SEVENTH FRAMEWORK PROGRAMME

SP4 – Capacities

Combination of CP & CSA

Integrating Activities

FP7 Infrastructures-2012-1.1.13

Project acronym:	**EUFAR2**
Project full title:	**European Facility for Airborne Research in Environmental and Geo-sciences**
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EUFAR2 FP7

WP5 – Expert Working Groups (N4EWG)

D5.1 – Booklet on innovative EUFAR technologies (jointly with N5-TTO)

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4 July 2016

Technology Profiles' Booklet of the EUFAR members' community

TABLE OF CONTENTS

Preface and Summary

Preface

Scientists are keen on doing science. They explore new things, get excited by surprising results, and usually do not consider practical applications. Science is purely driven by curiosity; it is considered part of the culture of the mankind. Scientists enjoy discussing and arguing with their colleagues, and subjecting their results to critical reviews. But after publication of their new findings, they commonly consider their mission accomplished.

This is the old-fashioned point of view, and it is only part of the story!

Nowadays science is becoming more and more commercialised, and this, at least partly, for good reasons. Good science, in particular in observational branches, and even more in the field of airborne research, is to a good degree a matter of available financial resources. Bright brains are everywhere, but the financial means to realise new ideas is limited. In most cases, these funds come from the taxpayer who deserves to know how scientists use this contribution. This has forced scientists to rethink their position in this context. Airborne research is so expensive that writing papers cannot be the conclusive and finite purpose of research. It is more than justified that scientists are being pushed increasingly to produce more than just publications out of taxpayers' funding. However, we would like to stress explicitly that the other extreme, i.e. sell yourself and your work to industry, is equally dangerous. Nevertheless, if scientists have invented new methods and instruments, e.g. in the area of airborne measurements, which can be used for the benefit of the taxpayer and society at large, then the scientists have the obligation not to stop with the publication of their results, but continue to develop their invention further with the aim of its practical application in industry and other branches.

This step between inventing a new idea/ instrument and its application in applied fields is huge and challenging, and this is one of the major reasons why scientists are reluctant to follow this prospect. However, with the restrictions in financial means, scientists have no other choice but to take this step further, even if they are not used to it and are resistant. This is the major challenge we were faced with in working on this deliverable of the project, and to be honest, we greatly underestimated the efforts in achieving our goals in this respect. This is not an apology for being late in delivering this booklet, but it might help to understand the context.

In this respect we are proud to be able to present a catalogue of 11 innovative ideas with some potential to be further developed as industrial applications. In order to achieve this collection, we have designed a template, distributed it in the EUFAR community and beyond, and performed numerous meetings and teleconferences, etc.

The booklet is considered a living document to be completed and revised during the course of the EUFAR2 project. We plan further meetings with EUFAR scientists, and hope that the booklet will constitute a seed for further proposals.

Manfred Wendisch and Florin Paun, July 2016

Summary

EUFAR laboratories allow all industrial players, namely Innovative Small and Medium-Size Enterprises (SME), access to its store of knowledge and test facilities.

Furthermore, the technical innovations and scientific discoveries made by EUFAR scientists that have been conceived primarily for successful airborne research activities, such as atmospheric measures and analysis, can be applied to other sectors as well. A number of leading companies are already aware of this, and have obtained great results by integrating among their services/products the technologies developed within laboratories/research teams of EUFAR partners and members. They have what we call the “Rocket/Aerospace Scientist Reflex”, meaning that whenever a new need arises, they first check to see if the solution is not already available in the EUFAR toolbox!

Our task now is to let Industrial Actors know that we may have just the solution they need, and we are taking a very proactive stance to spread the word, based on a carefully thought-out initiative.

Hereby a short list of Services Tailored for Industrial Partners the EUFAR associated laboratories could provide:

- Design studies,
- Technology developments,
- Technical analyses,
- Software licenses,
- Technology transfer, and
- Testing.

These could be shaped through Flexible Partnerships like:

- Payment when the service is performed,
- Support opportunities through aids to innovation and development,
- Development based on shared risks*,
- Detached engineers-researchers*, and
- Support for technology 'seeding'*

** Only in practice by some of the EUFAR laboratories.*

The following Profiles show some examples of what the EUFAR laboratories could offer to Industrial Players. For further inquiries about a specific knowledge/technology listed below, please contact the EUFAR project coordinator.

Profile 1	Standardised assembly to measure soil reflection under undisturbed conditions in the field
Profile 2	Field detector for assessing soil contamination with total petrol hydrocarbon
Profile 3	Airborne Laser Interferometric Drop Sizer
Profile 4	Optical Parametric Oscillator - Accordable laser source with continuous variable frequency
Profile 5	Surveillance and Observation Radar
Profile 6	Analysis of Atmospheric Icing
Profile 7	Analysis and prevention of the risks of lightning
Profile 8	Diagnosis of electromagnetic compatibility
Profile 9	Cryogenic Technology
Profile 10	Sethi; The new-generation airborne imaging system with radar and optronic sensors
Profile 11	COSI camera system

This booklet is aimed to be dynamically updated by the EUFAR scientists.

