Annual Report 2008



List

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Editorial

2008 was an especially good year in terms of scientific progress, enabling us to consolidate and strengthen our industrial and academic partnerships.

The year was marked by some major milestones, including the development of a data processing software platform for molecular imaging applications - part of the European Computis project – and the first breakthroughs in the automotive field of Oasis technology devoted to the safety of embedded systems. February saw the opening of the GERIM non-destructive testing platform in Saclay, in the presence of our partners and members of the Ile-de-France Regional Council. With the new platform, our partnership-based R&D activities will benefit from equipment that is unmatched in Europe. The Articulated Inspection Arm (AIA), also known as the "snake", was successfully deployed for the first time in the Tore Supra reactor in Cadarache, demonstrating the feasibility of the concepts proposed by LIST for inspecting a tokamak under ultra-high-vacuum and high-temperature conditions. Several innovative technologies were brought to light in the sensorial interfaces field at LIST, such as MR-Drive for automotive applications or Vibee, a portable haptic interface.

During the year, many technology transfers took place and new start-ups were born. One example was the strategic agreement signed with Thales for a joint laboratory, called Vision Lab, specialised in image processing and analysis for video surveillance purposes. Another example is Kalray, a start-up which has set up the initial funding for a highly ambitious project to develop a new generation of high-performance, programmable, integrated circuits, based on massively parallel embedded computers.

CEA LIST also consolidated its international partnerships, in particular through its strong involvement in the InterCarnot projects, with the Fraunhofer Institutes, and its active participation in the Eureka and FP7 programmes.

Lastly, LIST took its commitment to its ecosystem in the Greater Paris area one step further with the French government's "Plan Campus" and the certification of the "Plateau de Saclay" project. The Digiteo joint projects and the System@TIC Paris-Région cluster have played a pioneering role in driving innovation in the region.

I hope you enjoy reading this annual report.

Riadh CAMMOUN, Director of the LIST

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Highlights 2008

Unisim: system simulation for "specialist" solutions

UNISIM, a platform dedicated to simulation of complete equipment systems, has been developed together with INRIA. A first industrial trial was successfully undertaken as part of the Usine Logicielle (Factory Software) project (System@TIC), with an estimated industrial gain of order 6 months in the development of "artisan" solutions.

eISP boosts video in mobile telephones

The innovative processing architecture, eISP (embedded Image Signal Processor), was designed to improve the quality of images provided by CMOS sensors in mobile telephones. Based on an array of processing cores and supporting video, that meets the HD 1080p standard, eISP architecture is one of the most competitive on the market, with a performance of 56 MOPS/mW.

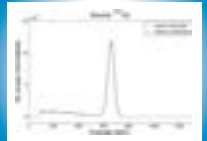
FLUCTUAT is successfully used in the aerospace domain

The must critical command and control code for an ATV (ESA - Automated Transfer Vehicle) has been tested by the abstract interpreter Fluctuat. The tool has demonstrated the numerical stability of the algorithms and the impact of the tested software design on numerical precision. It has also made it possible to validate the overall behaviour of the system.

First inspection under vacuum for AIA

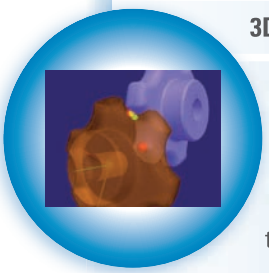
The robot, AIA (Articulated Inspection Arm), was successfully deployed for the first time under high vacuum conditions (10^{-4} Pa, 40°C) in the plasma chamber of the Tore Supra tokomak. The poly-articulated arm (9.5m span) demonstrated its ability to perform robotic work and inspection in the fusion reaction chambers, by carrying out an inspection of the internal walls of the reactor using an on-board camera.

Development of dead time digital management in radioactivity metrology



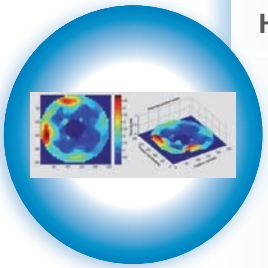
The replacement in radioactivity metrology of analogical conventional systems by digital management system constitutes an important project of LNHB.
Today, this transition at the metrological level is acquired with the development of two prototypes, the one for the gamma rays crystal well measurements, the other one for the coincidence liquid scintillation. Very satisfactory results were obtained. They allow envisaging the pursuit of the project until its term, by widening him in new features brought by this new technology.

3D collision detection algorithm



A new method for detection of 3-D collisions has been designed to simulate actual digital models in real-time. Giving access to complex industrial scenes via the extraction of tasks which can be executed in parallel, the method has been trialled on industrial test cases. The first results have already been able to reduce the processing time by a factor of 7 using architecture with 8 microprocessor cores.

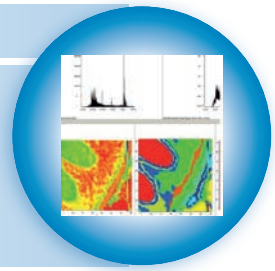
High speed tomography



Innovative, high-speed, absorption tomography techniques have enabled modelling of cavitation produced in CNES Vulcain engines (Ariane launcher). Observation of the sites where fluids and vapour are produced and distributed has provided information on previously undetected behaviour. The SAFRAN-SNECMA group wishes to perform equivalent tests on flight engines using real cryogenic fluids.

Data processing for molecular imaging

A software platform, intended for developing new methods of biochemical analysis for molecular imaging, was delivered in 2008 by the European project, Computis. It enables, for the first time, visualisation, processing and analysis of the very large volumes of complex data which are generated by mass spectrometry.

