

RESEARCH
BUSINESS
REPORT

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BUSINESS
REPORT

2008/2009/2010



Research

Research and technology transfers are the core business of our Institute. During the 2008-2010 period, INSA-Rennes' scientific policy has placed the emphasis on synergy with its local and regional environment. The involvement of our research teams in joint laboratories with staff from PRES UEB - (Brittany European University) has allowed us to reach critical mass while preserving the level of excellence that permits our teams to compete on the international stage.

In the Audit Report from the AERES Committee of Experts for the 2006-2009 period, research is mentioned as one of the Institute's strong points, particularly in terms of favorable indicators, good resources and excellent potential.

The results of the last three years are therefore very positive:

- good audit results for our laboratories,
- significant growth of the contractual activity,
- increase in the numbers of Ph.D students,
- significant investment in PRES UEB,
- strong involvement in business clusters and systems of investments for the future.

The audit of the "UMR" (joint research units) in which INSA-Rennes is involved produced the following grades: A+ for the two IRISA and IRMAR units, A for FOTON, IETR and SCR, and B for the Associated LGCGM team. In fact, the audit of the INSA teams within these units is very positive, with most of them receiving an A grade and others A+. This reflects the excellence of the research undertaken at INSA-Rennes.

Contract work with industry has undergone strong development. The financial value of the contracts has risen by 30% over the last four years and now stands at more than 4 M€ per year, including VAT. The "Civil Engineering and Mechanical Engineering" platform was set up in 2010. In the future, it will enable us to offer new industrial partners some outstanding resources for full-size testing. The significant efforts in terms of publications, papers and numbers of contracts made by the various researchers in the Institute was particularly appreciated by the AERES Committee of Experts.

In line with the increase of the number of cooperative projects, the number of Ph.D students and theses also rose significantly - from 135 Ph.D students in 2007/2008 to 159 in 2009/2010 and from 37 theses in 2007 to 44 in 2010.

Over the last three years, INSA-Rennes has also increased its investment in PRES UEB, playing a leading role in the direction of its research work through vice-presidency of the Scientific Council.

Last but not least, INSA-Rennes has continued to be involved in business clusters and has made a significant contribution to the drafting of a large number of dossiers for investments for the future (Labex CominLabs, IRT B-COM, IDEX IC Ouest, SATT etc.).

In doing so, INSA-Rennes has continued to confirm its ambitious development policy for partnered research by increasing its many cooperative projects at regional, national and international level and facing the scientific challenges of the future.

Jean-François HELARD
Director of Research

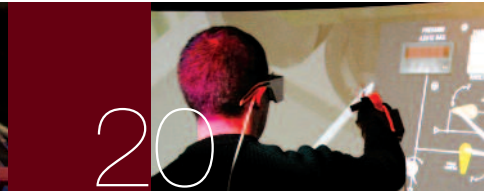
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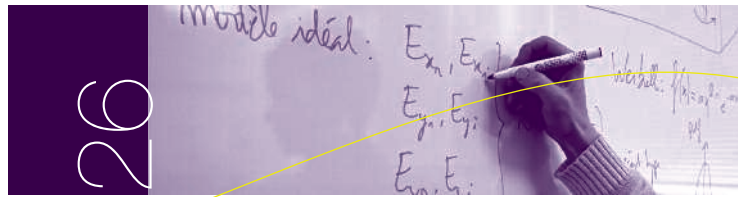
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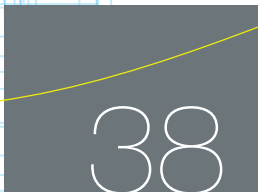
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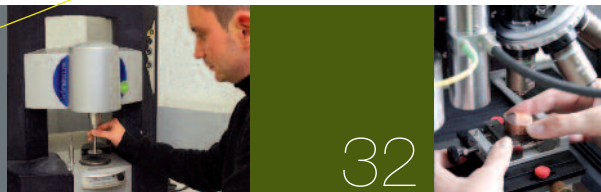
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Areas of research

Over the 2008-2010 period, INSA-Rennes improved the structure of its research, in partnership with other institutions in Brittany and two national research agencies, CNRS and INRIA. The current structure is the result of initiatives taken in its research laboratories and a policy aimed at encouraging new projects, notably through the redeployment of its human resources.

To be more precise, its lecturer-researchers work within two poles that are focusing on the development of new information and communication technologies (STIC Centre - Sciences and Technologies of Information and Communication) and the invention of new sustainable, environmentally-friendly materials and structures (MSM Centre - Materials, Structures & Mechanical engineering).

The main areas of excellence lie within 5 strategic specialties:

- Computer networks, imaging and virtual reality,
- Nanostructures and On-Chip photonics,
- Antennae and digital communications systems,
- Materials and systems engineering,
- Statistics and applied mathematical analysis.

These spheres of work, which are closely linked to the specialist engineering courses available at INSA, provide an overall response to the needs expressed by the socio-economic world.

Staffing levels and results (2008 - 2010)

Staff in December 2010 and AERES evaluation

Research is conducted in 6 laboratories employing 112 lecturer-researchers, 33 engineers, technicians and admin. staff (IATOS) and 159 Ph.D. students. According to AERES criteria, 90% of the lecturer-researchers at INSA-Rennes are considered as productive.

The results from the assessment committees (AERES, CNRS, INRIA) carried out in 2010 reflect the excellence of the research undertaken within the 5 research units (UMR) and the one associated team (EA):

	Professors associate- professors	IATSS*	Ph.D. students 2009/2010	AERES assessment end 2010
UMR CNRS 6082: FOTON-INSA Optical Functions for Information Technology	17	9.3	13	A
UMR CNRS 6164: IETR-INSA Institute of Electronics and Telecommunications - Rennes	25	7.85	59	A
UMR CNRS 6074: IRISA-INSA Institute of Research in Information Science and Random Systems	18	2	29	A+
UMR CNRS 6625: IRMAR-INSA Mathematics Research Institute - Rennes	14	1	4	A+
UMR CNRS 6226: SCR-INSA Chemical Sciences - Rennes	11	5	9	A
EA 3913: LGCGM Laboratory of Civil and Mechanical Engineering	27	7.95	45	B
Total	112	33.1	159	

* Engineers, technicians, admin. staff



Research

Academic results

Year	Master's*	Thesis presented**	Thesis presented through 2 institutes**	HDR***
2008	72	29	1	4
2009	68	30	5	3
2010	63	44	3	1
Total	203	103	9	8

* Matriculated at INSA-Rennes - ** Presented during the calendar year

*** Habilité à diriger des recherches (accredited as research director)

Scientific and contractual results

Year	International publications	International communications	Income from research contracts*	Patents / Extensions
2008	172	229	3 947	1/5
2009	141	256	3 879	2/8
2010	140	199	3 470	4
Total	453	684	11 296	7/13

* excluding CNRS and INRIA credits in K€ - value excluding VAT



INSA-Rennes has received significant funding (from local and regional authorities, CPER etc.) for the construction of the Technology Platform (PFT) and for significant investments. Assistance from local and regional authorities takes the form of involvement in the CPER - Contrat de Projets Etat-Région (15% of the fundings), funding to cover the costs of hosting professors, grants for Phd students and research projects. INSA-Rennes' involvement in Networks of Excellence and European projects is on the rise and must continue in years to come.

Lastly, business start-ups remain a priority for technology transfers from within the Institute and two of them won awards in the MESR competition, in the "Emerging Companies" and "Start-ups and Development" categories

The research teams have recorded ongoing, sustained growth in scientific output compared to the previous period. This is reflected in the significant increase in the number of publications in international journals (453 publications over the 3-year period), with an annual average of 2.6 publications per Full Time Equivalent in research.

The AERES committee has especially noticed the scientific production as the number of invited papers at international conferences (40 within 3 years). Likewise, the Institute's researchers attend large numbers of international conferences and congresses (684 international communications), more than a dozen of which are organised each year by teams from INSA-Rennes. As regards the protection of results, a portfolio of 15 groups of patents and 30 registered software programs has been in existence since the end of 2010.

Lastly, the financial value of research contracts amounting to 11,296 M€ excluding VAT over the last three years (not including CNRS and INRIA funding), also shows a significant, 30% rise compared to the previous period.

Industrial, academic and international cooperation

Industrial partnerships

The fundamental and applied research undertaken at INSA-Rennes is based on a large number of partnerships with the world of industry. Research work plays an active role in the dynamic of regional and national socio-economic development through business clusters and national, European and international programmes.

Funding for research over the 2008-2010 period has come from industrial partnership contracts and consortia (36%), ANR (national research agency) projects (27%), European projects (7%) and public funding on a regional and local level (30%). This distribution reflects the duality of upstream and finalised research and the strong partnership with industry (cf. figure 1). A marked increase in ANR agreements is evident compared to the previous period and there has been a similar rise in cooperative projects linked to business clusters. This corresponds to the current method of funding for research.

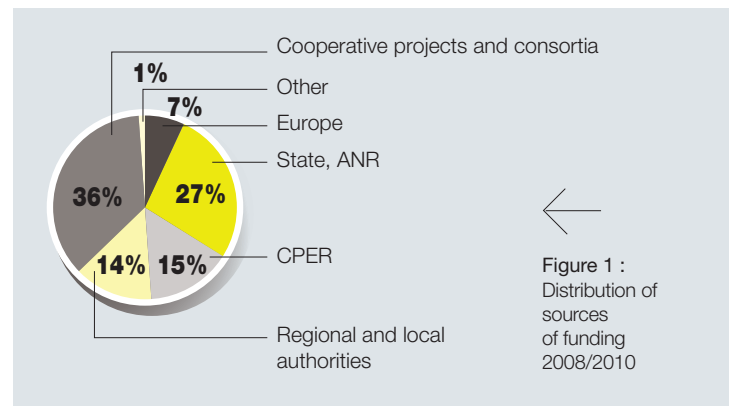


Figure 1 : Distribution of sources of funding 2008/2010

Business clusters

With its academic and industrial partners, INSA-Rennes has been involved in the setting up of business clusters. At present, its research teams are partners in several projects accredited by four business clusters - Imaging & Networks, Sea, iD4CAR and EMC2.

Business clusters	Accredited projects
Imaging & Networks	TECHIM@GES, SCALIM@GES, MOBILE TV WORLD, SVC4QoE
	CAPNET, PART@GE, LAMBDA@CCES, CASTEL
	CP2C, ScriptEveryWhere, METAPHORT, MOBISKETCH
Mer	RUBI3, M ³ , CORVETTE TRIMARAN, ARA ICOS-HD, ENGINES
iD4CAR	INTERNET PECHE BAS COUT, GRAND LARGUE, SAPHIR
	CIRHMA, CIFAER

The lecturer-researchers at INSA-Rennes are extensively involved in the governance of two of the four clusters, in particular the global Imaging & Networks cluster. Almost all the projects accredited by the business clusters have been funded by ANR or Brittany Regional Council.

Government/Region project contract

In 2006, INSA-Rennes negotiated its involvement in the Government/Region project contract for the 2007-2013 period. The Institute has enjoyed joint support from both partners for the development of the following projects: PALMYRE 2 (platforms for future communications systems), PONANT (nano-objects for photonics on InP and silicon substrates), Support Invent'IST (virtual reality and GRID 5000) and PRINTAN (materials and systems engineering).

European Networks of Excellence

Research teams from INSA-Rennes are currently involved in six European Networks of Excellence, working either on steering committees or in working groups. A number of research projects undertaken jointly with these networks are based on the Institute's platforms e.g. the nanostructure technology platform (FOTON - INSA) and the close field measurement system for integrated antennae (IETR - INSA).

European Networks of Excellence	Acronym	Partners
Network of excellence (NoE) "Antenna Center of Excellence"	ACE 2	50 partners (including 21 industrial) 17 countries represented Partially extended since 2008 within the European EurAAP association
NoE Photonic Integrated Components and Circuits	ePIXnet	32 partners (including 9 industrial) 11 countries represented
NoE Self-Assembled semiconductor Nanostructures for new Devices in photonics and Electronics	SANDIE	28 partners (including 5 industrial) 11 countries represented
NoE Wireless COMMunications	NEWCOM ++	33 partners 10 countries represented
NoE Virtual reality and virtual environments applications for future workspaces	INTUITION	68 partners 15 countries represented
NoE Grids and peer-to-peer technologies	CoreGrid	41 partners
NoE Service-oriented architectures and grid	S-Cube	15 partners 10 countries represented
NoE Resistance to faults and system security	ReSIST	20 partners 8 countries represented

European projects

INSA-Rennes has taken part in numerous European projects, particularly within FP7:

European projects	Acronym	Partners
ICT FP7 Home Gigabit Area, Converged Ultra High Speed Home and Access Networks	OMEGA	20 partners 8 countries represented
ICT FP7 Wireless Hybrid Enhanced Radio Positioning Procedures	WHERE	14 partners 10 countries represented
ICT FP7 Natural Interactive Walking Project	NIW	6 partners 4 countries represented
ICT FP7 Development of a platform for the auto-repair of web-services	WS-Diamond	8 partners 4 countries represented
Broadcast for the 21 st century (programme CELTIC)	B21C	32 partners, including 24 industriels 7 countries represented
Enabling Next Generation Networks for Broadcast Services (programme CELTIC)	ENGINES	26 partners 5 countries represented
European Space Agency project (large antenna networks for satellites)	ARTES	
NanoBioAll on alloys for biomedical use (EUREKA programme)	MNT-ERA-net	
Optimisation of seismic efficiency of steel and mixed concrete / steel constructions	OPUS	7 partners 5 countries represented

International cooperation

Generally speaking, the improvement to the quality of scientific output from INSA-Rennes gives its research teams more of a draw card on an international level. In addition to contract work, two indicators are used to measure this favourable development: the increase in the numbers of foreign students studying for a Master's in research or a Ph.D and the ongoing increase in the number of Post-doctoral positions remunerated by research contracts of the Institute.

To encourage international mobility among Ph.D students, the Scientific Council at INSA-Rennes has instigated a system which complements the ones already on offer from PRES UEB and Rennes Métropole. In the long term, the aim is to provide every Ph.D student in the Institute with international experience. Moreover, during the 2008-2010 period, some fifteen theses were prepared through two establishments, with dual direction or joint mentoring provided in partner laboratories in various countries e.g. Cambodia, Vietnam, Lebanon, Morocco, Algeria, Senegal, Tunisia, Sweden, Italy, Armenia etc. Another example of international cooperation is the UT-INSA-CSC programme with China, which has allowed 24 Chinese Ph.D students to come and work with research teams at INSA-Rennes since 2006.

Lastly, INSA-Rennes welcomes some fifteen guest professors every year, for periods of between one and six months. The mobility of teaching staff adds to the training of students taking Engineering and/or Master's in Research courses with lectures and seminars, and strengthens the international dimension.

Training for research jobs

Master's in research

As part of the joint accreditation with its partners in Brittany, INSA-Rennes is considered as the main establishment for the management of two Master's degrees in Research (cf. figure 2):

- Master I-Mars (Microtechnology Architecture Networks and Communications Systems)
- Master IMGEC (Mechanical and Civil Engineering).

For the five other Master's degrees, INSA-Rennes's involvement is essentially on a teaching level. Students taking these courses provide a significant pool of resources for laboratories. The percentage of foreign students is on the rise.

Ph.D courses

Laboratories at INSA-Rennes welcome and mentor Ph.D students. As a member of the Board for the two Ph.D colleges, MATISSE (Mathematics, Computing, Signals, Electronics and Telecommunications) and SDLM (Science of Matter), INSA-Rennes plays an active role in training Ph.D students.

The number of Ph.D students has risen significantly, from 135 for the university year 2007/2008 to 159 for the year 2009/2010 (cf. figure 3). The sharp increase in the number of students should be compared with the increase in the number of cooperative projects over the same period. In 2009/2010, 92 Ph.D students matriculated in MATISSE and 67 in SDLM. Figure 3 details their distribution across the various INSA-Rennes laboratories.

The number of Phd defenses over the last three years has also undergone a significant increase, rising from 29 in 2008 to 44 in 2010. During the last year, 2010, the 44 theses were presented after an average of 40 months. The proportion of foreign Ph.D. students is also significant; it now far exceeds 50% of the total (cf. figure 4), showing the international attraction of INSA research teams.

Funding for Ph.D. students is diversifying (cf. figure 5). Over the 2008-2010 period, the portion from research grants amounted to 24%. The level of funding from research contracts has significantly increased over the same period, representing more than 17% by the last year. The level of funding provided through CIFRE agreements practically doubled compared to the previous period. It now accounts for 18% of funding.

INSA-Rennes monitors its Ph.D. graduates' entry in the workplace jointly with the Ph.D. colleges (cf. figure 6). Overall, their position in the jobs market is very positive. This observation is reflected in the level of jobseeker payments (Allocations pour la Recherche d'Emploi, ARE) paid by the Institute. They are rare and never last for more than a few months.



Figure 2 : Admissions to Master's in Research

	New students in Master's in Research	Incl. foreign students	Incl. engineering students
2008/09	72	47	28
2009/10	68	50	21

Figure 3 : Number of Ph.D students registered at INSA-Rennes per laboratory in university year 2009/2010

University year	FOTON	IETR	IRISA	IRMAR	LGCM	SCR	TOTAL
2009/10	13	59	29	4	45	9	159

Figure 4 : Admissions to Ph.D.

