RECENT MAJOR PUBLICATIONS

(since 2015)

- S. Boscolo, A. Tonello, A. Barthelemy, K. Krupa, V. Kermene, A. Desfarges-Berthelemot, B. Shalaby, S. Turitsyn, and J.-D. Ania-Castañón, "Secret key exchange in ultra-long lasers by radio-frequency spectrum coding", Light: Science & Applications, (2015)

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- P. Darre, R. Baudoin, J.-T. Gomes, N.J. Scott, L. Delage, L. Grossard, J. Sturmann, C. Farrington, F. Reynaud, and T.A. Ten Brummelaar, First On-Sky Fringes with an Up-Conversion Interferometer Tested on a Telescope Array, Physical Review Letters (2016)

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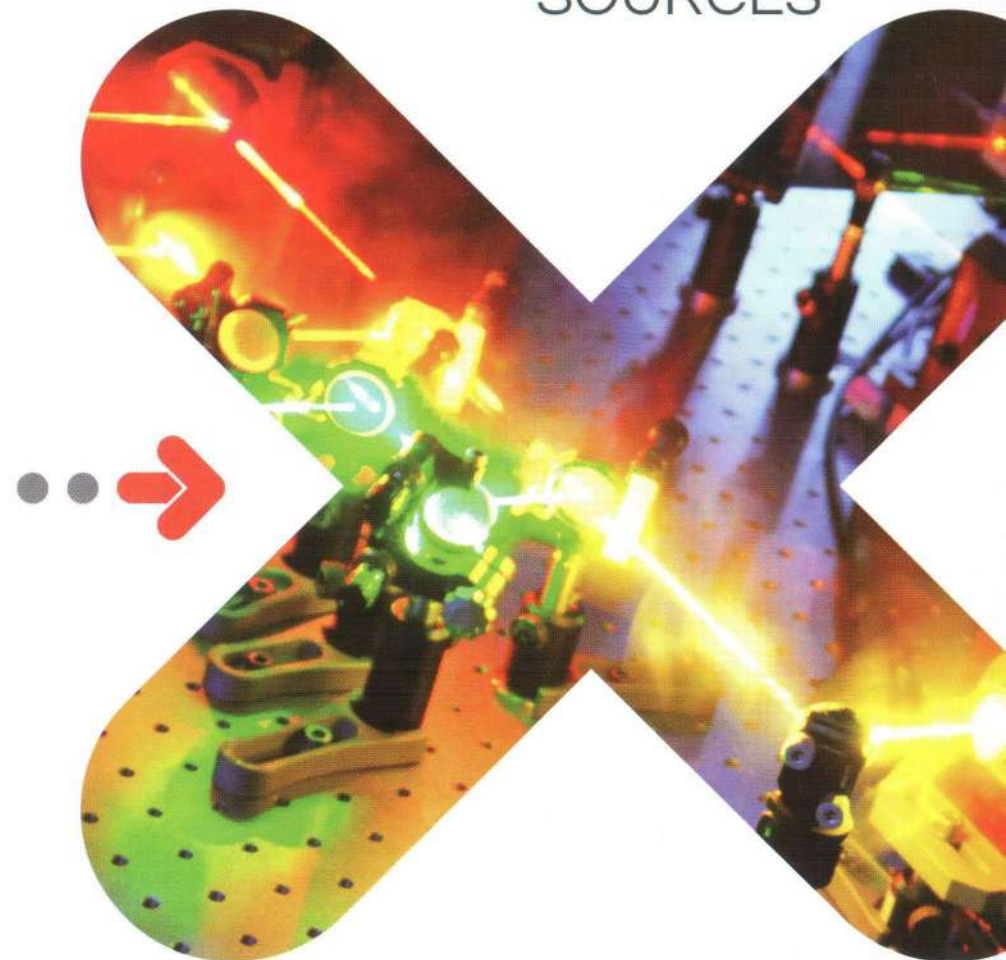
XLIM PHOTONIQUE

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INSTITUT DE RECHERCHE

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UMR 7252

FIBRE PHOTONICS & COHERENT SOURCES

Université de Limoges

Cnrs

Université de Poitiers

CERTIFIÉE ISO 14001

FIBRE PHOTONICS AND COHERENT SOURCES

The skills of the research group include coherent and nonlinear optics, lasers, fibre optics, ultrafast optics, quantum and atom optics, biophotonics and advanced imaging. In addition, the group has developed technical know-how in specialty fibre fabrication, fibre components and interfaces, endoscopic devices and optoelectronic switches, ...
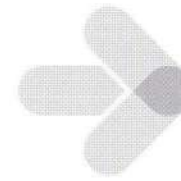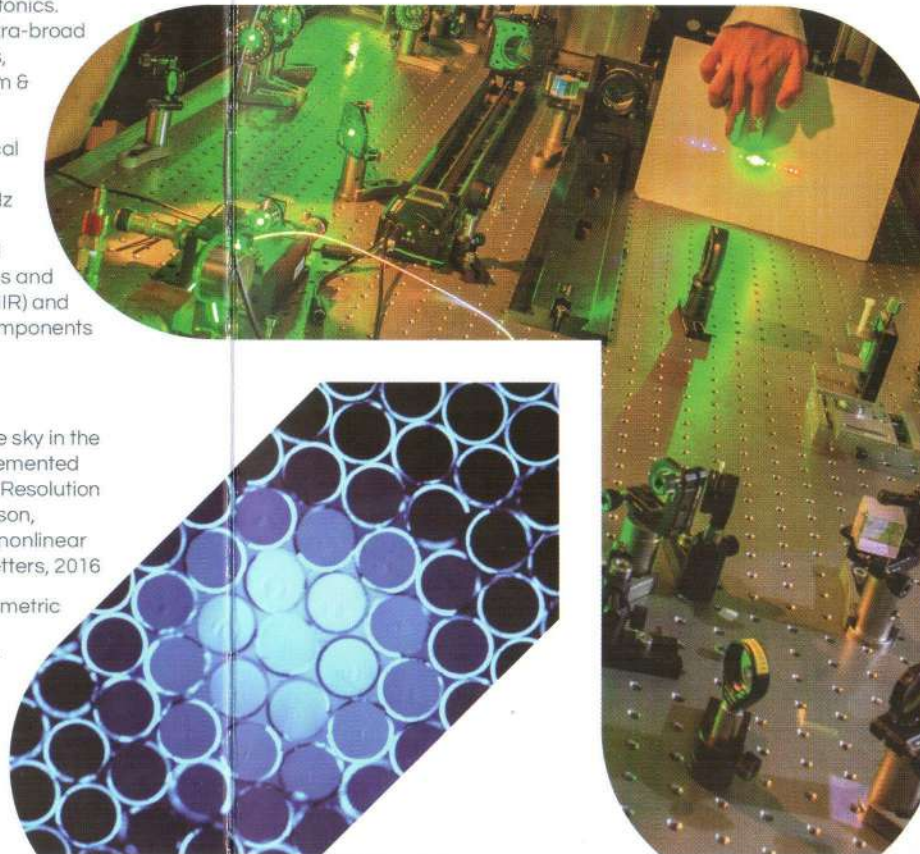
THE MAIN RESEARCH TOPICS OF THE FOUR GROUPS OF THE DEPARTMENT ARE AS FOLLOW:

- **PHOCAL** (Laser, Coherent and Nonlinear Photonics) investigates the control of coherent optical fields in complex media/ systems like fibre arrays or multimode waveguides with gain and/or nonlinearity. The staff is known for his contributions to supercontinuum laser sources, laser combining techniques and advanced imaging system for astronomy.

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MAJOR RESULTS
From 2014 to 2016

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- Observation of geometric parametric instability induced by the periodic spatial self-imaging of multimode waves, Physical Review Letters, 2016

KEY FIGURES
(june 2016)

25	Professors, lecturers, researchers and engineers	**30**	Doctoral students and post-doctoral fellows
580	International scientific articles and communications since 2011	**4**	start-up companies created since 2011
26	patents and patent extensions since 2011	**1**	Joint laboratory with industry - X-LAS

MAIN EQUIPMENT AND TECHNICAL RESOURCES

FIBER FABRICATION
- 3 drawing fiber towers
- Advanced fusion splicer benches

IMAGING
- Raman/CARS microscope
- Multiphoton microscopes
- Multiphoton endoscope

LASERS
- Nano-pico-femto laser sources
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PARTNERSHIPS

Active international and national academic partnerships 2016
Aston University (Birmingham, GB), ESO (Garshing, Chile), FORC and ICHPS (Moscow, Russia), Georgia State University (Atlanta, USA), IPHT (Jena, Germany), Mount Wilmson Observatory (USA); SINTRA (Singapor), Southern Methodist University (Dallas, USA); Université de Brescia (Italy), University of Tsukuba (Japan), University of Tokyo (japan), Ecole Polytechnique (Palaiseau), Femto-st (Besançon), CVN, Ecole Centrale (Paris), ICB (Dijon), ICMCB (Bordeaux), IGR (Villejuif), Institut Langevin (Paris), Institut Fresnel (Marseille), IPM (Bordeaux), ISM (Bordeaux), LKB (Paris), LOB (Palaiseau), LP2N (bordeaux), PHLAM (Lille), SPCTS (Limoges), UGMA (limoges)

Active industrial partnerships 2016
Amplitude Systemes (Pessac), CILAS (Orléans), EOLITE systems (Pessac), Femto engineering (Besançon), GLOPhotonics (Limoges), Horiba medical (Montpellier), Leukos (Limoges), NOVAE (Limoges), Thales (Elancourt)
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- S. Boscolo, A. Tonello, A. Barthelemy, K. Krupa, V. Kermene, A. Desfarges-Berthelemot, B. Shalaby, S. Turitsyn, and J.-D. Ania-Castañón, "Secret key exchange in ultra-long lasers by radio-frequency spectrum coding", Light: Science & Applications, (2015)

