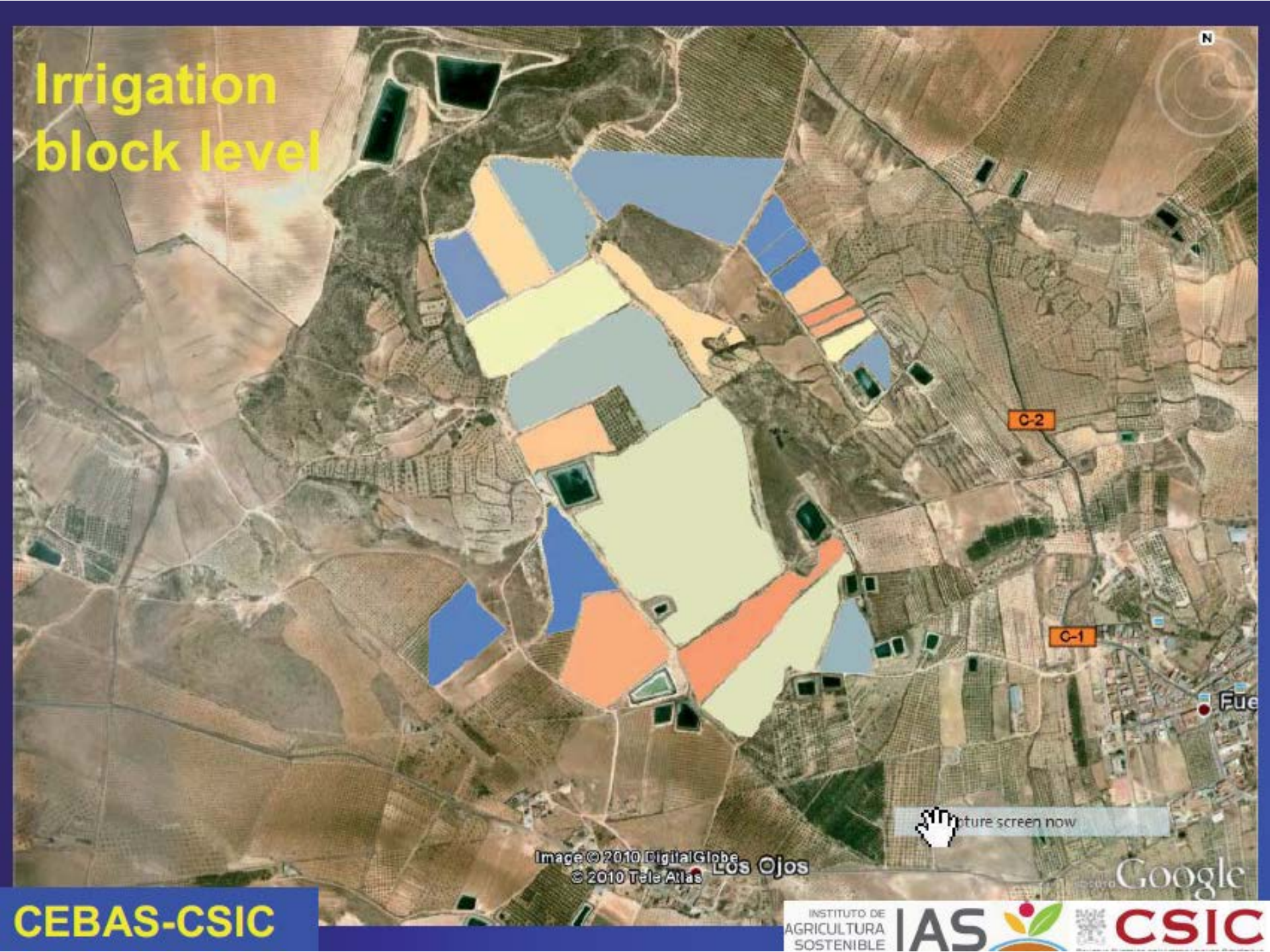