	Nb. of Ph.D. students	New Ph.D. students	Incl. foreign Ph.D students
2007/08	135	44	22
2008/09	154	49	25
2009/10	159	39	25

Figure 5 : Funding of Ph.D. students matriculated in 2008/2010

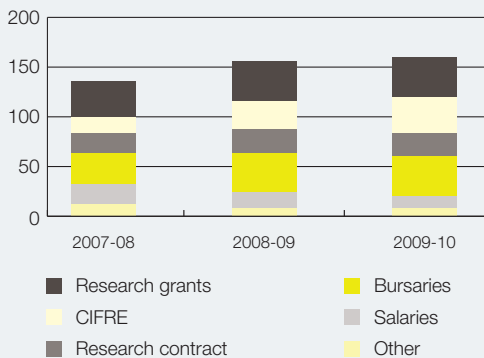
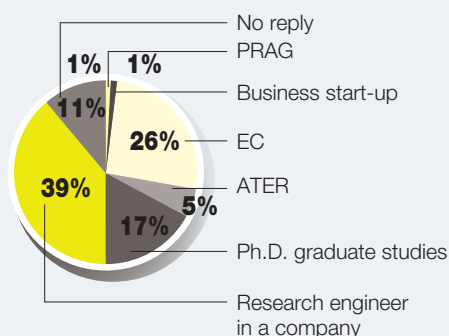


Figure 6 : Employment of Ph.D. graduates from INSA-Rennes in 2008/2010 (ATER: Temporary Lectureship/Research position; EC: Lecturer-Researcher; PRAG: Senior Lecturer ("agrégé"))



Prospects

The significant efforts in terms of publications, papers and numbers of contracts made by the various researchers in the Institute over the 2008-2010 period was particularly appreciated by the AERES Committee of Experts, which emphasised the Institute's excellent potential for research. These efforts will be maintained over the next few years and there will be an attempt to increase the percentage of lecturer-researchers who publish work, even though, at 90%, this figure is already high.

In the short or medium term, a number of actions will be continued or developed:

- Increased involvement of the laboratories in business clusters, ANR research programmes and European programmes.
- As part of the investments for the future, INSA-Rennes contributed to the preparation of a number of dossiers and is particularly involved in the following successful projects:
 - COMIN Laboratory of excellence - FOTON, IETR and IRISA laboratories,
 - B-COM Institute for Technological Research - FOTON, IETR and IRISA laboratories
 - La Société d'Accélération et de Transfert Technologique (SATT) Ouest Valorisation.

Involvement of all the researchers at INSA-Rennes will further strengthen this role and the visibility of the research units overall, and the Institute in particular, within these various entities. Linked to investments for the future, they are being set up for a period of ten years.

- The Institute will seek new resources and new partnerships, with an emphasis on long-term agreements. Links with companies and partnerships should aim to further increase the connections with business, INSA-Rennes and INSA group alumni and regional and local authorities.
- The "Civil and Mechanical Engineering" technology platform will provide new partners with ambitious resources for full-sized testing. More generally, support will continue for the development of efficient technical platforms.
- To maintain the attraction of INSA-Rennes and offer young lecturer-researchers an environment favorable to the production of high-quality research, the service arrangement system will be continued. Likewise, the CRCT attribution policy, to enable a researcher to prepare HDR or to convert an area of research with strong potential within a foreign laboratory, will be maintained. In the same way, INSA-Rennes will continue to encourage secondment applications for EPST (CNRS and INRIA) to further increase the research activity of the lecturer-researchers who benefit from the system.

FOTON-INSA Optical Functions for Information Technology

UMR CNRS 6082

Research

FOTON-INSA is the INSA branch of CNRS research unit 6082 FOTON. It is a joint research unit, combining research teams from the University of Rennes 1, TELECOM Bretagne, ENSSAT-Lannion (Ecole Nationale Supérieure des Sciences Appliqués et de Technologie) and INSA-Rennes.

FOTON-INSA is now well-known and recognised for its excellence in nanotechnologies. Its research concentrates on the growth, study and use of the electrical, optical and opto-electronic properties of structures with quantum wells and dots.

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**FOTON-INSA
In Brief**

- Nanostructures
- Photonics
- Optical telecommunications
- Ultra-high-speed component
- Lasers
- Quantum dots
- Carbon nanotubes
- Epitaxy
- Nanophysics
- III-V semiconductors
- Silicon photonics
- Nanotechnology

Its most outstanding feature is its high-level skill in material III-V components for photonics. Its expertise in growth by molecular beam epitaxy makes it a world leader in quantum dots for the active zones of the lasers used in telecommunications.

FOTON-INSA was one of the laboratories behind the setting up of the PONANT scientific group working on optics for the telecommunications industry. The group receives active support from Brittany Regional Council and involves several research teams from TELECOM Bretagne, ENSSAT-Lannion, the University of Rennes 1 and INSA-Rennes. FOTON-INSA is also involved in the "Optical Telecommunications" project within the "Imaging & Networks" business cluster.

Research teams

The FOTON-INSA laboratory employs some 40 people, working in three areas of research:

- **Nanostructures for optical telecommunications**
The laboratory's main area of research.
Contacts : Rozen Piron, Cyril Paranthoën, Olivier Dehaese
- **Nanostructures for mid infrared**
Diversification into the medical, Defence and environmental sectors
Contacts: Nicolas Bertru, Herve Folliot, Mathieu Perrin
- **On-chip photonics**
VHB components for optical interconnection and high-performance photovoltaic cells.
Contacts: Olivier Durand, C. Cornet

Staffing levels and results (2008-2009-2010)

Staffing levels

Year	Lecturer-Researchers	ATER Ph.D students**	Ph.D graduates	IATOS*	
2008	18	1	14	1	8,7
2009	19	0	11	0	8,7
2010	19	0	12	0	8,7

Academic results

Year	Masters**	Thesis presented	Thesis presented through 2 institutes	HDR
2008	12	5	0	0
2009	7	2	1	0
2010	2	5	0	0
Total	21	12	1	0

Scientific and contractual results

Year	Publications	Papers	Current contracts	Patents
2008	27	30	8	0
2009	19	15	9	0
2010	16	19	9	0
Total	62	64	26	0

*Engineers, Technicians and Admin. staff - **Matriculated at INSA-Rennes

Equipment - New resources

FOTON-INSA now has equipment for optical characterisation (optical absorption luminescence, subpicosecond pump-probe measurements, laser characterisations), electrical measurements (I-V, C-V, Hall), nanometric characterisation (AFM) and structural characterisation (x-rays). Its technical platforms include two epitaxy chambers (GSMBE and SSMBE) for III-V materials, an LPCVD chamber for Si and Ge materials and a clean room.

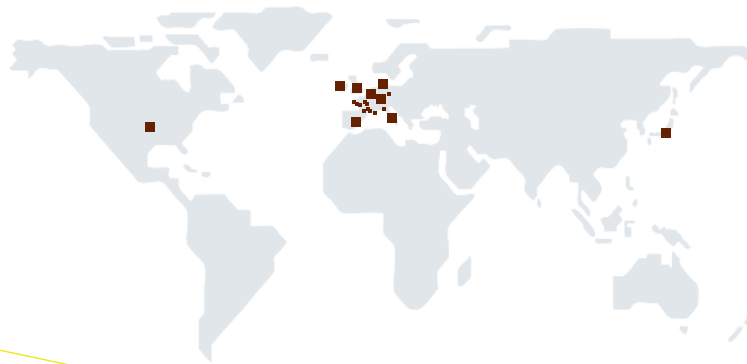
Over the last few years, the major material change to the laboratory has been as follows:

- **installation of a new LPCVD epitaxy chamber (January 2010)**
This latest-generation chamber (Riber LPCVD 21) used for Si and Ge growth is connected to the III-V epitaxy chamber (Riber SSMBE compact21). The cluster is useful for the on silicon substrate growth of heterogeneous structures and III-V nanostructures and the development of technologies that will lead to the convergence of photonics and microelectronics on silicon substrate.
- **modernisation of the clean room**
The clean room was renovated and extended to 140 sq. metres to allow for the installation of a consistent set of equipment: 2 RIE chambers for dry etching of III-V semi-conductors and silicon, an electron gun for metal contact deposits, a sputtering chamber and a PECVD chamber for dielectric deposits. In 2009, FOTON-INSA purchased a new-generation Süss Microtec MJB4 alignment system that integrates a nanoprinting function.

Since 2002, the technical areas for FOTON-INSA and the IETR micro-electronics team have been combined within the NanoRennes platform, which is a member of the proximity technology centres network (C'Nano). The agreement was renewed by the CNRS in 2009. The platform specialises in technologies for microelectronics and photonics.

Today FOTON-INSA has expertise in the growth and technology of III-V optoelectronic components. A new area of highly competitive development is on silicon substrate photonics. This is an area with high potential, which will lead to the convergence of photonics and electronics.





Research

Networks and partnerships

FOTON-INSA enjoys international recognition for its areas of particular expertise:

- **world leader in quantum dots**
- **partner in two European networks of excellence, SANDIE and ePIXnet**
- **involvement in, or organisation of, international workshops**

The SANDIE European network of excellence focuses on the growth and study of quantum nanostructures. FOTON-INSA is reputed for its expertise in the growth of quantum dots. As to ePIXnet, this network is more concerned with new-generation optical components and functions for the telecom sector. FOTON-INSA is project leader for the study of ultra-fast direct modulation lasers based on the use of quantum dots.

Within these two networks, FOTON-INSA works closely with the LPN (Laboratoire de Photonique et Nanostructures) in Marcoussis on the organisation of international workshops:

- IPRM' 2008 20th International Conference on indium phosphide and related materials
- ePIXnet international workshop in July 2008, entitled SQDA (Semiconductor Quantum dot Devices and Applications)
This seminar followed on from the IWSQDA and LWQD conferences co-organised by FOTON-INSA in 2006 and 2007. Its main subject was quantum box components, the corresponding characterisation techniques and optoelectronic applications.

SANDIE and ePIXnet have helped to establish close partnership between INSA-Rennes and foreign universities:

- Berlin's technical university (D. Bimberg's group) through the ongoing exchanges of Ph.D students and joint work on the simulation of the electronic properties of quantum dots.
- The universities of Louvain and Eindhoven to characterise the dots grown at INSA-Rennes using XSTM and magnetoluminescence.
- The University of Sheffield and the Technical University of Denmark with a view to collaboration on quantum dot lasers.

There is no doubt that these international projects strengthen FOTON-INSA's position in these areas of research.

FOTON-INSA and its partners

- locally: Telecom-Bretagne and ENSSAT, founder members of the FOTON joint research unit, the IETR joint research unit, the SCR joint research unit and the IPR at the University of Rennes 1.
- nationally: LPN in Marcoussis, INL joint research unit in Lyon, LETI in Grenoble, CHREA in Valbonne, CEMES in Toulouse, LAAS in Toulouse, LPCNO joint research unit at INSA-Toulouse and CEA Saclay.
- internationally: TU Eindhoven (Holland), DTU Fotonik (Denmark), TU Berlin (Germany), University of Sheffield (UK), Polytecnico Torino (Italy), Laboratoires Tyndall (Ireland), Tohoku University in de Sendai (Japan), University of New Mexico (USA), University of California Los Angeles (USA).

FOTON-INSA and its joint industrial projects

Joint work with a number of industrial SMEs and other companies is based mainly on projects or contacts established by members of the team. Nanostructures and components for the telecom sector: Kerdry Lannion, Vectra-Wave Loges en Josas, Intexsys Toulouse, Orange Lab, 3-5 Lab Alcatel. Silicon photonics: Ultimara - France, EDF.



Scientific production

Some outstanding research results should be highlighted here:

- optical lasers and SC amplifiers with off-chip transmission using quantum dots and wires (cooperative project with LPN and AT 3-5 lab)
- surface-emitting lasers (VCSEL) at 1.55 μm using polarisation stabilised quantum wires (cooperative project with FOTON-ENSSAT and Telecom Bretagne)
- fast saturable absorbers made with carbon nanotubes for the regeneration of broadband telecommunication signals (with FOTON-ENSSAT and ONERA-LEM).

FOTON-INSA is highly-skilled in the growth of InAs nanostructures on InP substrates. A high density of quantum boxes is required to build lasers. By maximising growth parameters, it has been possible to obtain the highest density of quantum dots ever measured by using (311)B substrates and, more recently, disoriented (001) substrates. The use of a nominal (001) substrate produces a high density of anisotropic dashes (cf. figure 1).

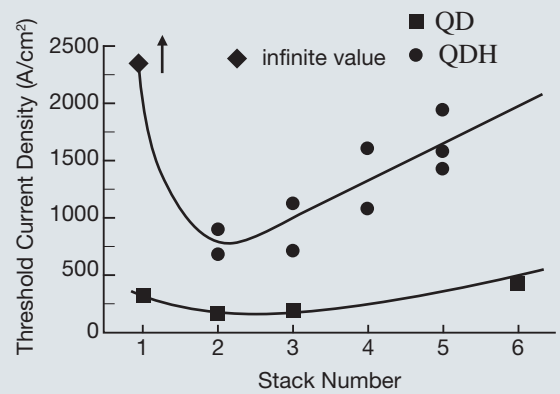
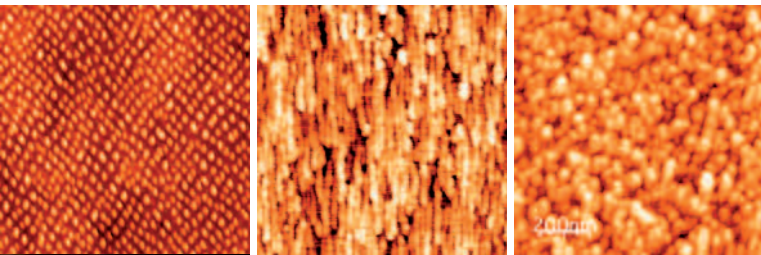
These nanostructures have been used to develop laser sources for optical telecommunications. FOTON-INSA has made some significant progress:

- the lowest threshold currents for wide band lasers (cf. figure 2)
- single-mode lasers with improved dynamic performance
- optical amplifiers with InAs/InP(311)B quantum dot semiconductors and a bandwidth of 70 nm
- impulse laser sources with mode blocked based on the use of quantum dashes functioning at 10GHz (cf. figure 3)

↓ **Figure 1:**
Growth of InAs nanostructures on InP (113)B and InP (001) substrates

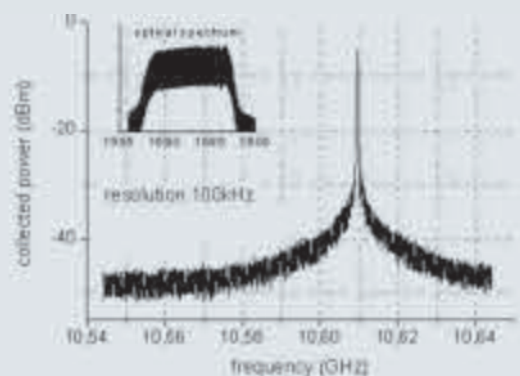
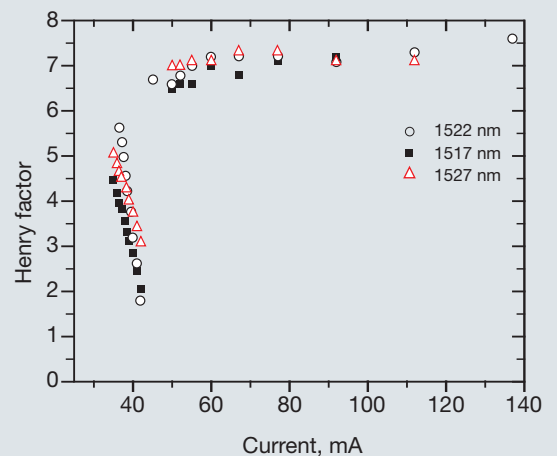
Quantum dots on InP (113)B substrate

Quantum dashes and dots on InP (001) substrate



↗ **Figure 2:**
Results on broad area lasers based on quantum dots ($L_{\text{cav}}=3\text{mm}$) and dashes ($L_{\text{cav}}=1.2\text{mm}$) depending on the number of dot layers (APL 93, 161104, 2008)

→ **Figure 3:**
a) InAs laser ridge with quantum dots on InP(113)B substrate: Measurement of the Henry factor depending on the injection current
b) Two-section mode locked laser using quantum dashes, RF spectrum of the fundamental peak at 10.6 GHz, insert optical spectrum



FOTON-INSA also has developed expertise in the realisation of accordable vertical lasers. These lasers use high-reflectance Bragg mirrors manufactured using dielectric Si/SiNx deposits on each side of the cavity which includes an active quantum nanostructure zone and a liquid crystal phase zone for tunability. The VCSEL tunable laser project is funded by the national research agency, ANR (ANR λ Access project) and has been granted by the "Imaging & Networks" business cluster. An initial demonstration was carried out in 2006 with Télécom Bretagne.

Other outstanding results include:

- the development of a **Flip-chip technology** as a result of joint work with Intexys and CEA LETI on the carryover of the on-chip VCSEL structure and the integration of a layer of liquid crystal for tunability.
- the first demonstration of the **stabilisation of optical polarisation for VCSEL laser transmission** thanks to the use of InAs/InP quantum dashes (cf. figure 4)

FOTON-INSA has developed a centre of excellence for digital simulation of the electronic and optical properties of nanostructures (strong bond, ab-initio and kp methods) and the dynamic properties of optical components (cf. figure 5)

FOTON-INSA has demonstrated the application of carbon nanotubes in telecom area. The ANR CASTEL project aims to use the non-linear optical properties of these carbon nanotubes to build a saturable absorbant for use in the regeneration of an optical signal. By comparison with the AS based on Fe quantum wells, the nanotubes have the advantage of stronger differential transmission, faster dynamics (subpicosecond), total recovery of absorption and a lower

saturation threshold (cf. figure 6). All-optical regeneration using AS based on carbon nanotubes will then be realized at very high rates (>10GHz) on the PERSYST platform at FOTON-ENSSAT.

As part of the CPER PONANT project, FOTON-INSA is expanding its research into silicon photonics. The aim is the development of new substrates consisting of III-V semiconductors epitaxied on silicon. These substrates are suitable for the mass production of large wafers with a view to the monolithic integration of photonic devices on chips. This approach will open the way to the convergence of photonics and silicon-based microelectronics and the development of high-performance photovoltaic cells. The substrates are obtained by MBE growth of III-V diluted nitrogen materials adapted to the lattice parameters of the silicon substrate. These pseudo-substrates must have a very low number of structural defects so that they are compatible with the building of high-performance photonic devices.

Current research is focusing on the following:

- expertise in the initial stages of GaP of growth on Si substrate
- the growth of III-V nanostructures on GaP and Si. First attempt at building a DEL with GaAsPN/GaPN quantum wells on GaP transmitting at 734 nm at ambient temperature (cf. figure 7).