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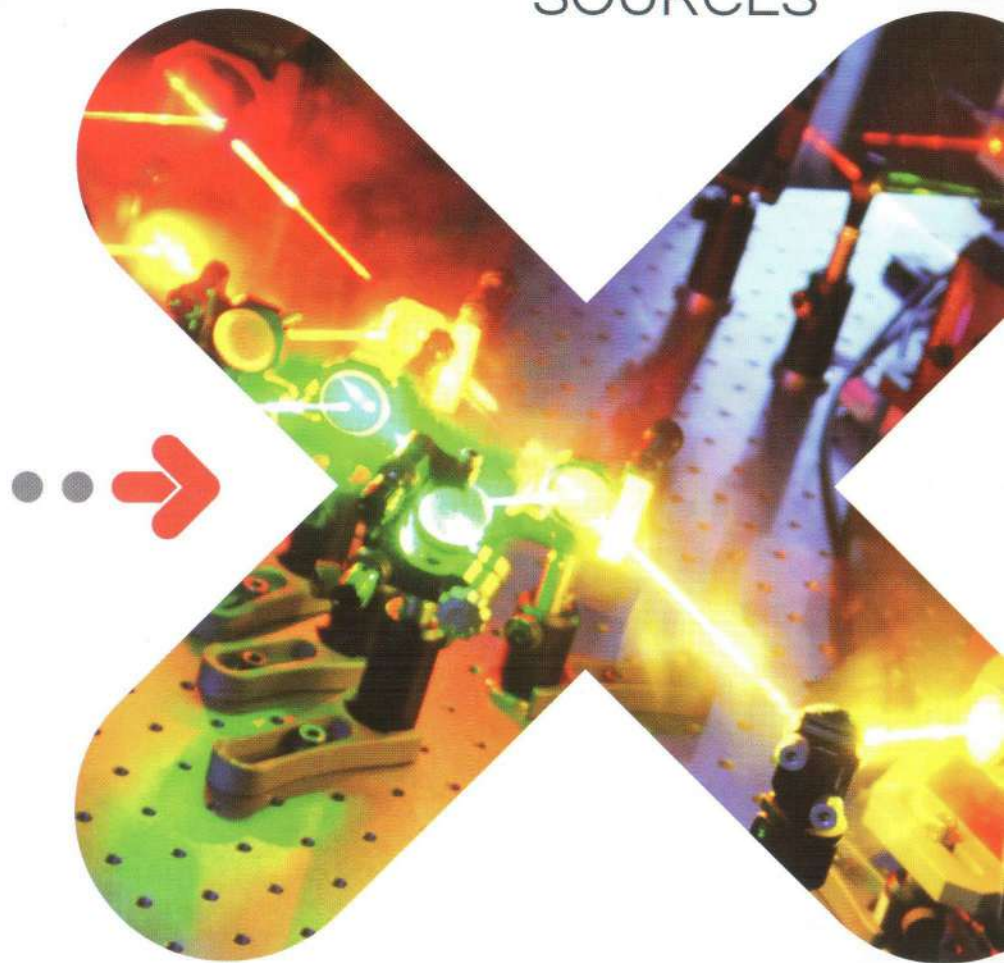123 av. Albert Thomas
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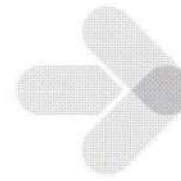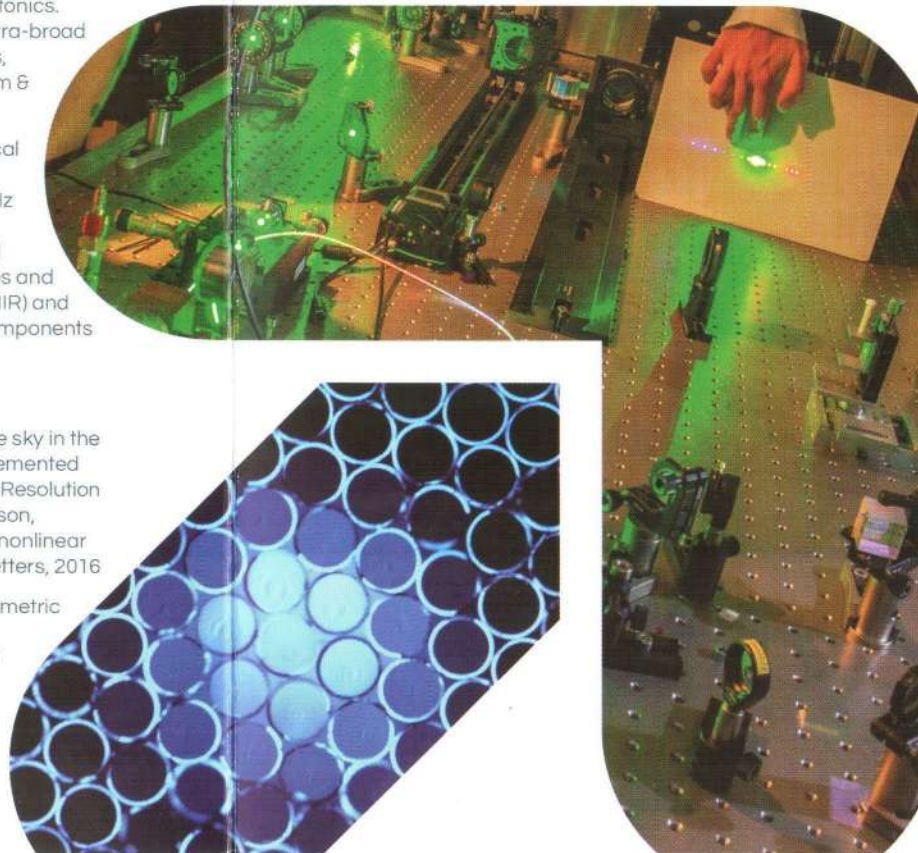
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SCIENTIFIC PRODUCTION OF MATHIS

International articles: **176**
International Conferences: **132**
Others: **23** books chapters, **3** patents.

RECENT MAJOR PUBLICATIONS (2011-2016)

- S. ADLY AND H. RAMMAL, A New Method for Solving Pareto Eigenvalue Complementarity Problems, Computational Optimization and Applications 55, No 3, pp 703-731 (2013).

- P. ARMAND AND J. BENOIST, Uniform boundedness of the inverse of a Jacobian matrix arising in regularized interior-point methods, Mathematical Programming, Serie A, 137:587-592, (2013).

- M. A. BARKATOU, T. CLUZEAU, L. DI VIZIO AND J.-A. WEIL, Computing the Lie Algebra of the Differential Galois Group of a Linear Differential System, International Symposium on Symbolic and Algebraic Computations (ISSAC) 2016.

- P. GABORIT, O. RUATTA AND J. SCHREK, On the Complexity of the Rank Syndrome Decoding Problem. IEEE Trans. Information Theory 62 (2): 1006-1019 (2016).

- A. MOVAHHEDI AND T. NGUYEN QUANG DO, On universal norms and the first layers of Zp-extensions of a number field. Mathematische Annalen 362 (2015), no. 3-4, 817 – 838.

- The MOD team participated in the creation of the common laboratory X-LAS (with Photonic), SPDOPT software (free access), production of several packages in Maple (IntegrableConnections, AppSing, miniISOLDE, Mathemagix Lindalg), 3 patents.

Mathis carries two masters specialities: Cryptis and ACSYON with around 45 graduates students per year. The master ACSYON has an international positioning based on partnerships, courses in English and the M1 is online.

www.cryptis.fr
www.unilim.fr/acsyon/

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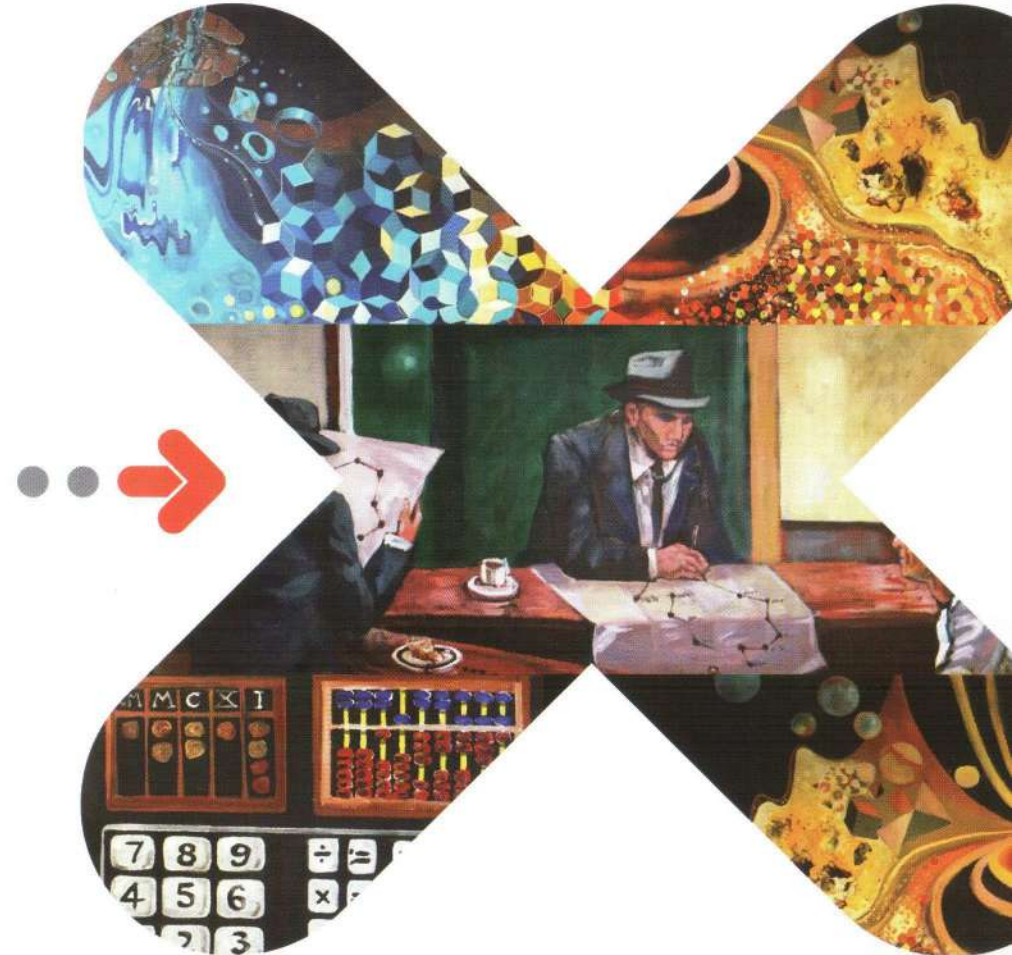87060 LIMOGES CEDEX
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INSTITUT DE RECHERCHE

xlim | MATHIS
MATHEMATICS, INFORMATION SECURITY

UMR 7252

THE MATHIS DEPARTMENT GATHERS RESEARCHERS IN THE DOMAIN OF MATHEMATICS AND INFORMATION SECURITY.

Mathis currently includes 13 Full Professors, 22 Associate Professors (including 5 HDR), 1 CNRS-IR, 1.5 ITA, 1 Post-doctoral and 24 PhD students. All located on the campus of the Faculty of Sciences and Technology. All members belong to CNU (National Committee) sections 25, 26 and 27 : mathematics and computer science.

The scientific output of its members provides a fine balance between fundamental contributions, applications and interactions.

MATHIS IS ORGANIZED AROUND FOUR RESEARCH GROUPS:

- **Computer Algebra (CA):** Algorithms for differential and functional equations, Algebraic curves and systems, Numeric-symbolic computation, p-adic methods and computation, Numerical linear algebra, Structured matrices.

- **Cryptis:** cryptography, information security, smart card, discrete mathematics.

- **Modeling, Optimization, Dynamics (MOD):** Numerical Optimization, Variational and nonsmooth Analysis, nonregular dynamical systems, Optimal control, PDE's and optimal mass transport.

- **Number Theory (NT):** Algebraic and analytic number theory, K-theory of ring of integers, field of norms and Iwasawa theory of Zp-extensions.

Mathis is intensely involved in transversal research with the other departments in XLIM, the plateform PREMISS, the labex Sigma-Lim as well as the research federation MIRES.

MAJOR RESEARCH ACHIEVEMENTS (2011 – 2016):

- Development of effective post-quantum cryptography systems based on the Hamming metric and rank metric.

- First Algorithm for Computing the Lie Algebra of the Differential Galois Group of a Linear Differential System.

- Development of a new solver in numerical optimization in C: SPDOPT « Strongly Primal-Dual Optimization » (the code is available in free access).

- New robust and rapid algorithm to compute the Pareto eigenvalues of complementarity problems.

- Determination of the Kummer radicals of first layers of Zp-extensions.
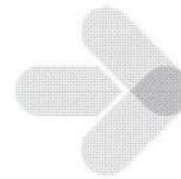
KEY FIGURES
(2011-2016)

13	Full Professors	**22**	Associated Professors	**4**	Post-docs
24	PhD students	**1**	Research Engineer	**1,5**	Adminsitrative agents
25	Dissertations defended (2011-2016)	**5**	Habilitations defended (2011-2016)		

SOME FACTS:

- About fifteen members of Mathis had been invited to present their works in selective conferences with scientific committees.

- Organization of several international conferences: Terryfest on 2015, FELIM for 10 years « Functional Equation in Limoges », PQCrypto on 2013, Structured Matrices days (for 4 years), WISTP (2015), session ACA (since 2012), Alicante-Elche-Limoges Meeting on Optimization (on 2011 and 2014), Ultrametric Biduum (2011).

- Coordination of an European Structural program TEMPUS (36 months: 2010-2014/710 k€) bringing together 12 universities (5 European, 7 Moroccan).

- CNRS Research Networks: GDR « Mathématiques, Optimisation, Applications » GDR « Informatique-Mathématiques » GDR « Structuration de la théorie des nombres ».

PARTNERSHIPS

Active National Universities Partnerships:
Avignon, Bordeaux, Poitiers, Montpellier, Toulouse, Paris VI, Marseille, Orléans, La Réunion, Amiens, Besançon, Pau, Dijon. INRIA: Rocquencourt, Sophia-Antipolis, Rhône-Alpes.