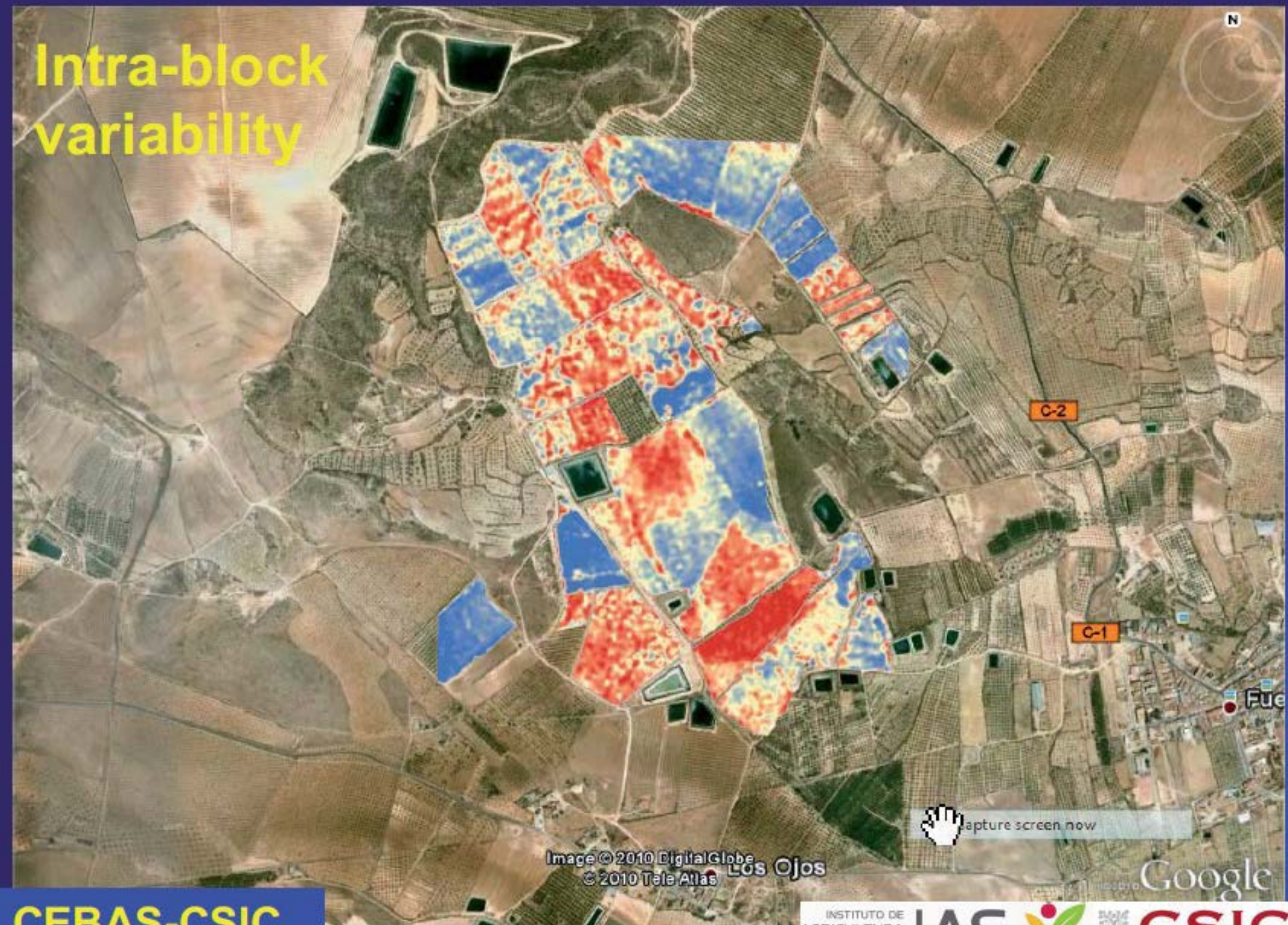


