



Marie Curie Actions  
Human resources and mobility

Sixth Framework Programme

# HYPER-I-NET: European Research Network on Hyperspectral Imaging

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# Outline



1. Introduction
2. Main goals and research methodology
3. Training plans
4. Scientific topics (open Ph.D. positions):
  - a) *Hyperspectral sensor design*
  - b) *Calibration and validation*
  - c) *Advanced hyperspectral data processing*
  - d) *Science applications*
5. Concluding remarks

# Consortium



	Participating institutions:	Scientist in charge:
	University of Extremadura (UEX), <b>SPAIN</b>	Antonio Plaza (coordinator)
	German Remote Sensing Data Center (DLR), <b>GERMANY</b>	Andreas Mueller
	Norwegian Defence Research Establishment (FFI), <b>NORWAY</b>	Torbjorn Skauli
	Institute of Systems Biology and Ecology (ISBE), <b>CZECH REPUBLIC</b>	Zbynek Malenovsky
	Instituto Superior Técnico (IST), <b>PORTUGAL</b>	José Bioucas Dias
	Kayser-Threde GmbH (KT), <b>GERMANY</b>	Stefan Hofer
	Technical Institute of Grenoble (INPG), <b>FRANCE</b>	Jocelyn Chanussot
	Laboratory of Planetology and Geodynamics (CNRS), <b>FRANCE</b>	Veronique Carrere
	Remote Sensing Laboratories, University of Zurich (UZH), <b>SWITZERLAND</b>	Klaus Itten, Jens Nieke
	Spectral Imaging Oy, Ltd. (SPECIM), <b>FINLAND</b>	Timo Hyvarinen
	University of Pavia (UNIPV), <b>ITALY</b>	Paolo Gamba
	University of Iceland (UNIS), <b>ICELAND</b>	Jon Atli Benediktsson
	Norsk Elektro-Optics (NEO), <b>NORWAY</b>	Peter Kaspersen
	Wageningen University (WUR), <b>THE NETHERLANDS</b>	Michael Schaepman
	Warsaw University (WURSEL), <b>POLAND</b>	Bogdan Zagajewski



# Main goals



1. Bridge the *gap* between *sensor design, hyperspectral data processing, and science applications* in remote sensing activities in Europe
2. Develop *standardized and innovative techniques/products* for hyperspectral image analysis
3. Establish standardized *data processing and validation/quality* mechanisms in all the steps of the hyperspectral processing chain
4. Integrate *knowledge from different disciplines* (e.g., sensor design, data processing, scientific applications)
5. Improve the *cooperation and transfer of knowledge (ToK)* from research centres and university groups to SMEs
6. Create a powerful *multidisciplinary synergy*

# Research methodology



1. *Hyperspectral sensor specification.* Investigate the sensor requirements for various applications and develop new sensor specifications
2. *Processing chain definition and implementation.* Develop a well-defined hyperspectral data processing chain including parallel implementation and support to be used as standardized procedure
3. *Calibration, validation and definition of standardization mechanisms.* Calibration/validation of hyperspectral sensors and the result from steps of the processing chain described above
4. *Science applications.* Compiling relevant applications and methods applied using imaging spectrometer data, and creating a product catalogue of both

# Research methodology



## HYPERSPECTRAL SENSOR SPECIFICATION

Investigate the sensor requirements for various applications and develop new sensor specifications

*Coordinator: DLR*

## HYPERSPECTRAL PROCESSING CHAIN

Develop well-defined hyperspectral data processing chains to be used as standardized procedures

*Coordinator: University of Pavia*

## COORDINATION

University of Extremadura

## CALIBRATION AND VALIDATION

Calibration/validation of hyperspectral sensors and the result from steps of the processing chains