Current International Universities Parterships:
Moscow (Russia). London, Natthingham (UK). Pisa, Catania, Naples, Roma (Italy). Elche, Alicante, Barcelona, Santander, Valladolid (Spain). Marrakech, Safi, Rabat, Fez, Meknes, Essaouira (Morocco). USTBH Algiers, Blida (Algeria). Madison Wisconsin, Ann Arbor, Seattle (USA). Berlin (Germany). Ballarat, NewCastle, Sydney (Australia). IMPA Rio (Brasil). Aveiro, Coimbra (Portugal). Lodz (Poland). Prague, Pilsen (Czech Republic). Hanoi, Quy Nhon, Ho Chi Minh (Vietnam). Victoria, Vancouver, UBC Okanagan, Sherbrooke, Montreal (Canada).

Several industrial contracts:
Thales Security, FIME company, Inside Secure company, la Caisse des Dépôt et Consignation, GEMALTO, OSEO company; Worldline; XLAS (with Photonic);

SCIENTIFIC PRODUCTION

116 peer-reviewed international articles
192 international communications

8 patents
38 book chapters / direction

RECENT MAJOR PUBLICATIONS (2011-2016)

- M. MARIA, S. HORNA, L. AVENEAU, « Constrained Convex Space Partition for Ray Tracing in Architectural Environments », Computer Graphics Forum, Wiley, 2016.

- H. DEBORAH, N. RICHARD, J. Y. HARDEBERG, « A Comprehensive Evaluation of Spectral Distance Functions and Metrics for Hyperspectral Image Processing », IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 2015

- I. IATSUN, M-C. LARABI, C. FERNANDEZ-MALOIGNE, « Investigation and modeling of visual fatigue caused by S3D content using eye-tracking », Displays, Elsevier, 2015

- R. SOULARD, P. CARRÉ, « Elliptical Monogenic Wavelets for the analysis and processing of color images » IEEE Transactions on Signal Processing, 2015

- S. ALAYRANGUES, G. DAMIAND, P. LIENHARDT, S. PELTIER, « Homology of Cellular Structures Allowing Multi-incidence », Discrete and Computational Geometry, vol. 54 (1), 2015.

- C.T. TRAN, B. CRESPIN, M. CERBELLAUD, A. VIDECOQ, « Brownian dynamics simulation on the GPU: virtual colloidal suspensions », ACM/Eurographics workshop on Virtual Reality Interactions and Physical Simulation, 2015

- J. GERHARDS, F. MORA, L. AVENEAU, D. GHAZANFARPOUR, « Partitioned Shadow Volumes », Computer Graphics Forum, 34 (2) (Eurographics), 2015

- G. GILET, B. SAUVAGE, K. VANHOEY, JM DISCHLER, D. GHAZANFARPOUR, « Local random-phase noise for procedural texturing », ACM Transactions on Graphics, 33 (6) (Siggraph Asia), 2014

- S. ROUSSEAU, D. HELBERT, P. CARRÉ, J. BLANC-TALON, « Compressive Pattern Matching on Multispectral Data », IEEE Transactions on Geoscience and Remote Sensing, 2014

- J.-L. TOUTANT, E. ANDRES, T. ROUSSILLON, « Digital Circles, Spheres and Hyperspheres: From Morphological Models to Analytical Characterizations and Topological Properties », Discrete Applied Mathematics, Elsevier, 2013, 161.

- A. BONY, B. BRINGIER, M. KHOUDEIR, « Accurate image quantization adapted to multisource photometric reconstruction for rough textured surface analysis », Journal of the Optical Society of America A, 2013.

- N. MÉRILLOU, S. MÉRILLOU, E. GALIN, D. GHAZANFARPOUR, « Simulating How Salt Decay Ages Buildings », IEEE Computer Graphics and Applications, 32 (2), 2012

- O. PETRENKO, M. SBERT, O. TERRAZ, D. GHAZANFARPOUR, « Modeling of Flowers with Inverse Grammar Generation Interface », International Journal of Creative Interfaces and Computer Graphics, 3 (2), 2012

- Y. WEBER, V. JOLIVET, G. GILET, K. NANKO, D. GHAZANFARPOUR, « A phenomenological model for throughfall rendering in real-time », Computer Graphics Forum, 35 (4), 2012

- A. CHOLLET, G. WALLET, L. FUCHS, E. ANDRES, G.LARGETEAU-SKAPIN, « Foundational aspects of multiscale digitization », Theoretical Computer Science, Elsevier, 2012, 466.

XLIM ASALI

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xlim
INSTITUT DE RECHERCHE

ASALI
IMAGE SYNTHESIS AND ANALYSIS

UMR 7252

RENDERING & VISUALIZATION, DIGITAL CONTENT MODELING, BIOENGINEERING, SAFETY, ANIMATION

Within the Mathematics-Computer Sciences-Images group, ASALI is a research structure dedicated to the synthesis and analysis of images, composed of about 40 permanent staff and 35 PhD students. ASALI is located at two geographical sites: Limoges and Poitiers.

RENDERING & VISUALIZATION

DIGITAL CONTENT MODELING

BIOENGINEERING

SAFETY OF PLACES AND PEOPLE

ANIMATION

ND MODELS OPTIMIZATION

- Topological models: analysis of the topological properties of cell structures, construction of discrete objects and in particular of discrete surfaces defined in a parametric way.

- Image Representation: definition of an original multivalued texture analysis based on the monogenic signal; Tools for image processing on irregular grids integrating invariant geometric models.

MODELING THE LIGHT-MATTER INTERACTION

- Lighting visualization and simulation: integration of new physically plausible BRDF models, focusing on microscale, to widen possible materials.

- Procedural texture synthesis: in order to define photo-realistic models that are both quick to evaluate and that allow to reproduce a great diversity and complexity of appearances at several scales, including structured elements

- Optical metrology: design of a complete framework, from measures to realistic physically based rendering to propose a reliable characterization of the studied surface.

- Ray tracing: topology-based strategy, permitting to handle a stochastic soup of triangles.

BIO-ENGINEERING APPROACH

The psycho-visual dimension is one of the driving forces of our development through bio-inspired models.

- Links between perception and rendering: studying the way in which virtual objects are perceived to define models of perception permitting to optimize image synthesis

- Understanding human perception: handling the mechanisms of perception when the human visual system is confronted with various contexts such as multi-modality and deducing computational and reliable perceptual models (development of metrics quality for stereoscopy, BRDF perception, textures, 3D mesh saliences).

ASALI PERSPECTIVES

In addition to strengthening our core research fields, ASALI's perspectives are at interfaces with other disciplines. Current studies are related, for example, to digital processing of multivalued medical images from polarized light microscopy (in coordination with the Photonic axis) or to interactive visualization of biological and medical data, in coordination with teams in the Health research field.
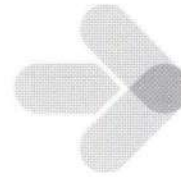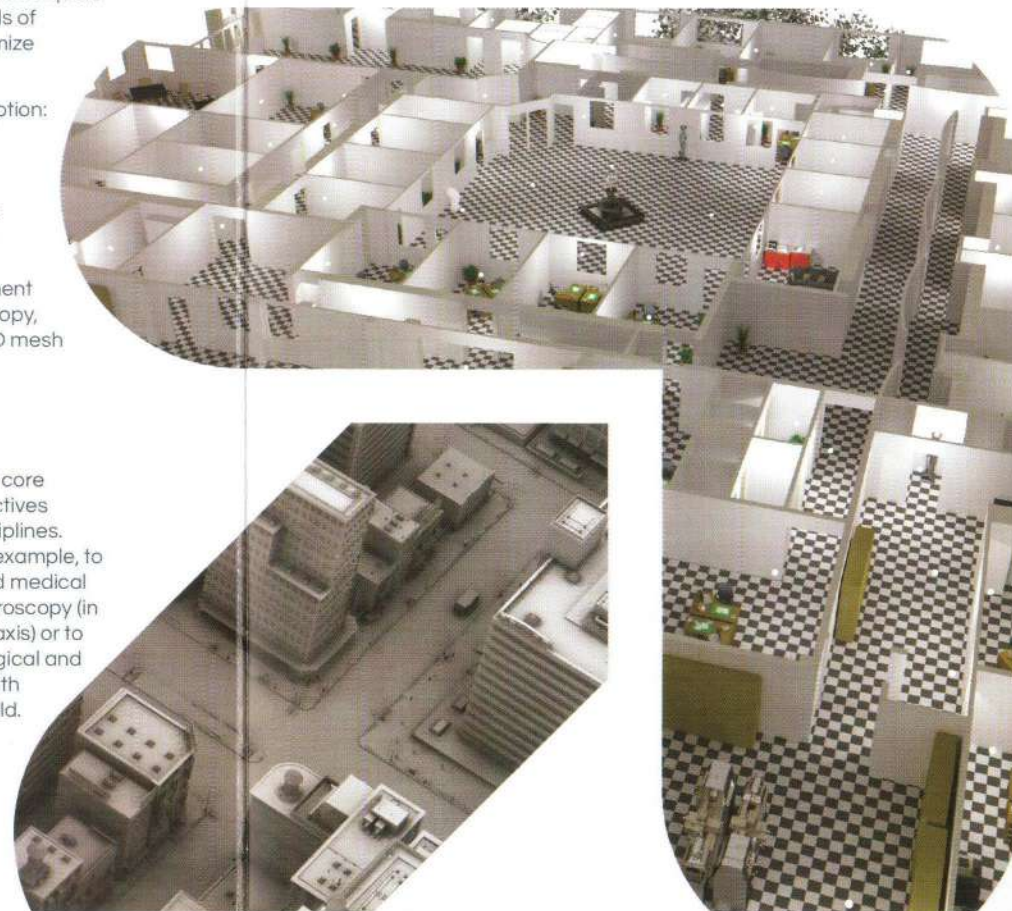
SCIENTIFIC PRODUCTION

from January 1st, 2011 – to June 30, 2016

171 peer-reviewed international journals
418 international communications including **36** invited talks and
7 awarded presentations
12 book chapters
22 patents et **2** software repositories (APP)

MAIN RESEARCH PROGRAMS

- FP7 COMETS: Converters Broadband Low Power High Performance for Telecommunications in Space (2010-2013)

- FP7 ALINWON: AlGaN and InAlN Based Microwave Components (2010-2014)

- ANR VERSO EXPRESSO, coordination by XLIM (2010-2013)

- PEA SCERNE, coordination by XLIM (2011-2013)

- EUREKA EURIPIDES IDEATA: Innovative Design Architecture for Thin Electronic Steering Antennas (2011-2014)

- FP7 NETTUN: New Technologies for Tunnelling and Underground Works (2012-2016)

- ANR ASTRID BALADE, coordination by XLIM (2012-2015)

- ANR ASTRID CONFORME, coordination by XLIM (2013-2016)

- Chaire indus. ANR DEFIS RF, coordination by XLIM (2014-2017)

- EUREKA CATRENE CORTIF: Coexistence of RF Transmissions in the Future (2014-2017)

- PIA PSPC FELIN (2014-2017)

- ANR Intern. MAESTRO, coordination by XLIM (2014-2017)

- ANR ASTRID COCORAM, coordination by XLIM (2014-2017)

- ANR SECU PIXEL, coordination by XLIM (2015-2018)

- H2020 MASTERS, coordination by XLIM (2016-2019)