Image © 2010 DigitalGlobe
© 2010 Tele Atlas Los Ojos

Picture screen now

Intra-block variability



Tree Level



Image © 2010 DigitalGlobe
© 2010 Tele Atlas Los Ojos

Google

Tree Level

Pablo on a WS 2013 in Köln:

- 500 ha in one campaign
- 3 days for analyzing data

My assesment:

- $3 \text{ d} * 1000 \text{ €/d} / 500 \text{ ha} = 6 \text{ €/ha}$

Image © 2010 DigitalGlobe
© 2010 Tele Atlas

Los Ojos

capture screen now

Google

Tree Level

Significant economies of scale!

Image © 2010 DigitalGlobe
© 2010 Tele Atlas Los Ojos

capture screen now

Google

Example: Skymaging Spain



SKYMAGING ▾ PRODUCTS ▾ TECHNOLOGY NEWS



SKYMAGING VERY HIGH RESOLUTION IMAGES WITH UAV FOR THE EUROPEAN COMMISSION

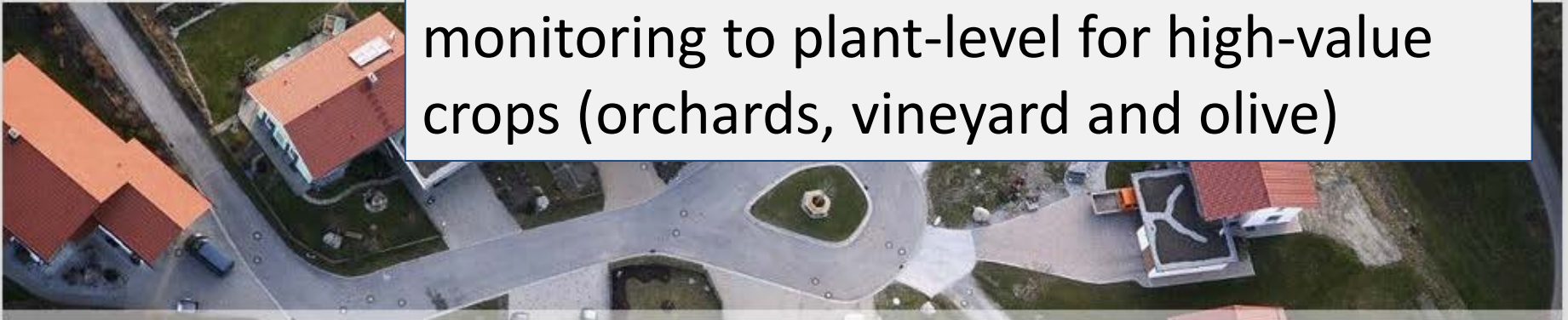
Barcelona, October 11, 2011. The company SKYmaging has been awarded with first tender for Very-high resolution Image acquisition with UAV for Joint Research Center of the European Commission. Tuesday, 11 October 2011 10:35

SKYmaging has accomplished during August the acquisition of very high resolution images with small UAV over two test areas of 1 km² each one, located in Maussane (Southern France). The images has been processed to obtain orthorectified products with the precision required by the Institute for Environment and Sustainability (IES). The goal is to evaluate the feasibility of including images taken by UAV in the methodology for the control of agricultural subsidies in the EU.

IES is one of seven institutes that constitute the Joint Research Centre (JRC) of the European Commission. The mission of the IES is to provide scientific-technical support to the European Union's policies for the protection and sustainable development of the European and global environment. Furthermore, the Action supports development and testing of standardized and sustainable control methods for the effective implementation of Common Agricultural Policy (CAP), across the Union and in Candidate Countries.



Skymaging Agroview: monitoring to plant-level for high-value crops (orchards, vineyard and olive)



AGROVIEW – IMPROVE CROP PRODUCTIVITY



- Detection of water and nutritional stress in crops
- Crop growth
- Detection of pests and diseases (Verticillium, iron chlorosis, mildew)
- Irrigation management
- Quality of wine (IMAD and CIRG rates)



Example: Geo Sense, UAS Application in Malaysia

Utilizing Hyperspectral Imaging System in unmanned aerial vehicle (UAV) for Agricultural/Palm Oil Analysis



Geo Sense Sdn. Bhd.
79A, Jalan Seri Impian 1
Taman Impian Emas
81300 Johor Bahru

T06-03, Jln Centry Square
Block 2320
63000 Cyberjaya



ismaili@geosense.com.my

<http://de.slideshare.net/flixmill/geo-sense-uav-service-unmanned-remote-sensing>