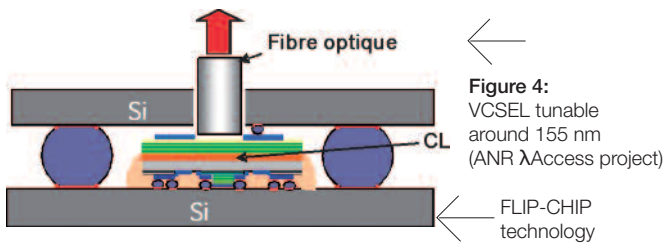
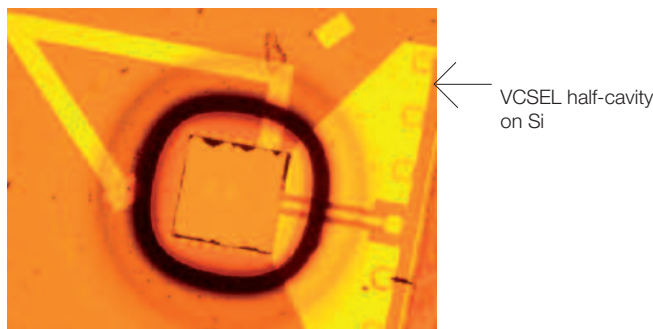


Figure 4: VCSEL tunable around 155 nm (ANR λ Access project).



VCSEL half-cavity on Si

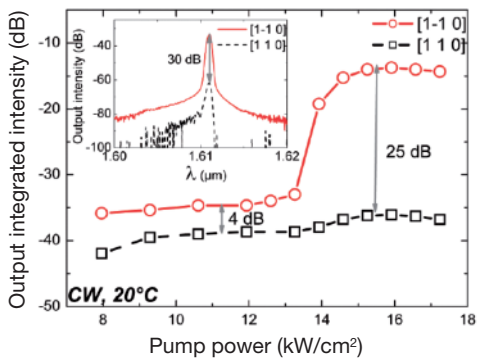
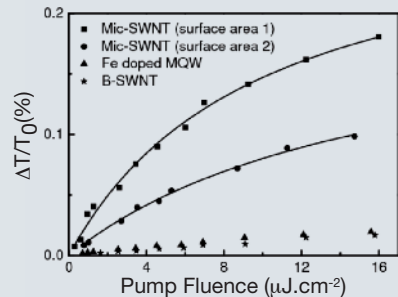
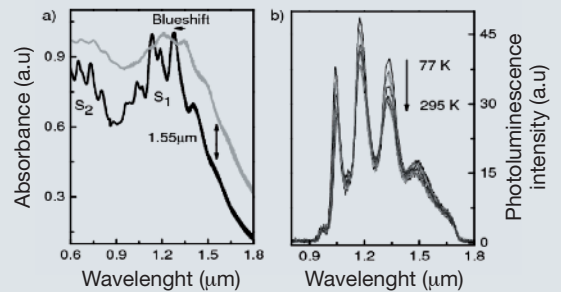
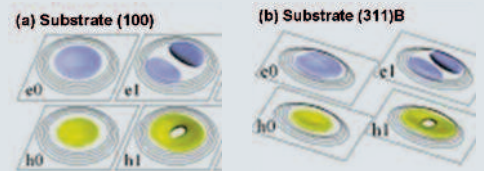
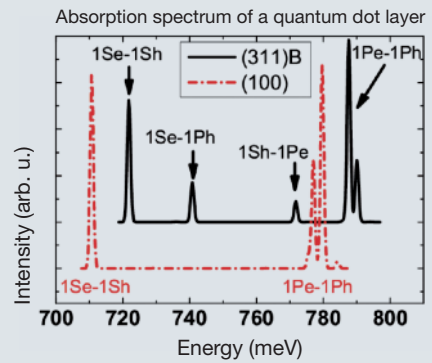
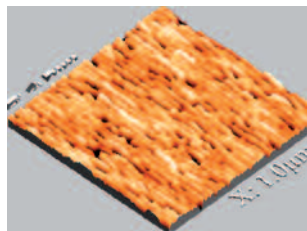
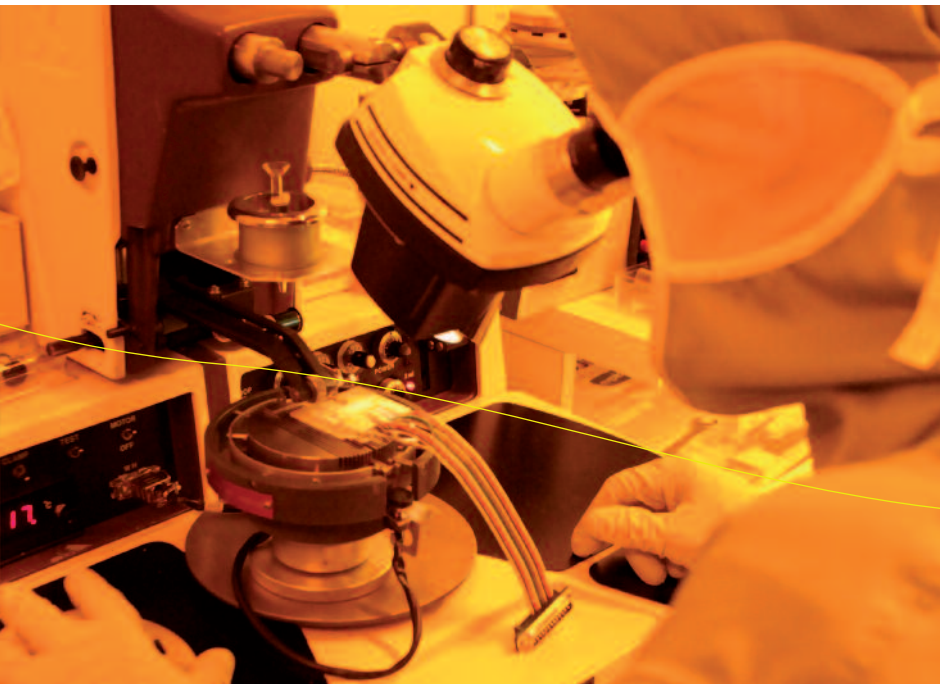


Figure 4: Stabilisation of the optical polarisation of a quantum dash VCSEL





Research

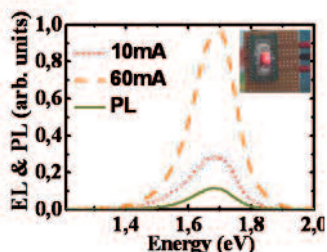


Figure 5:
Absorption spectra and electronic states of InAs/InP single quantum dot layer at $T=0K$ on (113)B and (001) substrate

Figure 6:
Saturable absorber using carbon nanotubes at $1.55\mu m$
a) Absorption spectrum
b) Photoluminescence of SWNT micelles depending on the ambient temperature
c) Differential transmission depending on pump fluency, comparison between an MQW doped with Fe and B-SWNT and Mic-SWNT.



Figure 7:
Electroluminescence of a GaAsPN/GaPN quantum well DEL



Prospects

Over the last few years, a large number of advances have been realized within FOTON-INSA. The thorough understanding of the phenomena of nanostructure growth and the demonstration of quantum dot lasers have allowed the laboratory to benefit from devices based on quantum dots and dashes which establish at the moment the state of the art of III-V nanostructures grown on InP.

These results make FOTON-INSA a significant partner for the development of quantum dot opto-electronic components within the framework of national projects and European Networks of Excellence (Sandie and ePIXnet). Within the FOTON research unit, the laboratory also provides expertise on devices, enabling the unit to apply to calls for regional programmes (CPER, PRIR) and national projects (national clean rooms, technology organisation).

In the near future, FOTON-INSA will continue its skill improvement in nanostructure growth and opto-electronic applications such as lasers or silicon photonics, the laboratory's new area of research. The skills of FOTON-INSA combined with the purchase of new equipment give the laboratory new prospects for the future:

- expertise in the realisation of single-mode lasers and silicon photonic technology, working jointly with CCMO- Rennes (IETR research unit),
- the development of its work to more diversified applications (micro-processors, computing, audio-video, automobile, medical, Defence, environment, energy, research etc.).

IETR-INSA Institute of Electronics and Telecommunications - Rennes

UMR CNRS 6164

Research

IETR-INSA is the INSA section of CNRS research unit 6164 IETR. The Institut d'Electronique et de Télécommunications de Rennes (Institute of Electronics and Telecommunications) is a joint research unit of some 280 people drawn from research teams at the University of Rennes 1, SUPELEC (Ecole supérieure d'électricité, Electrical Engineering College) and INSA-Rennes (Institut National des Sciences Appliquées, National Institute of Applied Sciences).

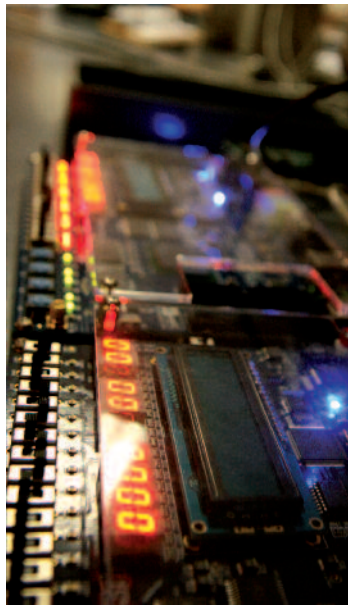
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Antennas
 Microwave circuits
 Electromagnetic model-building
 Electromagnetic compatibility
 Communications and signal processing systems
 Fast prototyping
 Propagation channels
 Image compression and interpretation
 Algorithm architecture adequation



The areas of research covered within IETR are connected with the information and communication sciences and technologies.

More precisely, they range from the study of microwave devices (antennae, circuits) and electromagnetic compatibility to the design of communications systems (encoding, modulation, channel) integrating signals and images. Their applications lie in the communications systems of the future such as future cell networks, LANs, personal and household networks, satellite transmissions, digital television and intra-vehicle communications.

Quite apart from this broad spectrum of skills, IETR's strength lies in its ability to provide a comprehensive solution to the work commissioned from it, from theoretical design to full-size testing. Thanks to the wide range of knowledge and expertise available from IETR, the results of research can be exploited very quickly in a business or industrial setting.

Research teams

IETR-INSA employs over 100 people in three areas of research:

• Antennas and Microwaves

Microwave and millimetric circuits and antennas, electromagnetic modelling, new antenna array structures and electromagnetic compatibility.

• Radar Propagation Communications

Communications systems and the corresponding signal processing technologies (OFDM, MIMO, encoding, UWB, time reversal, multi-user etc.), radio wave propagation for all types of channels, fast prototyping.

• Imaging and Remote Sensing

Image analysis and definition, representation and compression of 2D / 3D / multiview images and videos, prototyping on parallel and mixed architectures.

Thanks to its large set of technical test beds suitable for full-size experiments, IETR is involved in a large volume of scientific research at national and international level as well as a large amount of contract work with industrial companies.

1. ANTENNAE AND HYPERFREQUENCIES

Team leader: Raphaël GILLARD
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 raphael.gillard@insa-rennes.fr

This research team concentrates mainly on research into new types of antennas for the communications networks of the future. Its work also includes the electronic circuits associated with antennas, especially in microwaves, and electromagnetic compatibility.

Its work is organised in the following six sections, with particular attention being paid to the first two within INSA-Rennes:

- Electromagnetic modelling and optimisation
- Electromagnetic compatibility and signal integrity
- New antenna designs and architectures
- Reconfigurable antennas and innovative materials
- Millimetric antennas
- Interaction between EM waves and biological tissues

Electromagnetic modelling and optimisation

Development of rigorous new approaches to the analysis and design of antennas for today and for the future.

The team focuses on two main areas. The first is the understanding of antennas in their environment and not as a single isolated component. This holistic approach is doubly worthwhile because it assesses the impact of the environment on the antenna performance and, at the same time, more accurately quantifies and controls the levels of radiation emitted into the environment (potentially also quantifying the consequences for users located in the vicinity). The second area is part of the research into reconfigurable systems. In this case, an antenna must be designed to adapt to its environment and to the context in which it is functioning.

Electromagnetic compatibility and signal integrity

Study of the possible electromagnetic interactions between the various electronic components within a single system or several different systems. The team's aim is to update the measurement resources and methods (reverberation chambers, near field characterization etc.) to highlight any electronic malfunctions and propose new approaches based on predictive computation during the design stage (application for large systems such as planes, cars, trains, etc.).

A significant example:

Developing a methodology for the integration of an antenna on board a rail car to transmit safety data from the train to the control infrastructure.

IETR-INSA puts the accent on theoretical studies and modelling but also integrates a technological dimension in its work. Its research has wide-ranging applications (space antennas, antennas for mobiles, etc.) and is the subject of numerous national and international industrial partnerships. High-tech research equipment (anechoic chambers, reverberation chamber etc.) provide it with unique capacity for the validation of tests.



2. COMMUNICATIONS-PROPAGATION-RADAR

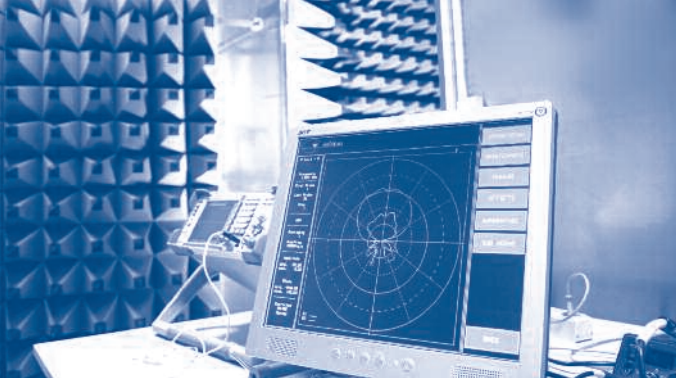
Team leader: Ghais EL ZEIN
Tel : +33 (0)2 23 23 86 04
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This research team studies **the communications systems of the future** (cellular networks, LANs, personal and home networks, digital television, intra-vehicle communications, satellite transmissions etc.). Its main objective is **to provide increasingly high transmission rates while guaranteeing excellent quality of service.**

Its work is organised in three areas as follows:

Communications systems

Study of new digital broadband communications systems and the corresponding signal processing technologies (MIMO, OFDM, UWB, channel coding, time reversal etc.). The team is very involved in a number of ambitious European projects under the 5th, 6th and 7th Research Framework Programmes. Its area of excellence covers all broadband wireless applications (post-UMTS and 4th generation cellular networks, broadcasting of terrestrial and second-generation mobile digital television, WLAN, WPAN, ultra high broadband home networks, satellite transmissions etc.), green radio and a large number of applications for digital subscriber lines or powerline communications.

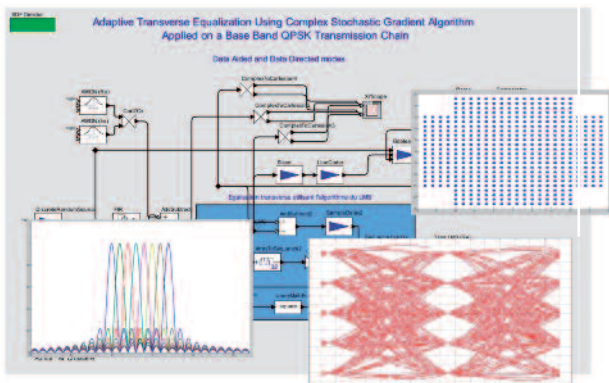


Anechoic chamber for near field measurements ranging from 0.8 to 6 GHz

Research



Simulation of digital communications systems



Propagation

Study of radio wave propagation and its impact on communication quality. Several types of transmission channel are looked at (indoor, mobile radio, atmospheric, tropospheric, ionospheric, satellite, cable etc.) in several frequency ranges, from HF bands to 60 GHz for the new communications systems. Work naturally resulting from this includes the development of propagation channel sounders and simulators, and aspects relating to systems, signal processing and exploitation.

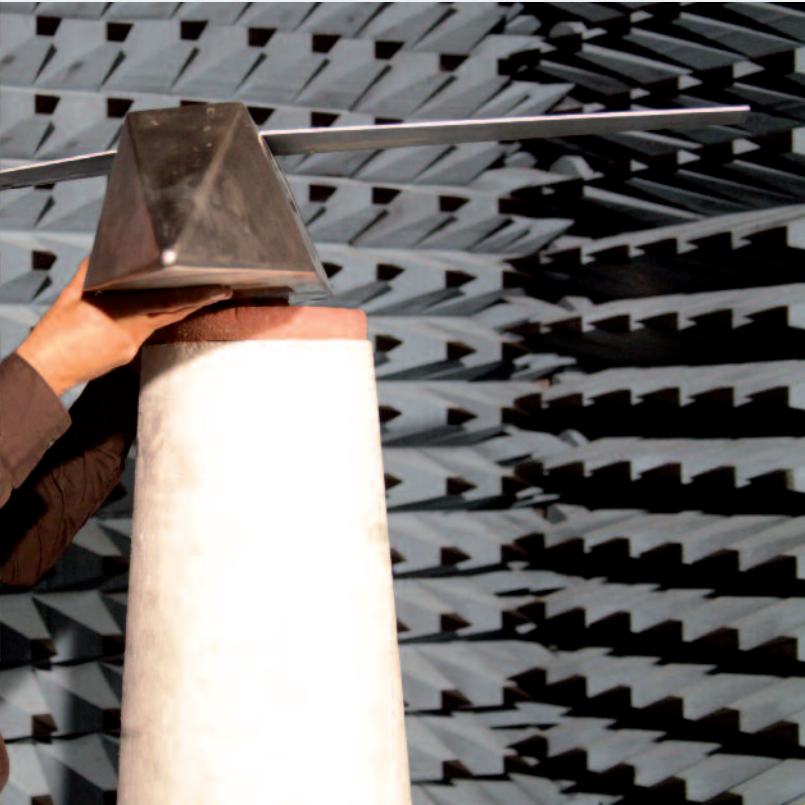
A significant example:

Second-generation terrestrial digital television

IETR-INSA has made a significant contribution to the study and optimisation of the future terrestrial and mobile digital television systems through the European B21C project ("Broadcast for the 21st Century"). The aim of this very ambitious CELTIC-type project is to propose a new system for second-generation terrestrial digital television. Most of INSA-IETR work has concentrated on maximising the combination of OFDM and MIMO techniques in 3 dimensions to increase transmission rates by up to 50% compared to current TNT. Studies of future digital television systems are continuing at the present time through the ANR M3 project and the European ENGINES project, which aims to define a new standard for mobile digital television.