XLIM RF SYSTEMS

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Technopôle - ENSIL
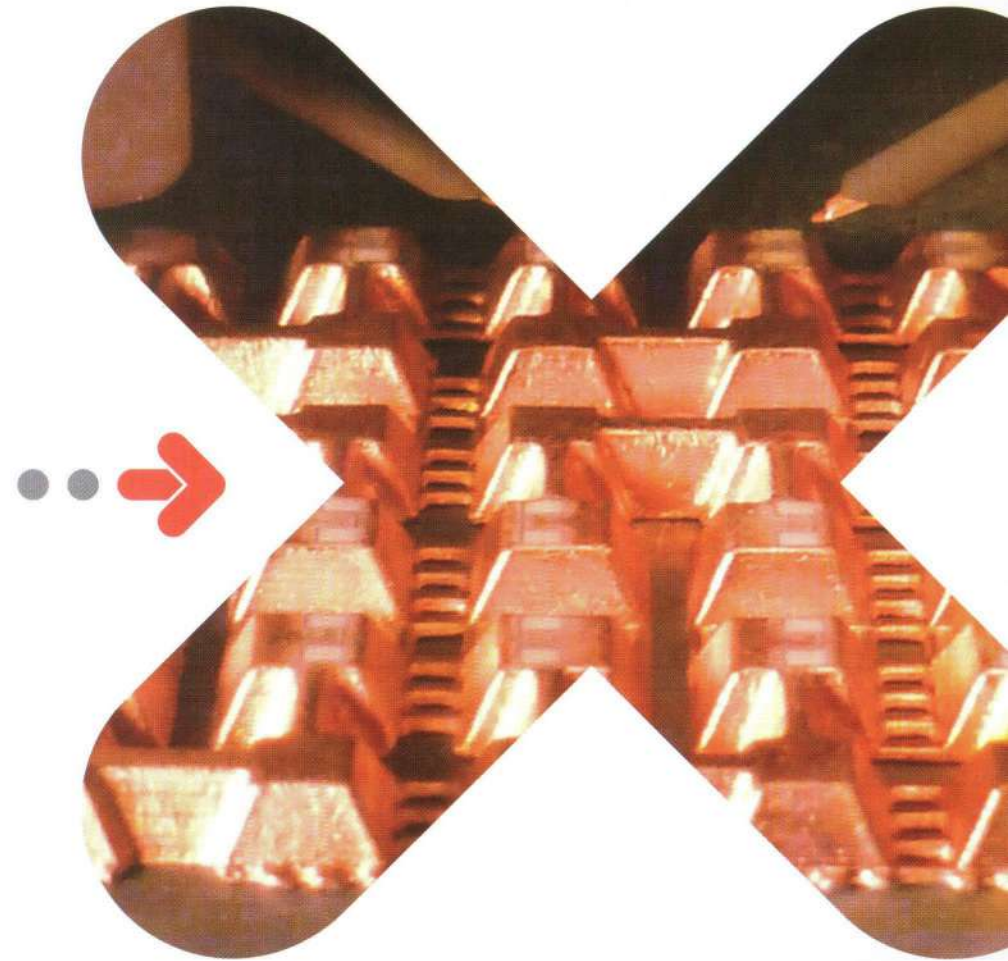Parc d'Ester Technopole
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xlim INSTITUT DE RECHERCHE | **RF SYSTEMS**

UMR 7252

Université de Limoges — CNRS — Université de Poitiers

RF SYSTEMS

The RF Systems department brings together some fifty researchers, faculty members and engineers from the Electronics division, and is divided into 4 research teams. The research activities carried out in the RF Systems department generally concern components, circuits and systems in the field of radio frequencies from a few hundred of MHz to some hundred of GHz and are applied to the design of new equipment for wireless communications, detection and localization, in the field of ICT, safety, defense and space.

A&S: ANTENNAS AND SIGNALS

The general activity of the team is oriented towards finding new architectures and technological solutions for addressing advanced functionalities of antenna systems (agility, efficiency…), in the fields of telecommunications, radars and space. In each field, the constant increase in the amount of measured information imposes strong constraints on associated transmission systems. The aim of the team's work is to simplify RF architectures by combining technological solutions for efficiency optimization and operation at higher frequencies.

C2SNL: NON-LINEAR COMPONENTS, CIRCUITS, SYSTEMS

The activities of C2SNL team are dedicated to the analysis, modeling, design and characterization of active non-linear components, functions, and subsystems, for RF front ends. In order to cover this field of science, the team is structured into three complementary research projects: IN-OV (Advanced Instrumentation) on nonlinear RF metrology, SIM3RF (SImulation/Modeling Multi-level/Multi-physics) on numerical CAD tools for simulation and modeling, and ACT-RF (ArChiTectures and design of RF transmitters) on the development of new architectures of transmitters and receivers.

CEM: ELECTROMAGNETIC COMPATIBILITY

The EMC team focuses on the electromagnetic compatibility of complex systems, from component to system, including cabling and electronics packaging, and evolves numerical resolution methods to meet the challenge of complexity. The work concentrates on the one hand on the research of models and on the other hand on the development of parallel algorithms for intensive computing. The industrial partnerships allow access to test benches that are not accessible to a university laboratory (aeronautical field) allowing the validation of theoretical results for the certification or qualification of equipment.

MACAO: ADVANCED DESIGN METHODS BASED ON ANALYSIS AND OPTIMIZATION

The MACAO team develops modeling, synthesis and optimization tools for the design of new microwave devices (particularly in the field of filtering and packaging) in order to improve their performance, facilitate dimensioning and predict their behavior in realistic environment. The development of these tools is accompanied by the use of original manufacturing technologies and the development of specific characterization techniques for the advanced integration of high frequency electronic functions.
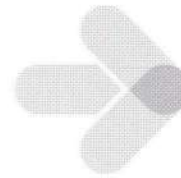
KEY FIGURES
(June 30, 2016)

32,2	Faculty staffs	**8**	CNRS researchers	**5**	Research engineers
3	Administrative staffs	**55**	PhD students	**10**	post-doctoral researchers
19	ANR projects	**6**	European projects	**5**	projects with European agencies

CHALLENGES

High-performance low-cost systems

The challenge is to exploit new materials and technologies, including 3D technologies, to propose and develop original architectures and associated design methodologies, for innovative devices meeting cost reduction and performance optimization

Highly integrated systems in complex environments

The increasingly dense and complex integration of circuits and systems, and even their coexistence, requires taking into account multi-physical and multi-scale models, for design and simulation, from component level to system level, including their environment.

Millimeter-wave and sub-millimeter-wave systems

The requirements in terms of spectrum allocation for high data-rate communications or high-resolution microwave imaging are driving the development of millimeter-wave and sub-millimeter-wave technologies, based on appropriate design methodologies and characterization models for devices, from basic components up to integrated systems.

Reconfigurable and energy-efficient systems

The reduction of energy consumption in communication systems becomes a major issue with the growth of the exchanges. A part of the answer lies in the reconfigurability of systems, with a demand for flexibility in terms of coverage, power and frequency.

MAIN ACADEMIC COLLABORATIONS

In France: IEMN (Lille), IETR (Rennes), INRIA Sophia Antipolis, IMS (Bordeaux), LabS-TICC (Brest), SPCTS (Limoges)

International collaborations: Carleton University (Canada), City-U Hong-Kong (China), Duke University (USA), NIMP (Romania), NTU et CINTRA (Singapore), University of Mostaganem (Algeria), University of Padova (Italia), Lebanese University (Lebanon)

JOINT LABORATORIES

- **AXIS** with Thales Alenia Space on micro-wave technologies for space
- **MITIC** with III-V Lab on high-power III-V components
- **NXL** with NXP on silicon front-ends integration
- **LEV3E** with CEA Gramat on high-power microwaves and microwave imaging
- **Ino-Gyro** with INOVEOS on gyromagnetic components
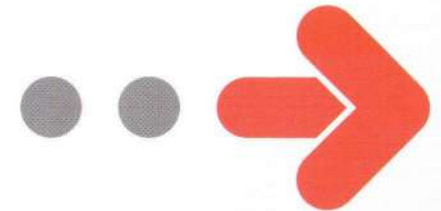
SCIENTIFIC PRODUCTION

Website publication: **hal.archives-ouvertes.fr/XLIM-RFEI**
78 % of journals are in quartiles Q1 or Q2
30 % of journals are co-authored with at least one foreign laboratory

MAJOR PUBLICATIONS AND/OR PATENTS FROM 2010 TO 2016

- E.J. Spadafora, R. Demadrille, B. Ratier, B. Grevin - Imaging the Carrier Photogeneration in Nanoscale Phase Segregated Organic Heterojunctions by Kelvin Probe Force Microscopy - Nano Letters, American Chemical Society, 2010, 10 (9), pp.3337-3342

- H. Melhem, P. Simon, J. Wang, C. Di Bin, B. Ratier, Y. Leconte, N. Herlin-Boime, M. Makowska-Janusik, A. Kassiba, J. Bouclé - Direct photocurrent generation from nitrogen doped TiO2 electrodes in solid-state dye-sensitized solar cells: towards optically-active metal oxides for PV applications, Solar Energy Materials and Solar Cells, 2013, 117, 624-631

- L.Y. Zhang, C. Bounaix Morand du Puch, C. Dalmay, A. Lacroix, A. Landoulsi, J. Leroy, C. Mélin, F. Lalloué, S. Battu, C. Lautrette, S. Giraud, A. Bessaudou, P. Blondy, M.O.Jauberteau and A. Pothier - Discrimination of Colorectal Cancer Cell Lines using Microwave Biosensors, Sensors & Actuators: A. Physical, Volume 216, 1 September 2014, Pages 405-416.

- V. Thery, A. Boulle, A. Crunteanu, J. C. Orlianges, A. Beaumont, R. Mayet, A. Mennai, F. Cosset, A. Bessaudou, M.Fabert - Role of thermal strain in the metal-insulator and structural phase transition of epitaxial VO2 films grown on (001) sapphire by electron beam evaporation, Phys. Rev. B, 93 (18), 184 106, 2016.

- S. Poughon, L. Dassas, B. Ratier, Module photovoltaïque et son procédé de réalisation, French patent n° 12 54 138 registered in 4/05/2012, PCT le 04/05/2013

- P. Blondy, S. Courrèges, A. Pothier, J-C. Orlianges, Electromechanical microsystems with air gaps, United States, Patent n° 8941452. 2015

XLIM RF-ELITE
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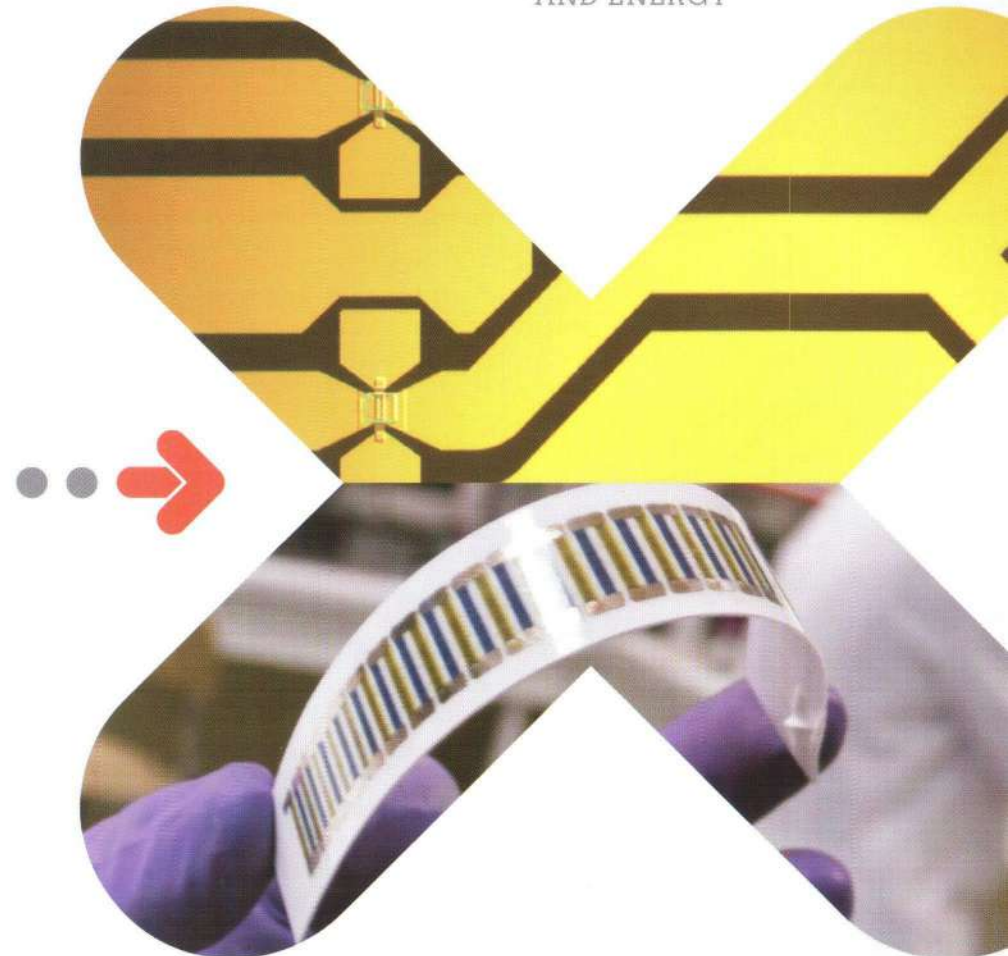123 av. Albert Thomas
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RF ELITE

INSTITUT DE RECHERCHE

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RADIO FREQUENCY AND PRINTED ELECTRONICS FOR TELECOMMUNICATIONS AND ENERGY

The RF-ELITE department designs and manufactures innovative electronic and optoelectronic components by developing micro and nanotechnologies and integrating new materials.