Geo Sense Malaysia

Products & Services



1 Unmanned Aerial Mapping



2 GIS / Web GIS



3 GPS – Geo Tagging Mobile application

Technology Collaboration



UTM
UNIVERSITI TEKNOLOGI MALAYSIA

ISKANDAR MALAYSIA
UTM Research Centre
IMREC



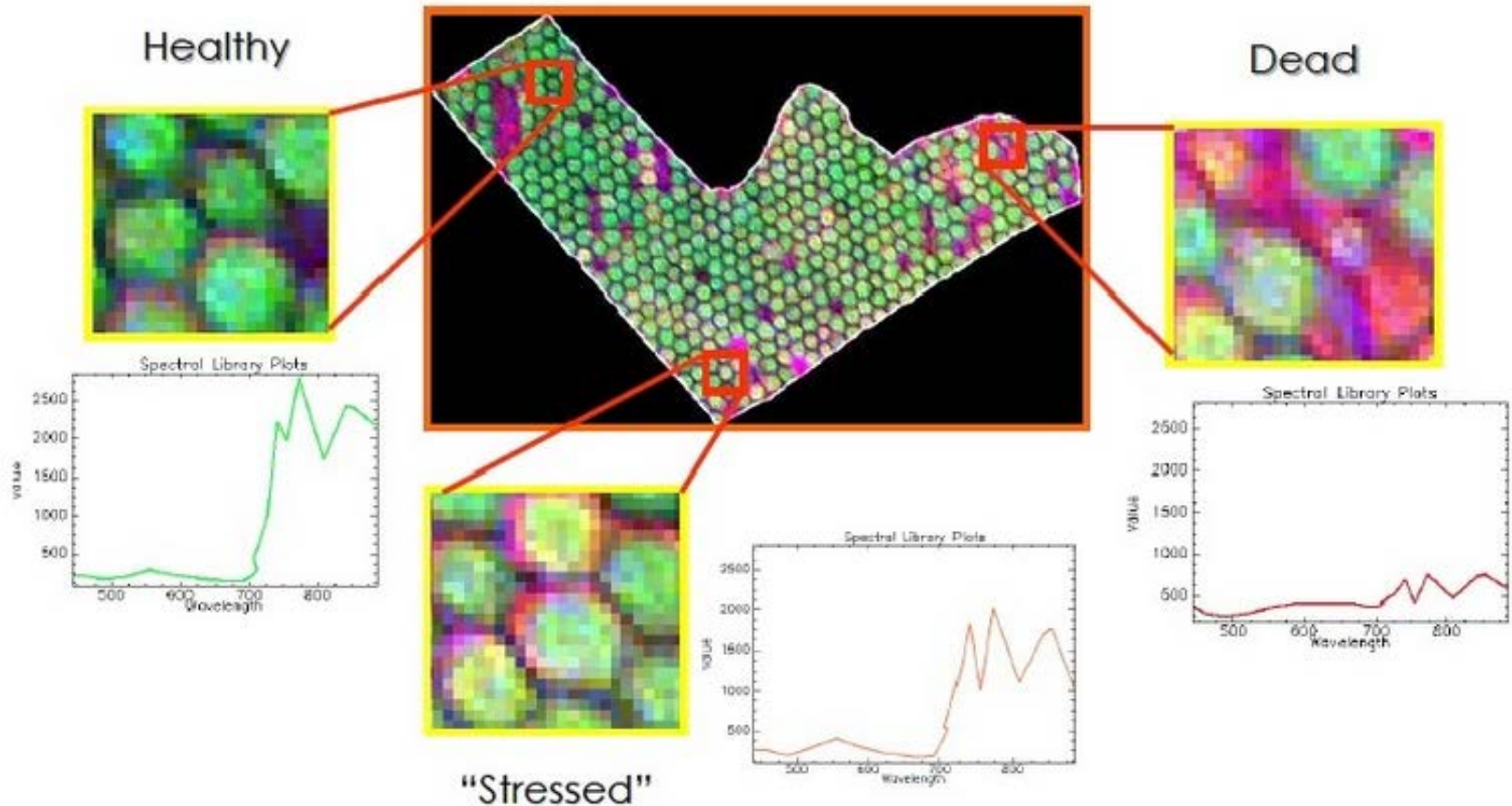
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R&D Proposal

IDENTIFICATION OF SELECTED OIL PALM CHARACTERISTICS USING DEVELOPED SPECTRAL SIGNATURE LIBRARY



Example: UAS for National Mapping and Cadastral Agencies

Institut für Photogrammetrie

ifp

The UAS@LGL BW Project – A NMCA Case Study

Michael Cramer

Norbert Haala, Mathias Rothermel,
Benedikt Leins & Dieter Fritsch

Photogrammetric Week 2013

Universität Stuttgart



The UAS@LGL BW Project – A NMCA Case Study (2013)

Michael Cramer, Stuttgart ; Abstract:

“The flexible use of unmanned aircraft systems (UAS) in geodetic-photogrammetric applications has been demonstrated on several occasions, but mostly in the private sector environment. A proof of the suitability of this technology in the context of national mapping was not available so far - at least in Germany. Therefore, a pilot study of the **Landesamt für Geoinformation und Landentwicklung Baden-Württemberg** - the official mapping agency of Baden-Württemberg - and the Institute of Photogrammetry at University of Stuttgart was initiated to independently estimate the potential of UAS-based photogrammetric data acquisition. [...]”

Presentation: <http://www.ifp.uni-stuttgart.de/phowo/2013/presentations/150Cramer.pdf>

Paper: <http://www.ifp.uni-stuttgart.de/publications/phowo13/150Cramer.pdf>

The UAS@LGL BW Project – A NMCA Case Study (2013)

“NMAs typically work on a national or at least country wide level, where data are captured in regular update intervals. This type of data acquisition cannot be covered by current micro/mini-class UAS. Still, there are quite some scenarios even in national mapping, which are covering smaller areas only and where UAS can be used. Such governmental applications might be in ...”

The UAS@LGL BW Project – A NMCA Case Study (2013)

- cadastre, especially where direct access of land boundaries might not be possible;
- 3D mapping of any smaller area, for example change detection. This might be changes in coast lines or cliffs, for example due to storm events, [...]
- Emergency mapping, i.e. mapping of (local) flooding or after landslides in mountainous areas;
- monitoring, for example regular survey of flood protection devices like river or sea dykes.

Standard-Mapping vs UAS-Mapping?



Are there any UAS-applications in national mapping?