Prototyping and System on Chip

Prototyping of various applications on a range of platforms using "System on Chip (SoC)", with particular emphasis being placed on methodological aspects. The team considers the algorithmic constraints, material systems that can be reconfigured dynamically or remotely, application constraints (runtimes, consumption etc.) and the problems posed by the new communications systems.



↑
Radar Cross Section
measurement platform
8 to 40 GHz

A significant example:

The problem of indexing images

Taking a given image, the aim is to extract from a database all the images that are similar from the point of view of certain attributes e.g. shape, colour or texture. The request is then transmitted on search engines, supplying the attributes contained in each image by using an analysis system.

The images in the database must have an effective representation based on these attributes i.e. they must be encoded. For a high level of efficiency, the search must be processed quickly, hence the need for absolute adequation between the computations required and the architecture of the processors: this is the role of algorithm architecture adequation.

Last but not least, if the ensemble is to be used as a system embedded in a vehicle, it raises problems of imaging and embedded systems.



3. IMAGING & REMOTE SENSING GROUP

Team Leader: Olivier DEFORGES

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This research team covers **the two major areas of digital image processing i.e. analysis and interpretation on the one hand and, on the other, representation and compression**. Its research is unusual in as much as it combines the development of new image processing methods with the quasi-automatic porting of the corresponding algorithms on embedded digital systems. Its work is organised in four areas as follows:

- Analysis for the interpretation of satellite images and the description and recognition of shapes
- Representation and encoding of 2D and 3D images and videos
- Algorithm architecture adequation
- Imaging and embedded systems

Analysis

Classification and merger of remote sensing images for interpretation of the information content and multiscale analysis to describe shapes present in the image for recognition purposes. Development of an image indexing system for the exploration of an image database and the monitoring of objects in a video sequence. This part of the work also involves the extraction of three-dimensional data from multi-view images and videos.

Representation and encoding

Development of compression diagrams and study of current standards. The work carried out in this area ranges from very low rate compression to 2D and 3D (i.e. multiview) image and video lossless compression by integrating advanced functions (scalability, ROI encoding, global encoding etc.). The research now includes data security, with compression and security tending to merge in a joint encoding phase.

Algorithm architecture adequation

Research into, and development of, a methodology that provides portability for image processing algorithms onto specialist architecture. This leads to the development of software tools that assist in the integration of algorithms into existing, target, multi-DSP (Digital Signal Processor) and ASIC (Application Specific Integrated Circuits) architectures. The tools include PREESM, Graphiti, SDF4J and Orcc. They are available on SourceForge (<https://sourceforge.net/>).

Imaging & embedded systems

Understanding the problems inherent to the integration of image processing systems, by offering continuity between algorithm definition phases until they are implemented on the embedded and distributed targets.

Staffing levels and results (2008-2009-2010)

Staff

IETR research unit includes 280 lecturer-researchers, Ph.D students, engineers, technicians and admin. staff. IETR-INSA laboratory employs some 100 people i.e.:

Year	Researchers	Researcher Lecturers	Ph.D students**	ATER	Post-Ph.D	PAST	IATOS*	Total
2008	2	22	53	1	3	1	11	93
2009	2	23	58	0	2	1	16	102
2010	2	25	55	1	3	0	19	105

Academic results

Year	Masters**	Thesis presented	HDR
2008	31	10	1
2009	25	13	2
2010	45	17	0
Total	101	40	3

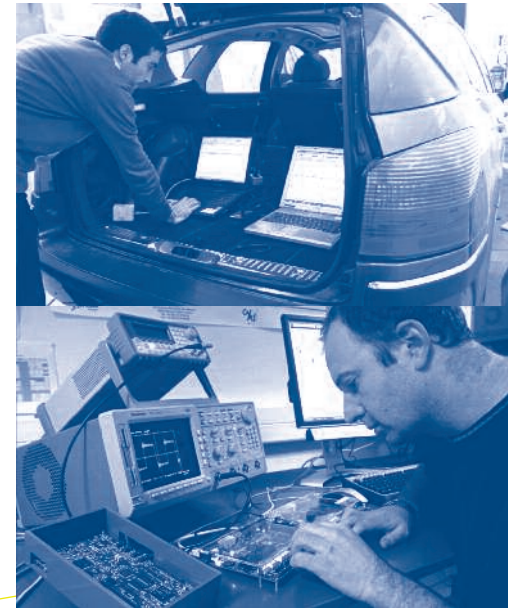
Scientific and contractual results

Year	Publications	Papers	Current contracts	Patents/Extensions PCT
2008	32	94	43	1/2
2009	35	167	42	2/1
2010	44	104	61	1/1
Total	111	365	146	4/4

Year	Papers			
	Conference papers Peer-reviewed papers	Guest papers	Oral presentations	Posters
2008	87	2	5	-
2009	152	4	11	-
2010	87	1	16	-
Total	326	7	32	-

*Engineers, technicians, admin. staff - **Matriculated at INSA-Rennes

↓ Embedding PLC (Power Line Communication) technologies in vehicles



↑ Prototyping of embedded electronic systems

Equipment - new resources

IETR-INSA has a range of simulation resources and measuring instruments. It also has a unique set of technical test beds:

- two anechoic chambers and one reverberation chamber to measure antennas up to several GHz,
- one probe station, 45 MHz to 65 GHz,
- a mobile laboratory for the measurement of radio wave propagation,
- platforms for fast prototyping and software radio.

Innovation and technology transfer

Business start-ups

IETR-INSA has been behind the start-up and development of a number of companies i.e. IPSIS (1986), ST2E (1992), SIRADEL (1994), ADVANTEN (2004), RF MONITORING (2007) and SCORVITECH (2008).

The laboratory still maintains very active contacts with these companies and other SMEs in the local industrial sector.

Registration of patents

In the period under consideration, 4 patents were registered:

- A patent on the **minimisation du PAPR in a digital television signal** (contribution to the future mobile digital television standard, DVB-NGH),
- A patent on **antennas with reconfigurable beams and frequencies**,
- A patent on **channel reduction**,
- A patent on **time reversal communications**.

Open Source tools

- PREESM and ORCC for prototyping.

Networks and partnerships

Since it was set up in 2002, IETR has developed strong partnerships with the industrial sector on a regional, national and international level.

Thanks to its close involvement in European projects, Networks of Excellence and business clusters (Imaging & Networks, iD4CAR and Sea Brittany), IETR is seen as a significant partner for the world of industry.

European Networks of Excellence

- European Antenna Centre of Excellence (ACE-2); certain areas of work extended since 2008 within the European EurAAP association
- Network of Excellence in Wireless COMMunications, NEWCOM++ (new communication systems)

European projects

- European project **ICT FP7 OMEGA** (UHB house)
- European project **ICT FP7 WHERE** (4G cell networks and localisation)
- European project **CELTIC B21C** (terrestrial digital television or second-generation TDT)
- European Space Agency **ARTES** project (large antenna arrays for satellites)

Other international work

- **CEDRE** programme with the Lebanese University (contact-free microsensors for the detection of vital signs)
- Leadership and responsibility for Ph.D programmes, jointly with China (CSC programme) and Lebanon (UL&UT-INSA programme)

Standards committees

- **MPEG** et **JPEG** groups (future standards for video and still images respectively)



Competitive clusters

- “Imaging & Networks”, a globally-oriented cluster (projects: Techim@ges, Scalim@ges, SVC4QoE, FUTURIMAGE, Mobile TV World, CAPNET). The laboratory is involved in the governance of the cluster, providing one member of the Board of Management and one member of the Monitoring and Evaluation Committee.
- “Premium Automobiles”, now renamed “iD4CAR” (CIRMHA project)
- “Sea Brittany” (Internet-Fishing and SAPHIR projects)

National projects: ANR/RNRT/PREDIT

CAIMAN, PERSEE, MIRTEC, R3MEMS, CIFAER, METAPHORT, VIPERE.

Regional projects: PRIR/UEB

CAPTIV, IGCYC.

CPER - PALMYRE II

Palmyre II is a wireless communications project. Its aim is to provide public research laboratories and industry with a test bed on which to develop and assess WB video transmissions on radioelectric channels. The project involves six research centres in Brittany through IETR and Lab-STICC laboratories and is funded by central government and Brittany Regional Council in the form of a CPER. Launched in 2007 for a period of seven years, Palmyre II is the extension of an initial project undertaken between 2000 and 2005. Thanks to these projects, the laboratory has been able to obtain several pieces of equipment such as measurement devices, computation units, fast prototyping test beds, and resources for the design and realisation of microwave printed circuits.

Contract work

Numerous **industrial and government partners** (Orange Labs, Thales Alenia Space, Technicolor (ex-Thomson), Mitsubishi Electric ITE, CEA-LETI, DGA, CNES, PSA, Renault, Alstom, Valeo, Siradel, Advanten, Texas Instruments, Thales Systèmes Aéroportés, Delta dore, INNES, AtlanticRF, NXP/ST Ericsson, etc.).

Chairmanship of CNRS research groups

- ISIS : Algorithm architecture adequation,
- Waves: Model building of electromagnetic and acoustic diffraction and propagation phenomena. Near field devices. Electromagnetic compatibility.

Prospects

Over the next few years, IETR-INSA intends to extend the scope of its research and, in particular, develop work on the following:

- Green communications
- Interactions between complex radiating systems and their environment
- Intelligent transport systems
- Sensor networks

A number of areas will be reinforced as a priority:

- Reconfigurable antennas
- Definition in near-field techniques and reverberation chamber
- Advanced communication techniques (MIMO, UWB, time reversal)
- Cross-layer optimisation of communications systems, cooperative and relay techniques
- 2D/3D compression and image security
- Smart video encoding

One new European project and two new ANR projects will be developed:

- The European ENGINES project: study and optimisation of a new system for second-generation Mobile Digital Television
- Multimedia in Mobility project - M3: convergence of 3GPP-LTE telecommunication networks and DVB-NGH broadcasting for a future mobile digital television service
- TRIMARAN project (time reversal and spatial focalisation)

IRISA-INSA Institute of Research in Information Science and Random Systems

UMR CNRS 6074

Research

IRISA-INSA is the INSA section of CNRS research unit 6074 IRISA. The institute of research in computing and random systems is a public research centre employing some 580 people. Its partners are CNRS, the University of Rennes 1, ENS Cachan and INSA-Rennes. The IRISA research unit is also associated with INRIA Rennes - Bretagne Atlantique centre.

IRISA
Bruno Arnaldi - Interim Director

IRISA-INSA
Bruno ARNALDI
Director

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IRISA-INSA
In brief

P2P
Cloud
Distributed systems
Digital documents
Virtual reality
Virtual human
Learning
Diagnosis
Logical information systems
Dynamic systems
Multimedia
Indexing

Research teams

IRISA-INSA's research teams consist of approximately 40 people. The teams presentation is based on a classification proposed by IRISA, in four areas of study: large-scale system, language and software engineering, media and interaction, and data and knowledge management. In other words, the scientific objectives of the laboratory's teams mainly cover the following subjects:

- **Improvement of large-scale computer systems:**
Widespread access to the Internet, the development of social networks and the increasing use of "cloud" infrastructures by large numbers of people make this area of research a major issue for the construction of the Internet of the future and tomorrow's digital society.
- **Imaging, from processing to CGI, and from digital document to multimodal interaction.** This area has undergone significant development over the past few years.
- **Abstraction, representation and organisation of complex data.** For logical information systems or multimedia data, the ability to process large quantities of complex data is still of vital importance.
- **Digital processing of knowledge and formal model-building of complex phenomena** to improve knowledge and control of industrial or natural systems.

1. LARGE-SCALE SYSTEMS

Asap Team: As Scalable As Possible, Foundations of dynamic large-scale systems

Contact : Marin.Bertier@irisa.fr

The team's aim is to supply a set of abstractions and algorithms that enable the building of large-scale distributed applications to link a large number of entities with limited capacities which are geographically remote and potentially mobile.

Myriads Team: Large-scale autonomous environments and systems
Contact : Jean-Louis.Pazat@irisa.fr

The aim of the Myriads team is to design and implement large-scale autonomous environments and systems for the management of services and resources. We are particularly targeting distributed virtual architecture of the "cloud" type, proposing methods and tools for the reliable running of applications and the effective management of resources for the future "Internet of Services".

2. LANGUAGE AND SOFTWARE ENGINEERING

Triskell Team: Reliable, efficient construction of applications by assembling software components

Contact : Arnaud.Blouin@irisa.fr

The team uses MDE (Model-Driven Engineering) for the reliable, efficient construction of applications by assembling software components. Areas of research include: model engineering, formal manipulation of UML models, contract design with components and aspects, and intra- and inter-component verification and validation.

3. MEDIA AND INTERACTIONS

Intuidoc Team: Intuitive User-Interaction for Document

Contact : Eric.Anquetil@irisa.fr

The team's work focuses on the composition and interactive analysis of documents. Handwritten interaction is central to the research, enabling the design of new forms of man-document communication.

Texmex Team: Techniques of EXploitation of Multimedia documents

- Exploration, indexing, searches in very large databases

Contact : Pascale.Sebillot@irisa.fr

Structuring of multimedia documents, audiovisual flows and very large collections of documents. Multimodal analysis and description of documents. Application to the search for information, exploration of large collections, understanding of the corpus, detection of copies and re-editing.

VR4i Team: Virtual Reality for Improved Innovative Immersive Interaction

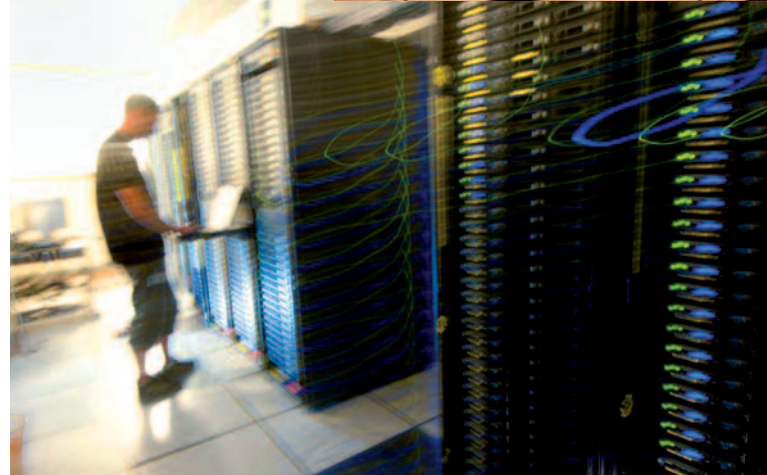
Contact : Bruno.Arnaldi@irisa.fr

The research work concerns real-time simulation of complex dynamic systems in a situation of interaction between users and these systems. The areas of research are as follows: mechanical simulation, control of dynamic systems, real-time simulation, haptic interaction, multimodal interaction, collaborative interaction and model-building of virtual environments.

A significant event:

The introduction of the new virtual reality platform, Immersia3. This project is based on partnership with IRISA, INRIA and local or regional authorities and consists of the building of a global immersive virtual reality environment. The equipment has already been used for national and international collaborative projects (e.g. Infrastructure FP7 VISIONNAIRE).





4. DATA AND KNOWLEDGE MANAGEMENT

Dream Team: Diagnosis, REasoning and leArning, Model-building
 Contact : Laurence.Roze@irisa.fr
 Assistance with the monitoring and diagnosis of complex systems or activities subject to change over time. The aim is to infer the status of a system using observations from sensors in order to detect and define any system malfunction.

Lis Team: Logical Information Systems
 Contact : Mireille.Ducasse@irisa.fr
 Development of formal models for information systems enabling browsing, querying, updating and analysis of collections of heterogeneous data. The basic model for the representation of information is logical concept analysis.

Modal Team: Algebraic model-building of dynamic systems
 Contact : Farida.Benmakrouha@insa-rennes.fr
 Algebraic model-building of “black box” type approaches, formal computation, neuron networks and development of applications in the environmental and health sectors.

Staffing levels and results (2008-2009-2010)

Staff

IRISA employs 582 people including 173 researchers or lecturer-researchers, 196 Ph.D students, 139 engineers, technicians or admin. staff and numerous contractual workers or international guests staying for shorter lengths of time. The IRISA-INSA laboratory employs more than 40 people as follows:

	Researcher Lecturers	ATER	Ph.D student*	IPAST	ATOS**
2008	20	0	20	0	3
2009	20	0	20	0	3
2010	19	1	20	0	3

Academic results

	Masters**	Thesis presented	HDR presented
Approximate annual figures	12	6	6

Scientific and contractual results

	Publications in national peer-reviewed journals	Publications in international peer-reviewed journals	Peer-reviewed conference papers
Approximate annual figures	3	13	39

*Engineers, technicians, admin. staff - **Matriculated at INSA-Rennes



PIM platform
at IRISA

Equipment - New resources

Immersia3: a virtual reality platform

see "significant event" p. 21

Grid5000: a national computation grid

Grid5000 is a research project aimed at developing a national test infrastructure on computation grids. The grid consists of clusters of machines situated mainly in 9 locations and linked by a broadband network. Seventeen laboratories are involved in the project, which can be used to carry out sizing tests at every level of software from network protocols to applications. By the end of 2010, the hardware configuration of the Rennes site was the following: 1 cluster of 40 HP Proliant (80 CPU x 12 cores), 1 cluster of 25 SUN FIRE x2270 (50 CPU x 4 cores), 1 cluster of 64 CARRI Systems machines (128 CPU x 4 cores) and 1 cluster of 33 DELL PowerEdge 1950 (66 CPU x 2 cores).

PIM: video indexing platform

The experimental Telemex platform is funded by INRIA, FNADT (Fonds national d'aménagement et de développement du territoire, national territorial development fund), the University of Rennes 1 and INSA-Rennes. It consists of three sections:

- a televisual data capture and stored data display server that can be fully controlled from a remote site using a Web interface
- a library of functions so that image or sound data stored on the server can be easily recovered using a given program
- an annotation tool for audiovisual flows

The platform, which is coupled with a computation cluster consisting of some thirty processors, has a storage capacity of 100 Tb.