1. Standardised assembly to measure soil reflection under undisturbed conditions in the field

Highly standardised technique for field soil spectral acquisition to assure so far unprecedented comparability among many users

Fields of application:

Soil contamination, agricultural survey, soil diagnosis, civil engineering, remote sensing validation, electro-optical companies, asphalt and concrete monitoring

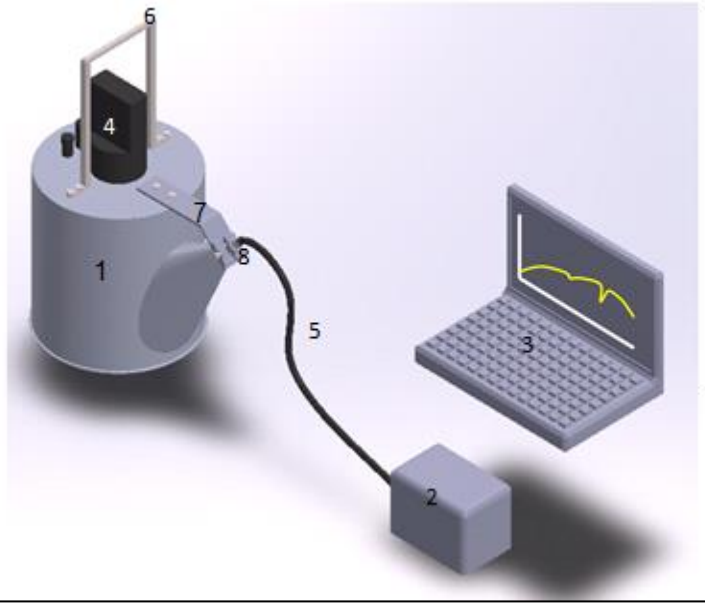
Technical description of invention:

Initial problem: Soil reflectivity measurements in both laboratory and field are obtained by different instruments and users yielding results which are not fully comparable. The suggested method and assembly delivers stable and comparable results that can be shared by a wide user base, and can be compiled to obtain a global reflectivity database. The measurements represent exactly what an airborne sensor would acquire. The new approach avoids collecting soil samples and bringing them into the laboratory for analysis, which unavoidably includes changes of the samples.

The instrument consists of a closed chamber furnished with a tungsten halogen standard lamp, and an internal soil standard, hooked to any field spectrometer by fibre optics with standard connectors. The assembly is furnished also by a laser pointer and CCD imaging detector for soil structure measurements.
It works under all sky conditions and inherent to atmosphere and users variations.

Advantages:

- It works under all sky conditions
- Standardised data products
- Stable under any user
- High power capacity
- Light-weight, easy to apply, cheap, compatible accuracy to high-end spectrometers, stable because easy



1. SoilPro® main body
2. Spectrometer
3. Operating computer
4. Light source
5. Optic fiber
6. Handle
7. Fiber connecting rod's mount
8. Fiber connecting rod

Level of maturity:

Provisional version exists and has been characterized/tested in the field. TRL4 stage.

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Future Partnership:

Field Spectrom

2. Field detector for assessing soil contamination with total petrol hydrocarbon

In situ, rapid (1 Hz) measurements of soil contamination

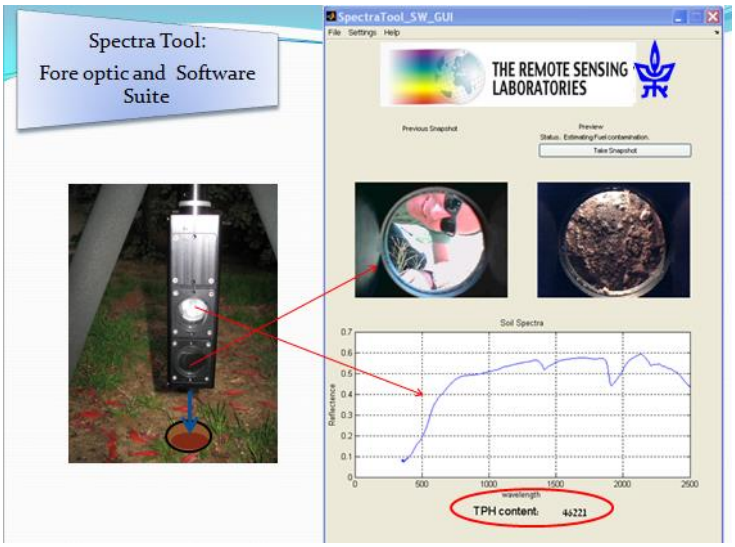
Fields of application:

Environmental monitoring/ inspection, regulation authorities, agriculture activities, civil engineering, oil companies, gas station owners, army.

Technical description of invention:

Samples do not have to be taken to the laboratory. On the way, a sample loses several chemical components, denatures, and takes some time, because the laboratory analysis takes a lot of time and is expensive. Transporting samples may also cause dangers in the lab: Today the most commonly used analytic method for assessing TPH in soil samples is based on the no longer approved Environment Protection Agency (EPA) method 418.1. (use of Trichlorotrifluoroethane (Cl2-FC-CClF).

The idea is to hook to every field spectrometer a fore-optic head that will enable acquiring soil spectroscopy using the endoscopic way (for profile measurements) + CCD camera for soil structure assessment furnished with software to extract TPH concentration from the reflectance measurements.



The possibility to carry out analysis in situ in the field is much more appropriate than the laboratory approach. Using the soil reflectance information mainly focussing on the absorption feature of phenol in 1.72 µm wavelength band.

Advantages:

Saving time, uncontaminated measurement in real time, representing true outdoor conditions, cheap, can be adopted to other soil contamination including physical chemical agronomy soil attributes.

Level of maturity:

Patent is approved. TRL3.

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Future Partnership:

Start-up companies, angels and investors from the petrol industry who are under a lot of pressure to preserve the environment. Testing and measuring laboratories if regulation will become constraining and the traditional TPH extraction method is overpassed.