These activities rely on the PLATINOM platform facilities (micro-fabrication technologies and low and high-frequency instrumentation) and are carried out, in collaboration with the material science SPCTS laboratory (within the common laboratory of excellence ∑-LIM).

These scientific developments are performed for electronic systems from radiofrequencies up to THz and for optoelectronic components.

RF-ELITE DEPARTMENT IS ORGANIZED AROUND TWO RESEARCH TEAMS:

- **The ELITE research team** (Printed ELectronics for Telecom and Energy) is involved in the fundamental and experimental research on organic and hybrid optoelectronics for telecom and energy applications, from the integration of materials, fabrication of devices, their optoelectronic characterization, to the numerical modeling of their physical properties. The ELITE team focuses on the development of a large variety of devices (solar cells, light-emitting diodes, etc).

- **The MINT research team** (MIcro and Nano structures for Telecom) develops RF and microwave circuits based on specific functional materials and/or manufacturing technologies. It has a recognized knowhow in the design and realization of relevant RF demonstrators using new materials or micro and nano-structures.

MAJOR RESULTS OBTAINED FROM 2011 TO 2016

- World first: Successful Space-borne launch of RF-MEMS in geostationary orbit (cooperation XLIM/Thales Alenia Space/CNES) (Feb. 2014) – Patent : P. BLONDY and al., Patent n° : 2012 020 095, 2012 - Creation of AirMEMS start-up, 2013

- World first: Plastic polychromatic photovoltaic modules with custom design for perfect integration (June 2015) - Patent: B. RATIER and al., FR2990300 (A1) - 2013-11-08 - contract RAPID/DGA/PHASME 2012-2015 - EURIPIDES contract Sprintronics 2011-2015 - 2 PhD grants - CIFRE Disasolar – CNRS innovation letter No. 260, 2015 - Annual Activity Report of the CNRS 2015, significant scientific results, pp 23

- Hybrid solid state solar cells with low gap metal oxydes (world first) (collaboration XLIM/CEA-IRAMIS) (2013)

- DC-millimeter waves bi-stable micro switches using Phase Change Materials (GeTe, GST, …) (collaboration XLIM/Thales Alenia Space/CNES)

- Reconfigurable THz circuits and frequency selective surface using phase transition and phase change materials (Collaboration University of Marbourg, Institute of Saint-Louis-ISL, Chinese University and City University of Hong-Kong)
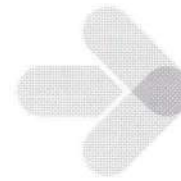
KEY FIGURES

RESEARCH STAFF AS AT 30 JUNE, 2016

16 Faculty members

2 CNRS researchers

1 Technicians, engineers and administrative assistants

3 Post-doctoral researchers

18 PhD students

SCIENTIFIC AND TECHNOLOGICAL OUTPUT
(annual average)

25 Major publications or papers

2 Patents

5 PhD dissertations defended

BUSINESS-ENTERPRISE

Launch of AirMEMS start-up, 2013

Joint Laboratory: AXIS with Thales Alenia Space on microwave technologies for space

Industrial Research chair: ANR DEFIS RF, coordination by XLIM- RF Systems (2014-2017)

Active Partnerships (project and/or journals and/or patents)

National University Partnerships
SPCTS (Limoges), HCP (Limoges), CHU (Limoges), LPM (Nancy), IMMM (Le Mans), IMS (Bordeaux), EMN (Lille), PCM2E (Tours), CEISAM (Nantes), FEMTO-ST (Besançon), IM2NP (Marseille), Lab-STICC (Brest), SATIE, LAC et PPSM (Cachan), ICG (Montpellier), ISL (Saint-Louis), IETR (Rennes).

**Partnerships with National Organizations or Institutions**
CEA-IRAMIS (The French Alternative Energies and Atomic Energy Commission), CEA-INAC, CEA-LETI, CEA-CESTA, CNES (National Centre for Space Studies), DGA (Directorate General for Armaments), ESA (European Space Agency).

International University Partnerships
University of Western Australia, Jan Dugloz University (Poland), Warsaw University of Technology (Poland), University of California, San Diego (USA), University of Bangor (GB), IHP microelectronics (Germany), Universitat Autònoma de Barcelona (Spain), Bellaterra, Universitat Ramon Llull (Spain), Universitat Politècnica de Catalunya (Spain), University of Valencia (Spain), Queen's University Department of Chemistry (Canada), National Institute of Materials Physics (Romania), University My Ismail (Morocco), Petrozavodsk State University (Russia), International Islamic University of Malaysia, Kanazawa University (Japan), Chinese University of Hong-Kong, City University Hong-Kong, UNISA (University of South Africa).
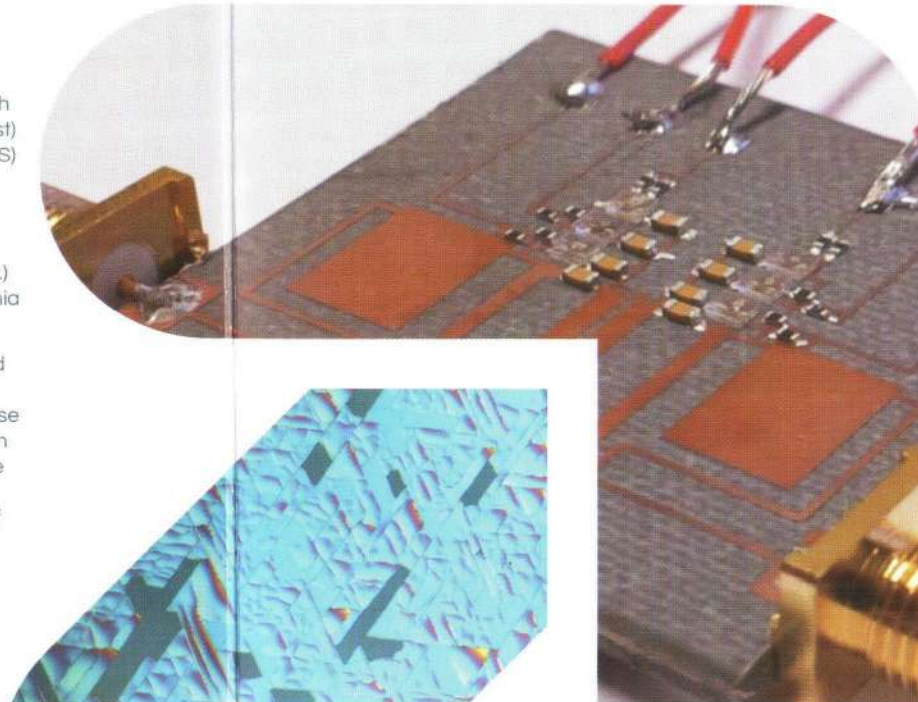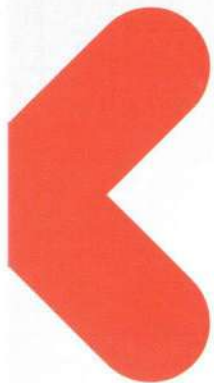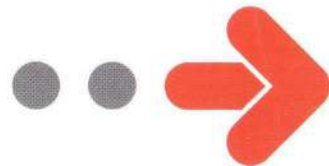
OPTICS FIBRE

LASER INSTRUMENTATION

RF AND MICROWAVE CIRCUITS

MICROWAVE DEVICE MODELING

MICROWAVE AND MILLIMETER-WAVE
MEASUREMENTS

ANTENNA CHARACTERIZATION

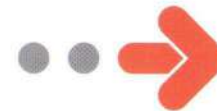SMART MATERIALS AND MEMS
INTEGRATION

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PLATINOM
OPTICS AND MICROWAVES
TECHNOLOGY PLATFORM

OFFERED SERVICES

The PLATINOM platform utilizes the fabrication and measurement equipment at XLIM for microwaves and optics applications. Available for external academic and industrial researcher use, the platform can provide a full cycle service from fabrication through measurements.

XLIM Circuits Technology Center combines clean room resources for Micro and Nano Technologies development for application in fields such as RF MEMS, MOEMS, polymer materials for electro-optic applications and innovative oxide materials. It is one of the main technological apparatus used for laboratory research projects. Microelectronics and MEMS processing is conducted in our 180m² clean room. It includes equipment for microelectronic modeling and fabrication with an emphasis on ceramics and oxides substrates.

Printed Electronic Technologies and Instrumentation at XLIM bring together a set of fabrication and characterization techniques dedicated to the development of organic/hybrid optoelectronic and printed electronic devices (photovoltaic cells, field-effect transistors, light-emitting diodes, sensors, etc). Specific instrumentation (for example glove boxes under inert atmosphere) allows the implementation of various components based on organic semiconductors, such as pi-conjugated polymers and small molecules.

The XLIM laboratory has a world-renowned expertise in the field of the next generation of optical fibers. These fibers are made with a fully controlled process and are also a fundamental element of the work developed by the two research teams «Fibre photonics» and «GPPMM». This platform is part of a scientific interest group, namely, GIS - GRIFON, national platform of the CNRS for optical fibres, whose other partners are PhLAM (Lille) and LPMC (Nice).

The fabrication facilities are composed of three drawing towers, two of which dedicated to PCF applications and the other to upstream developments. As a result of the superior performance of this new equipment, we are able to accurately control all the drawing parameters: for example temperature with a stability or +/- 1°C, step-by-step digital servo-motors, mass-flow for gas flow inside capillaries, etc.

Microwave and sub-millimeter-wavelength measurement benches for linear devices.

Combining equipment and benches at XLIM allows for RF and microwave testing and characterization on components, circuits and materials in linear domain. These equipments can assess various ranges of frequencies according to the devices being tested.

Linear S parameters can be measured up to 330GHz.

The XLIM laboratory also has equipment and RF and microwave test benches that allow the characterization of components, circuits and subsystems under operational conditions in a highly nonlinear established regime. These devices have differing behaviors according the power and frequency ranges of the devices being tested.

The XLIM laboratory also has three antennas measurement benches, up to W band.

XLIM Optical Instrumentation and Laser facilities house home-made and commercial state of the art instruments. Thanks to the expertise of the Photonics department, they are under regular improvement and maintenance in order to match industrial needs and to realize new research challenges.