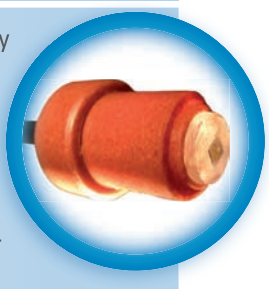


Bragg grating for railway transport

Instrumentation based on Bragg gratings has been developed in order to optimise maintenance and to improve the availability of railway infrastructure through the European project, Catiemon. More than 200 trains have been characterised, using measurements of catenary line deformations, for traffic speeds up to 250 km/hr. The installed gantry enabled successful detection of abnormal convoys.

Single crystal diamonds for radiotherapy applications

Optimisation of the technique of chemical vapour-phase deposition assisted by plasma microwaves, has enabled development of new dosimetry detectors using synthetic diamonds. The prototypes ("tissue-equivalent" point dosimeters) have been produced and tested by the Institut de Physique Nucléaire at Cracovie and the Institut Gustave Roussy, and several validation exercises have been carried out at European cancer treatment centres. The excellent results obtained, in terms of stability, repeatability, signal to noise ratio and response speed, have satisfied the most severe radiotherapy criteria, in particular those for the new techniques of mini-beams and hadron therapy.



Key events in 2008

Success of MAESTRO project international conference on use of Monte Carlo codes in radiotherapy

Jointly organised by CEA LIST and Institut Gustave Roussy (IGR) under the auspices of the European Union and the Île de France Region, the "Monte Carlo treatment scheduling systems: towards a new paradigm in radiotherapy" conference took place on 4 April 2008 at the IGR. The conference was attended by 120 medical physicists, software developers, radiotherapy equipment manufacturers and students.

It began with a description of the European MAESTRO project and the ANR TELEDOS project, as well as a summary of the advantages of Monte Carlo codes for the calculation of dosimetric scheduling in treatment planning systems (TPS). The medical introduction was made by Professor Gilbert Lenoir, Director of Research at IGR and director of the Campus Cancer project.

Delegates were able to watch real-time demonstrations of LIST technologies in computer code parallelisation. The conference closed with a round table chaired by Alan Nahum of Imperial College, London.

CEA LIST and Renault receive the Laval Virtual Trophy 2008 for InnovIA, a technical gesture learning platform

As part of the InnovIA programme (Innovation for the automobile industry) in partnership with Renault, CEA LIST has developed a platform using 3D-enhanced reality, designed for training in technical gestures and dexterity, which combines a high level of realism with multimodal assistance to facilitate learning. The platform seeks to reduce costs and improve quality through more effective training. For the first application considered – applying a bead of filler – the platform offers a simulation environment that is very close to real shop conditions and visual, auditory and tactile sensory assistance to guide the user.

Presented at the Laval Virtual exhibition in April 2008, the application developed for Renault by LIST won the Laval Virtual Trophy in the "Automotive, aeronautics and transport industry" category.

European research into embedded systems – Artist unites hardware and software

Artist, the only European network of excellence specialising in embedded systems, was created in 2003. It represents Europe's entire research community in the field of real-time, embedded software. From the outset, CEA LIST was asked to join the core of key partners. It won the recognition of the leading European research organisations in embedded systems for its expertise in a unified language (UML) for the specification and modelling of real-time software. The Artist network met with such success that an extension known as ArtistDesign was proposed in 2007. This focuses on the hardware aspect of embedded systems. Many industrial players have joined the initiative to express their requirements and steer scientific research in their direction.

CEA LIST has been made Core Team Leader of two groups in ArtistDesign (Modelling and Validation, Hardware Platforms and MPSoC), which is a clear indication of the recognition of its academic partners in the network. ArtistDesign will teach us more about future market requirements, particularly in terms of safety and dependability of architectures with a high degree of parallelism.

GERIM: Ile-de-France acquires an R&D platform dedicated to industrial testing that is unique in Europe

The GERIM platform, a large-scale multisensor instrumentation research facility, was inaugurated on 20 February at CEA LIST in Saclay in the presence of all its founders, CEA, the Ile-de-France Region and its R&D partners from industry and academia. Around 100 people visited the facility and took part in the various tours organised.

The platform, equipped with multicomponent ultrasound and eddy current sensors and a robot for data acquisition on different types of test pieces, is unique in Europe. It is also used to study new sensor technology, develop new testing methods and validate the related processing tools. Research will also focus on testing composite pieces with complex geometry, very thick materials, laser welds and on methods to detect and characterise cracking. The platform is available for use by key players in the Ile-de-France region: the public research laboratories that develop new test methods and the industry labs that use them. Complete installation of the platform took 18 months in development, and it is already booked for the next four years by the various partners.

CEA LIST's embedded systems come away with two prizes at the Carrefour du PREDIT event

The Carrefour du Predit, an event devoted to the French Predit programme for research, experimentation and innovation in land transport, was held on 5-7 May at the Palais des Congrès in Paris. Some 1,400 delegates attended the conference and visited an exhibition gathering about thirty exhibitors and showing many demonstrations of innovative vehicles.

An award ceremony for the most promising Predit projects was also organised in the presence of Luc Chatel, the French Minister in charge of Industry and Consumer Affairs. CEA LIST came away with two prizes. The SEEDS project (Smart Embedded Electronic Diagnosis Systems) focusing on wiring diagnostics, was awarded the "Information and Communication Systems Integration" prize. SEEDS was launched in 2006, under LIST coordination, to study and prove the feasibility of an automobile wiring diagnosis system for use in the garage or on board vehicles to monitor wiring bundle status.

SAS-VH, a project focused on a safe access system enabling people with reduced mobility to board trains, received the "Mobility Services" prize. Led by SNCF, the project seeks to provide disabled people with easier access to trains by "bridging" the difference in level between station platforms and railway carriage floors. LIST developed image processing algorithms for accurate positioning of the access ramp for disabled people.