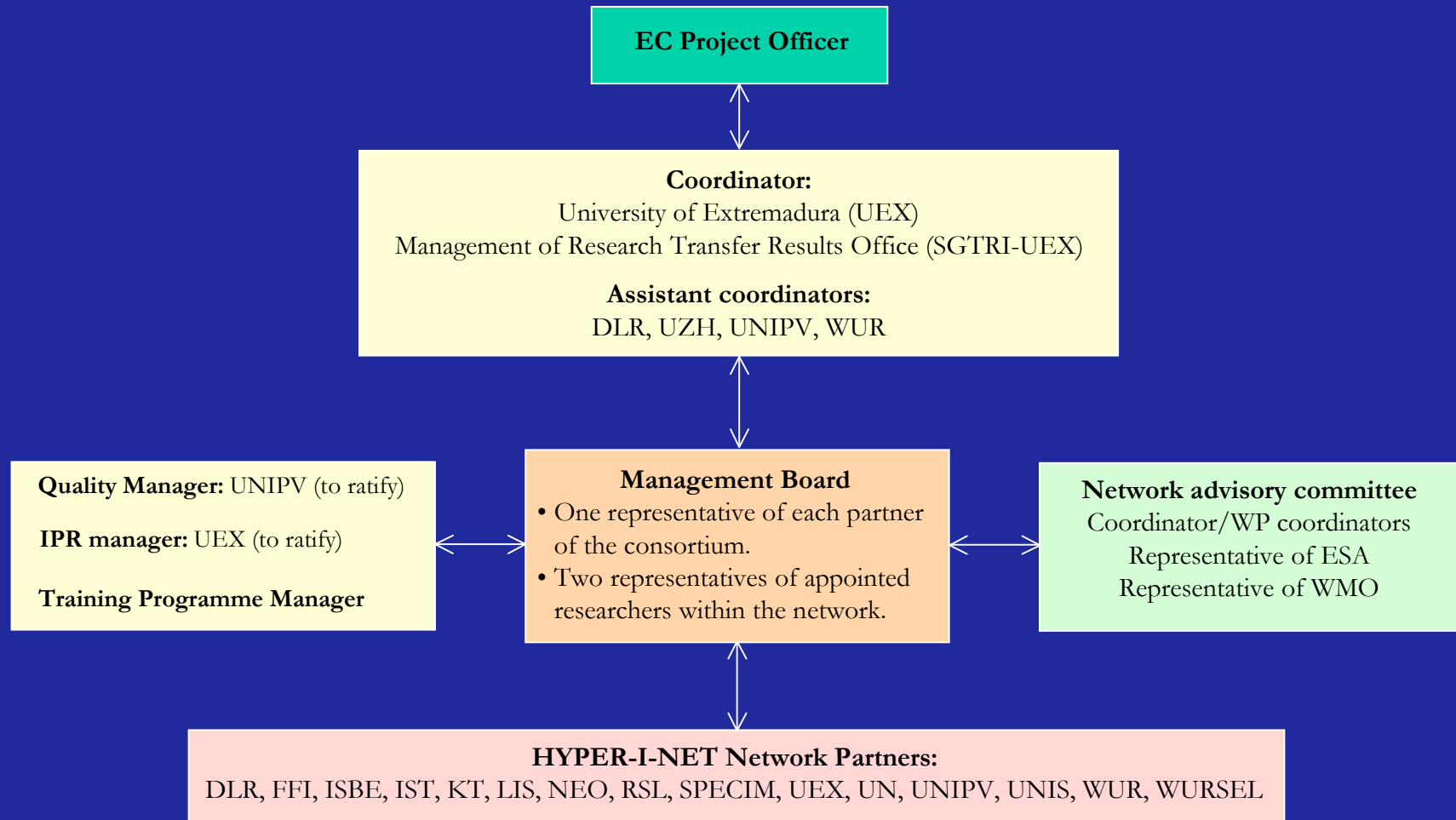
*Coordinator: University of Zurich*

## SCIENCE APPLICATIONS

Explore relevant applications using imaging spectrometer data, and create an application catalog

*Coordinator: Wageningen University*

# Management structure



# Main activities



Description:	Coordinator	Partners involved
Management and coordination	<b>UEX</b>	DLR, UZH, UNIPV, WUR
Hyperspectral imaging survey	<b>DLR</b>	All
Improved hyperspectral sensor design	<b>DLR</b>	FFI, KT, NEO, UZH, SPECIM
Processing chain definition & implementation	<b>UNIPV</b>	All
Calibration and validation	<b>UZH</b>	All
Science applications	<b>WUR</b>	All
Local and network-wide training measures	<b>UEX</b>	All
Network e-learning platform implementation	<b>UNIPV</b>	All
Dissemination of results	<b>WUR</b>	All