Networks and partnerships

IRISA-INSA is very strongly involved in international cooperation networks. Through its involvement in numerous European Networks of Excellence (NoE), its research teams have established ongoing strategic partnerships with other leading laboratories and industrial companies in Europe working in the relevant fields. These networks encourage links that can then assist in putting together future projects.

European networks of excellence

- **FP6 - INTUITION** (Virtual Reality and Virtual Environments Applications for Future Workspaces). It federates virtual reality activities - 68 European partners from 15 different countries. IRISA-INSA is a member of the Core Group.
For further information: www.intuition-eunetwork.net
- **FP7 - NIW** (Natural Interactive Walking Project): This is a STREP with 5 European partners. Its aim is to propose innovative conditions for movement through virtual environments.
For further information: www.niwproject.eu
- **FP6 - CoreGrid**: The only European network of excellence specialising in grid and peer-to-peer technologies. The network is coordinated by the team at IRISA-INSA / PARIS.
For further information: www.coregrid.net
- **FP7 - S-cube**: Service Oriented Architectures: This network of excellence includes 15 partners focusing on the problems of dynamic adaptation of service-oriented architectures from "business" to infrastructure level. IRISA-INSA is responsible for the Infrastructure WP.
For further information: www.s-cube-network.eu
- **FP6 - ReSIST**: Resistance to faults and system security - 20 partners.
For further information: www.resist-noe.org



Other European projects

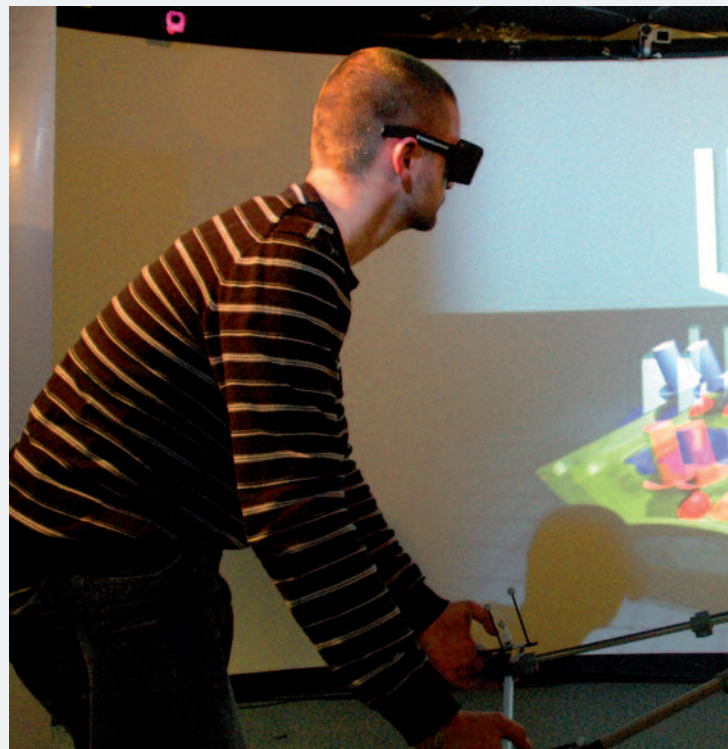
IRISA-INSA is also closely involved in a number of collaborative European projects:

- **STREP - WS-Diamond:** Development of a platform for the self-repair of web services.
For further information: wsdiamond.di.unito.it

Associated INRIA teams

Last but not least, IRISA-INSA is involved with associated teams (twin-location INRIA team, one part of the team working in an INRIA research centre and the other in a leading foreign laboratory):

- **Epi-net associated team:** Working on the design of peer-to-peer mechanisms based on Gossip (Vrije universiteit in Amsterdam and the ASAP team at IRISA).
- **SER-OF associated team:** Working on the management of virtual infrastructures for high performance computation (Oak Ridge National Lab. USA and the MYRIADS team at IRISA)



Innovation and technology transfer

Start-ups

• **Powedia :**

Set up in 2010 by a former Ph.D graduate from IRISA after the installation of the PIM platform, Powedia aims to market products that assist with the assembly and multi-channel broadcasting of video contents to various terminals (PC, box, smart phones).
For further information: www.powedia.com

• **Golaem :**

Set up in 2009, this company enhances the Bunraku team’s scientific work on virtual humanoids. In both the industrial sector (digital factory) and the multimedia market, Golaem’s products enable simultaneous processing of the mobility and behaviour of virtual humanoids.
For further information: www.golaem.com

Involvement in collaborative research projects

IRISA-INSA is involved in national collaborative research programmes linked to ICTs:

• **ANR programmes**

RNTL Part@ge platform: A project on collaborative interaction coordinated by INSA-Rennes and accredited by the “Imaging and Networks” business cluster.
For further information: www.rntl-partage.org

RNTL Collaviz platform: This project focuses on analysis and remote cooperation, with scientific simulation results.

ANR Corvette: Corvette (COLlabaRative Virtual Environment Technical Training and Experiment) is a project that offers an innovative approach to industrial training (maintenance and safety) by using virtual reality techniques. The project is more particularly concerned with cooperative work and interaction between virtual homanoids and real humans. The partners involved in Corvette are INSA-Rennes, ENIB, CEA-List, Nexter Training, Virtualys and Golaem.

RNRT SensLab : A project to set up four platforms (in Lyon, Lille, Rennes and Strasbourg), consisting of 256 sensors that can be used in real conditions to test wireless protocols and distributed algorithms.

RNRT SVP : A project looking at the design of systems based on sensor networks. Design, building and testing of an integrated ambient architecture.

ANR ARA SSIA SafeScale : A project on security and safety in ambient systems and P2P environments.

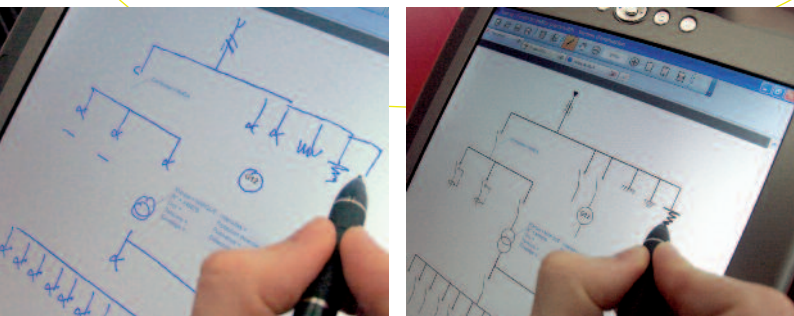
ANR MobiSketch : (<http://mobisketch.irisra.fr/>, Accredited by the “Imaging & Networks” business cluster): The aim of this project is to build a generic pen-oriented software solution for retro-conversion and the production of technical documents (diagrams, plans etc.) by explicitly integrating the user in the analysis process. Cooperating on this project are the INTUIDOC research team, the CRPCC laboratory at the University of Rennes 2 and the Script&Go company.

• **Big Data programme**

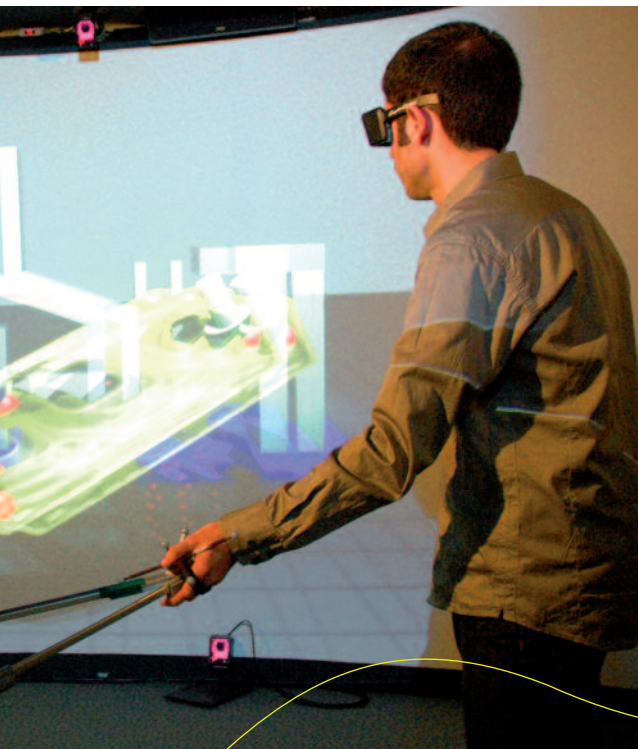
Involvement in the following projects: ACI DEMI-TON study tools for large audiovisual entities), ANR Navidomass (development of image analysis tools for browsing large volumes of documents), ANR Alpage (algorithms for large-scale platforms) and ANR ARA ICOS-HD ((representation areas allowing both compression and description of flows). The latter project has been accredited by the “Imaging and Networks” business cluster.

• **Miscellaneous**

Brittany Regional Council ScriptEverywhere project (accredited by the “Imaging & Networks” business cluster). The aim of this project is to design a software solution for the manual entry and revision of electrical diagrams on a Tablet PC. Cooperating on this project are the INTUIDOC research team, the APAVE Nord Ouest inspection company (industrial pilot) and the Evodia company.



↑ The image on the left shows the lines drawn by the user while the image on the right shows the diagram recognised and formatted as the lines are drawn



Part@ge Project:
demonstration of local and remote
cooperative interaction

Led by INSA-RENNES (VR4i team), this ANR platform has produced scientific and technical results proving the relevance and usefulness of cooperative working techniques for applications. The project involved the use of a digital dummy.

For further details: www.rntl-partage.fr/



Research

Cooperative research contract between INTUIDOC and the École de Technologie Supérieure (ETS) - University of Quebec: Within the context of a joint project, the teams are studying man-document interactions in the production of notes and diagrams on Interactive Whiteboards (IWB) or Tablet PCs for applications linked to the medical or education sectors.

Cooperative research contract between INTUIDOC and the École Polytechnique de Montréal (Scribens Laboratory): The aim is to use knowledge derived from the cinematic theory of human movement (Sigma-Lognormaux models) to improve the algorithms dedicated to the developing and self-adaptive recognition of handwriting.

Grand Largue: A project accredited in February 2007 by the “Sea Brittany” business cluster to develop an automated sail handling system in commercial shipping.

OSEO Quaero Programme: The programme combines an R&D project in new technologies with series of assessments of these technologies and application projects supported by industrialists and based on the technologies developed. The projects focus on the use of multimedia data analysis techniques to provide data mining information, Internet gateway sites, audiovisual services or the use of archives.

NextTV4All : This project centres on the definition and development of a system for the distribution of enriched audiovisual contents, based on IMS (IP Multimedia Subsystem) and providing fixed/mobile convergence in both networks and services, ensuring that the contents are available everywhere at all times.

Direct industrial collaboration

- **GVT Project:** Building of a generic, high-performance and unusual training tool called GVT®, thanks to close partnership with the Nexter-Systems company. GVT® combines information, procedures and practicalities in a virtual environment.
For further information: www.gvt-nexter.fr

- **Research project with the “county” archives in Yvelines:** a project focusing on the assisted transcription of handwritten sections in administrative archive documents, funded by Yvelines “county council” (conseil général).

Prospects

In the short and medium term, IRISA-INSA will continue to aim for a number of complementary objectives:

Confirmation of scientific excellence through greater visibility for contributions, in terms of both quality and enhancement.

Continuity in the setting up of long-term strategic, academic and industrial partnerships. Long-term cooperation results in effective preparation for major national and European projects.

Extensive consideration of the enhancement of the research, with specific attention being paid to the social impact of research work (health, environment and sustainable development).

Development of technological platforms, a strong point for the maximisation of scientific subjects and cooperative work.

Strengthening of current areas of research, in particular clouds and P2P systems, virtual reality, digital and multimedia documents and logical information systems.

Technology watch to track the emergence of new areas of research with strong potential, such as software engineering, which has been given a larger place in the laboratory.

Finally, IRISA-INSA's work is based on research by lecturer-researchers, Ph.D students and trainees and on support from technical teams. Particular attention will be paid to provide a satisfactory balance in this respect.

IRMAR-INSA Mathematical Research Institute - Rennes

UMR CNRS 6625

Research

IRMAR-INSA is the INSA branch of CNRS research unit 6625 IRMAR. This mathematical research institute is a public research entity employing 143 people. Its partners are the University of Rennes 1, ENS Cachan and INSA-Rennes.

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Scientific computation
Control theory
Curves and surfaces
Partial Differential Equations
Homogenization
Markovian models
Oceanography
Dependent data statistics



Figure 1 : Hermite interpolation operator on a rectangular network with a monotony constraint along x

Research teams

IRMAR-INSA employs 14 lecturer-researchers and works in two main fields:

- Modeling and numerical analysis
- Probability and statistics

The common aim to these two areas is **to build theoretical models with a view to applications in various fields e.g. industrial design, economics, data filtering, medical imaging, composite materials, operating safety and heat therapy.**

1. MODELING AND NUMERICAL ANALYSIS

The research team focuses its work on the following nine topics:

- Approximation
- Study of Taylor fields
- Mathematical imaging
- Evolution of interfaces and Hamilton-Jacobi equations
- Homogenization of composite media
- Optimal robust control and Hamilton-Jacobi equations
- Modeling, calibration and numerical methods
- Oceanography
- Modeling of quantum and classical transport in nanostructures

Approximation

The two main subjects of research being studied are the subdivision methods and quasi-interpolation operators used in CAGD (Computer Aided Geometric Design).

The subdivision methods are a new approach for the construction and plotting of curves and surfaces [DM] for image built in the medical sector and video games. The drawings are obtained by using iterative algorithms that build new sets of points based on the previous points, forming a curve or continuous surface at the limit.

The approximation measurements based on polynomial quasi-interpolant splines (P. Sablonnière) creates curves and surfaces [LMS] close to a set of given points without solving large systems of linear equations (cf. figure 1). These areas of research are being conducted jointly with C. Dagnino (Turin) D. Barrera (Grenada) and D. Sbibi (Oujda) and are the subjects of theses being prepared jointly with these universities.

The main applications for this research are imaging and industrial design (e.g. automobiles, boats and planes), as well as CGI imaging for animated films.



Study of Taylor fields

E. Le Gruyer proposes a mathematical formula that is consistent with the principles of stability for extension for fields of order m in Hilbert spaces and for functions with a single real variable. One significant result on the problem of minimal extension is the achievement of the inner expression of the Lipschitz constant of a field of order 1, leading to a theorem for Whitney extension in any Hilbert space. The link between the harmonious extensions and the solutions of viscosity of the infinite Laplacian is established and a metrically convex convergent numerical method proposed to approach the Absolutely Minimal Lipschitz Extensions defined in metric spaces (cf. figure 2).

Mathematical imaging

Current research is focusing on the mathematical modeling of concrete problems arising from imaging. The purpose is to quantify the information and assist with diagnostics. Particular attention is being paid to segmentation and registration.

Image segmentation consists of dividing the image into subsets and detecting the boundaries. The use of Level Set methods to build moving boundaries allows for great flexibility in shapes. C. Le Guyader and L. Vese (University of California) are developing a segmentation model based on active geodesic curves that preserve the shapes [LV]. 3D simulations are validated on the human cortex (cf. figure 3).

Taking two images called "template" and "reference" respectively, the aim of registration is to determine a geometric transformation so that the deformed template image coincides with the reference image. At present, C. Le Guyader and L. Vese are developing a model that allows for major deformations. C. Le Guyader, D. Apprato and C. Gout are working on the building of deformations that retain the initial topology.

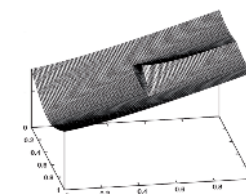


Figure 2 : Interpolant approximation of an AMLE in a metric space



Figure 3 : Segmentation of the brain under topological constraints

Evolution of interfaces and Hamilton-Jacobi equations

Interfaces and free boundaries appear in many contexts e.g. in physics, engineering and material sciences, biology, imaging etc. The work being undertaken by O. Ley and his colleagues is based on a level-set approach and the notion of viscosity to obtain existence and uniqueness in geometric flows modeling front propagation with a prescribed normal speed. The main contributions concern:

- the dynamic of dislocations, which explains certain macroscopic plastic properties of crystals [BCLM] (cf. figure 4);
- a polymer growth model;
- certain FitzHugh-Nagumo systems used in biology [BCLM];
- gradient flows used in shape optimisation.

Collaborations: G. Barles (Tours), P. Cardaliaguet (Paris-Dauphine), H. Mitake (Tokyo), R. Monneau (Ecole des Ponts et Chaussées), A. Monteillet (Brest) as part of the ANR "Movements of interfaces, computation and applications".

Homogenization of composite media

Homogenization describes the physical macroscopic characteristics of a composite material using microscopic information. The work being carried out by M. Briane and M. Camar-Eddine includes the study of the problems of high or low-contrast conduction.

A. Braides (Rome 2), M. Briane and J. Casado-Díaz (Seville) show the homogenisation stability of high-contrast conduction in 2D. M. Briane and M. Camar-Eddine, on the other hand, are highlighting the appearance of degeneracy in the case of very stiff 2D elasticity.

M. Briane and G.W. Milton (Utah) [BM] are obtaining composite meta-materials which, using geometry and inter-phase contrast, produce pathologies in classical electrophysics (cf. figure 5): change in the Hall coefficient sign (a) (© Dylon Whyte), giant Hall effect (b), and antisymmetric Hall (c).

Optimal robust control and Hamilton-Jacobi equations

There are two main areas of study: optimal robust control of nonlinear partial differential equations by A. Belmiloudi, F. Mahé (UR1), A. Rasheed and J.-P. Yvon, and Hamilton-Jacobi equations by F. Camilli (Rome), F. Da Lio (Padua), N. Ichihara (Hiroshima) S. Koike (Saitama) and O. Ley. The main applications are as follows: fundamental physics, with the study of fluctuations in superconductivity and solidification; oceanography; transfer of heat and mass; optimal stochastic control, mechanical engineering; and asymptotic behaviour of certain systems.