SEEDS Project Manager, Marc Olivas, of CEA LIST, receives the Predit 3 "Information and Communication Systems Integration" prize from Ludovic Valadier, the Manager of ANR's Partnership and Competitiveness Department.

Ville Européenne des Sciences: EURITRACK under the spotlight at the Grand Palais

During the French Presidency of the European Union, the French Minister of Higher Education and Research decided to increase the scope of the 2008 edition of the Fête de la Science science fair. The Ville Européenne des Sciences event held from November 14 to 16, 2008, in the Grand Palais (Paris) allowed over 43,000 visitors to explore the everyday applications of projects conducted within the European Research Area.

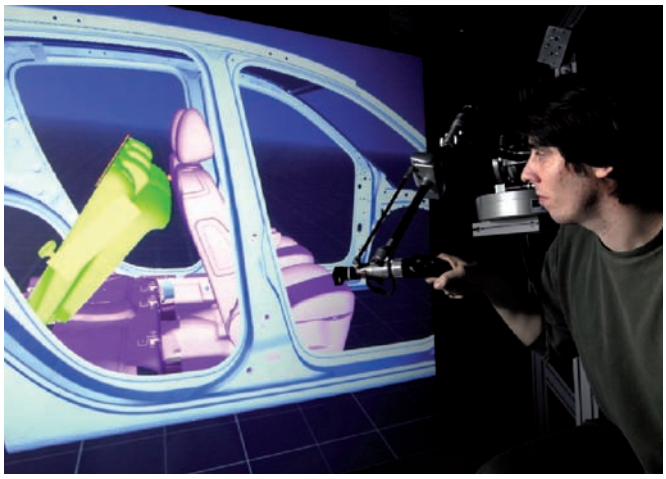
As a leading research institute, CEA actively participated in this event, which is intended for the general public. An area covering over 200 m^2, named "Carrefour de la prévention", was set up to present the most significant scientific results in the field of security. LIST was proud to present the EURITRACK project for a neutron interrogation-based system that performs a non-intrusive analysis of the chemical composition of shipping containers to detect the presence of any illegal substances.

The project was presented using a full-scale model of the demonstration system installed in the industrial port of Rijeka (Croatia). During the official inauguration, Hervé Bernard, CEA Vice-Chairman, presented the EURITRACK system to Valérie Pécresse, French Minister of Research, Janez Potoznic, European Commissioner for Research, and Jean-Louis Borloo, French Minister of Ecology.

Innovating

Positioning centred on innovation

Continuity and seamless connections between upstream and downstream research activities are vital to innovating and creating value. With this in mind, LIST conducts research into cutting-edge technology, covering the entire innovation chain, from concept to pre-industrial demonstrator. It thus helps to develop its industrial partners' competitive edge as part of a determined partnership-based approach.



Strategic partnerships

This original positioning has enabled LIST to build industrial partnerships with a hundred business organisations - both major groups and SMEs - in the automotive, aeronautics, nuclear, security and medical sectors. It has also resulted in the creation of many joint R&D laboratories and programmes built around shared and lasting technological views. These relations are highly profitable, generating more than 200 contracts per year. Since 2001, they have also led to the creation of six high-tech start-ups and a portfolio of 176 international patents corresponding to 70 active licences.

Renault Innovia

What?

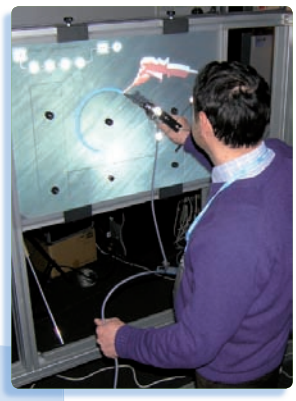
- Joint research programme for the design of virtual reality tools.

How?

- Renault and CEA LIST have jointly developed a 3D augmented reality platform, designed for training in technical gestures and dexterity. The platform combines realism with multimodal assistance (visual, audio and tactile) to make learning easier.

Why?

- To teach operators technical gestures in the factory under "real" conditions in terms of equipment and learning times (preparation, cleaning the equipment used, etc.). Faster, higher quality training helps cut costs and improve safety and working conditions.



LIST was awarded Carnot label certification in 2006, in recognition of the quality of its research partnership activities. It is a member of the Association of Carnot Institutes (AiCarnot), a network of more than 12,000 research scientists and 6,000 doctoral students, and can therefore provide businesses looking for research partnerships with a comprehensive range of skills.

Thales Vision Lab

What?

- Thales-CEA LIST joint laboratory, specialised in image processing and analysis for video surveillance.

How?

- By building demonstrators that represent a genuine breakthrough, integrating novel technology developed by CEA LIST. Deploying robust, operational automatic video surveillance solutions that make it possible to obtain an immediate grasp of complex situations.

Why?

- To protect critical infrastructures (stations, airports, city areas, industrial sites). This is a key point in security-related activities and viewing technologies are now nearing readiness for massive deployment.

LIST is actively involved in the Digiteo research network and in the activities of competitiveness clusters. The Institute's development is thus rooted in a global ecosystem, allowing it to fulfil its role as an effective driver of innovation. This is best illustrated by its strong involvement in the governance and leading research projects of the System@TIC Paris-Région world-class cluster and in the Cap Digital, Aerospace Valley, Moveo, Medicen and Minalogic clusters.

Kalray

What?

- Kalray-CEA joint laboratory specialising in processors and computing architectures.

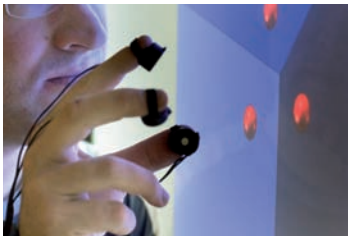
How?