Will UAS-mapping provide sufficient accuracy?



UAS Application Fields for NMAs



Ordnance Survey
Great Britain



Flexible mapping – sea coast/cliffs, high/low water surveys



Kadaster
Netherlands



Verification process of cadastral borders of ownership



IGN
France



Dyke surveys, more general use of UAS (own UAS-camera development)



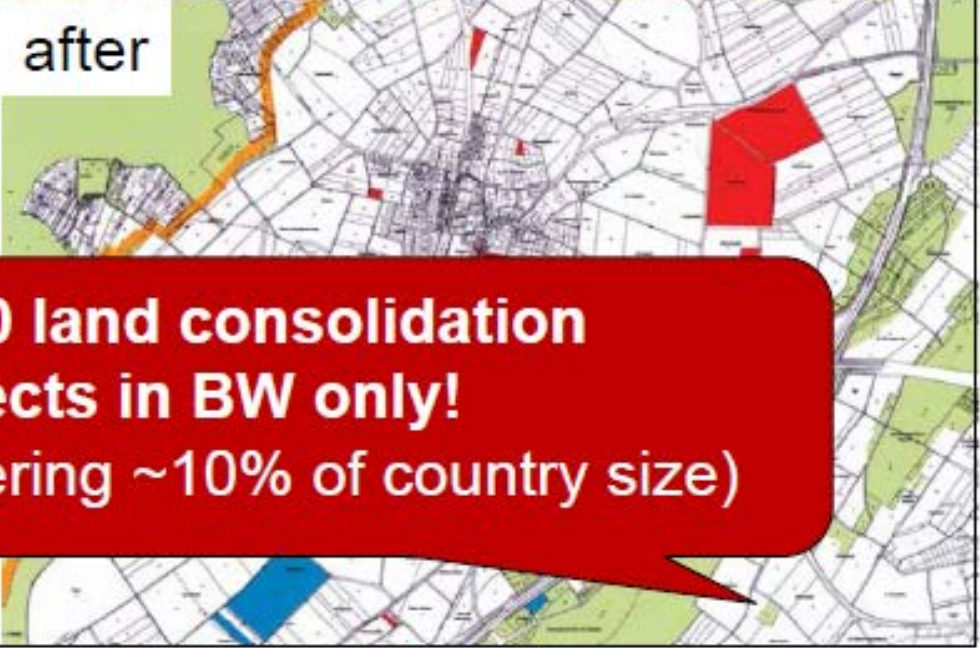
UAS Application Fields for NMAs



LGL Baden-Württemberg
Germany



Land consolidation



> 450 land consolidation projects in BW only!
(covering ~10% of country size)



Results from pilot study UAS@LGL BW

- All requested products had been derived
- Accuracy expectations (over-)fulfilled
- **Flexible & easy data acquisition** (15min flight)
- Frequent flights (**photogrammetry on demand**) possible (in principle)

Use of UAS for NMAs in general

- UAS is of interest and developments are followed by NMAs
- UAS will not replace the traditional large format sensors, but will be advantageous for **local area applications**
- Harmonized flight regulations throughout Europe will be the requirement for further use of UAS in NMAs
- Find appropriate business model?

Institute for Photogrammetry



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Prof. Dr.-Ing. Dieter Fritsch

Institute

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	+49 711 685 83297
	4.309
	email

Head of institute

Prof. Dieter Fritsch is the head of the Institute for Photogrammetry at the Universitaet Stuttgart since 1992. He has served six years as Rector of the Universitaet Stuttgart and is the academic Co-Founder of The German University in Cairo (GUC), Egypt. Prof. Fritsch published three hundred articles on topics of GIS, Photogrammetry, LIDAR and Remote Sensing. He has served on steering committees in both academia and industry and is a much asked for keynote speaker on academic as well as political events. Prof. Fritsch hosts

Direct to:

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News

55. PHOWO

15.09.13

7.-11. Sept. 2015

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Fritsch et al., Deutsche Gesellschaft für Photogrammetrie und Fernerkundung

- **Fritsch, D., Grimm, A., Kremer, J., Rothermel, M. & Wenzel, K. (2013):** Bilddatenerfassung mit eine **Gyrocopter** - Erste Erfahrungen zur "Photogrammetrie nach Bedarf". DGPF Tagungsband 22/2013, Dreiländertagung, Freiburg, 9 S

Summary of Fritsch et al.

„Die Bilddatenerfassung nach Bedarf (Photogrammetry on Demand, PoD) hat sich in jüngster Zeit zu einem spannenden Thema entwickelt, nicht zuletzt durch den Einsatz von Unmanned Aerial Vehicles (UAVs). Obgleich die photogrammetrische Bilddatenerfassung mit UAVs eine Lösungsmöglichkeit für den ad-hoc Bedarf an Orthophotos und Oberflächenmodellen zu sein scheint, sind speziell in Deutschland häufig föderale bürokratische Hürden zur Erlangung der Fluggenehmigung zu überwinden. „

Summary of Fritsch et al.