A. Belmiloudi has published a book [B] on the theory of robust control and the stabilisation of dynamical systems controlled by non-linear coupled PDE (with or without time lags).

The Bellman approach to optimal control consists of bringing the control problem back to the study of a nonlinear partial differential equation satisfied by the value function of the problem.

As part of the ANR "Hamilton-Jacobi and weak KAM theory", the long-time behaviour of solutions to Hamilton-Jacobi equations is being studied.

Modelisation, calibration and numerical methods

A. Belmiloudi and A. Rasheed have developed a new model for the solidification of binary alloys under the influence of magnetic fields, using some appropriate numerical methods.

To analyze and improve the thermodynamic behaviour of plaster plaques, A. Belmiloudi and F. Mahé improved existing models by introducing parameters that are important for heat but generally ignored in civil engineering.

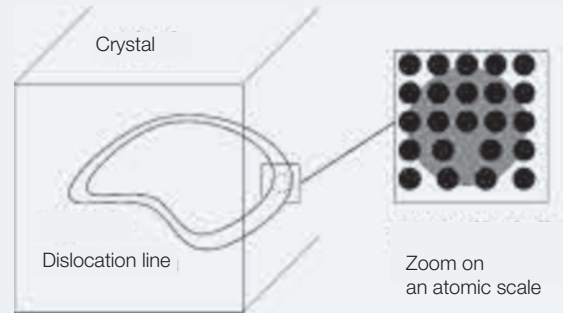
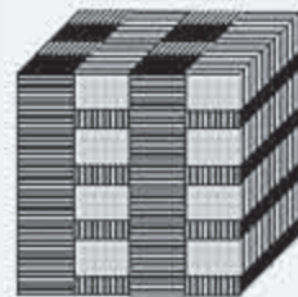


Figure 4 : Dislocation in a crystal



(a) Chainmail

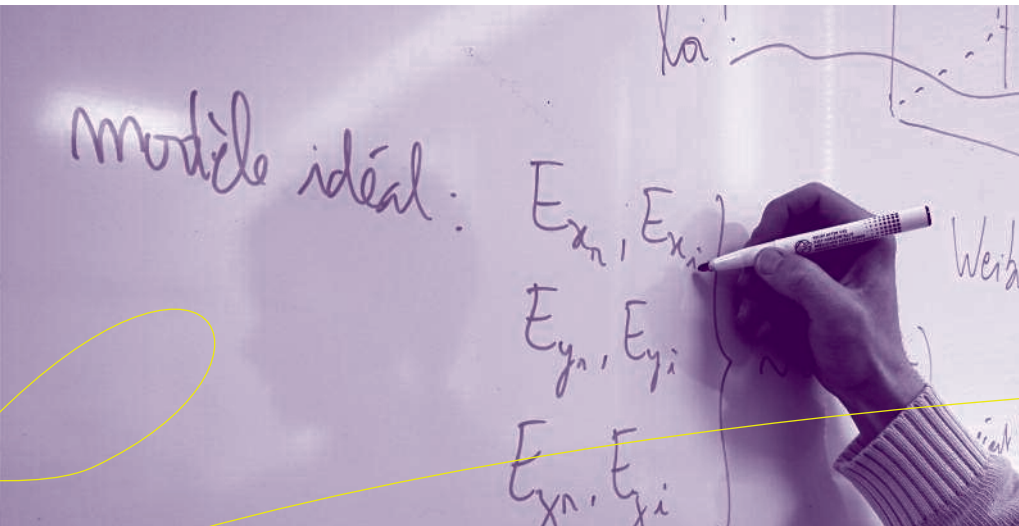


(b) Laminate



(c) Spiral

Figure 5 : Three composite metamaterials



Oceanography

There have been abnormal changes in ocean flow through the Mozambique Channel. Sea level has risen along the West coast of Madagascar, flooding the lowest-lying land. L. Monier and F. Razafimahery (UR1) have developed a 3D model (cf. figure 6) [MR] of oceanic circulation in this area, simulating seasonal variations in flow and the topography of the surface. They studied the impact of the wind and the Coriolis force on circulation and tested the models in realistic areas (Mozambique Channel), forcing them with satellite data.

Modeling of quantum and classical transport in nanostructures

As part of the ANR “QUATum TRANsport In Nanostructures”, R. El Hajj is looking at the modeling and simulation of electronic transport in nanostructures. His work, undertaken jointly with N. Ben Abdallah (Toulouse), refers mainly to the following areas of research:

- mathematical modeling of the transport of spins from the microscopic (quantum) to the macroscopic (drift-diffusion); application to the simulation of spin-FET (cf. figure 7);
- study and approximation of the Schrödinger-Poisson system in partially confined structures such as gases from 2D electrons [EB];
- approximation of particle transport fluid in the presence of strong magnetic fields.

2. APPLIED PROBABILITY AND STATISTICS

This group is concentrating on the following 6 areas:

- Limit theorems for Markovian processes
- M-estimation of Markovian data
- Stochastic filtering and reliability
- Biostatistics
- Statistics of vector auto-regression models
- Estimating equations and statistical inference

Limit theorems for Markovian processes

L. Hervé, J. Ledoux, D. Ferré (doct.) and D. Guibourg (doct.) are studying limit theorems for Markovian processes. More particularly, they are quantifying the quality of the Gaussian approximation for the analysis expansions of long sequences of data using Berry-Esseen type results, Edgeworth expansions. They are also looking at the renewal theorems. The rate of convergence of the Poissonian approximation for the counting of rare events has also been studied. Lastly, limit theorems to stable laws are established in [HH].

M-estimation of Markovian data

Statistical methods for decision making are based mainly on probabilistic limit theorems that are well known in the case of independent data but which are still the subject of numerous research projects in the case of dependent observations. L. Hervé, D. Ferré, J. Ledoux and V. Patilea are developing the statistical aspects of limit theorems for the Markovian data referred to in the previous area of research.

Stochastic filtering and reliability

J. Ledoux is concentrating part of his work on the estimation of the parameters of hidden Markovian models using stochastic filtering techniques. This provides for a Bayesian approach to problems of system reliability. Reducing the complexity of the filtering of the directive component of an additive Markov chain, J. Ledoux, working with G. Brush and L. White (Adelaide), has produced conditions under which the filter for a hidden state function satisfies a linear dynamic [LWB].

Biostatistics

V. Patilea has continued his work on the applications of statistical methods in biology and medicine. With D. Böhning (Reading University), he has looked at the construction of thresholds above which there is a presumption of disease (defect) during screening for a disease (defect), based on the measurement of a continuous value indicator. I. van Keilegom (UCL Louvain), O. Lopez (Paris 6) and V. Patilea have developed a new procedure for the estimation of a single-index regression models in the presence of censure.

Statistics of vector autoregression models

V. Patilea and H. Raïssi are studying the estimation and validation of vector autoregression models adjusted to processes with time-dependent volatility. In particular, tests based on the adaptive estimation of volatility are proposed for the specification of temporal dynamics. H. Raïssi has also analysed the effects of the presence of non-linearities in co-integrated systems [R].

Estimating equations and statistical inference

V. Patilea is involved in a project on statistical inference based on estimating equations. With P. Lavergne (Simon Fraser) and O. Lopez, he is studying the estimation and testing of parameters in the presence of incomplete data. This project is an extension of the results obtained by Lopez and Patilea [LP] using a regression model. M. Saumard has begun work on a thesis on estimating equations in the presence of functional variables.

Figure 6 : 3D simulation of oceanic flow

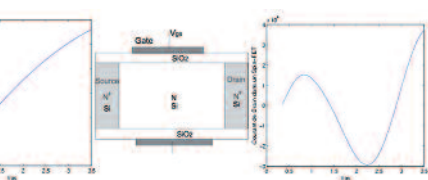
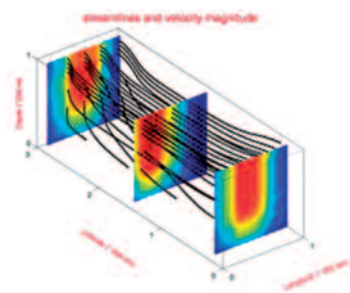


Figure 7 : MOSFET-type transistor and its current-voltage characteristics without a spin rotation effect (left) and with a spin rotation (right).

Staffing levels and results (2008-2009-2010)

Staff

IRMAR employs 143 people as follows: 108 lecturer-researchers (53 professors and 55 senior lecturers), 18 CNRS researchers (4 research directors and 14 researchers) and 17 ITA-IATOSS members (engineers, technicians and admin. staff). The IRMAR-INSA staff consists of 23 people i.e.:

	Lecturer-Researchers	Ph.D students**	IATOS*
Total	14	8	1

Academic results

Years	Thesis presented	Joint thesis from 2 institutions
2008		
2009		1
2010	1	1
Total	1	2

Scientific and contractual results

Years	Publications	Papers	Current contracts
2008	29	4	1
2009	18	6	1
2010	18	6	
Total	65	16	1

Years	Publications			
	Publications in national peer-reviewed journals	Publications in international peer-reviewed journals	Peer-reviewed conference papers	Books
2008	-	28	4	1
2009	-	18	6	
2010	-	18	6	
Total	-	64	16	1

Years	Papers		
	Guest papers	Oral presentations	Posters
2008	7		
2009	5		
2010	7		
Total	19		

* Engineers technicians admin. staff - ** directed by an IRMAR-INSA lecturer-researcher

A few significant publications

[BCLM] Barles G., Cardaliaguet P., Ley O. & Monteillet A., Uniqueness Results for Nonlocal Hamilton-Jacobi Equations, *J. Funct. Anal.*, 257 (2009), 1261-1287.

[B] Belmiloudi A., *Stabilization, Optimal and Robust Control. Theory and Applications in Biological and Physical Sciences*, Springer-Verlag, London, (2008).

[BM] Briane M. & Milton G.W., Homogenization of the three-dimensional Hall effect and change of sign of the Hall coefficient, *Arch. Ration. Mech. Anal.*, 193 (3) (2009), 715-736.

[DM] Dubuc S. & Merrien J.-L., Hermite Subdivision Schemes and Taylor Polynomials, *Constr. Approx.*, 29 (2009), 219-245.

[EB] El Hajj R. & Ben Abdallah N., High density limit of the stationary one dimensional Schrödinger-Poisson system, *Multiscale Model. Simul.*, 7(1) (2008), 124-146.

[HH] Hennion H. & Hervé L., Stable laws and products of positive random matrices, *J. Theoret. Probab.*, 21 (4) (2008), 966-981.

[LWB] Ledoux J., White L.B. & Brushe G.D., On the relationships between lumpability and filtering of finite stochastic systems. *J. Appl. Probab.*, 45(3) (2008) 650-669.

[L] Le Gruyer E., Minimal Lipschitz extensions to differentiable functions defined on a Hilbert space, *Geom. Funct. Anal.*, 19 (2009), 1101-1118.

[LV] Le Guyader C. & Vese L., Self-repelling snakes for topology-preserving segmentation models, *IEEE Trans. Image Process.*, 17(5), (2008), 767-779.

[LMS] Lyche T., Manni C. & Sablonnière P., Spline quasi-interpolating projectors in several variables, *J. Comp. Appl. Math.* 221 (2008), 416-429.

[MR] Monier L., Brossier F. & Razafimahery F., Validation of the Three-dimensional modelisation of the Ocean Circulation. *American Institute of Physics (AIP) Conf. Proc.*, Vol. 1067, (2008), 271-278.

[LP] Lopez O. & Patilea V., Nonparametric lack-of-fit tests for parametric mean-regression models with censored data, *J. Multivariate Anal.*, 100(1), (2009), 210-230.

[R] Raïssi H., Testing the cointegrating rank when the errors are uncorrelated but nonindependent. *Stochastic Anal. Appl.*, 27, (2009), 24-50.

Networks and partnerships

IRMAR-INSA is involved in numerous networks:

- ANR MICA "Movements of interfaces, Computation and Applications" ANR-06-BLAN-0082
- ANR KAM FAIBLE "Hamilton-Jacobi and Weak KAM Theory" ANR-07-BLAN-0361
- ANR QUATRRAIN "QUATum TRAnsport In Nanostructures" 2007-2011
- GdR 3273 MOA "Mathematics of Optimisation and Applications"
- GdR RO "Operation Research"
- CPER Nord-Pas-de-Calais Project "Dynamics of the Art and Culture Economy" Participation in the section, "Long-term relations with the Price of Art"
- GdR FQM-309 2007-10 regional funding from Andalusia
- Spanish National Project MTM2008-00306 2008-11

Within IRMAR-INSA, international exchanges consist mainly of cooperative work with foreign researchers and joint awarding of Ph.Ds.

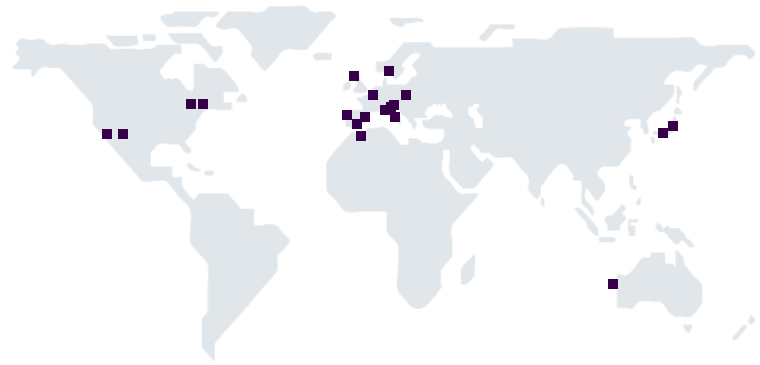
Its main partners are:

• North America

S. Dubuc - University of Montreal, G. Milton - University of Utah, S. Damlin - University of Georgia Southern, P. Lavergne - Simon Fraser University and L. Vese - University of California

• Australia

L. White - University of Adelaide



• Southern Europe and North Africa

A. Daniilidis - UAB Barcelona, D. Barrera - University of Grenada, A. Braides, L. Gori et C. Manni - University of Rome 2, F. Camilli and V. Nesi - University of Rome 1, J. Casado Diaz - University of Seville, C. Dagnino and V. Demichelis - University of Turin, F. Da Lio - University of Padua, I. C. Delatta and B. Franchi - University of Bologna, D. Sbilih - University of Oujda

• Northern Europe

D. Böhning - Reading University, I. van Keilegom - UCL Louvain, T. Lyche - University of Oslo, T. Sauer - University of Giessen, V. Spokoiny - Humboldt Universität

• Japan

N. Ichihara and H. Mitake - University of Hiroshima, S. Koike - University of Saitama

Research



Prospects

In the light of recruitment over the last five years, it is evident that IRMAR-INSA is currently focusing its efforts on two areas of research, with the following aims:

- To strengthen and set up collaboration
 - between staff within IRMAR-INSA, particularly in the areas of:
 - Partial differential equations derivatives and their applications, a subject whose applied analysis component draws on several areas of research;
 - statistics: mentioned in the previous Report, this project has been launched and supported, in particular, by the provision of a new MCF and new Ph.D students. This collaboration will be validated by publications in the next report.
 - with members from Random and Analysis teams within IRMAR.
 - with researchers from other disciplines.
- Internationally
 - participation in international research programmes;
 - invitations to foreign researchers;
 - mentoring of foreign Ph.D students.

The indicators, especially as regards scientific output, show that the scientific directions and recruitment policy already in place should be continued into the future.

SCR-INSA Chemical Sciences Rennes

UMR CNRS 6226

Research

INSA-Rennes has two SCR teams:

- SCR / CM - INSA :
“Chemistry - Metallurgy” team
- SCR / MI - INSA :
“Chemistry of Solids and Materials” team

Set up on 1st January 2006, **the UMR CNRS 6226 SCR - Chemical Sciences** is a joint research unit of some 400 people, including 231 permanent staff in three higher education establishments in Rennes - the University of Rennes 1, ENSCR and INSA-Rennes. It consists of twelve research teams working jointly on a common scientific project.

There are three main areas of research:

- Syntheses and processes
- Functional molecules and materials
- Chemistry for the storage, transport and processing of information

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SCR / CM - INSA

In brief

Alloys
Fusion
Diffusion
Nitriding
Titanium
Microstructure
Biomaterials

Research teams

Research in the SCR / CM - INSA laboratory focuses on **the synthesis, study and development of metal alloys, more particularly titanium or zirconium-based alloys**. One of its particular characteristics is the diversity of its potential as regards the resources it uses to produce refractory alloys in a controlled atmosphere. These resources include an arc furnace, medium and high-frequency magnetic induction kilns, and miscellaneous heat processes. Its aim is to meet industrial demands in the aeronautics and automobile sectors (titanium-based alloys, aluminium), the nuclear industry (zirconium-based alloys) and the biomedical sector (titanium-based alloys combined with molybdenum or tantalum, nitriding).

1. TEXTURES AND MECHANICAL BEHAVIOUR OF ZIRCONIUM AND TITANIUM ALLOYS

In other words: **the study of titanium alloys for aeronautic applications.**

An analysis of the mechanical behaviour and structural changes in materials with a hexagonal structure was carried out on the industrial alloy TA6V to define the influence of the materials' anisotropy. The textures of samples taken from basic sheet metal were then studied:

- Analysis of the influence of cold-rolling on crystallographic textures during the alpha phase after plastic deformation and heat treatment of recrystallisation in a vacuum
- Measurements of specific changes in texture immediately after plastic deformation alone and after recrystallisation annealing
- Traction tests to define the anisotropy of the material in terms of elasticity, extension to breaking point and damage

2. PRODUCTION AND METALLURGICAL DEFINITION OF TITANIUM ALLOYS FOR BIOMEDICAL APPLICATIONS

In other words: **production of biocompatible alloys for use as a bone substitute (hip prosthesis).**

The alloy is produced by electromagnetic levitation in a divided crucible in a controlled atmosphere. The β phase is retained by high-temperature heat treatment followed by dipping in water. The elements of betagen and biocompatible alloys such as Mo, Fe and/or Ta were used. The alloys were defined by means of x-ray diffraction (goniometers for powders and textures), EBSD, optical and electronic microscopy, and the measurement of electrical resistance and microhardness.