XLIM optical instrumentation offers imaging equipment such as nonlinear, Raman and CARS microscopes and nonlinear endoscopes, but also high resolution, high dynamic or fast cameras. Such devices find applications in biological and bio-medical research, in material characterization and more generally are useful to observe fundamental optical phenomena in complex linear and nonlinear media.
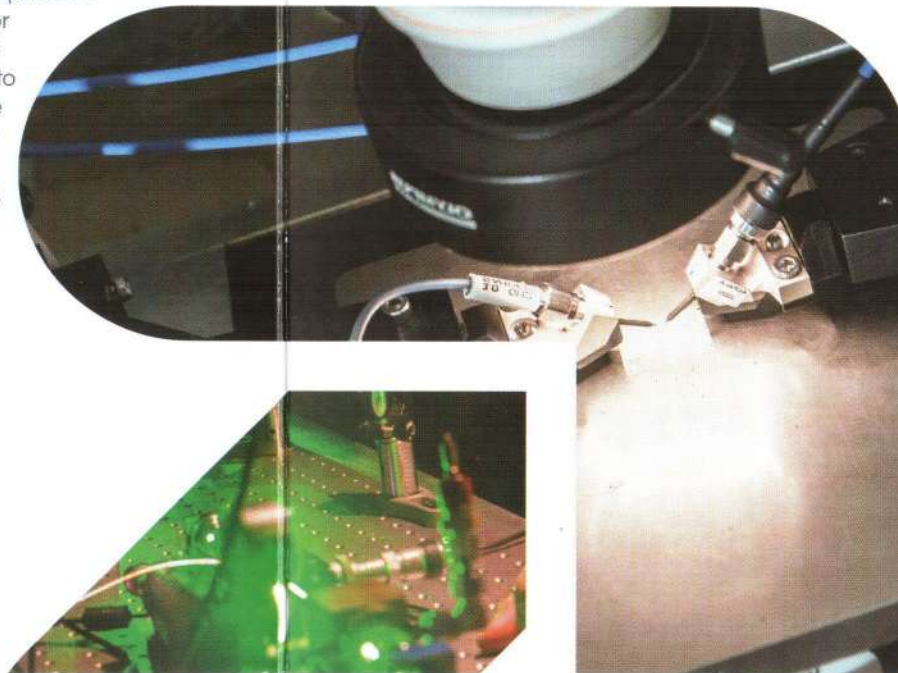
Thin film μ wave circuit fabrication

HF device characterization

Antenna measurements

μ wave and mmwave measurements

Fiber optics fabrication

Non-linear optics

SCIENTIFIC PRODUCTION

from January 1st, 2011 – to June 30, 2016

Peer-reviewed international journals: **102**
International communications: **196** included **30** invited talks
Others : **8** book chapters, **2** patents

RECENT MAJOR PUBLICATIONS (2011-2016)

- SAMY KAMBOU, CLENCY PERRINE, MÉRIEM AFIF, YANNIS POUSSET, CHRISTIAN OLIVIER, " Resource allocation based on cross-layer QoS-guaranteed scheduling for multi-service multi-user MIMO–OFDMA systems", Wireless Networks, 2016

- LUDOVIC CHEVALIER, STÉPHANIE SAHUGUEDE, ANNE JULIEN-VERGONJANNE, "Optical Wireless Links as an Alternative to Radio-Frequency for Medical Body Area Networks", IEEE Journal on Selected Areas in Communications, 2015

- DAT-DUONG PHAN, EMMANUEL MOULAY, PATRICK COIRAULT, ANNE-MARIE POUSSARD, RODOLPHE VAUZELLE, "Potential feedback control for the power control in wireless sensor networks", IET Control Theory and Applications, 2015

- ROMAIN LEFORT, RODOLPHE VAUZELLE, VINCENT COURTECUISSE, NADIR IDIR, ANNE-MARIE POUSSARD, " Influence of the MV/LV transformer impedance on the propagation of the PLC signal in the power grid", IEEE Transactions on Power Delivery, 2016

- WENDYIDA ABRAHAM KABORE, VAHID MEGHDADI, JEAN-PIERRE CANCES , PHILIPPE GABORIT, OLIVIER RUATTA, "Performance of Gabidulin Codes for Narrow-band PLC Smart Grid Networks", IEEE ISPLC, 2015

- HUTU FLORIN, DAVID CORDEAU, JEAN-MARIE PAILLOT, " 2.4 GHz antenna array using vector modulator based active phase shifters for beamforming", IET Microwaves Antennas and Propagation, 2011

- M. BOLEA, R.P. GIDDINGS, MOHAMED BOUICH, CHRISTELLE AUPETIT-BERTHELEMOT, JIANMING TANG, "Digital filter multiple access PONs with DSP-enabled software reconfigurability", Journal of optical communications and networking, 2015

- SÉBASTIEN PEYRAUD, ERIC ROYER, STÉPHANE RENAULT, DOMINIQUE MEIZEL, " Collaborative Methods for Real-time Localization in Urban Centers", International Journal of Advanced Robotic Systems, 2015

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SMART SYSTEMS AND NETWORKS
UMR 7252
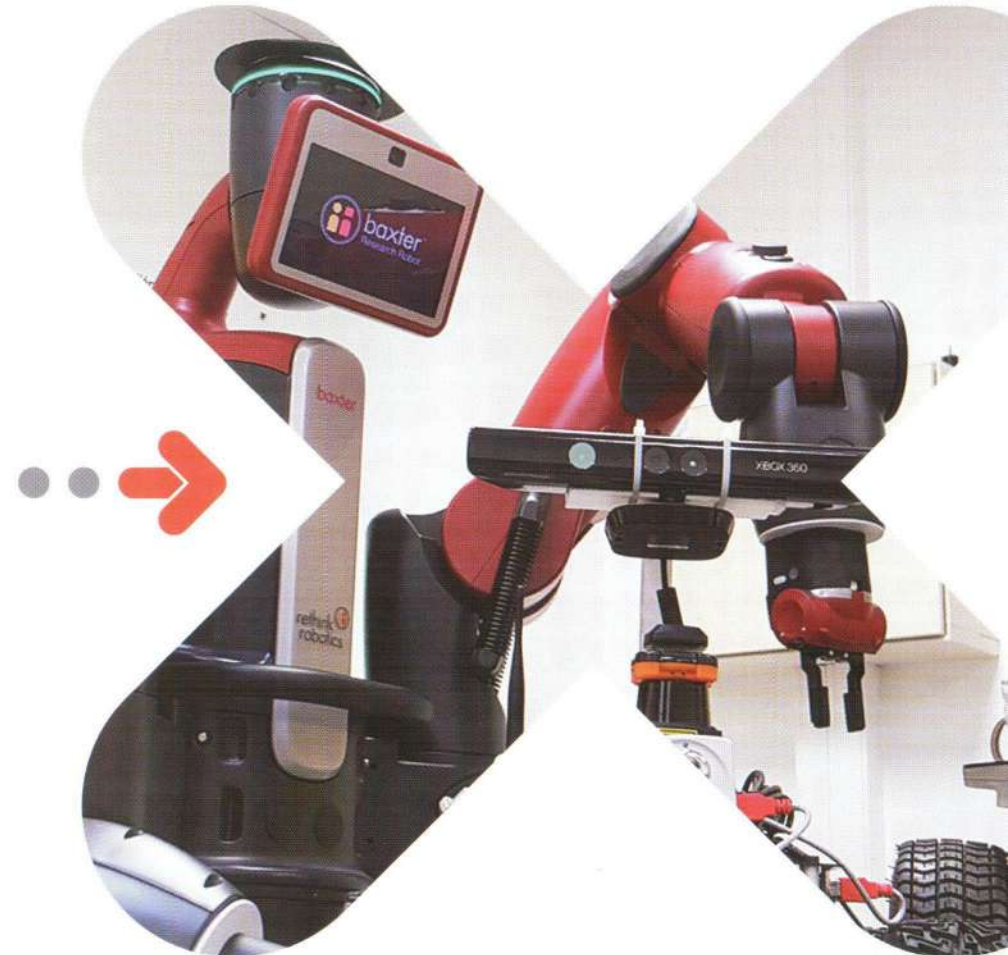
IOT, 5G, ROBOTICS, CYBER-PHYSICAL SYSTEMS

Using a systemic approach, both scientific groups of the SRI department study systems and heterogeneous intelligent networks ; that are variable and heterogeneous entities that exchange information to ensure predefined missions. These entities can be mobile objects, vehicles, robots, drones, sensors, cameras...

The scientific project is centered on the deployment and the optimization of these network performances in terms of: QoS, energy efficiency, resources allocation, location, environment perception, mobility in complex (electromagnetic, topology) environments. User's requirements are also an entry point.

It adresses the main societal challenges : Health, Industry 4.0, Energy transition.

CHALLENGES:

### HETEROGENEOUS SYSTEMS AND NETWORKS

This project focuses more particularly on low cost sensor network or ad hoc networks which consider a few numbers of nodes and resources. Our goal is to optimize the PHY and MAC layers according to some quality criteria. A promising solution we want to investigate is the use of mixed optical and radio technologies in order to cope with the huge number of transmission contexts that will be encountered in the future 5G network. The objective is to improve the connectivity, the reliability, the rate or the energetic consumption.

An important point concerns the development of demonstrators and in particular two platforms, one allowing the optimized instrumentation of a building based on the IEEE 802.15.4 and the other one which is a self-configurable multi-standard platform. It joins a set of sensors which can be wearable, or embedded in a robot, a drone to be deployed in multiple configurations.

OPTIMIZATION CROSS LAYER OF MULTIMEDIA COMMUNICATION NETWORKS

In this project we are mainly concerned with high capacity broadband networks where, compared to the first project, the nodes are less constrained in terms of energy. Another specificity of this context consists in the availability at the transmitter place of the channel state information, thanks to a return link from the receiver. Using the channel state information, it is possible to adapt the available resources at the transmitter to the quality of radio links. The framework of this project will be the future 5G network where M2M communications from the IoT world will cohabitate with classical multimedia transmissions.
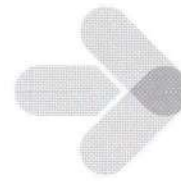
In this context of massive connectivity resource scheduling to jointly optimize the QoS (and the QoE) and the energetic consumption will constitute a major challenge that will be addressed by a cross layer approach.

PERCEPTION AND LOCALIZATION FOR AUTONOMOUS MOBILE ROBOTICS

The work focuses on modeling, perception, localization and mobility of individual or networked systems. The activities address the complete chain, from perception by integrating observability, localization and mapping, to robot execution control in real worlds (Real Robots in Real Worlds). The originality of this work is based on an active and enactive approach to perception. The latter, besides being active, is contingented by the interactions of the system with its environment, and is characterized by the construction of anticipatory actions that, in turn, guide perception. It allows thus to consider unknown, changing, or dynamic environments at different scales. These activities are based on a platform of heterogeneous robots made up of several ground mobile robots, drones and a cobot, equipped with inertial sensors, vision, Lidar,... with applications concerning the "factory of the future", mobility for Health and exploration and monitoring of natural or industrial sites.

A MULTI-DISCIPLINARY, SCIENTIFIC ORGANIZATION
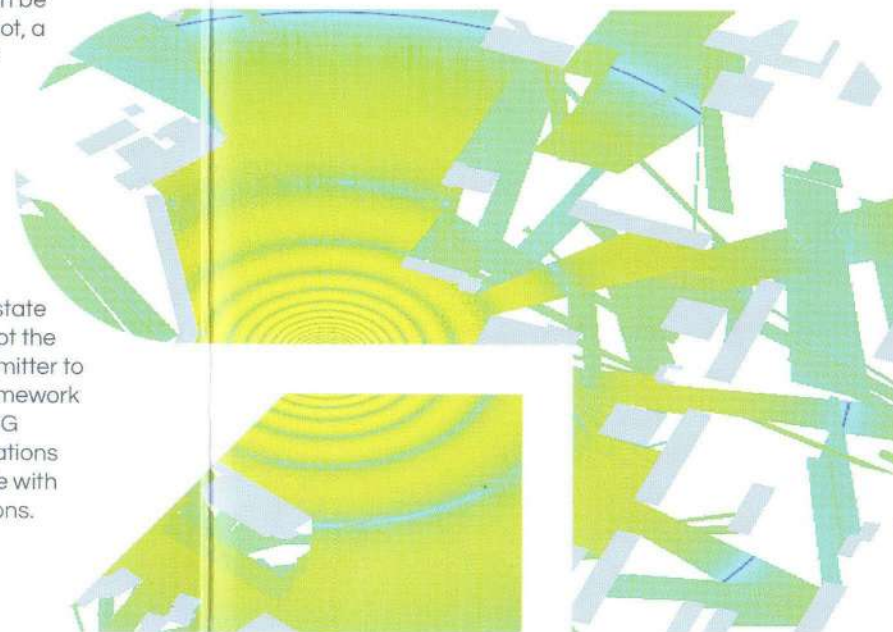
XLIM is a Joint Research Unit of the CNRS, the University of Limoges and the University of Poitiers.