„[...] Da die Hessigheim-Befliegung im Rahmen eines Pilotprojekts UAV@LGL BW zwischen dem Landesamt für Geoinformation und Landentwicklung (LGL BW) und dem Institut für Photogrammetrie der Universität Stuttgart (ifp) durchgeführt werden konnte, bei dem es in erster Linie um die Erprobung von zwei UAV-Systemen für Zwecke der Landesvermessung ging, war der Gyrocopter-Flug eine ideale Ergänzung.“

Summary of Fritsch et al.

„[...] Um dennoch der Nachfrage nach Produkten der Photogrammetrie zeitnah zu entsprechen, wird in diesem Beitrag ein neues System vorgestellt und in einem Test erprobt. Erste Erfahrungen durch die Auswertungen des Bildflugs Hessigheim, Baden-Württemberg zeigen, dass ein bemanntes Gyrocopter-System einer ‚Photogrammetrie nach Bedarf‘ in idealer Weise entspricht. [...]“

Example: Photogrammetry on Demand with Gyrocopter

₹ 100/-

08 2013 www.geospatialtoday.com | FNI NO.: APENG/2002/7101 | DATE OF PUBLICATION: 03-08-2013

geospatial

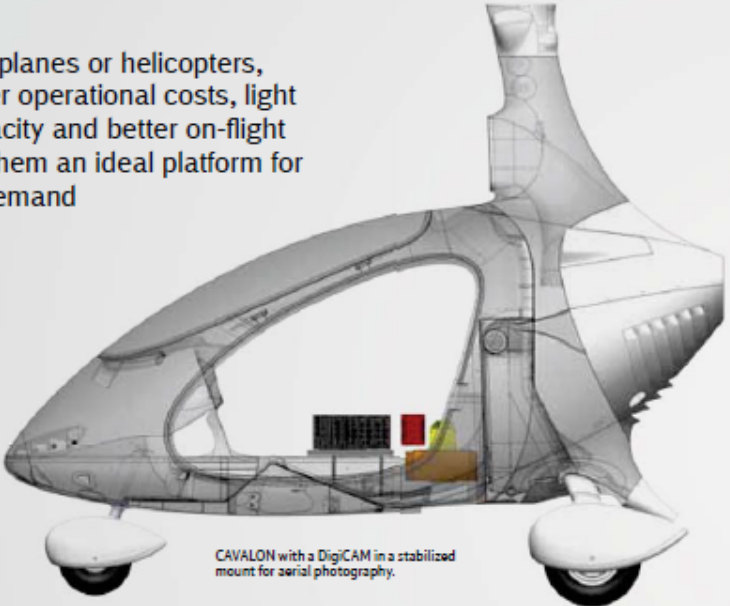
TODAY

POSTAL REGISTRATION NO.: LI/RNP/HD/1125/2013-15

IMAGING

A perfect platform for image acquisition

Compared to small airplanes or helicopters, Gyroplanes have lower operational costs, light weight, high load capacity and better on-flight stability, which make them an ideal platform for photogrammetry on-demand



CAVALON with a DigiCAM in a stabilized mount for aerial photography.

News

Mikro-Mapping-Lösung steigt auf

[mehr...](#)

Flugobjekte kreisten um
"GeoEnergy"

[mehr...](#)

Drohnen-Einsatz für Baummodelle

[mehr...](#)

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Die Alternative zu UAVs

Tragschrauber wurden bereits 1923 erfunden. Aufgrund ihrer Konzeption eignen sie sich besonders gut für die Vermessung aus der Luft, wie die Firma IGI in Pilotprojekten unter Beweis stellen konnte.

Tragschrauber, auch Gyrocopter oder Tragflügler genannt, sind Flugobjekte, bei denen die Rotoren nicht durch einen Motor, sondern automatisch über die Flugbewegung angetrieben werden. Der Motor bewegt lediglich den horizontal angebrachten Propeller, der für die Geschwindigkeit sorgt. Aufgrund dieser konstruktiven Besonderheit sind die Fluggeräte leicht, besitzen dennoch eine hohe Traglast und haben geringere Betriebskosten, verglichen mit Kleinflugzeugen oder Hubschraubern. In den letzten Jahren haben sie im Hobbybereich viele Freunde gefunden. Da sie sehr stabil und ruhig in der Luft liegen, eignen sie sich aber auch ausgezeichnet für die Vermessung kleinerer Gebiete, die speziell in Auftrag gegeben werden können. Dieser sogenannten Bilddatenerfassung On-Demand wird ein großes Zukunftspotential zugeschrieben.