- By bringing together CEA LIST's software and architecture skills and CEA LETI's expertise in silicon. Developing an execution model, a programming language and a generic, many-core, MPPATM (Multi-Processing Parallel Array) integrated circuit containing more than 100 processors and memories arranged in a novel architecture in which the processors are orchestrated by the system software.

Why?

- Combining ASIC (Application-Specific Integrated Circuits) performance with FPGA (Field Programmable Gate Array) flexibility, the Kalray chip is both powerful and reliable and targets medium-run markets. The MPPATM solution is suited to embedded applications calling for high computing power, such as security, telecom and medical applications, etc.

Preparing for the future



Innovation and invention are an integral part of any effort to prepare for the future and promote the emergence of technological breakthroughs. With this in mind, LIST has set up a major science and technology resourcing programme that has enabled it to boost its technological potential by initiating numerous projects. Theses and post-doc activities play a key role in these initiatives. The main purpose of resourcing is to renew and develop scientific potential and intellectual property, notably by filing patent applications.

Scientific resourcing in Digiteo

With its team of 1,800 research scientists, the Digiteo thematic advanced research network organises its scientific excellence activities around major thematic or exploratory projects. It also supported resourcing in 2008 by awarding the Digiteo label to a number of new dedicated projects in which LIST is closely involved. Including the projects on complex systems already started in 2007, CEA LIST now works on more than ten collaborative projects with its Digiteo partners. This type of activity increases opportunities for interaction and thus helps develop a structural framework for the network's research community.

TomoX3D

What?

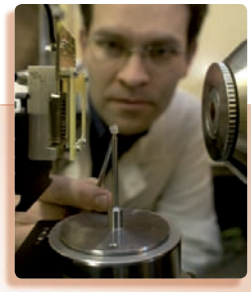
- New tomographic reconstruction techniques. TomoX3D is aimed at finding technological breakthroughs to push back the limits of conventional tomography methods used in industry. The quality of reconstruction is limited for very heterogeneous objects (copper in plastic), with a high aspect ratio (e.g. PCBs) and calling for high spatial resolution (such as fibrous or porous materials).

How?

- By combining the latest technological and algorithmic progress.
  - Hardware: micro- and nanofocus sources to reach resolutions of one micron and below.
  - Software: algebraic and iterative methods combining segmentation and 3D image reconstruction phases.

Why?

- To characterise the physical and morphological properties of samples in many fields, such as energy (electrolysers, fuel cells, future materials), transport (energy-absorbing foams, combustion), materials science (fibrous, porous, woven materials).



Another of the main goals of this network, which is centred on scientific excellence, is to increase the number of doctoral and post-doctoral students – current figures stand at 500 and 200 respectively – and train young researchers in sectors with high industrial potential. Not only do young researchers produce results in terms of intellectual property, they also help make the network more visible to the scientific community by taking part in international conferences and publishing in leading international journals.

PASO

What?

- Automatic analysis to demonstrate the safety and/or security of software.
- Design analysis software for the source code of computer programs (typically a numerical computer code) and demonstrate that its properties are maintained under all running conditions.

How?

- By combining a number of approaches to find new solutions.
  - Proposing new areas for mathematical modelling, numerical analysis, and equation solving through optimised accuracy and algorithms (and, therefore, computing times).
  - Trying out original methods for solving logic equations in these areas, in particular, fast convergence methods and/or methods allowing incremental resolution.

Why?

- To develop realistic tools for automatic source code analysis.

INSTITUT CARNOT CEA LIST

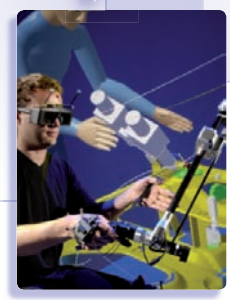
Carnot: technological resourcing

While it is true that obtaining Carnot label certification promotes the emergence of a community intent on finding outlets for its research activities, the label also provides a resourcing opportunity to fuel continuous technology transfer. LIST's commitment to the Carnot network has led to a significant increase in the number of patents filed. Figures for 2008 were 27% up on the previous year.

Manipulation intelligente

What?

- Understand and reproduce hand gestures.
  The project seeks to understand more about hand gestures and reproduce them in the finest detail to relieve humans of tasks requiring both physical and cognitive dexterity at the same time.



How?

- By optimising the operator-avatar relationship.
- Complex handling (supervised coupling, learning behaviour patterns and transitions, planning complex handling operations and assisted planning).
- Interfaces (portable kinesthetic interfaces, tactile sensory interfaces and miniature flexible pressure sensors).
- Interactive simulation (dextrous handling and grasping, unilateral and bilateral models and coupling).

Why?

- To obtain a realistic haptic rendering for the virtual model.

Resourcing projects concern human-machine interfaces (Manipulation Intelligente) and optimised use of radiotherapy (Optidose), as well as MPPA (Multi-Processor Parallel Array, multi-core processors for applications calling for high computing power and low consumption), CIVAmont2012 (new tools for non-destructive testing in industry) and Diamant (diamond substrates for large silicon surfaces, designed to improve heat dissipation in microelectronic components).

Optidose

What?

- Optimise doses given to radiotherapy patients.
  The concept is based on the principle of real-time, personalised dosimetry. This will be adapted to the equipment used for the treatment and will take into account the type of tumour and the body's response to radiotherapy.

How?

- By developing the dosimetric methods of the future.
- Optimising treatment planning (choice of beams, etc.).
- Calculating the dose precisely (Monte-Carlo methods) and quickly (target of 10 minutes).
- Reconstructing the 3D dose actually received by the patient.

Why?

- To obtain technology that can be transferred to radiotherapy centres.