3. Airborne Laser Interferometric Drop Sizer

Major performance of the invention/technology (for ex.: variation of 3Thz within 1ms)

Airborne spectrometer for spherical and irregular particles characterisation

Fields of application:

Airborne measurements:

- *Droplets size characterisation in the range 20 to 200 µm (other ranges are possible with different tuning or optical modification)*
- *Irregular particles*
- *Icing (mixed phase characterisation)*

Ground applications: Characterisation of multiphase flows

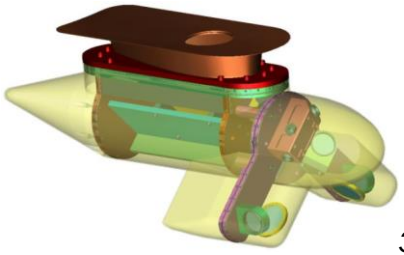
- *R&D for nuclear applications in hostile conditions (sprays, particles)*
- *Industrial applications: Food, spray dryer, Injection oil and gas, perfume, cosmetics, printing machines*
- *Agriculture, pesticide, fertilizer*
- *Purifying liquid*

Technical description of invention:

Interferometric Laser Imaging for Droplet Sizing (ILIDS) is a technique that provides the absolute instantaneous size and spatial distribution of transparent and spherical particles (droplets and bubbles) in a section of a flow.

ALIDS is the first compact instrument in which is implemented the physical principles of ILIDS. This instrument is adpated to hostile environments such as those experienced during of airbone measurements.

An extension of the ILIDS technique has been made to reach the capability to differentiate and characterise the size of droplets and irregular particles.



3D sketch of ALIDS instrument

Advantages:

The ALIDS probe is particularly well adapted to diluted environment such as clouds with droplet size larger than 20 µm (Probe volume ~ 100 cm^3, can be larger).

The probe is not sensitive to the variation of the droplets refractive index in the range of temperature between -40°C and 40°C.

With a very short laser pulse (5 ns) ALIDS is able to measure an instantaneous droplet size field without incidence of particles' velocity (or aircraft velocity in the case of airborne measurements).

The ALIDS optical setup is quite well adapted to industrial constraints or hostile environments (dust, temperature, vibration).

The adjustment of ALIDS instrument is easy and its settings are robust (comparatively to Phase Doppler instrument).

Level of maturity:

ALIDS instrument has performed a successful flight test. TRL is between 5 and 6.

Contact:

Isabelle Guyot (IRSN) –isabelle.guyot@irsn.fr

Christine Canet (Normandie valorisation)

Future Partnership:

Licence undergoing with start-up Atmosphere. Eventual licensing option is open for other domains…

4. Optical Parametric Oscillator - Accordable laser source with continuous variable frequency

Accordable laser source with continuous variable frequency

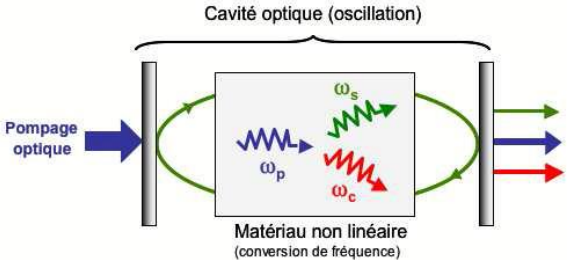
Fields of application:

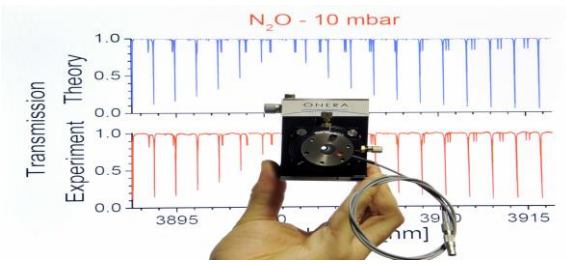
- *Gas or smoke analysis, industrial processes monitoring, reactive flows study (combustion bench deposition reactor, high enthalpy tunnel, ...), monitoring and characterisation of atmosphere composition, air quality, leak or polluting species detection, exhaled air analysis.*

- *Detection of chemical species at low concentrations in the atmosphere: air pollution, leak detection, explosives detection, warning chemical threat. Local or remote measurements (lidar remote sensing).*
- *Encrypting optical communications.*

Technical description of invention:

The patents relate to Optical Parametric Oscillators architectures called ' doubly resonant '. The principle of an OPO is to generate two radiation with frequencies (ωs and ωc) that are tunable from a fixed frequency (ωp) emitted by a laser. The wide spectrum of generated frequencies allows the analysis of 60+ molecules.





Advantages:

The OPO can produce lasers with appropriate frequencies for the targeted applications without being penalised by the limitations known for competing approaches. ONERA is the only actor to be able to develop a system that has:

- the ability to generate a wide range of precise and controlled wavelengths in the infrared;
- an accurate spectral narrowness which provides a very good selectivity;
- a low oscillation threshold allowing the use of highly compact laser (microlaser, laser diode, ...);
- a very simple architecture providing a compact and robust device.

Level of maturity:

TRL4 - Laboratory prototypes can be used for the development of new applications.

Contact:

Nicolas Laurenchet, ONERA, http://www.onera.fr/en/technology-transfer , nicolas.laurenchet@onera.fr

Future Partnership:

Industrial players interested in the development of new products/ applications based OPO
License on-going with Blue Science & Industry for gas analysers inside buildings.