This work resulted in **a granular structure with mechanical properties closer to bone**. The biocompatible behaviour of the new alloys was assessed using a population of human osteoblasts or osteoblasts taken from chicken embryos. Cytotoxicity was measured and the assessment of adhesion, migration and cell density (proliferation) was observed (partnership with the Biomedical Engineering laboratory, UMR 6600 at UTC).

SCR / CM - INSA Chemical Sciences - Rennes "Chemistry - Metallurgy" team

3. METALLIC GLASS AND NONSTRUCTURE ALLOYS

In other words: **the definition of nanocrystals**

Metallic glass is arousing a great deal of interest. Thermally-activated nanocrystallisation produces mechanical properties that may be better than the properties of the amorphous parent matrix. Maximisation of these properties has been envisaged, based on monitoring of the division and volume fraction of nanocrystals in the amorphous parent matrix. The nanocrystals were defined using an atomic tomography sensor.

This subject has been developed through national and international cooperation, with the "Physics of Materials" Group at the University of Rouen and the "Department of Materials Science and Metallurgy" at the University of Cambridge.

4. NITRIDING AND DIFFUSION IN TI-BASED ALLOYS

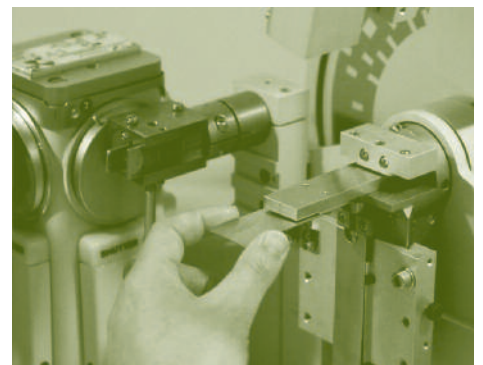
In other words: **exploring the possibilities of modifying the superficial microstructure of alloys**

The aim of nitriding is to obtain superficial hardening of titanium alloys so that they can be subjected to friction. Nitriding tests have enabled the team to explore the possibilities of modifying the superficial microstructure of alloys. The interactions between titanium alloys and hot gases have been looked at to obtain greater understanding of the problems of diffusion-reaction-precipitation in ternaries and the problems of surface treatment using gas-solid reaction (structural change in the treated areas during thermal treatment, effect on the mechanical surface properties etc.).

At the present time, SCR/CM - INSA's work on biomedical applications has led to a study of the nitriding of titanium alloys with betagen elements of the following types: Ti-Zr, Ti-Mo and Ti-Ta. Earlier research into interdiffusion throughout the duration of the high-temperature Beta phase of binary systems Ti-V, Ti-Nb, Ti-Ta, Ti-Mo and Ti-Hf and studies of diffusion in the ternary Ti-Mo-Ta were completed by the definition of diffusion in the binary Ti-Zr and ternary Ti-Hf-Zr.



Diffraction of x-rays: texture and powder goniometers



Staffing levels and results (2008-2009-2010)

Staff

The SCR/CM - INSA team includes 15 people as follows:

Year	Lecturer-Researchers	Ph.D students**	IATOS*
2008	7	5	3
2009	7	5	3
2010	7	5	3

Academic results

Year	Masters**	Thesis presented
2008	-	1
2009	1	1
2010	1	1
Total	2	3

Scientific and contractual results

Year	Publications	Papers
2008	8	12
2009	8	12
2010	14	10
Total	30	34

*Engineers technicians admin. staff - **Matriculated at INSA-Rennes

Equipment - New resources

SCR/CM - INSA has particular expertise in the electromagnetic levitation technique, using a divided cold crucible. This technology required the installation of a "production by fusion" platform to develop innovative alloys for use by industry. In 2009, the laboratory installed a mechanical surface definition platform combining nano-indentation, a scratch-test device and atomic force microscopy (MECASURF project).



↑ Alloy synthesis by means of fusion

Networks and partnerships

Thanks to its expertise, SCR/CM - INSA is now internationally recognised and is involved in numerous cooperative scientific, industrial and institutional projects:

Scientific partnerships

As an example, SCR/CM - INSA is closely involved in the following programmes:

- Exchange programmes with Austria (PAI Amadeus) on the nitriding of titanium-based alloys
- Research programme with Romania (Research of Excellence-CEEX program network) on titanium-based biomaterials
- Partnership with the University of Cambridge on nanostructure alloys
- ANR TIBBIA: Beta Biocompatible Adaptive titanium (MatetPro research programme)
- European EUREKA / MNT-ERA-net programme: NanoBioAll on alloys for use in the biomedical sector

Biomaterials constitute a particularly promising area of research on a European level. **SCR/CM - INSA's expertise in the production of alloys allows it to join the early stages of projects relating to titanium-based alloys for biomedical applications.**

Industrial partnerships

The research carried out by SCR/CM - INSA is mainly of interest to the metalworking industry, especially companies that use or develop zirconium and titanium-based alloys.

Examples of cooperation include:

- Correlations between the nanostructure and mechanical properties of Beta metastable titanium alloys, project conducted in partnership with the titanium section of SNECMA Moteurs.
- Study of the diffusion of nitrogen in the zirconium tubes used as fuel sheaths, in partnership with AREVA.
- Technology transfers to SMEs in the biomedical sector for the development of titanium devices for specific uses (staples, clips, stents, prostheses, implants etc.).
- 2 CIFRE contracts with Quertech Ingénierie

Institutional partnerships

SCR/CM - INSA has received significant support from regional and local authorities for its research into biomaterials:

- Rennes Métropole (district council): funding of some of the equipment used for high-temperature production, more particularly electromagnetic levitation
- Région Bretagne (Brittany regional council): multiple grants for the renewal of equipment and the funding of a Ph.D student

Prospects

Thanks to its expertise and acknowledged excellence, SCR/CM - INSA was given a very positive audit by divisions within the CNRS in 2010 as part of the new four-year plan for the 2012-2016 period.

Lanthanides
Coordination polymers
Polynuclear complexes
Molybdenum clusters
Cristallogenesi
Structural definition
Porosity
Molecular magnetism
Luminescence
Chromophores
Thermoelectricity



SCR / MI - INSA Chemical Sciences - Rennes Chemistry of Solids and Materials” team

Research teams

Coordination polymers are currently the subject of many different research projects worldwide. This recent enthusiasm is mainly due to their potential in the gas storage field. SCR / MI - INSA's work on coordination polymers using rare earths dates back some fifteen years. In fact, the laboratory was a pioneer in the development of original synthesis techniques (use of gels, low-temperature synthesis, freeze-drying) that meet the criteria for sustainable chemistry. The current social issues of sustainable development and energy saving are further increasing the interest in the research being conducted by this team. Over the past few years, hybrid materials have been the subject of strong global competition between research teams. Thanks to its experience, however, SCR / MI - INSA has retained its specific characteristics, its originality and its national and international reputation for excellence.

A few significant results

Porosity

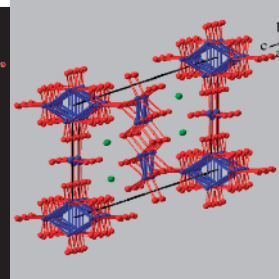
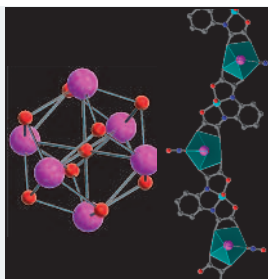
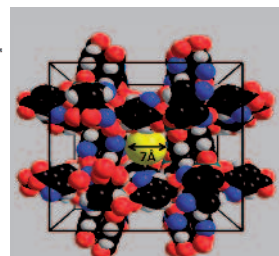
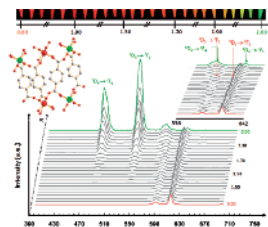
SCR / MI - INSA recently obtained coordination polymers from rare earths with the highest potential porosity. These compounds with the general chemical formula $\text{Ln}(\text{abcd})(\text{Habcd})\cdot n\text{H}_2\text{O}$ where abcd stands for amino-benzene di-carboxylate, crystallise in the cubic system and have channels with a section measuring 50\AA^2 . The compounds, obtained by processes that are environmentally-friendly, can be activated at ambient temperature by simple dehydration in a nitrogen flow. Their specific surface is of the order of $2000\text{m}^2\text{g}^{-1}$.

Luminescence

One example is the family of isostructural compounds with the chemical formula $\text{Ln}_2(\text{C}_8\text{H}_4\text{O}_4)_3(\text{H}_2\text{O})_4$ where $\text{Ln} = \text{La-Tm}$ or Y . These compounds can contain one, two, three or even fifteen different rare earths simultaneously, in controlled proportions. We demonstrated by X-ray diffraction that the lanthanide ions were randomly distributed and that these polynuclear compounds actually consisted of single-phase compounds and not of a mixture of homo-nuclear compounds. Under UV radiation, some of them emit visible white light with quantum outputs of the order of 30% to 40%. To date, this is a unique system and it is interesting both in fundamental terms and as regards its potential technological applications (it forms the basis of the technology developed by the Olnica company). We are currently using the system to increase our knowledge of the mechanisms of luminescence with a view to obtaining efficient chromophores that might be an alternative to the luminophores used at the present time.

Molecular magnetism

While working on the synthesis of hybrid materials, our team recently synthesised molecular structures that also had magnetic properties. Chains and molecule-magnets were therefore obtained, some of them with luminescent properties in addition to their magnetism.



These compounds are unusual in that they behave like magnets on a molecular level. A single crystal has an infinite number of nano-magnets, each with its own magnetism. The magnetism then has a quantum, rather than a conventional, definition.

The compounds are therefore potential qubits (supports for quantum computations) and excellent spin carriers (especially for spintronics).

Molybdenum oxide compounds

$\text{Nd}_4\text{Mo}_{18}\text{O}_{32}$ et $\text{Sm}_4\text{Mo}_{18}\text{O}_{32}$ are new molybdenum sub-oxides showing metal-isolation transition. We previously isolated the series of $\text{Ln}_4\text{Mo}_{18}\text{O}_{32}$ ($\text{Ln} = \text{Gd}, \text{Dy}, \text{Ho}, \text{Er}, \text{Tm}, \text{Yb}, \text{Lu}$ et Y) by solid-solid reaction in a crucible sealed with molybdenum. All these compounds crystallise in the monoclinic space group $\text{P2}/c$ and their crystalline structure includes three different types of infinite metal chains that all develop parallel to the b-axis of the monoclinic lattice:

- linear chains similar to the one observed in MoO_2 and consisting of molybdenum atoms at alternate intervals of 2,572 and 3,091 Å.
- chains consisting of Mo_4 rhomboids with common ridges similar to the ones observed in NaMo_2O_4 .
- infinite chains of octahedral Mo_6 clusters with common ridges showing the pairing of octahedra as in $\text{Gd}_4\text{Mo}_4\text{O}_{11}$.

These compounds are useful for their electrical properties since they all show a metal-isolation transition between 70 and 100K.

Staffing levels and results (2008-2009-2010)

Staff

The SCR/MI - INSA team includes some 10 people:

Year	Lecturer-Researchers	Ph.D students**	IATOS*
2008	4	5	4
2009	4	5	6
2010	4	5	3

Academic results

Year	Masters**	Thesis presented	HDR presented
2008	3	2	-
2009	0	1	-
2010	0	1	-
Total	3	4	-

Année	Publications	Papers	Current contracts	Patents
2008	17	17	5	5
2009	13	17	4	0
2010	19	7	6	3
Total	49	41	15	8

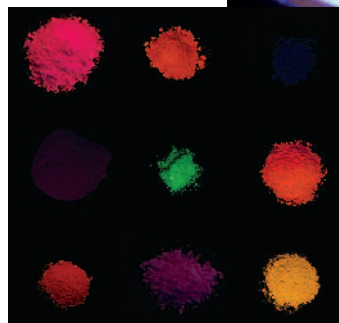
*Engineers technicians admin. staff - **Matriculated at INSA-Rennes



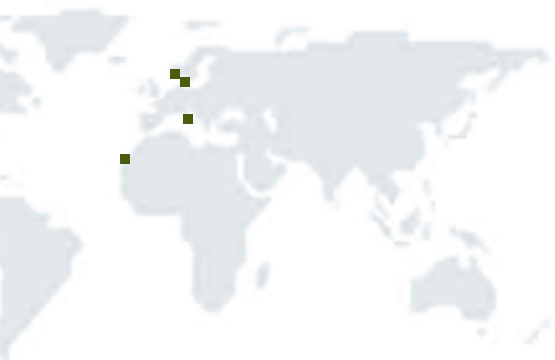
Equipment - New resources

SCR/MI - INSA has significant material resources in a number of fields:

- **synthesis and crystallogenesis** (cold store, glovebox, Schlenk ramps, freeze-drying, large-volume reactors, centrifuges, ovens etc.). The equipment is used to carry out syntheses ranging from mg to several kg.
- **physical/chemical definition and analysis** (DRX, ATG/TD, FTIR, ICP, MEB)
- **study of optical properties** (fluorimeter and UV-vis absorption, colorimeter).



Luminescent powders under UV radiation



Networks and partnerships

SCR/MI - INSA works closely with numerous industrial or academic laboratories in France and other countries.

Examples include: ICMMO - Institut de Chimie Moléculaire et des Matériaux d'Orsay - Laboratory of Molecular Magnetism (University of Florence, Italy) and EPFL - Ecole Polytechnique Fédérale de Lausanne, Switzerland. A partnership is in the process of being set up with the University of Dakar, Senegal.

Innovation and technology transfer

SCR/MI - INSA is extensively engaged in finalised research. Working with LGCGM, SCR/MI - INSA is undertaking a number of civil engineering research projects.

As an example, SCR/MI - INSA has recently signed a contract with Rennes City Council, expected to last several years, to survey the condition of, and damage to, all the sewage pipes in the city. SCR/MI - INSA will provide the physical and chemical analyses that are essential for the drafting of the damage diagnostic by LGCGM.

The team is also engaged in research into the durability and fire protection of materials based on sulphate-bearing binders.

At present, SCR/MI - INSA is devoting a great deal of energy to the enhancement of the results of its fundamental research. Some of the compounds resulting from the fundamental research may have such good luminescent, thermal and chemical stability properties that their use could be envisaged as material markers. This would provide an efficient way of combating counterfeit goods.

Two sets of patents have been registered in this respect and licensed to the Olnica company.



Research

A significant result

Founding of the Olnica company

The laboratory developed a range of luminescent markers and decided that a company should be set up.

In December 2007, it set up the Olnica® "Business Unit" within the laboratory with a view to the future founding of a company. The Business Unit developed the project for two years (market surveys, toxicology testing, design of reader prototypes, client prospecting etc.). The company has recently been set up.

The project won an award at the 10th and 11th national competition for innovative young corporate start-ups (Concours National d'Aide à la Création d'Entreprises de Technologies Innovantes OSEO - MESR) in the "Emerging Company" category in 2008 and the "Start-up & Development" category in 2009.

The relevance of the team's industrial protection policy was recognised and rewarded with a Regional Innovation Trophy from INPI (Institut national de la propriété industrielle) in 2008, in the "Laboratories" category.



Suspension of luminescent nanoparticles under UV radiation

Prospects

Ions from rare earths are metallic ions with very low toxicity, used in increasing numbers of technological applications. They have a promising future (lighting, pollution clean-ups, telecommunications etc.).

SCR/MI-INSA is focusing its activity on the synthesis and definition of materials containing rare earth ions.

In this area, it enjoys a reputation for excellence and its aim is to increase its visibility still further by developing its work in sustainable chemistry and multi-function materials.

LGCGM Laboratory of Civil and Mechanical Engineering

UPRES EA 3913

Research^h

LGCGM - Civil and Mechanical Engineering Laboratory - combines research teams from INSA-Rennes and the University of Rennes 1 (Institut universitaire de technologie, Rennes and St Malo).

Staff of LGCGM is approximately composed by 80 members.

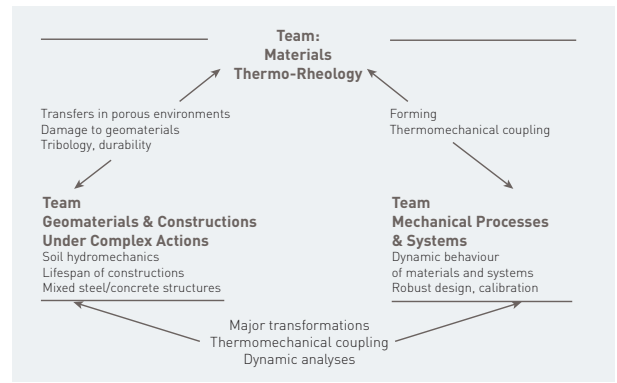
Three research teams structure the LGCGM:

- Geomaterials and constructions under complex actions
- Mechanical processes and systems
- Materials, Thermorheology

LGCGM
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- Mechanical engineering
- Materials
- Structures
- Rheology
- Porous environments
- Aquatic environments
- Complex fluids
- Assemblies
- Durability
- Thermal research
- Tribology
- Major deformation
- Forming
- Robotics



Research teams

1. GEOMATERIALS AND CONSTRUCTIONS UNDER COMPLEX ACTIONS

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 William.Prince-Agbodjan@insa-rennes.fr

The research undertaken within LGCGM cover the following areas:

- problems arising in the construction of buildings and civil engineering regarding soil, materials or structures
- subjects relating to the optimisation of industrial production tools such as the forming and assembly of components or the design, calibration and control of handling robots.

Emphasis is placed on the problems of interfaces and interaction: assemblies and links in structures, interfaces between fluids and solids, paste/wall, matter/tool, links between materials / processes / machinery etc.

The studied objects are subjected to a range of tests, some of them particularly stringent e.g. large deformation of materials, dynamic aspects (seismic, fast dynamic, thermal under various conditions), paired actions (thermo-mechanical, thermo-hydro, hydro-mechanical), fire etc. Most of the problems are considered from the point of view of experimentation, model-building or simulation - analysis of materials and structures, study of forming processes etc. The research teams use multi-scale approaches to obtain a more comprehensive definition of a system or process i.e. microscopic scale (mineral components, grains, pores, constituents of composite materials and metal alloys), mesoscopic scale (collection of grains, section of beam or post) and macroscopic scale of the construction (bridge, building etc.) or manufacturing system (machine + tool + material).