Meeting European challenges

The international aspect of LIST's activity is an integral part of its research and innovation work. It finds expression in large-scale research and development programmes, particularly at the European level, where it focuses on major social challenges, such as those raised by the information society and security.

Developing research activities

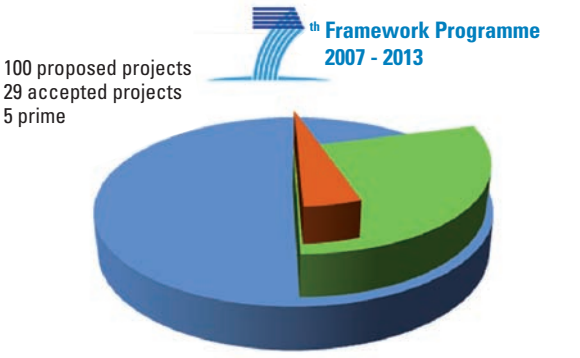
In 2008, LIST's activities focused for the most part on its commitments to European programmes and its support for SMEs on the European market.

The projects proposed by LIST for the 7th Framework Programme concern four major themes – Security, Transport, Healthcare and Information and Communication Technology.

LIST also continued its industrial R&D activities, as part of the Eureka programme, in the field of embedded and distributed software technology. It is now committed to a total of nearly 30 projects (Eureka, Medea+, Pidea, ITEA, ITEA2 and Catrene).

Two key projects involving LIST were selected in the field of embedded systems and in the context of the Artemis Joint Undertaking: Cesas (on software engineering and embedded computing) and Scalopes (on communication infrastructure applications, surveillance systems, mobile terminals and video platforms).

A source of new ideas for Europe



In line with its partnership policy to promote the development of the SMEs in its ecosystem on the export market, LIST set up a number of specific initiatives with the System@TIC Paris-Région competitiveness cluster. These initiatives are aimed at simplifying access to collaborative research for SMEs.

SYSTEM@TIC PARIS-REGION Pôle de compétitivité

Research with SMEs

Goals:

- Provide SMEs with easier access to European collaborative research.
- Promote their development by helping them gain a foothold in European markets.

CEA LIST activities

- Joint information and analysis meetings on FP7 ICT (Information and Communication Technologies) calls for projects and calls targeting SMEs.
- Assistance in setting up projects: defining intellectual property rules, financial engineering, setting up research consortia, etc.

Setting up ambitious partnerships

In an increasingly globalised R&D world, innovation calls for special partnerships with leaders in the Information and Communication Technology (ICT) field. Under the impetus of the Carnot network, a genuine development booster, LIST forged new collaborative ties with its European counterparts, such as the Fraunhofer Institutes, TNO, VTT and Tecnalia. Putting partnership research at the heart of their strategy, these partners possess the capabilities required to propose an integrated, multidisciplinary offer. This recognition of shared values helps to bring Europe's research players closer together.

It was with this in mind that LIST decided to join forces with Germany's Fraunhofer Institutes on a number of Europe's Carnot projects, with a special focus on the ICT, security and healthcare sectors. On behalf of the Carnot Institutes, LIST is more specifically involved in coordinating partnership initiatives with TNO in the security sector. This involves identifying any potential available within the Carnot Institutes and defining a joint approach for setting strategic objectives to take up the major challenges facing our society.

Lastly, LIST also promotes the development of cooperation networks with industry, research and technology organisations (RTOs), think tanks and end users, through its support activities for the European Commission. The Crescendo project is a good illustration of this in the security field. Its main objectives are to identify scientific experts from European countries and define technology roadmaps.

CRESCENDO Coordination action on Risks, Evolution of threatS and Context assessment by an Enlarged Network for an r&D rOadmap

Research programme

22 partners
14 European countries

Goal:

- to coordinate Security-related research more effectively.

CEA LIST activities

- **Programme coordination.**
- **Heading the working group set up to boost the European innovation process:**
  - by analysing the requirements of the subject in question and adopting a proactive process to anticipate their future development,
  - by analysing the connection between regulations and the supply chain, as well as ways to improve relations between the three parts of the "knowledge triangle": Education, Research and Industry.
- **Making recommendations to the European Commission to assist upstream research and help define activities for future European calls for Security-related projects.**

Committing to the future

LIST is actively involved in the ComplexEIT pilot project, where it explores new forms of governance for the European Institute of Innovation and Technology (EIT). The EIT seeks to stimulate innovation in order to promote sustainable growth and a lasting competitive edge for Europe. In doing this, its ambition is to have a positive economic and social impact. Its task is to set up highly integrated Knowledge and Innovation Communities (or KICs) to make optimum use of the innovative capabilities of those working in research, education and the business world, both inside and outside Europe.

ComplexEIT
complexity from nano to large electronic systems

CompexEIT project

Goal:

- **Create a European innovation network based on the knowledge triangle (research, education and industry) and the regions.**

CEA LIST activities

- **Coordination of the Centres of Excellence part of the project,** based on four case studies: Minatec (Grenoble, France), Digiteo (Paris, France), Imec (Leuwen, Belgium) and Fraunhofer VμE (Dresden, Germany).
- **Promoting the sharing of good practices** and experiences of the different clusters.

Interactive Systems

Robots, sensory interfaces, virtual reality systems and multimedia engineering: These interactive systems, which need to "communicate" with man in a multimodal manner, are becoming more and more complex. In this field, the work at LIST is concentrated in two areas: firstly on robotics and secondly on interactions with virtual or multimedia, digital objects. These two areas have a number of features in common, which has resulted in joint projects such as the development of humanoid robots, equipped with interactive envelopes.