# Network-wide training



- *Technical seminars* for the collaboration of PhD students (arranged to coincide with management board progress meetings)
- *Secondment programme* (in accordance with personal career development plans)
- *Summer schools* (four international joint schools)
- *Summer camps* (four summer camps will be held within summer schools and connected to ongoing imaging campaigns)
- *Round-robin calibration experiments* (during summer camps)
- *Occasional short visits* of students to other network partners
- *Mid-term* and *final* network workshops
- *Training courses*

# Training measures



Partner:	Year 1			Year 2				Year 3				Year 4			
UEX	EL	SC	12								12				12
DLR	EL						12				12		SC	12	
FFI	EL						12				12				6
ISBE	EL														12
IST	EL			6			12								6
KT	EL			6							12				12
INPG	EL			6			12				12				
CNRS	EL			6			12				12				
NEO	EL			12			12								
UZH	EL						12		SC	12	12				
SPECIM	EL			6			12								12
UNIPV	EL						12		SC	12	12				
UNIS	EL			6			12				12				
WUR	EL					SC	12	12			12				
WURSEL	EL										12				12

EL E-learning course   
 SC Summer school   
 12 ER months   
 6/12 ESR months

# E-learning courses



Title	Coordinator
Flight planning and operations	DLR
Hyperspectral camera technology	FFI
Retrievals of the ecosystem variables from the remotely sensed hyperspectral data	ISBE
Hyperspectral unmixing: State-of-the-art	IST
Hyperspectral imaging techniques: State of the art approaches and future prospects	KT
Signal processing	INPG
Applications of hyperspectral imaging to geological and coastal environments	CNRS
Calibration and characterization of hyperspectral cameras	NEO
Geographic information technology training	UZH
High-performance hyperspectral computing architectures	UEX
Urban remote sensing	UNIPV
Mathematical morphology	UNIS
Quantitative remote sensing	WUR
Remote sensing of environment	WURSEL

# Available instrumentation



Partner	Equipment that will be used in the context of HYPER-I-NET
<b>UEX</b>	High performance computing infrastructure
<b>DLR</b>	Airborne Reflective Emissive Sensor (ARES), expected to play a significant role
<b>FFI</b>	FieldSpec FR spectroradiometer and different hyperspectral cameras
<b>ISBE</b>	Pushbroom AISA Eagle VNIR hyperspectral sensor, LiCor Li-1800 and ASD spectroradiometers
<b>KT</b>	EnMAP (launch in 2010)
<b>CNRS</b>	ASD FieldSpec Pro spectroradiometer and Nicolet FTIR spectrometer (1.0 to 4.8 microns)
<b>NEO</b>	HySpex hyperspectral cameras, 30 cm diameter radiometrically calibrated integrating sphere
<b>UZH</b>	APEX instrument (expected to enter exploitation phase in 2008) and 9 portable field spectrometer
<b>SPECIM</b>	AISA line of hyperspectral imaging systems (VNIR, SWIR); also imagers for MWIR, LWIR
<b>UEX</b>	Hyperspectral camera, portable spectrophotometer and parallel supercomputing infrastructure
<b>WUR</b>	2 ASD FieldSpec Pro spectroradiometers, access to non-destructive spectroscopy lab
<b>WURSEL</b>	6 field spectrometers plus other instrumentation

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #1	Hyperspectral instrument design	FFI	NEO	U. OSLO



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## Training path:

1. Norsk Elektro Optikk AS (NEO, Oslo, Norway) – 24 months
2. Norwegian Defence Research Establishment (FFI, Oslo, Norway) – 12 Months

## Topics:

- Survey of existing technologies and relative assessment of new sensor concepts
- Detailed **instrument modeling** and quantitative comparison with existing instruments
- Automated **camera calibration**, including design of an **onboard calibration device**
- Modeling of a **novel instrument design**
- Experimental feasibility study of a novel instrument design
- Application-specific instrument optimization

## Contact person:

Dr. Torbjorn Skauli, Norwegian Defence Research Establishment (FFI), E-mail: [torbjorn.skauli@ffi.no](mailto:torbjorn.skauli@ffi.no)

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #2	Improved hyperspectral sensor design	DLR	KT	UZH

## Training path:

1. German Remote Sensing Data Center (DLR, Munich, Germany) – 24 months
2. Kayser-Threde GmbH (KT, Munich, Germany) – 12 Months