5. Surveillance and Observation Radar

SAR - Synthetic Aperture Radar

Fields of Application:

Environment & Oceanography	• *Pollution detection (ground and sea)* • *Bathymetry and measuring of sea currents* • *Cartography of terrestrial scenes, change detection* • *Ice layers monitoring*
Agronomy & Forestry	• *Vegetation, harvest & forest monitoring from satellite* • *Biomass monitoring*
Defence & Security	• *Target detection, identification & localisation* • *Airborne reconnaissance & surveillance, GMTI (Ground Moving Target Indication)* • *Maritime traffic surveillance* • *Disaster monitoring*

Technical Description of invention/expertise:

Testing

- Remote sensing with polarimetric, interferometric high resolution radar imagery
- A large range of possible host platforms (aircraft, helicopters, UAVs) dedicated to military, civil or dual applications carrying various radars sensors from 400 MHz to 95GHz, with 'X-track' interferometric (3D imaging), 'Along-track' interferometric (ATI) and polarimetric capabilities at high resolution (less than 0.5m).
- Combined use of electro-optical sensors (visible and infrared domains) for richer multi spectral information and a more robust intelligence gathering.

Testing

- Remote sensing with polarimetric, interferometric high resolution radar imagery
- A large range of possible host platforms (aircrafts, helicopters, UAVs)

Expertise

- Multiple data acquisition campaigns and image analysis
- Over 15 years of experience in: HF to EHF sensors development, SAR processing, innovative digitally generated waveforms, design & realisation of integrated system (platforms + sensors + exploitation), image interpretation

SAR Radar Image of a rural & urban area South of France

- *Maroon areas are mainly bare soils.*
- *Green areas are surfaces covered with vegetation.*
- *Blue points indicate the presence of buildings or artificial structures.*

Advantages:

- Largest range of state of the art SAR sensors in Europe.
- Unique combination of advanced hardware technology and signal/image processing.

Level of maturity:

In flight operational. TRL 6 stage.

Contact:

Nicolas Laurenchet, Nicolas.laurenchet@onera.fr, http://www.onera.fr/en/technology-transfer

Future Partnership:

Service companies in the fields of Environment & Oceanography, Agronomy & Forestry. Licence and know-how transfer envisaged. Suppliers to be identified and contracted under common decision…

6. Analysis of Atmospheric Icing

Numerical Predictive Tools for Accurate Analysis of Atmospheric Icing

Fields of Application:

- *Aeronautical, oil & gas exploration and production, infrastructures*
- *Design of bridges, buildings and other structures subjected to potentially high icing weather conditions*

Key Words: *Icing conditions, iced structures, aeronautic accidents, aerodynamics during icing, structure design under icing conditions, aerodynamic degradation*

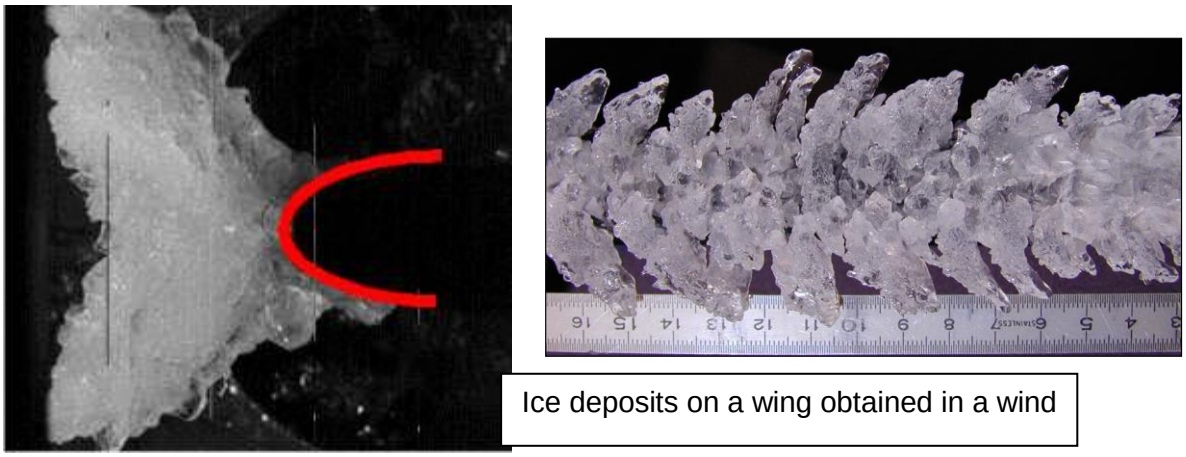
Technology/Competencies Description:

Testing:

- Ability to predict ice deposits on structures in an icy environment. Achieved in order to evaluate the consequences and reduce the number of test trials.
- Wind tunnel icing test design.

Expertise:

- Technical/scientific advice and expertise
- Test, monitor and diagnose risks
- Design of icing resistant devices on structures
- Design of defrosting devices
- Electrical de-icing modelling
- Hot air anti-icing devices modelling



Ice deposits on a wing obtained in a wind

Advantages:

- World leader in the development of icing computer simulation software in collaboration with industrial partners.
- Icing modelling with fully validated physics by icing wind tunnel tests; ice shape prediction.

Level of maturity:

Own homemade top of the art computer software not available for commercial distribution.

State of the art testing devices (envisaged in collaboration with partners).

Contact:

Didier Barberis, ONERA, didier.barberis@onera.fr, http://www.onera.fr/en/technology-transfer

Future Partnership:

On command studies, tests and granted deliverables for any icing issue.