Der Sensor- und Vermessungsspezialist IGI hat daher im letzten Sommer einen Tragschrauber von Auto-Gyro (Modell MTOsport), einem der weltweiten Marktführer für Gyrocopter aus Hildesheim, mit einer Luftbildkamera (DigiCAM-50) ausgerüstet, einer Mittelformatkamera, die IGI speziell für den Bildflug



Einfacher Transport: Per mobilem Hangar werden die Gyrocopter an den Bestimmungsort transportiert.

aerometrics

ASCENDING
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div

GEO SYSTEMS

HEIGHT • TECH
GMBH

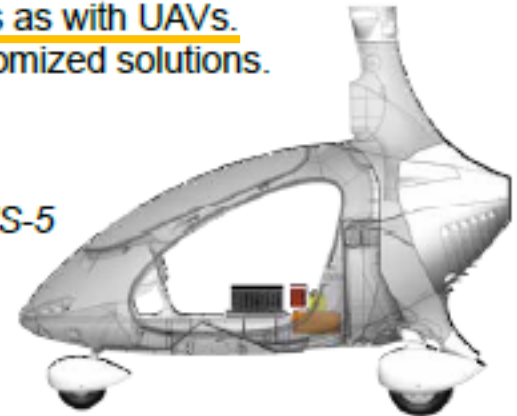
HERZOG
Systemtechnik

CAVALON Aerial Survey

The alternative to UAV. Gyroplanes have been invented in the year 1923. Due to their design, they are particularly good for aerial surveys and there are no regulations as with UAVs. IGI offers three standard configurations. Please contact us for customized solutions.

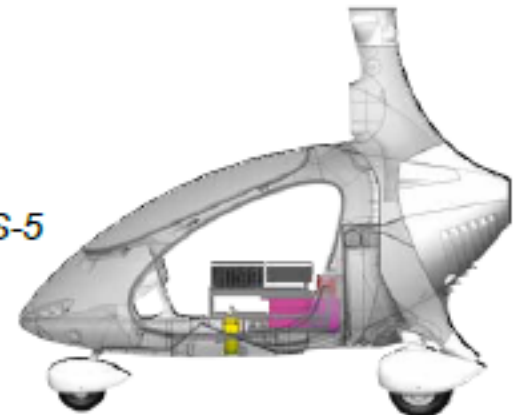
Photo-
grammetry

Guidance & Sensor Management: *CCNS-5*
GNSS/IMU-System: *AEROcontrol*
Digital Camera: *DigiCAM-40/50/60*
Stabilised Mount



Airborne Laser
Scanning

Guidance & Sensor Management: *CCNS-5*
GNSS/IMU-System: *AEROcontrol*
Digital Camera: *DigiCAM-40/50/60*
Airborne Laser Scanner: *LiteMapper*



3D City Modelling

Guidance & Sensor Management: *CCNS-5*
GNSS/IMU-System: *AEROcontrol*
Digital Cameras: *DigiCAM-40/50/60*
(x1 nadir, x4 oblique)



Cavalon Aerial Survey with portable hangar.

www.igi-systems.com

CAVALON Aerial Survey in the airborne laser scanning variant:

AEROcontrol & DigiControl
GNSS/IMU Computers (positioning system) & Data Storage

AEROcontrol IMU
Inertial Measurement Unit



CCNS-5
Guidance &
Sensor Management System



DigiCAM

Airborne Camera System available with 40 to 60 megapixel frame sensor. Both color images (RGB) and color-infrared (CIR) images are available. A wide range of lenses (28 - 300mm) ensures the optimal swath width and altitude for your projects.

LiteMapper

Airborne Laser Scanner System for DSM and DTM generation.



+49 (0)2732 5525-0



info@igi-systems.com



+49 (0)2732 5525-25



www.igi-systems.com

IGI mbH

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57223 Kreuztal
Germany

Example 2: Fraunhofer Application Center at Koblenz Univ. of Appl. Sci. (AMLS)

The screenshot shows the website for the Fraunhofer Application Center (AMLS) at the University of Applied Sciences (FH) Koblenz. The header features the university's logo and name, 'RheinMoselCampus', and navigation links for Home, Sitemap, and FH-Shop. A search bar is located in the top right corner. The main content area displays a news article dated Friday, January 25, 2013, titled 'Fraunhofer-Anwendungszentrum am RheinAhrCampus der Hochschule Koblenz eröffnet'. The article text describes the center's focus on applied research and its affiliation with the Fraunhofer Institute for High-Frequency Physics and Radar Technique (FHR) in Wachtberg. An image shows Prof. Dr. Jens Bongartz presenting the project to an audience. A caption below the image reads 'Prof. Dr. Jens Bongartz stellt das Projekt'. A sidebar on the left contains a menu for 'Info & Services' with various links like 'Beratung', 'Bewerbungsunterlagen', and 'Aktuelles'. A small box in the bottom left corner contains the text 'Press Release 2013-01-25'.