## Topics:

- A modular **sensor simulation tool** shall be designed and implemented, comprising the spectral, radiometric, and geometric instrument characterization using a modular software design
- The toolbox shall be flexible to support the **simulation and assessment** of future hyperspectral and multispectral instruments
- **Synthetic scenes** shall be simulated using spectral reflectance/emissivity databases for different applications employing results of radiative transfer calculations available in atmospheric databases
- The toolbox shall be used to support **lab and vicarious calibration** activities

## Contact person:

Dr. Rudolph Richter, German Aerospace Center (DLR), E-mail: [Rudolf.Richter@dlr.de](mailto:Rudolf.Richter@dlr.de)

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #3	Advanced cal/val of hyperspectral instruments	UZH	SPECIM	KT

## Training path:

1. Kayser-Threde GmbH (KT, Munich, Germany) – 6 Months
2. Remote Sensing Laboratories, University of Zurich (UZH, Zurich, Switzerland) – 24 Months
3. Spectral Imaging Oy Ltd. (SPECIM, Oulu, Finland) – 6 Months



## Topics:

- Conducting an **inventory of existing calibration equipment and methodologies**; and performing an inventory of methods and processors for onboard, laboratory and vicarious calibration and assimilation
- Development of **new generation scene-based calibration and assimilation methods and procedures**; and performing inter-calibration experiments of ground equipment (in laboratory, during field campaigns)
- **Testing and validation** of new generation scene-based calibration and assimilation methods

## Contact person:

Dr. Jens Nieke, University of Zurich, E-mail: [nieke@geo.unizh.ch](mailto:nieke@geo.unizh.ch)

**POSITION ALREADY FILLED: Mrs. Petra D'Odorico (Italy)**

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #4	Efficient spectral unmixing algorithms	UEX	IST	-

## Training path:

1. University of Extremadura (UEX, Caceres, Spain) – 18 Months
2. Instituto Superior Técnico (IST, Lisbon, Portugal) – 18 Months



## Topics:

- Different strategies (spectral versus hybrid, i.e., spatial-spectral approaches) will be explored for **endmember extraction** from hyperspectral images
- **Linear and nonlinear spectral mixture models** will also be developed and compared
- Given the extremely high dimensionality of hyperspectral imagery, particular attention will also be given to the **efficient implementation** of developed techniques using parallel computing infrastructure

## Contact person:

Dr. José Bioucas Dias, Instituto Superior Técnico, E-mail: [bioucas@lx.it.pt](mailto:bioucas@lx.it.pt)

**POSITION ALREADY FILLED: Mrs. Valeria Lotito (Italy)**

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #5	Spectro-spatial classification in hyperspectral imagery	UNIS	INPG	FFI

## Training path:

1. Norwegian Defence Research Establishment (FFI, Oslo, Norway) – 6 Months
2. University of Iceland (UNIS, Reykjavik, Iceland) – 24 Months
3. Institut National polytechnique de Grenoble (INPG, Grenoble, France) – 6 Months



## Topics:

- Definition and implementation of **advanced algorithms for classification of hyperspectral data**
- Innovating algorithms incorporating the **spectral information**, which characterizes the physical nature of the materials, and the **spatial information** about the objects (shape description/texture) will be addressed
- Key scientific issues include **feature extraction, dimension reduction and data fusion**

## Contact person:

Dr. Jon Atli Benediktsson, University of Iceland, E-mail: [benedikt@hi.is](mailto:benedikt@hi.is)

**POSITION ALREADY FILLED: Mrs. Yuliya Tarabalka (Ukraine)**

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #6	Vegetation monitoring and advanced processing	UNIPV	WURSEL	-

## Training path:

1. University of Pavia (UNIPV, Pavia, Italy) – 24 Months
2. Warsaw University (WURSEL, Warsaw, Poland) – 12 Months



## Topics:

- **Vegetation monitoring** using hyperspectral airborne/spaceborne data in mountainous and urban areas.
- **Definition and the implementation of a full processing chain** able to start with radiometrically calibrated data and ending with maps of vegetated species and tree status in various environments.
- **Joint spectral and spatial analyses** will be also considered to implement the final mapping chain.
- **Validation and accuracy assessment** of the outputs of the processing chain, by means of both in situ spectral measurements and visual inspection.