Referenced Customers: Airbus, Dassault, Liebherr, Turbomeca, Paulstra, Snecma…

7. Analysis and prevention of the risks of lightning

Analysis of Lightning Hazard and Design for Damage Prevention

Fields of application:

- *Space*
- *Aeronautical*
- *Electric industry*
- *Telecommunications*
- *Industrial sites protection*

***Keywords**: Atmosphere, Electromagnetic, Compatibility (EMC), Lightning, Lightning protection devices, Thunderstorms*

Technologies/Competencies Description:

Testing

Ability to:

- Develop physical models of original atmospheric discharge.
- Develop models of lightning strike probability.
- Design protection structures (e.g. Launch pad protection).

Achieved by:

- Phenomenon simulated in high tension laboratory (< 30kA) to achieve:
  - Global analysis of lightning strike environment
  - Mechanisms to develop flash
- Prediction adapted to each situation: probability of lightning, aggression level (running, electric fields, etc.).
- Experimentally validated computer codes used.
- Development of databases relative to various types of lightning (artificially started flashes, lightning strikes in flight).
- 3D computer programmes of the start and development of flash on a structure, on an aircraft or on the ground.

Artificially simulated lightning onto a model of the Ariane 5 rocket launch pad.

Expertise

- Technical/Scientific advice and expertise
- Numerical simulation
- Development of computer codes
- Design of solutions

Advantages:

Ability to protect (conceive) structures, in the air or on the ground, from lightning strike damage.

Unique top of the art Onera's property simulation software is not available for commercial distribution.

Level of maturity:

Operational state of the art testing devices (envisaged in collaboration with partners) and simulation tool

Contact:

Didier Barberis, ONERA, didier.barberis@onera.fr, http://www.onera.fr/en/technology-transfer

Future/ Sought-after Partnership:

On request studies and expertise for any related lightning issues

Referenced customers: DGA, Airbus, Dassault, DGAC, British Aerospace, CNES

8. Diagnosis of electromagnetic compatibility

Industrial applications:

Land transport	• *Electromagnetic susceptibility in motor vehicles* • *Electromagnetic topology in vehicle wiring*
Aeronautical	• *Electromagnetic topology in aircraft wiring* • *Measurements of a systems electromagnetic level* • *Electromagnetic data base processing*
Space	• *Electromagnetic simulation of electromagnetic coupling* • *Design of equivalent ground level tests*
Naval	• *Electromagnetic coupling between aerials* • *On board electromagnetic coupling and zoning constraints*
Ordinance	• *Electromagnetic safety related to propellers*

Key Words: *Electromagnetic compatibility (EMC), Electromagnetic topology, Electromagnetic coupling, Wiring, Lightning, HIRF (High Intensity Radiated Fields), Electrostatic discharges*

Technologies/Competencies Description:

Testing

Impedance measurements of: Material surface (Zs), Shielded cables transfer (Zt)

Testing facilities: Anechoic chamber (10 x 7 x 4 m3), Mode Stirred Chamber (4.9 x 3.7 x 3.2 m3), TEM cell, Stripline cell, EMIR Technique

Simulation and Computer codes

- 3D simulation of electromagnetic compatibility on complex systems, taking into consideration structure, wiring and equipment input.
- Time domain modelling: ALICE (FDTD), EIVE (FVTD), GD (Discontinuous Gallerkin)
- Frequency domain: ELSEM3D (Integral Methods), FERMAT (Asymptotic Methods)
- Cable harness modelling: CRIPTE
- High frequency stochastic modelling: RANDOMOP, PWB (Power Balance)

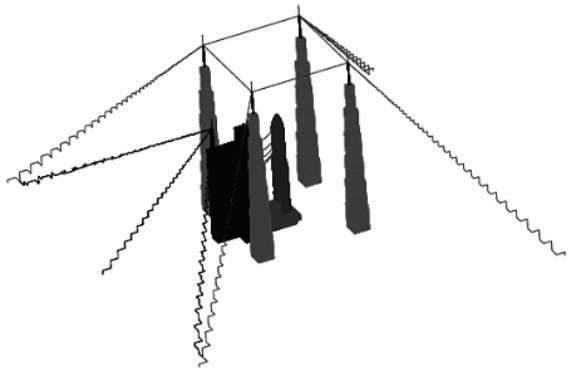
Expertise

- Wiring design and protection
- High level technical advice and expertise in the physics of electromagnetic coupling
- Control, test and diagnose of risks
- Design of lightning protection for structures and industrial sites
- Lectures and training sessions
- Measuring of electromagnetic constraints on large systems

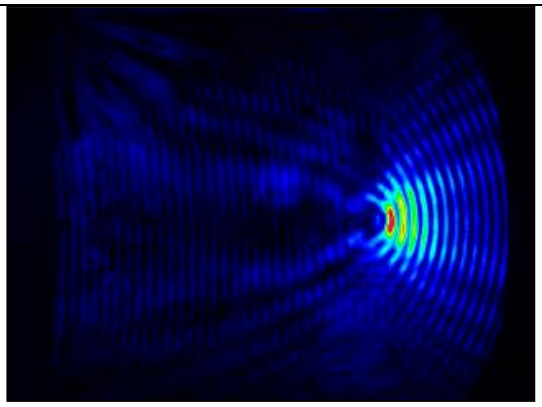
- System level functional electromagnetic compatibility
- System level stochastic electromagnetic compatibility

Advantages:

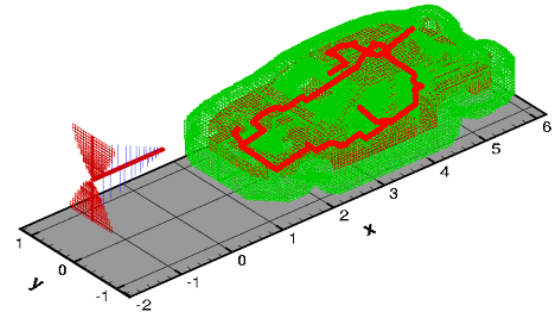
- High level of electromagnetic compatibility expertise at system level and of protection design, made possible by research oriented testing facilities combined with excellent numerical modelling capabilities.
- Various types of electromagnetic threats are considered: lightning, High Intensity Radiated Fields (HIRF), Electrostatic Discharges (ESD), Electromagnetic Interference (EMI)
- ONERA holds a leading position in electromagnetic coupling assessment of complex systems.
- Important electromagnetic compatibility data banks available including hundreds of bibliography references, achievements and tests.