In the first area, robotics, the research effort of the LIST teams is directed both towards control and monitoring systems and towards mecatronics, for four fields of application: autonomous systems (including drones), cobots (particularly robots assisting in surgery or kinesiotherapy, etc.), remote manipulation and finally navigation and positioning software for pedestrians. This last field reflects the institute's desire to increase the usefulness of technologies coming out of robotics and to spread them into other sectors. This approach has had very positive results for mechanical models of robots, which have enabled optimisation of the design, monitoring and maintenance of industrial machines.

Developments in the second area relate to knowledge engineering and sensory interfaces. Collision detection algorithms for use in virtual reality simulations, have increased in power, making it possible to produce ever more precise virtual prototypes by improving coupling with force-feedback interfaces. LIST teams have also developed new algorithms for simulating deformable objects. In the area of knowledge-engineering, multimedia data-extraction is becoming more and more effective, and may in the longer term enhance virtual reality, by adding semantic information to 3-D virtual scenes. Finally, the work on sensory interfaces is currently directed towards interactions with large surfaces, inclusion of these interfaces in transport systems, and even their miniaturisation for portable technologies.

Bruno Maisonnier

founder of Aldebaran Robotics

"Our partnership with CEA-LIST, is now growing much stronger."

What are your company's objectives?

Aldebaran Robotics was set up in 2005 and now has around fifty employees. We design, produce and sell humanoid robots. Our robot – called Nao – who is about sixty centimeters high, is an incredible means of exploring the possibilities opened up by robotics for our academic and industrial customers. They can program the robots to do anything they want, teach them behavior patterns and use them for specific applications. These systems are able to interact with humans and are connected to the Net, which means they can communicate and share programs with one another, thus enriching their behavior.

What is your relation with CEA-LIST?

Our partnership with CEA-LIST, albeit quite recent, is now growing much stronger. The arrival of Rodolphe Gelin, former Head of Interactive System Programs at the LIST, is a major plus for this relationship. Nao is available for sale, but we are constantly looking at ways to improve him and, in particular, we are working with the teams at CEA-LIST on certain elements for which there is still much room for improvement, such as his motorization, cognition and object recognition functions, as well as voice recognition. In addition, together with the LIST, we are committed to the Romeo Project, approved by the Cap Digital competitiveness cluster, which aims to develop a personal assistant robot measuring 1 meter 40 centimeters. This robot, the first prototype of which is slated for delivery by the end of 2010, will be able to handle everyday objects, help a person get around the home and even help should they have a fall. It will be tested by patients at the Institut de la Vision in Paris. Our company is then planning to develop and industrialize a new product, to be available in 2015.

Do you think there is a real future for robots?

We are convinced that there is. The market, and especially the European market, is ready. In the last few years that AIBO was available on the market, seven times more Sony robots were sold on the Old Continent than in Japan. And if you look at the number of scientific publications on robotics, France has the potential to become the top country for robotics. Thanks to Romeo, we have succeeded in setting up a "robotics cluster", called CAP Robotique – within Cap Digital. At the same time, we have inaugurated a professional robotics syndicate, to act as a primary reference point for the public authorities. Whereas the competitiveness cluster is designed to drive research in France and Europe, the syndicate – which also includes a number of foreign companies based in France – has been set up to promote robotics across society. Thanks to our technology and with the help of partners like the LIST, we are working towards the emergence of real robots capable of assisting us in our daily lives.

Interactive Systems

Virtual reality and knowledge engineering

Image searching: LIST reaches the 2nd step on the podium

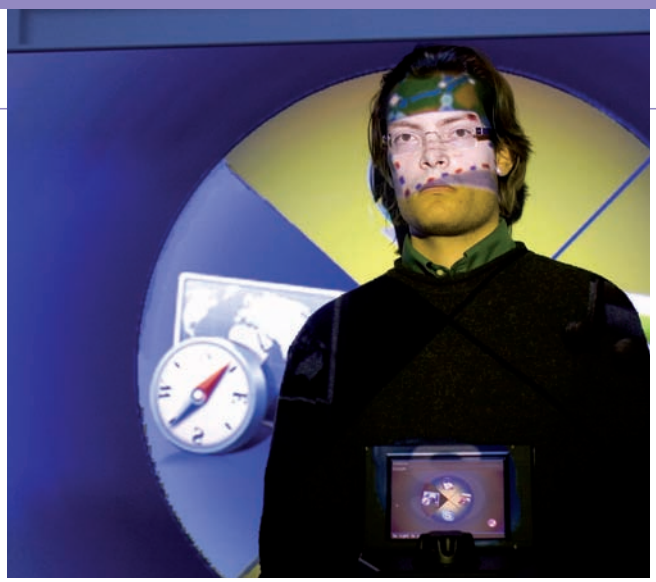
LIST was classed in the top four during the last ImageCLEF international evaluation exercise. Organised each year by the CLEF consortium (Cross Language Evaluation Forum), this evaluation exercise enables academic and industrial teams to compare their image searching technologies for multi-media and multilingual databases. This year the data was provided by Wikipedia, the on-line encyclopaedia, with 150,000 images and their associated text information. The challenge was to recover the maximum number of images corresponding to 75 requests of the type "cathedrals", "bridges at night", "cyclists", etc. The LIST method, based on identification of semantic concepts constructed from the on-line database (which for example enables an association to be made between terms such as "Notre Dame de Paris" and "cathedral") had been classified in fourth place out of the 77 methods submitted by 12 teams. This year, the team moved up to second place by linking this method with continuous analysis of the contents of the images: the system is then able to recognise visual concepts (night, external views, architecture, faces, etc.) and to perform a better classification of relevant photographs.