It is also a support unit for the “Science of Matter” Ph.D students in Rennes and for students working towards a Master’s in “Mechanical and Civil Engineering”, a joint diploma awarded by INSA-Rennes, the University of Rennes 1 and the University of Southern Brittany (Université de Bretagne Sud).

The team works in two main areas which have several features in common - firstly the use of testing, model-building or simulation to look at the various scientific problems and, secondly, a field of observation and multi-scale analysis to describe the objects and systems being studied.

Multi-scale and multi-physical model-building of geomaterials in their environment

The main aim is to study geomaterials (soils, rocks, building materials) in their environment, taking account of their differing characteristics, the effect of time and the effect of severe constraints. Among the research being undertaken is the simulation of interface defects between roadway layers, multi-phase transfer in porous environments and the durability of materials. This last area of research includes the problems of sustainable development, with the aim of developing innovative materials or materials with a low environmental impact, studying their behaviour under severe constraints and determining their durability.

A few of the topics covered: Digital model-building of the diffusion ability of cracked mortar. Digital model-building on a mesoscopic scale to demonstrate the behaviour of concrete; application to alkali-reaction. Digital 3D model-building of the behaviour of cement-based materials. Application to lixiviation. Digital and experimental study of the displacement of solid particles in a porous environment. Filling of porous materials subjected to poly-phase run-off. Behaviour of interfaces in mixed roadways; radar auscultation and discreet model-building. Structural auscultation of mixed roadways: detection of interface defects using deflection.

Multi-physical model-building of the behaviour and durability of structures

This research aims to develop detailed model-building to explain the behaviour of civil engineering structures, understand how they are damaged, and help to develop rules for the computation and introduction of maintenance and renovation strategies. The chosen approach is designed to integrate the behaviour of the material and the structure in greater detail, taking account of paired interactions and changes in interfaces. The approach also integrates notions of environmental classes and the main pathologies that can limit the durability of constructions or lead to their ruin: early cracking, carbonation, corrosion, alkali-reaction and sulphur damage. A number of non-destructive auscultation techniques are used in this research, e.g. acoustic transmission, propagation of ultrasound waves and infrared thermography.

A few of the topics covered: Model-building of the non-linear behaviour of mixed steel/concrete constructions. E.F. 3D beams undergoing major displacements: co-rotational approach. Behaviour of structures assembled with bolted ties. Capping to connect the beams of mixed steel / concrete bridges. Header to connect the beams of mixed steel / concrete bridges. Ductility of steel and mixed beams. Study of the steel / concrete interface using non-destructive techniques.



← “Comparative studies of thermal barriers”
 Structural insulating boxes with on place poured concrete.

2. MECHANICAL PROCESSES AND SYSTEMS

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This team has two main areas of research i.e. "Materials, Forming and Assembly Processes" and "Mechanical Systems".

Materials, Forming and Assembly Processes

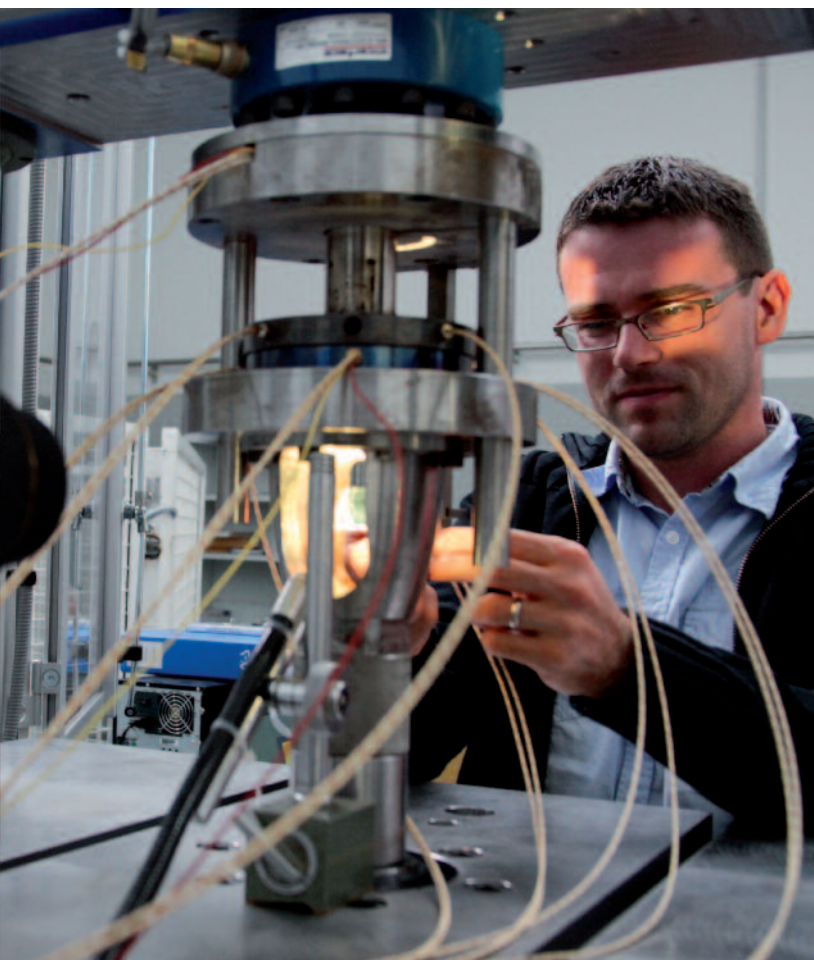
The research conducted in this area refers to the identification of the rheological behaviour (thermo-visco plastic behaviour, anisotropy, limit of formability etc.) and tribological behaviour of metal and polymer materials subjected to severe stresses: major deformation, high temperatures, high deformation speeds. These conditions are common in "conventional" forming processes such as forging or extrusion, in the so-called "innovative" processes such as hydroforming or hot pressing, or in assembly processes (laser welding, FSW etc.). The identification procedures developed require reliable experimental bases. To this end, a number of test devices ("Marciniak" press, test bed for dynamic biaxial traction, dynamic mono-axial tests, fatigue test bed, dynamic camera) have been installed. Together, these test resources have been used for a range of thesis work with the common aim of improving the prediction of rheological models implemented in digital computation codes.



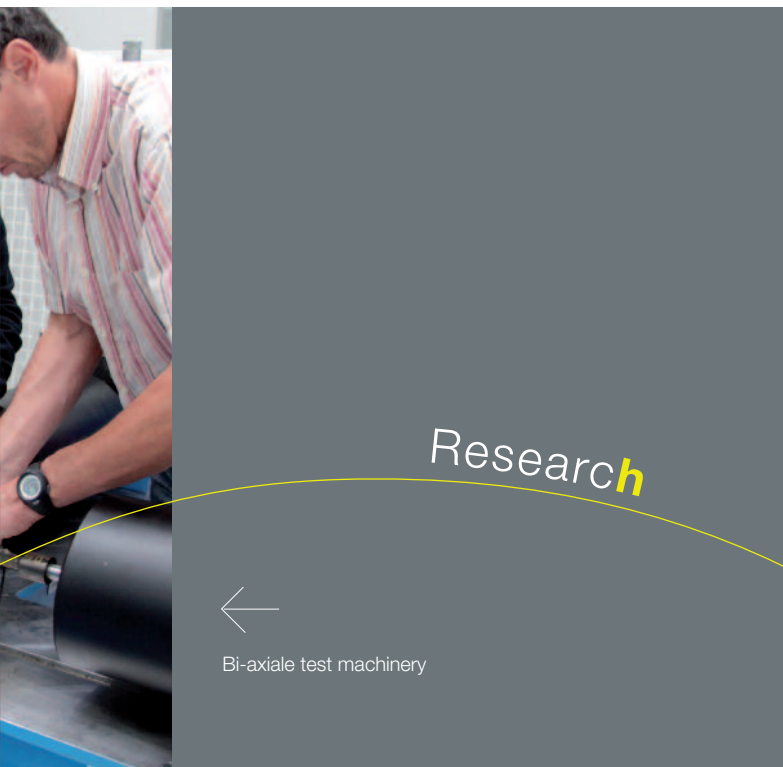
Mechanical systems

The main aim is to improve the accuracy of handling machinery and robots (series and parallel) by understanding all the stages from their design to their control as follows:

- **Robust design of multi-articulated systems:** a new family of parallel manipulator robots has been designed, with many advantages e.g. increased precision, use of various sources of energy from the activators and reduction in loads. Other mechanisms and devices have also been invented and designed to improve the static and/or dynamic precision of systems already used in industry (stacker cranes, 3D measuring devices) and in the medical sector. The results have led to the publication of five patents, the registration of a further two and the writing of two theses.
- **Machine accuracy (model-building, calibration and control):** the aim is to improve the accuracy of installation and trajectories in existing machinery. This involves the proposal of innovative methodologies for model-building, efficient calibration methods and new control processes. This work has been the subject of three theses.
- **Identification of the behaviour of non-linear systems using fuzzy inference systems:** a model-building methodology for strongly non-linear mechanical systems using "grey box" type models has been proposed. Unlike "black box" models, their "grey box" counterparts are based on a structure with known parameters, some of which are identified experimentally and integrated using fuzzy inference systems. This work was the subject of a thesis undertaken as part of the Grand Lague project accredited by the "Sea Brittany" business cluster.



Material definition test bed



Research^h



Bi-axiale test machinery

3. MATERIALS, THERMO-RHEOLOGY

Team Leader: Christophe LANOS
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 Christophe.Lanos@univ-rennes1.fr

The research activities of the M,T-Rheo Team can be described as follow:

Rheology and rheometry of complex fluids

The identification of the rheological behaviour of complex fluids (muds, pastes, mortars, concretes...) helps us to highlight the

extrusion flow properties, or to adapt the the mineral materials formulation (F. Micaelli and A. Pierre PhD Thesis), or to highlight the tribological behaviour (V.H. Hoang PhD Thesis).

Research works realised with natural suspensions allow the interactions between the quality of aquatic environments, the biogenic deposits and the sediment transport/structuration/deposition (scientific exchanges with Ifremer and Géosciences Rennes).

Solid concrete rheological behaviour

Models based on the combination of mechanical damage and plasticity has been developed (A. Hammouda PhD Thesis).

Mineral materials durability and hydro-thermal transfer/transport

Different materials (potential material resources, mineral wastes...) can be used for new compounds development. Such material can be used as passive fire protection for example (K.S. Nguyen PhD Thesis). The hydro-thermal characterisation of material with low impact on environment (hemp based materials...) (J. Chamoin PhD Thesis) helps us to test the efficiency of heat and mass transfer/transport models through equivalent wall structures (Y. Ait Oumeziane PhD Thesis). The hydro-thermal behaviour of mineral material submitted to high temperature is also studied for fire protection applications (K.S. Nguyen and A. Rojo PhD Thesis).

Energetic

Experimental and numerical research works are realised. The energetic efficiency increasing is the main objective for building applications. Works combine the building specificities, materials using and technical equipments (heating and cooling systems...) (M. Slavu, M. Ghetu and P. Byrne PhD Thesis). The flow properties in the heat exchange systems are also studied and the used fluids are composed with nano particles. High performances of such systems have been highlighted (R. Luciu PhD Thesis).



Top: Controlling the formulation of mineral foams.
 Bottom: Heat/water transfer in hemp concrete.

Staffing levels and results (2008-2009-2010)

Staff

LGCGM includes lecturer-researchers from INSA-Rennes ("Civil and Urban Engineering" and "Mechanical Engineering and Automation" departments) and from the University of Rennes 1("Civil Engineering" department at the IUT in Rennes and "Industrial Engineering and Maintenance" at the IUT in St-Malo).

Year	Lecturer-Researchers	ATER	Ph.D students**	Ph.D graduates	PAST	IATOS*
2008	38	1	32	1	1	8,4
2009	38	1	35	1	1	8,4
2010	38	2	38	-	1	8,4

Academic results

Year	Masters**	Thesis presented	HDR presented
2008	25	5	2
2009	35	11	1
2010	33	11	0
Total	93	27	3

Scientific and contractual results

Year	Publications	Papers	Current contracts	Patents	Books
2008	34	61	25	-	2
2009	35	44	25	3	1
2010	35	24	30	1	1
Total	104	129	80	4	4

*Engineers technicians, admin. staff - **Matriculated at INSA-Rennes

LGCGM has also been involved in the organisation of various conferences and scientific or technical meetings:

- "Journées des Jeunes Rhéologues" du Groupe Français de Rhéologie, Erdeven, 26-28 March 2008.
- "27^{ème} rencontres universitaires du Génie Civil" AUGC, St Malo, 3-5 June 2009.

Equipment - New resources

LGCGM now has several technical test beds:

- 120 m² mechanical test bed with a set of high-capacity cylinders (1500 kN)
- Machines and presses for static and dynamic testing (various capacities),
- Dynamic multi-axial press. Slave machinery for ground compressibility and shearing
- Series and parallel robots
- Rheometry equipment: plastometer, tribometers, extruders, concrete rheometers
- Laser display source with capture system (camera) and image analysis
- Heat-regulated enclosures, bi-climatic enclosure, ceramic ovens, hot guarded plate device, CTmeter, IR camera
- High-speed high-precision measurement acquisition devices, 3D contact-free metrology system
- Digital simulation tools for the mechanical and thermal study of fluids and solids: Abaqus®, Plaxis®, Fluent®, Forge2®, Castem, Comsol®, etc
- Acoustic transmission and ultrasound wave speed measurement device
- Helium permeameter
- Thermo material properties identification - micro and macro scales (conductivity, diffusivity, heat capacity) (TGA, DSC analysis)
- Device to measure specific surfaces, real and apparent volumes, and porosity
- Salt spray chamber, environmental chamber, carbonation chamber

Networks and partnerships

Local and regional networks

Working with various research teams from the Universities of Rennes 1, Southern Brittany (Bretagne Sud) and Western Brittany (Bretagne Occidentale), LGCGM is involved in a number of regional projects:

- Multi-Training Programmes
 - Transport in porous media with changing structures
 - From forming to the dynamic behaviour of metallic materials
- Federating structure, "Materials and systems engineering"
- CPER "PRINTAN" project: mechanical and materials platform (UBS-INSA Rennes)

Several PRIR (Programmes de Recherche d'Intérêt Régional, research programmes of regional interest) grants have been obtained by LGCGM .

National and international networks

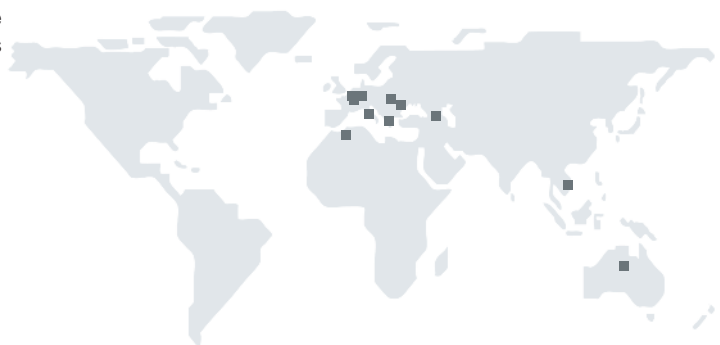
LGCGM is also involved in various multi-partner projects.

A few examples:

- ANR Physepat (Physics of paste extrusion) and Bétonchanvre (manufacture of hemp concrete)
- National Mikti project on the behaviour of composite steel /concrete bridges, in partnership with industrial companies and the French Ministry of Public Buildings and Works
- CEEC programme on energy efficiency and atmospheric quality in buildings, in particular involving research teams in Romania and Hungary
- European OPUS project on the maximisation of seismic resistance in steel and composite steel/concrete structures, with partners from Germany, Italy, Greece, Belgium and Luxembourg



The LGCGM's international work also includes **joint Ph.D theses**. In 2008 and 2009, there were 14 joint Ph.D theses with joint management provided in partner laboratories in the following countries: Germany (1), Italy (1), Romania (3), Algeria (5), Armenia (1), Vietnam (2) and Australia (1).





"Comparative study of thermal barriers"



Rheometry of concentrated suspensions.



Innovation and technology transfer

Industrial collaboration

During 2008, 2009 and 2010, LGCGM carried out numerous projects in the form of research contracts on behalf of companies or official bodies and in the form of theses covered by CIFRE agreements (Conventions Industrielles de Formation par la Recherche, industrial agreements on training through research).

A few examples of industrial partnerships:

Partners	Research Contracts
ADEME/EDF R&D	Experimental monitoring of the Solaris high environmental quality house
AIRBUS	Industrie Simulation of the drawing of single-curve panels
ARCELOR	Search for technical and economic solutions for the joining of composite bridge platforms
Comité Rance (COEUR)	Monitoring of sedimentation and analysis of deposits in the Rance Estuary
CSTB	Simplified methods and application guide for the calculation of composite steel/concrete beams
EDF	Absorption of iodine and caesium by an argillite
Société KP1	Rheometry and extrusion of construction components

CIFRE Agreement

CTICM	Model-building of composite frameworks: fire resistance
CTICM	Model-building of tie assemblies
EDF	Behaviour of materials used in rock-built dams
Société EXTHA	Thermal and chemical behaviour of mineral materials
Société K&Co	Control of adjuvants in concentrated suspensions
Société ISIS	Maximisation of the SurgiScope robotic system
Société SYDEL	Structure for a storage and retrieval machine with high dynamic capacity

Patent registrations

During this 3-year period, three patents were registered in the field of industrial robotics.

Prospects

In the immediate future, projects for LGCGM teams will be an extension of current areas of development:

- Mechanical and hydro-mechanical behaviour of geomaterials and structures in the long term: damage to aggregates and concretes, transfers in porous media, cyclical behaviour of assemblies,
- Rheology of complex fluids and study of fluid-solid transition, study of nanofluid-based heat exchangers, and transfers in materials with low environmental impact,
- Forming of stiffened structures and thin sheet metal (hydroforming), geometric, elastic and dynamic model-building, control of multi-jointed mechanical systems.

LGCGM also intends to strengthen its involvement in local and regional networks.

Research



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