465 staff > **243** + **222**

working towards excellence in research and innovation

Ph. D. students & postdoctoral fellows

permanent staff

43 engineers-technicians & administrative staff

158 academics

21 CNRS researchers

HOT TOPICS

Carbon Nanotubes for RF and millimeter wave devices packaging
C. BRUN & AL., "Flip Chip Based on Carbon Nanotube–Carbon Nanotube Interconnected Bumps for High-Frequency Applications" in IEEE Trans. on Nanotechnology, vol. 12, no.4, July 2013

Modeling and simulation of planes for lightning strikes
E. PERRIN & AL., "Using a Design-of-Experiment Technique to Consider the Wire Harness Load Impedances in the FDTD Model of an Aircraft Struck by Lightning" in IEEE Trans. on EMC, vol. 55, no. 4, Aug. 2013

Code based Cryptography
P. GABORIT & AL., "On the Complexity of the Rank Syndrome Decoding Problem" in IEEE Trans. on Information Theory, vol. 62, no. 2, Feb. 2016

XLIM RF-MEMS switches on board of the Athena Fidus satellite
PATENT P. BLONDY & AL., n° 2012020095, 2012 Microscoop, le magazine de la délégation CNRS, Centre Limousin Poitou Charentes, n°73, 2016

Novel technique to trap molecules and nano structure gas materials
M. ALHARBI & AL., "Raman gas self-organizing into deep nano-trap lattice", Nat. Commun.7:12779 (2016)

World's first polychrome organic solar module
PATENT: B. RATIER & AL., FR2990300 (A1) Science et Vie, "Les panneaux solaires prennent de la couleur", mai 2015

Changing the colour of starlight
P. DARRÉ & AL., "First On-Sky Fringes with an Up-Conversion Interferometer Tested on a Telescope Array", Phys. Rev. Lett., vol. 117, issue 23, 2016

Additive manufacturing of 3D ceramics for high frequency space applications
D. DI MARCO & AL., "Dielectric properties of pure alumina from 8 GHz to 73 GHz", Journal of the European Ceramic Society, vol. 36, issue 14, 2016

Nonsmooth analysis and its applications
S. ADLY & AL., "Preservation of prox-regularity of sets and application to constrained optimization", SIAM Journal on Optimization, vol. 26, no. 1, 2016

Multiphoton technique for imaging of the biological effects of nanosecond pulsed electric fields
S. BARDET & AL., "Multiphoton imaging reveals that nanosecond pulsed electric fields collapse tumor and normal vascular perfusion in human glioblastoma xenografts", Nature Scientific Reports 2016/10/04/ online

Nonlinear characterization and modeling of GaN devices
A. BENVEGNÚ & AL., "On-Wafer Single-Pulse Thermal Load–Pull RF Characterization of Trapping Phenomena in AlGaN/GaN HEMTs" in IEEE Trans. on Microwave Theory and Techniques, vol. 64, no. 3, March 2016

New coding schemes based on new metrics
A. W. KABORE & AL., "Performance of Gabidulin codes for narrowband PLC smart grid networks" in IEEE International Symposium on Power Line Communications and Its Applications (ISPLC), Austin, USA, 2015

Bio-inspired 3D qualité assessment of stereoscopic contents
R. BENSALMA & AL., "A perceptual metric for stereoscopic image quality assessment based on the binocular energy", Multidimensional Systems and Signal Processing, 2013, 24, 281-316

A new spatial beam self-cleaning method in multimode fiber
K. KRUPA & AL., "Observation of geometric parametric instability induced by the periodic spatial self-imaging of multimode waves", Physical Review Letters, 116, 2016
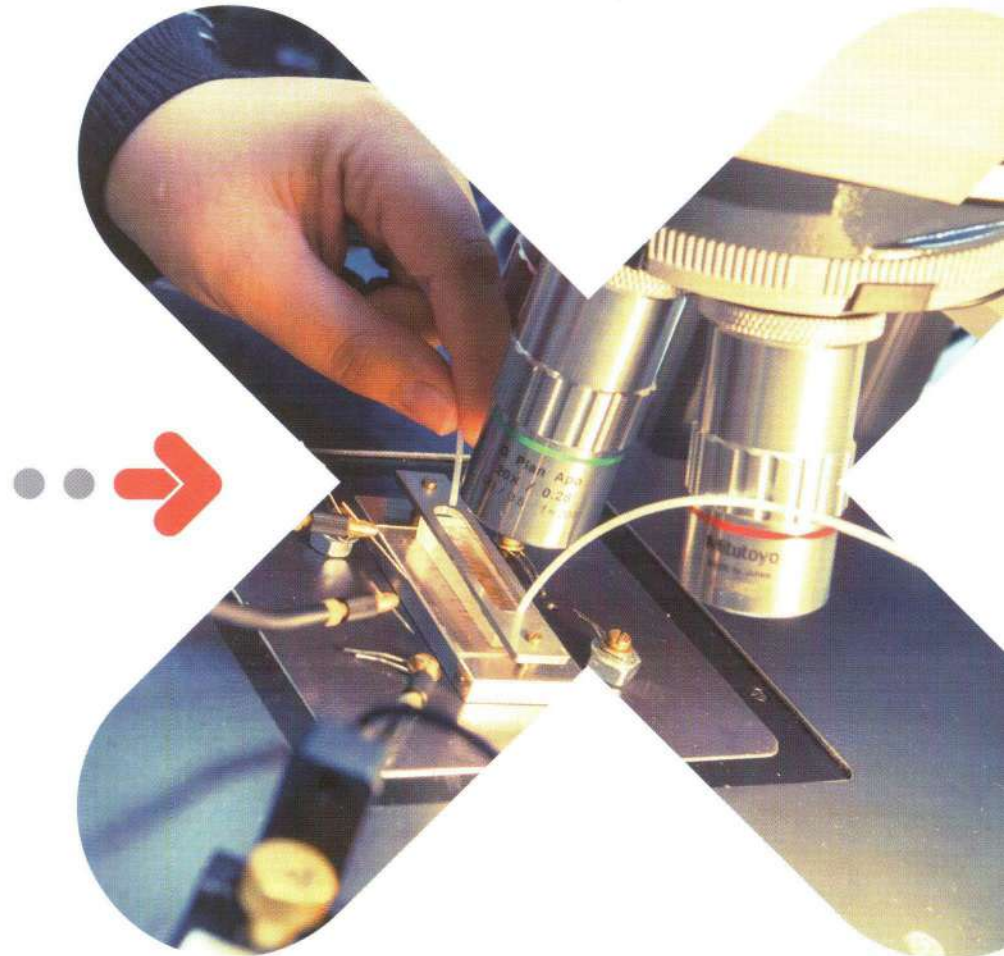
Pioneer work in the modeling of binocular energy for bio-inspired prediction of 3D quality
R. BENSALMA & AL., "A perceptual metric for stereoscopic image quality assessment based on the binocular energy", Multidimensional Systems and Signal Processing, Springer Verlag, 23 (1-2), 2012.

and many more on www.xlim.fr

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xlim
INSTITUT DE RECHERCHE
UMR 7252

A MULTI-DISCIPLINARY RESEARCH TOWARDS INNOVATION

THE LABORATORY

3 scientific divisions in **Electronics - Photonics - Mathematics, Computer Science and Image** including 6 departments and 21 research groups

● SMART SYSTEMS AND NETWORKS

This department is engaged in the deployment and optimization performances of heterogeneous networks in terms of: QoS, energy, radio resource, localization, environment perception, mobility in complex environment, usage constraints and operability.

● MATHEMATICS, INFORMATION, SECURITY

The MATHIS department gathers researchers in the domain of mathematics and information security. It includes research in the following fields: Computer Algebra, cryptology and Information Security, Optimization and Variational Analysis, Algebraic and Analytic Number Theory.

● IMAGE SYNTHESIS AND ANALYSIS

Scientific challenges developed in this department are the creation of complex but structured objects in arbitrary dimension, modeling and processing of colorimetric and spectral information in still or animated pictures, and realistic image synthesis relying on procedural models, either statistically- or physically-based.

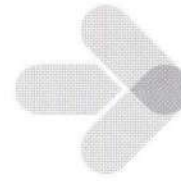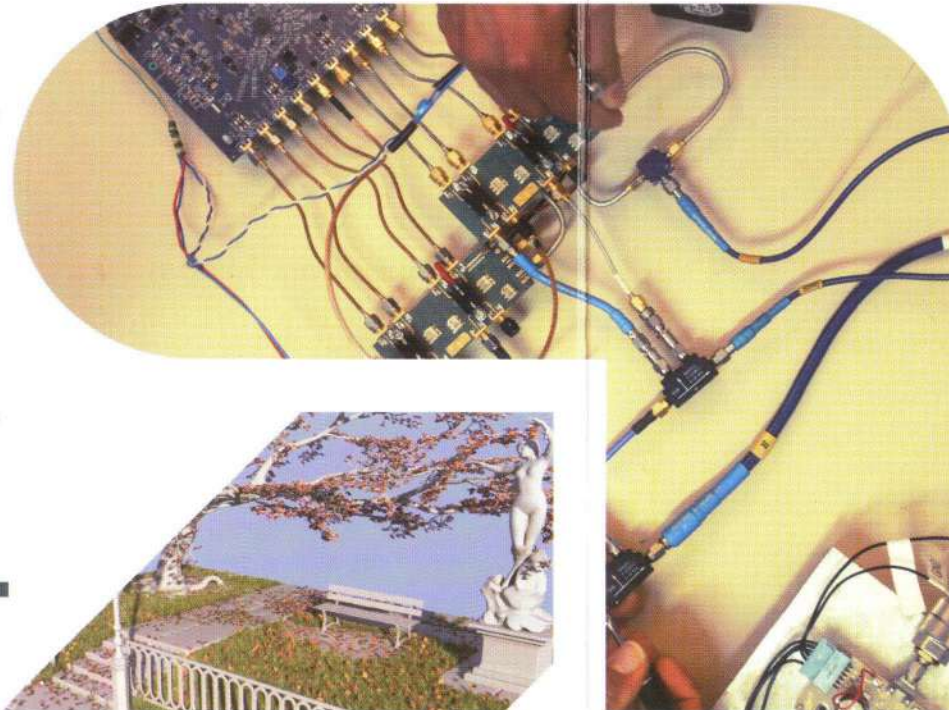### ● RF-ELITE (RF and printed ELectronics for Telecommunications and Energy)

The expertise of this department relies on development of innovative electronic and optoelectronic components using emerging micro and nano technologies based on new processes, devices and functional materials integration. These developments are carried out for electronic and optoelectronic systems from low frequency up to the THz domain.

● RF SYSTEMS

The research activities carried out in this department concern components, circuits and systems in the field of radio frequencies from a few hundred of MHz to some hundred of GHz and are applied to the design of new equipment for wireless communications, detection and localization, in the field of ICT, safety, defense and space.

● FIBRE PHOTONICS AND COHERENT SOURCES

The research activities include the study of fundamental phenomena connected with the propagation of coherent optical radiations in linear and nonlinear complex media, the design of advanced lasers and imaging systems, the design and realization of specialty optical fibres and fibre components.