Partage, a platform for collaborative virtual work

The Partage project, which is being undertaken by around ten academic and industrial partners, aims to develop a collaborative, working platform in a 3-D, virtual environment. Using its interactive, mechanical simulation engine as a base, LIST is developing software which allows remote teams to act simultaneously on the same digitally simulated object, in interaction with the environment, in particular using haptic interfaces. The architecture used for this platform is decentralised or peer-to-peer. Each user in the digital model, whilst working locally on a physical simulator, is connected with the other users to update his information and hence ensure a true interaction. This architecture makes it possible to ensure good quality, local, haptic execution, in spite of the 200 ms network latency. Depending on the remoteness of the users, and the propagation time for data over the telecommunication networks, information exchange between physical simulators may be subject to delays, and may experience haptic stability problems and parasite forces during manipulation of the interfaces. The architecture which is used, limits instability problems by regulating the servo-controls between the physical simulators when there are continuous delays (even if of significant length) and, by cancelling out the parasite forces, provides good conditions for cooperative tasks between users, with a real sensation of collaboration.

For the standardisation of "watch" applications

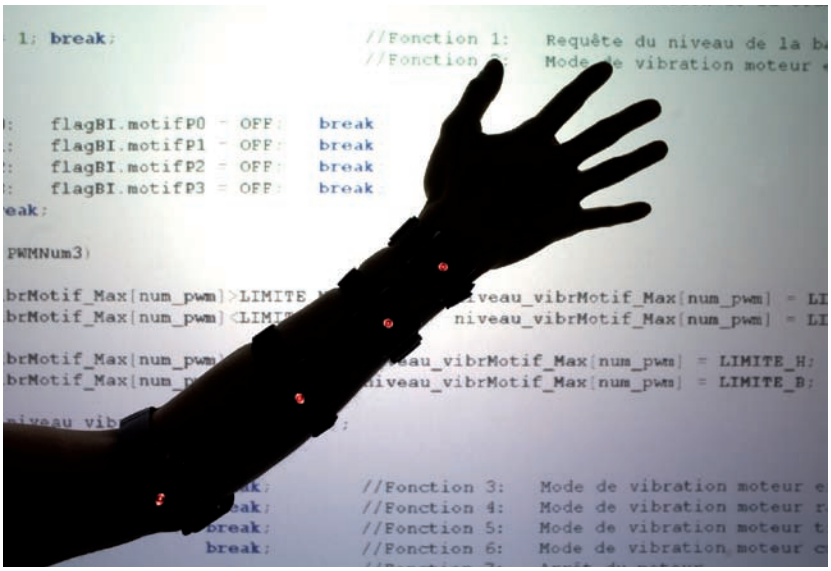
Although there are many tools available today for collecting data intended for watch applications, it is difficult to make them communicate with each other. The Webcontent project, which is now in progress, was launched to address this problem. It brings together nineteen partners (EADS, Thalès, INRA, INRIA…) including LIST, in order to develop a complete software infrastructure for the creation of watch applications, based on web semantic techniques and open standards. It provides a web-services library (annotation of named items, semantic annotation, indexing and searching of documents, etc.) starting from which, the user can develop his own watch application. Four demonstrators have been proposed: A watch on seismic events (developed by LIST), a watch on aeronautic press releases (EADS), monitoring of bacteriological incidents in the agro-food industry (Soredab and INRA) and finally for crisis management in the area of defence (Thalès). The platform is available on the project website www.webcontent-project.org.



Boom in haptic interfaces – from the automotive industry to applications for the disabled

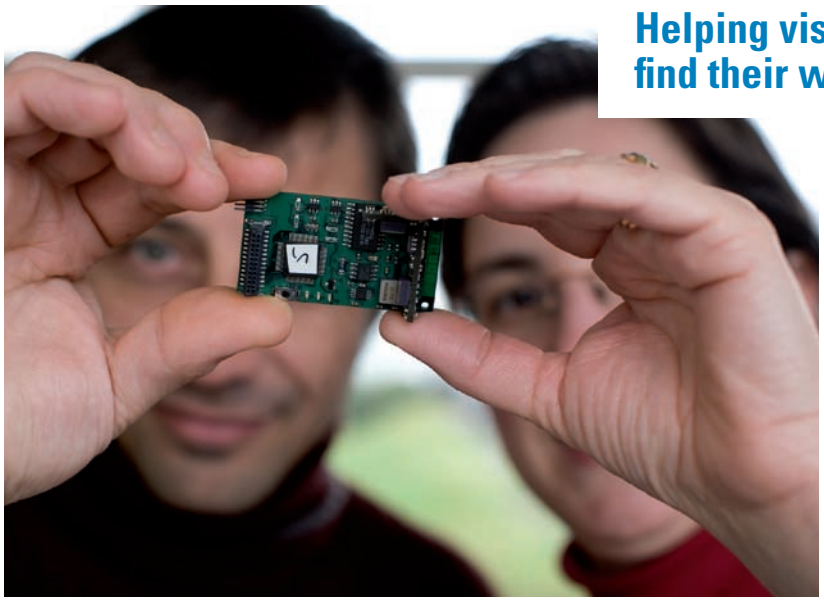
Over the years, the haptic interfaces research programme has become an independent section at LIST. Several systems have been developed, notably the MR-Drive rotating button, which has captured the attention of automotive equipment manufacturers. "With MR-Drive, we aim to centralise control of functions such as GPS, car radios, air conditioning, etc.", says Moustapha Hafez, the team leader for the LIST sensory interfaces team. The principle of this patented, ergonomic button lies in the use of magneto-rheological fluids. These fluids are made up of microscopic, metallic particles which become aligned when a magnetic field is applied. Variation of the applied field changes the viscosity of the fluid with a response time of several milliseconds: the fluid can pass from a liquid to a solid state, slowing down the rotation of the button or stopping it altogether. "When using this technology, the user feels a wide variety of textures", explains Moustapha Hafez. Different functions can be associated with different textures. After a short training period, the driver is able to achieve "tactile" control of the "comfort" functions in his vehicle, using minimal visual references. A simplified graphics screen has also been produced in collaboration with motor manufacturer, Volvo, and the University of Luela, in Sweden. "Our strength has been to develop the entire application environment around one technology", adds Moustapha Hafez.