## Contact person:

Dr. Paolo Gamba, University of Pavia, [paolo.gamba@unipv.it](mailto:paolo.gamba@unipv.it)

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #7	Source separation in hyperspectral imagery	INPG	UNIS	UEX

## Training path:

1. University of Iceland (UNIS, Reykjavik, Iceland) – 6 Months
2. Institut National polytechnique de Grenoble (INPG, Grenoble, France) – 24 Months
3. University of Extremadura (UEX, Caceres, Spain) – 6 Months



## Topics:

- Definition and implementation of **advanced algorithms for source separation** in hyperspectral imagery
- Perform **endmember extraction** using statistical methods such as the Independent Component Analysis (ICA) or Bayesian approaches
- **Physical considerations modeling the mixture of elements** at the pixel resolution should be incorporated for a better separation (linear or non-linear model?). Different strategies (spectral vs spatial approaches) will be investigated

## Contact person:

Dr. Christian Jutten, GIPSA-Lab, E-mail: [Christian.Jutten@inpg.fr](mailto:Christian.Jutten@inpg.fr)

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #8	Radiative transfer models to bridge scaling gaps in boreal forest	WUR	ISBE	-



## Training path:

1. Wageningen University (WUR, The Netherlands) – 24 Months
2. Academy of Sciences of the Czech Republic (ISBE, Brno, Czech Republic) – 12 Months

## Topics:

- A **model suite** based on radiative transfer theory (PROSPECT, DART, 4SAIL2) will be used in combination with advanced experimental field methods to simulate and validate imaging spectrometer data
- Development of **spatially distributed Boreal forest parameters at regional to larger scales** using refined retrievals defined for sunlit vs. shaded canopy pigment system
- Achieved product will be of outmost relevance for **improved parameter quantification** in Boreal forest ecosystems

## Contact person:

Dr. Jan Clevers, Wageningen University, E-mail: [Jan.clevers@wur.nl](mailto:Jan.clevers@wur.nl)

**POSITION ALREADY FILLED: Mrs. Lucía Yañez (Spain)**

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #9	Extracting information at subpixel level from hyperspectral images	WUR	CNRS	-

## Training path:

1. Institut Planétologie et Géodynamique, University of Nantes (CNRS, France) – 30 Months
2. Instituto Superior Técnico (IST, Lisbon, Portugal) – 6 Months



## Topics:

- Dealing with **complex spectral mixtures**: spatial mixing, a linear optical process, and intimate mixtures, a non linear process
- Establish a hierarchy of the different factors influencing the **observed surface reflectance** at different scales and develop semi-empirical models based on field and laboratory spectral measurements
- Spatial distribution of boulders, rocks, gravels, etc. at the surface as well as their mineralogical composition and degree of alteration analyzed to understand the impact of surface structure on the spectral signature
- Final products relevant for **preparation of future spaceborne hyperspectral missions** such as EnMAP

## Contact person:

Dr. Jan Clevers, Wageningen University, E-mail: [Jan.clevers@wur.nl](mailto:Jan.clevers@wur.nl)

# PhD opportunities



Contract	Title	Promotor #1	Promotor #2	Promotor #3
ESR #10	Advanced Land Surface Applications using Imaging Spectroscopy	WUR	SPECIM	WURSEL

## Training path:

1. Spectral Imaging Oy Ltd. (SPECIM, Oulu, Finland) – 18 Months
2. Warsaw University (WURSEL, Warsaw, Poland) – 12 Months
3. Spectral Imaging Oy Ltd. (SPECIM, Oulu, Finland) – 6 Months



## Topics:

- Integrated retrieval approaches will include the assessment of the atmosphere, the soil and vegetation contributing to the final signal at the sensor
- Use of existing **Soil-Vegetation-Atmosphere-Transfer schemes (SVAT)** will be an integral part
- Use of real time downwelling spectral irradiance data at flight altitude for actual assessment of the condition of the atmosphere will be included
- Based on these schemes products, soil organic carbonate and total columnar water vapor will be generated

## Contact person:

Dr. Jan Clevers, Wageningen University, E-mail: [Jan.clevers@wur.nl](mailto:Jan.clevers@wur.nl)