KEY FIGURES
(2011-2016)

14	start-ups since 2004	**6**	joints laboratories since 2004	**58**	patents
30%	of articles co-authored with international laboratories	**35**	jobs/year on own resources	A research consolidated budget of 19.5 M€/year with 30% own resources	
38%	of contractual resources with industrial companies	**14**	fundings/year from industrial companies	**4-5**	cofundings/year with government agencies

1 COOPERATIVE RESEARCH CENTER HAP@XLIM

- for stimulating interdisciplinarity
- for contributing to the emergence of new research topics

1 LABORATORY OF EXCELLENCE SIGMA-LIM

in partnership with the SPCTS laboratory UMR 7315. The objective is to develop specific ceramic materials and components to secure, smart and integrated communication systems. Sigma-Lim is a project of the French National Research Agency program "LABEX"

2 PLATFORMS IN SUPPORT OF RESEARCH PROJECTS, OPEN TO INDUSTRIAL PARTNERS

THE PLATINOM platform is the technological resource centre of XLIM (180 m² clean room, 3 optics fiber drawing towers, measurement benches, electromagnetism and laser optics instrumentation).

THE PREMISS platform applies interdisciplinarity by grouping together modeling and simulation activities in XLIM, from materials to systems.

1 INDUSTRIAL CHAIR *DEFIS-RF*

is a four years collaborative project for enhancing and developing research and higher education on the DEsign of Future Integrated Smart Radio Frequency transmitters. It is co-funded by the French National Research Agency (ANR) and Thales.

14 START-UPS SINCE 2004

AMCAD Engineering – APTICOD (acquired by Eurofarad) DEVOPSYS – DIOPTIK PEARL – LEUKOS HORUS LASER – WYTEK – NOVAE GLOPHOTONICS – AIRMEMS TCM – KAMAX Innovative System – VTD (acquired by AGILENT)

6 JOINT LABORATORIES

AXIS (Thales)
NXL (NXP)
MITIC (III-V lab)
LEV3E (CEA Gramat)
XLAS (CILAS)
INOGYRO (Inoveos)

Founding member of the
"ALPHA ROUTE DES LASERS & DES HYPERFRÉQUENCES"
competitive cluster (ALPHA-RLH)

PREMISS

PLATFORM GATHERING TOOLS FOR MODELLING AND SIMULATION OF SYSTEMS

The PREMISS platform applies interdisciplinarity by grouping together modelling and simulation activities in XLIM.

OFFERED SERVICES

Being at the interface of physics, mathematics and computer science, PREMISS offers several services:

- Models development, from materials to circuits
- Simulators development
- Inventory, archiving, diffusion and dissemination of calculation codes

This platform is intended not only for XLIM members but also for their collaborators, whether they are academic researchers or industrials. It pursues its goals by several means:

- By offering a software forge available at forge.xlim.fr
- By integrating new models or existing ones in systems simulators, especially in a home-made simulator of complex systems named as SCERNE. More information: www.xlim.fr/plateformes/premiss/developpement-de-modeles-et-integration
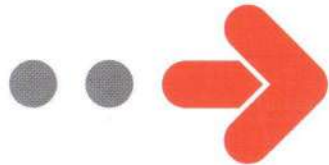
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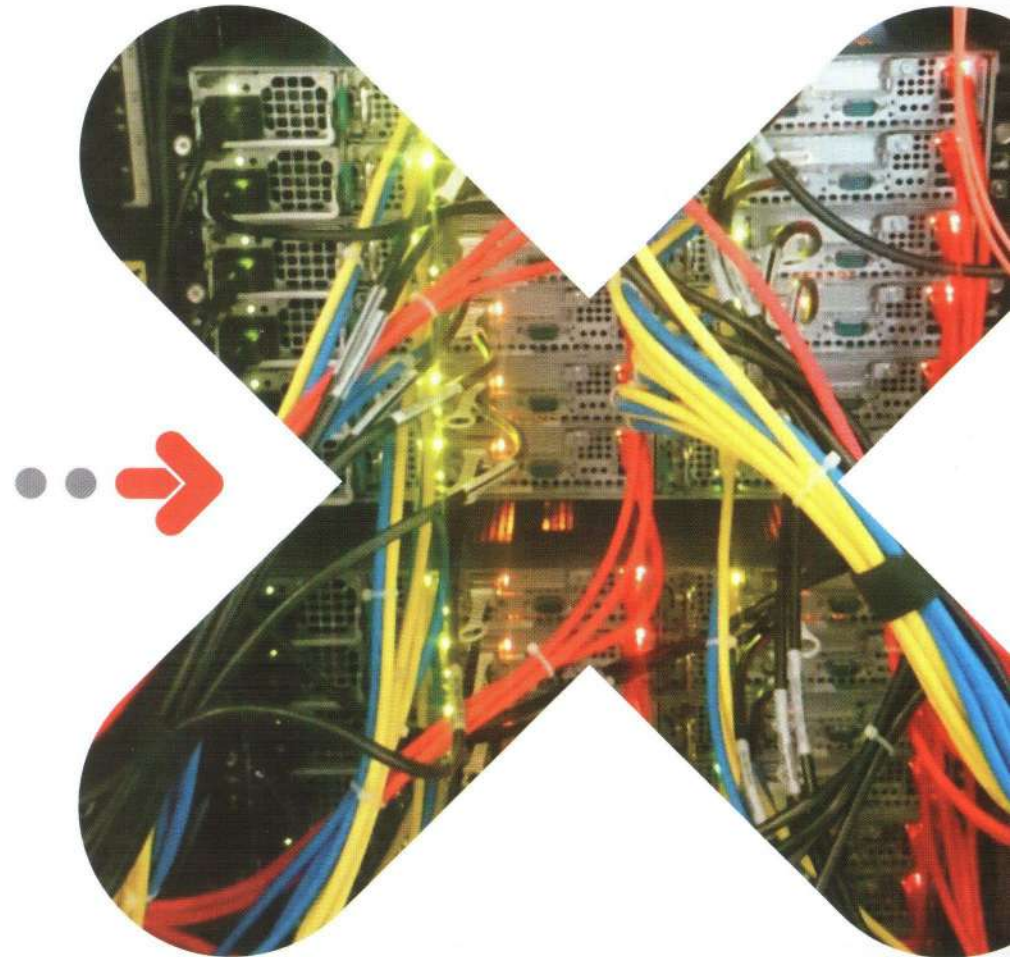87060 LIMOGES CEDEX
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PREMISS

PLATFORM GATHERING TOOLS FOR MODELLING AND SIMULATION OF SYSTEMS

PREMISS
PLATFORM GATHERING TOOLS FOR MODELLING AND SIMULATION OF SYSTEMS

SOFTWARE FORGE

forge.xlim.fr

Tools aiming at sustainability and dissemination of models and simulation codes.

- Software forge
- Computer code
- Git
- Subversion (SVN)
- Sustainability
- Dissemination

The PREMISS platform has set up a software forge. This tool is structured around a website (http://forge.xlim.fr) and offers services enabling to develop informatics projects in a collaborative manner, easing project management and increasing visibility.

The reason of being of the software forge is the sustainability of the projects developed in XLIM and beyond. It fights against the obsolescence of calculation code by saving them and by easing their maintenance and the collaborative writing of rationalised documentation. Therefore the forge enables for an increase of the quality of calculation code, which in the long term is beneficial for its dissemination.

The PREMISS platform also brings its know-how to realise the porting of code to different operating systems and the creation/enhancement of human-computer interfaces, while supplying information for the choice of relevant software licenses. The path toward dissemination is then shortened and communication can be more efficient.
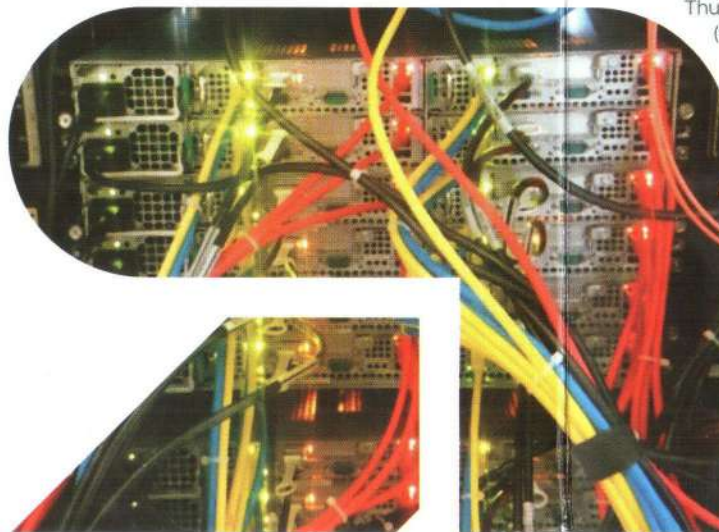
MODELS DEVELOPMENT AND INTEGRATION

TOWARD SYSTEM SIMULATION.

PREMISS accrues XLIM's know-how, stimulates the creation of new models and integrates them in system simulators.

- Models
- Simulators
- Integration
- System simulation
- Interface with commercial softwares

XLIM and to a greater extent the Sigma-LIM Labex generate a significant modelling activity, from technology to circuits. In parallel, optimisation algorithms and mathematical analysis tools are also developed. The simulator called SCERNE (Simulation of Emission/Reception Chains of New Generation) integrates these elements and enables the models to be integrated into a multi-domain heterogeneous system simulation.

MODELS DEVELOPMENT

The PREMISS platform offers a modelling service in support of XLIM's scientific activity. Moreover it enables the reuse of already developed code thanks to the software forge.

INTEGRATION INTO SYSTEM SIMULATORS

The PREMISS platform offers model integration (whether new or ancient models) in system simulators which deal with broader scientific thematic (multi-physics and multi-scale). In particular it ensures the development of SCERNE in support of collaborative research projects whether they are internal (XLIM/Sigma-LIM) or external.

SCERNE'S ARCHITECTURE

SCERNE is interfaced to Matlab/Simulink and therefore it consists of block-schemes with can be graphically cabled into circuits or systems. These blocks may represent devices, small circuits, tabulated experimental characteristics, matrixes of S-parameters, etc.

Thus it is possible to use physical models (thermal, electrical, electromagnetic…), blocks of circuits/systems numerical simulation and experimental data coming from electrical characterisation to simulate for instance the performance of large dimension systems with a very good accuracy. SCERNE is provided with simulation control tools (parameters sweep, statistical analysis and optimisation) in order to evaluate upstream complex architectures or innovative concepts.

SCERNE plateform… for an efficient hierarchical modeling process
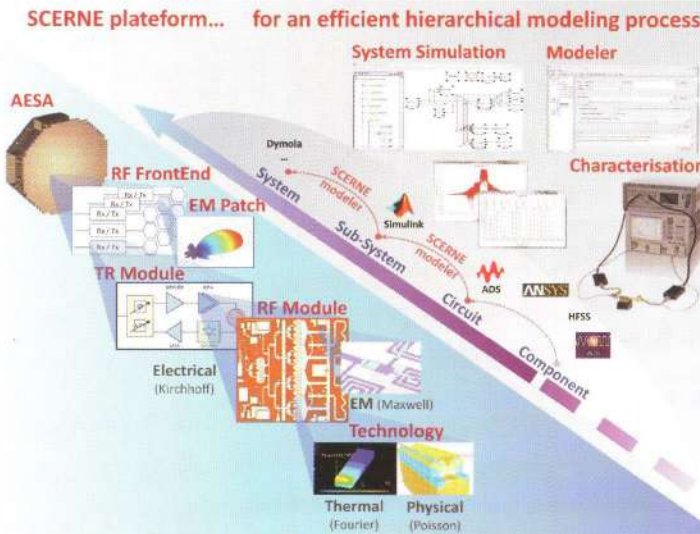
SCERNE'S OPENNESS FOR DISSEMINATION

SCERNE features APIs (Application Programming Interfaces) which enable it to be open to commercial softwares.

EXISTING APIs:

- Thalès/SAFAR (network antennas)
- Thalès/ASTRAD (radar)
- Matlab/Simulink

APIs IN DEVELOPMENT:

- Keysight/SystemVue
- Keysight/Ptolemy
- AWR/VSS

APIs IN THE PLANNING STAGE:

- Dassault-Système/Dymola
- Altair/Hyperworks