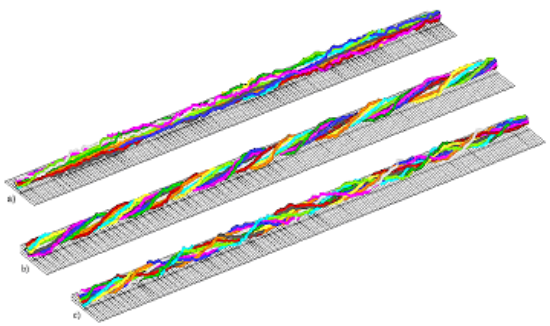
Electromagnetic modelling for lightning protection of the ELA3 launch pad



EMIR technique used to measure the near field radiated by an antenna



DTD/FVTD and wiring model of a car illuminated by a biconical antenna (GEMCAR UE project)



Non-uniform cable models

Level of maturity:

Own homemade top of the art computer various software not available for commercial distribution (excepting CRIPTE distributed by ESI-Group under PAM suit)
State of the art testing devices (envisaged in collaboration with partners)

Technology Transfer Officer contact details of the organisation:

Nicolas Laurenchet, ONERA, nicolas.laurenchet@onera.fr,
http://www.onera.fr/en/technology-transfer

Future Partnership:

On command studies, tests and granted deliverables for any Electro Magnetic Compatibility issues.
Referenced Customers: Renault, Peugeot, ALSTOM, SAGEM, SNECMA, Airbus Innovation Works, DCN, CNES, Airbus helicopters, DASSAULT, IDS…
Licence on-going with EISI-Groupe to distribute commercially CRIPTE on adapted n-1 version of Onera's CRIPTE developments.

9. Cryogenic Technology

Fields of Application:

Aeronautics & Space:

- *behaviour of aerospace structures at high altitude/in space*
- *design of stings, parts and airplanes models for cryogenic wind tunnels*
- *cryogenic tanks/recipients*

Cryogenic Systems:

- *storage of cryogenic fluids, food and chemical industries, energy and health domains*

Transport:

- *transportation of cryogenic fluids (insulation of tanks for boats, lorries and vans,…), cryogenic taps and joints*

Key Words: *Cryogenic tests, tanks, storage, fluids, energy, measurements, space, health, food, chemistry*

Technologies/Competencies Description:

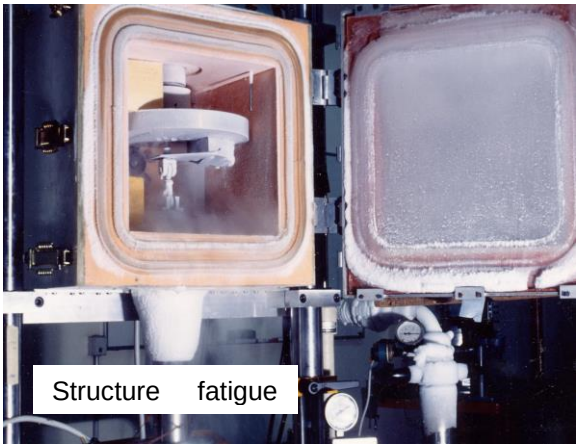
Testing

- Realisation of conventional mechanical tests (tensile, flexure…but also more specific to brittleness, fatigue failure with stress concentration evaluations, realisation of dynamic tests
- Tests of various materials, assemblies (bonded, welded, screwed or bolted joints) and complete parts

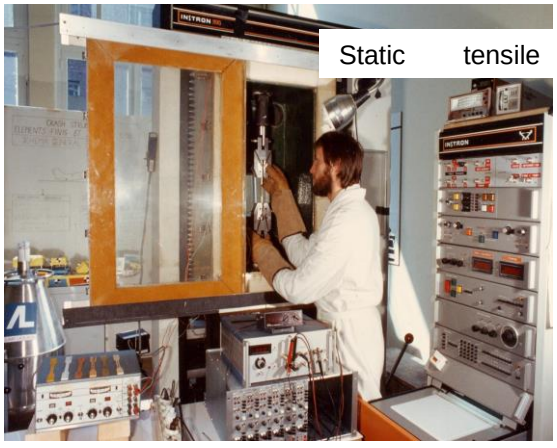
Facilities: tensile static and dynamic machines equipped with cryogenic cabinets and fed by LN2 supplies - specimen instrumented with adapted sensors

Expertise: Over 25 years of experience in:

- The manufacture of tunnel parts and models for cryogenic wind tunnels
- Materials and mechanical parts characterisations for various and numerous customers



Structure fatigue



Static tensile

Advantages:

- Full range of mechanical tests performed on materials and equipment from -196° to 20 °C
- Instrumentation calibration (temperature sensors, strain gages, pressure,…)
- Insulation evaluation at low temperature
- Realisation of very specific and customised tests: friction, roughness,…

Level of maturity:

Operational state of the art testing devices (envisaged in collaboration with partners)

Contact:

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http://www.onera.fr/en/technology-transfer

Future/Searched Partnership:

On request Tests and Expertise for any related Cryogenic issues

Referenced Customers: ETW, Cryospace, SNCF, EDF, Dassault, DCN,

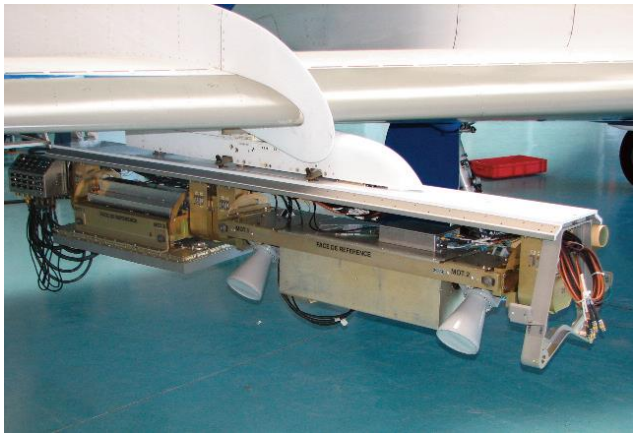
10. Sethi: The new-generation airborne imaging system with radar and optronic sensors

Fields of application:

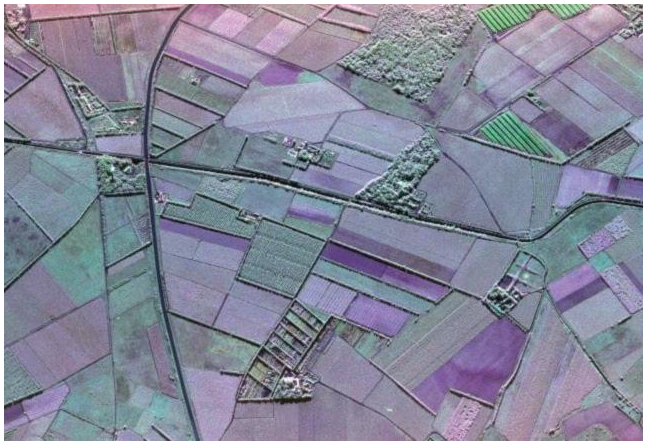
- *Acquisition of high-resolution images over a broad spectrum, from visible to microwave, to provide day/night mapping under any weather conditions.*
- *Classification of objects or environments by IR spectral imagery or radar polarimetry.*
- *Acquisition of 3D images, production of digital terrain models, or detection of changes since the baseline image was taken, using radar interferometry.*
- *Detection of objects hidden by vegetation or even in the ground.*
- *Detection of activity indices using thermal analysis.*

Technical description of invention:

Sethi is a complete imaging system with radar and optronic sensors. A veritable flying laboratory, it comprises two pods that can be fitted with powerful optronic and radar payloads, attached under the wings of a Falcon 20 aircraft. Payload control and data acquisition systems are located in the aircraft cabin, and operated in real time.



Sethi right-hand pod



Radar image

Turnkey data acquisition service: preparation of measurement missions; acquisition of data using ONERA's proven sensors; and pre-processing for the specific application (geometry, radiometry, etc.). ONERA can also contribute its expertise in the analysis of the scene's physical aspects and image analysis.
Validation of prototype sensors, by supporting our customers during instrument qualification, integration on the aircraft, operation and data analysis to evaluate the sensor's performance. ONERA can also help customers define their requirements and design instruments.

Advantages:

Enriched functionality drives synergies between the optronic and radar sensors.

- Modular design, with a configuration adaptable to user requirements.
- Plug & play design for easy use: any new sensor can be fitted without requiring additional development, which means substantial savings for companies that want to qualify or operate their own sensor.

Level of maturity:

Operational. TRL8 stage.

Contact:

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Future Partnership:

Climatologists, agronomists, geologists and biologists to better analyse and understand the operation of ecosystems, whether studying the biosphere, urban and marine environments, or risk management.

11. The COSI camera system

High ground resolution hyperspectral mapper

Fields of application:

The COSI Cam is a complete solution for high resolution hyperspectral mapping from drones. It offers the unique combination of very high spatial and high spectral resolution, thus enabling a whole new range of applications.

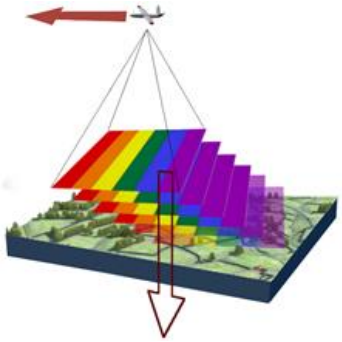
In order to keep up with increasing demand, the agriculture market will have to revolutionise the way it produces food and become much more productive. Demands based on hyperspectral imagery (such as crop supervision, health assessment, soil and field analysis) will allow farmers to take better decisions, increasing yields and saving costs.

Similar usage of high quality hyperspectral imagery also shows huge potential in the infrastructure, mining and environmental monitoring markets. The flexibility of using a compact camera on a drone outperforms in many ways ground measurements, airborne or satellite based solutions.

Technical description of invention:

The COSI-cam can be mounted on a variety of small drones and monitor up to hundreds of hectares in one single flight. The high spatial and high spectral resolution are realised by capturing frames at very high frame rates (up to 100 fps) and image overlap (more than 99%) using a novel hyperspectral imaging chip.