# Summary



## Distribution of person/months allocated to pre-doctoral students:

Career path #	Contract #1	Contract #2	Contract #3	Contract #4	Contract #5	Contract #6	Contract #7	Contract #8	Contract #9	Contract #10	Others
Path 1			KT	IST	FFI		UNIS		CNRS	SPECIM	
Duration			6	6	6		6		6	6	
Path 2	NEO	DLR	UZH	IST	UNIS	UNIPV	INPG	WUR	CNRS	SPECIM	FFI
Duration	12	12	12	12	12	12	12	12	12	12	12
Path 3	NEO	DLR	UZH	UEX	UNIS	UNIPV	INPG	WUR	CNRS	WURSEL	KT
Duration	12	12	12	12	12	12	12	12	12	12	12
Path 4	FFI	KT	SPECIM	UEX	INPG	WURSEL	UEX	ISBE	IST	SPECIM	
Duration	12	12	6	6	6	12	6	12	6	6	
Total	36	36	36	36	36	36	36	36	36	36	24

## Proposed distribution of person/months allocated to post-doctoral students:

Career path #	Contract #1	Contract #2	Contract #3	Contract #4	Contract #5
Path 1	UEX	DLR	UZH	UNIPV	WUR
Duration	12 (year 1)	12 (year 4)	12 (year 3)	12 (year 3)	12 (year 2)

# Potential applicants



- Nationals of *Member States, Associated Countries, Third Countries.*
- Not nationals of contractor's country (exception: MS/AC nationals who have resided for > 4 years in 3rd country *immediately prior to appointment*)
- Not resided in contractor's country for > 12 months in 3 years prior to appointment.
- Limitation for Third Countries: *up to 30%* of total person-months.

Member States (MS)	Associated Countries (AC)		Third Countries (other than MS and AC)
	Candidate Countries	Non-candidate Countries	
Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom	Turkey and Croatia	Iceland, Israel, Liechtenstein, Norway and Switzerland	Limitation: Up to 30% of total person-months

# Upcoming activities



Month	Milestone	Description	Coordinator
<i>February</i>	<i>M1.1</i>	<i>Network kick-off meeting</i>	<i>WUR, UEX</i>
<i>April</i>	<i>M1.2</i>	<i>Network-quality assurance plan delivered and web site set up</i>	<i>UNIPV</i>
<i>April</i>	<i>M8.1</i>	<i>E-platform documentation available</i>	<i>UNIPV</i>
<i>July</i>	<i>M5.1</i>	<i>Calibration inventory set up</i>	<i>UZH</i>
<i>July</i>	-	<i>Progress meeting (co-located with IGARSS'07)</i>	<i>UEX</i>
<i>October</i>	-	<i>Early-stage researchers (ESRs) recruited</i>	<i>All</i>
<i>October</i>	-	<i>Preparation of campaign plan for data collection</i>	<i>DLR</i>
<i>Oct-Nov</i>	<i>M7.1</i>	<i>Training School to be held in Cáceres, Spain</i>	<i>UEX</i>
<i>December</i>	<i>M4.1</i>	<i>Processing chain definition completed</i>	<i>UNIPV</i>
<i>December</i>	<i>M8.2</i>	<i>E-platform with e-learning courses and materials online</i>	<i>UNIPV</i>
<i>December</i>	-	<i>Audit certificate for first reporting period</i>	<i>All</i>
<i>December</i>	-	<i>Annual activity report</i>	<i>UEX</i>

# Concluding remarks



- There is a need to *overcome fragmentation* in hyperspectral imaging activities across Europe.
- There is a need for *standardized hyperspectral data processing* chains and products.
- With the purpose of addressing the issues above, HYPER-I-NET offers *interdisciplinary training* opportunities to young researchers.
- Four main areas addressed and synergized via consolidated partners: *sensor design, hyperspectral data processing, calibration/validation* and *science applications*.
- Synergies with other hyperspectral-oriented initiatives such as HYRESSA and hyperspectral airborne/satellite developments.

# Links and other info



- Project website
- CORDIS website



First HYPERnet meeting

Madrid, Spain:

Left to right: J. Bioucas (IST), J. C. Calado (FEEL), J. Chouksey (IST), J. C. C. Chanussot (INPG), Z. Marcichovsky (ISDE), M. Schaeplman (WUR), T. Gamba (UNIPV), B. Zagajewski (WURSEL), J. Skauli (FFI), P. Kaspersen (NEO), A. Plaza (UEX), K. Itten (RSL), J. Chouksey (IST), J. C. Calado (FEEL), J. C. Chanussot (INPG), Z. Marcichovsky (ISDE), M. Schaeplman (WUR), T. Gamba (UNIPV), B. Zagajewski (WURSEL)



# HYPERinet



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