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RheinMoselCampus

RheinMoselCampus

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- » **Aktuelles**
 - Archiv
- » Kinder-Uni
- » Presse- und Öffentlichkeitsarbeit
- » Terminkalender
- » Anreise
- » Freizeit
- » Hochschulsport

Freitag 25.01.13
271 Tage
Fraunhofer-Anwendungszentrum am RheinAhrCampus der Hochschule Koblenz eröffnet

Die Hochschule Koblenz hat sich der praxisorientierten Lehre verschrieben und macht zudem mit bemerkenswerten Aktivitäten im Bereich der angewandten Forschung von sich reden. Nun konnte gemeinsam mit der Fraunhofer-Gesellschaft am Hochschul-Standort Remagen das „Anwendungszentrum für multimodale und luftgestützte Sensorik (AMLS)“ eröffnet werden. Das Fraunhofer-Anwendungszentrum am RheinAhrCampus ist eines der ersten seiner Art in Deutschland und ist als Abteilung an das Fraunhofer-Institut für Hochfrequenzphysik und Radartechnik (FHR) in Wachtberg angebunden.

Ziel der Arbeit des Anwendungszentrums ist es, basierend auf einem Tragschrauber eine fliegende Sensorplattform zu entwickeln, die insbesondere für Fernerkundung in den Bereichen Land- und Forstwirtschaft sowie für zivile Beobachtungs- und Umweltüberwachungsaufgaben eingesetzt werden soll. Der Tragschrauber konnte von der Hochschule im Jahre 2011 im Rahmen eines Großgeräteantrages bei der Deutschen Forschungsgemeinschaft (DFG) angeschafft werden.

Bereits zum 1. November 2012 nahm das AMLS seinen operativen Betrieb auf. Das neu gegründete Anwendungszentrum leitet Prof. Dr. Jens Bongartz, der bis Ende August 2012 das Amt des

Prof. Dr. Jens Bongartz stellt das Projekt

Press Release 2013-01-25

Gyrocopter financed by DFG, 2011



> 80.000 €

Fraunhofer Anwendungszentrum für multimodale und luftgestützte Sensorik (AMLS)

- Fraunhofer Application Center for Multimodal Airborne Sensors
- Founded 2012-11-01
- Fraunhofer-Institut für Hochfrequenzphysik und Radartechnik (FHR), Wachtberg (Bonn) & Hochschule Koblenz, Ahrweiler
- FHR was FGAN before, lead by Bundeswehr (German army)
- Civil applications, e.g. agriculture & forestry

AMLS Example: Environmental Monitoring Project

- Press release 2013-06-20
- Major nature conservation project
- Ahr sub-catchment
- 3300 ha
- Renaturation
- Hyperspectral imaging & high res. photography

http://www.rhein-zeitung.de/region/lokales/bad-neuenahr_artikel,-Kamera-spaecht-von-oben-aufs-Ahrtal-_arid,612412.html

Example OLGA: Observational Light Aircraft for Geophysical Applications



The Bad News

- AutoGyro MTOsport: 55.000,- EUR
- Modifications (transponder, constant speed propeller) 6000,- EUR
- Gyrocopter-Trailer: 4500,- EUR
- Training for gyrocopter license: 8000,- EUR
- Application for radio frequency: 130,- EUR
- Duration: 1500 h – 3000 h
- Official licensing (DULV): 100,- EUR
- Flight Clothing:
 - Helmet: 350,- EUR
 - Overall: 225,- EUR
- A gyrocopter needs about 15 liters of petrol per hour!
- Insurance per year: 4.000,- EUR
- Rent for aircraft hangar per month: 180,- EUR
- Annual inspections have to be done: 340,- EUR

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The Good News: Relatively cheap!

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- **Bad News again: It is a „Luftsportgerät“!**
- **The Bezirksregierung NRW does not like commercial application.**

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Conclusion: Complementary Tools



Summary

- UAS: State of the art
- UAS: Skymaging Spain
- UAS: Geo Sense Malaysia
- UAS: Nat. Mapping and Cadastral Agency BW
- Gyro: WekuFly / IGI
- Gyro: Fraunhofer AMLS
- Gyro: OLGA

Conclusions

- A global hype because of reduced prices
- Many business ideas popping up all over the world
- Basic ideas:
 - Sensors
 - Platforms
 - Services (flight + data hosting + final maps)
 - Continuous or singular operation
- Some survive, some don't. Why?
- Real costs?
- Real regulations?

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Let's discuss!