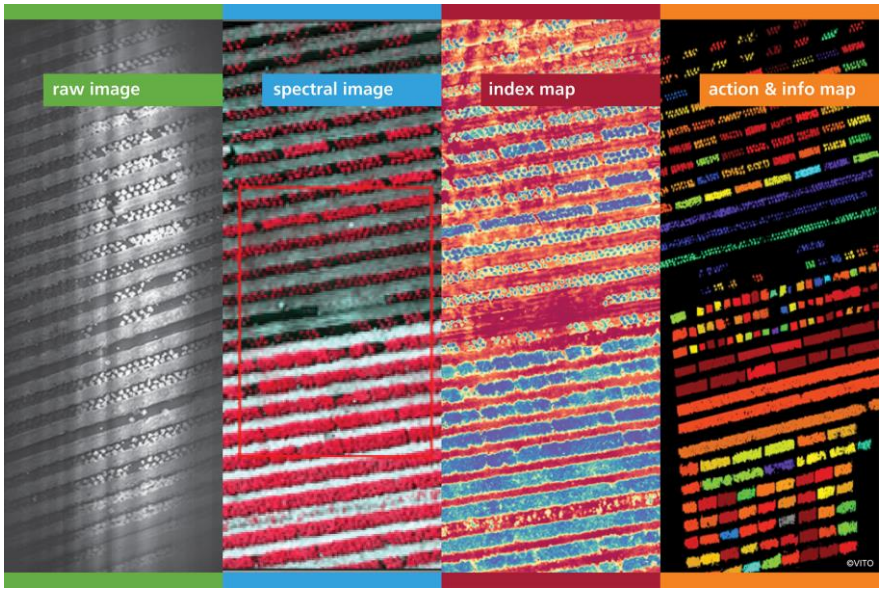
COSI camera mounted on a drone



Imaging concept using a linear variable filter

After flight, the image processing software generates a hyperspectral ground map. To handle the data processing, a cloud based service is provided, offering optimal scalability.

The processing does not stop at the provision of spectral data maps: processing solutions are tailored to each specific application request, allowing the user to gain ready to use action and information maps.



Advanced processing workflow (strawberry field example)

Advantages:

The COSI solution offers a turnkey solution for easy hyperspectral mapping. It will be one of the first high resolution hyperspectral mapping devices put into market suitable for lightweight drones. Also, the cloud service for enhanced data processing and accessibility is seen as a major enabler.

Compared to traditional approaches, such as ground measurements, airborne campaigns or satellite imagery this drone based approach offers an interesting trade-off between costs, the area that can be covered and flexibility of operations. Other hyperspectral camera solutions are often much heavier, more complex and of lesser quality.

Level of maturity:

A patent on the geometric referencing of the hyperspectral imagery has been filed. Also, a broad range of study cases (strawberries, winter wheat, pear orchard) using a prototype version of the COSI camera and processing software were successfully executed. Currently, an FTP server is being used for transferring imagery to the semi-automated processing chain, which runs on VITO's cluster architecture.

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Future Partnership:

Currently, *Cubert* and *VITO Remote Sensing* have come to an agreement to commercialize the system for which the payload mass does not exceed 700g and it will soon (Summer 2016) be included into the Cubert hyperspectral imaging system portfolio, as the first high resolution hyperspectral mapping device.

Other specific licences of the hyperspectral image processing approach could be envisaged (excluding the field of the already granted licence for lightweight airborne payloads) and we are looking for industrial actors searching for other scope applications (e.g. industrial, airborne or satellite based).

12. Conclusion

In conclusion, we have compiled below the major points of this document in the following table:

Profile #	Title	Contact Organisation	Country	Level of Maturity
1	Standardised assembly to measure soil reflection under undisturbed conditions in the field	Oren Calfon	Israel	Provisional version exists and has been characterised/tested in the field. TRL4 stage.
2	Field detector for assessing soil contamination with total petrol hydrocarbon	Oren Calfon	Israel	Patent is approved. TRL3 stage.
3	Airborne Laser Interferometric Drop Sizer	IRSN	France	ALIDS instrument has performed a successful flight test. TRL is between 5 and 6
4	Optical Parametric Oscillator - Accordable laser source with continuous variable frequency	ONERA	France	TRL 4 - Laboratory prototypes can be used for the development of new applications.
5	Surveillance and Observation Radar	ONERA	France	In flight operational. TRL 6 stage.
6	Analysis of Atmospheric Icing	ONERA	France	Own homemade top of the art computer software not available for commercial distribution. State of the art testing devices (envisaged in collaboration with partners).
7	Analysis and prevention of the risks of lightning	ONERA	France	Operational state of the art testing devices (envisaged in collaboration with partners) & simulation tool.

8	Diagnosis of electromagnetic compatibility	ONERA	France	Own homemade top of the art computer various software not available for commercial distribution (excepting CRIPTE distributed by ESI-Group under PAM suit). State of the art testing devices (envisaged in collaboration with partners).
9	Cryogenic Technology	ONERA	France	Operational state of the art testing devices (envisaged in collaboration with partners).
10	Sethi: The new-generation airborne imaging system with radar and optronic sensors	ONERA	France	Operational. TRL 8 stage.
11	The COSI camera system	Cubert and VITO Remote Sensing	Belgium	Patent on the geometric referencing of the hyperspectral imagery has been filed.

The next step is to distribute the booklet within the EUFAR community and, by doing so, stimulate other EUFAR members to join in and send in their promising technologies. We will organise another joint N4EWG/N5TTO meeting before the end of 2016, and revise the booklet thereafter. In this way the final version will be delivered according to the deliverable schedule of EUFAR2.