Another notable achievement is the Vibee haptic interface, developed in partnership with motor manufacturer, PSA. Distributed over the body, these compact portable modules use vibrations to relay information to the user who is immersed in a virtual environment. "Around twenty modules can now be controlled and we have developed a variant for the fingertips", says Moustapha Hafez. Most importantly, the Vibee modules have now found a new application: helping to rehabilitate handicapped individuals. The Réactive project (2008-2010), piloted by the Hopale foundation, at Berck-sur-Mer, in partnership with LIST, INRIA and industrial partner Idées3com, aims to develop a virtual reality tool for rehabilitation of victims of cerebrovascular accidents. "Following an attack, the patient may loose certain cerebral functions. The muscles and nerves are operational, but the brain no longer knows how to make certain movements", explains José Lozada, a researcher on the sensory interfaces team. The idea is to immerse the patient in a virtual environment representing an everyday-life situation, such as a supermarket, and then make him repeat movements such as grasping an object, with the optimum tactile response being provided by the modules. "A traditional rehabilitation programme lasts for only 4 months and, even if it works well for the lower limbs, still only restores 10 % of the function of the upper limbs", observes José Lozada. This new system, developed by the Réactive project, aims to accelerate and improve this upper limb rehabilitation.



Interactive Systems

Robotics

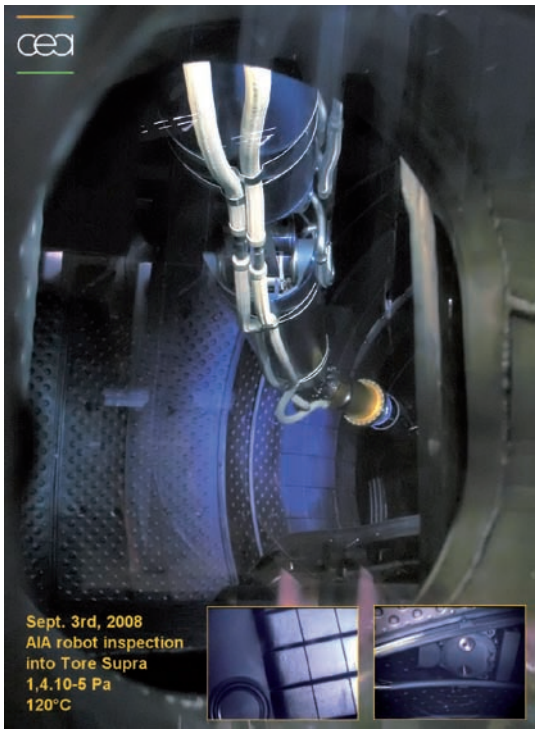


Helping visually impaired passengers find their way on the underground

Between now and 2015, public transport must become accessible to individuals with reduced mobility, to conform to French Handicap legislation passed on February 11th 2005. With this goal in mind, LIST, in partnership with RATP, PGES (Robosoft) and Université Paris 8, has developed the first prototype of a new navigation-assistance device for the blind, when using the corridors of the Metro (the Danam project). The system is made up of an inertial unit, carried by the person, linked to location and guidance software. The information provided by the unit enables the position and heading of the individual to be calculated. This position is then fitted on a map to locate the person in his environment. Once this position has been determined, the guidance software can plot a course for the user to follow and feed instructions to him via an earpiece. Tests undertaken in the laboratory have shown that the algorithms used in the calculation, which were developed by LIST, result in longitudinal positioning errors of less than 1 % and a heading error over 100 metres of less than 1.5°. The residual differences have then been eliminated by comparing the calculated position with that of key locations in the system, such as stairs or barriers, etc. The Danam prototype will shortly be undergoing testing at the Bercy Metro-station in Paris. The navigational device, which has been the subject of several patents, may find further applications with the police and emergency services.

Success of the Tore Supra inspection robot

This year, AIA (Articulated Inspection Arm), the robot developed by the teams at LIST, undertook its first full deployment in the Tore Supra tokamak under operational conditions of ultra-high vacuum and a temperature of 120 °C. This poly-articulated arm, with a length of 9.5 metres and equipped with a camera, was able to inspect the interior of the vacuum chamber and then return to its storage garage in under half a day. Just twenty-four hours later, the scientific experiments could recommence, whereas previously this type of inspection has required a downtime for the machine of between three and four weeks. To produce this unique type of robot, LIST scientists, who are experts in the fields of long-reach carriers, modelling of flexible structures, hardened electronics and real-time instrumentation and control, have been collaborating with scientists from the research institute for fusion using magnetic confinement, CEA (IRFM), who are specialists in tokamak technology. This success provides a real demonstration of the possibilities for robotic inspection and action, in this type of machine, particularly for the forthcoming international tokamak, ITER.



Able, the multi-purpose exoskeleton

Whether assisting handicapped individuals in their everyday lives, improving functional rehabilitation programmes for paralysed patients, controlling a slave arm for remote operation or even acting as a haptic interface for virtual reality applications, to name but a few, the force-feedback exoskeleton, ABLE, possesses a vast range of applications. It was displayed this year at Automatica, the European robot exhibition in Munich. Its major advantage stems from the mode of activation employed which is unique in its field: cable-actuated jacks. Five patents have already been filed. "The principle is to marry a screw and nut system with a ball and cable", explains Philippe Garrec, from the LIST Interactive Robotics team. "The special mounting process enables the screw to be isolated from all external disturbances. It can then be used to transmit force via the cable." This is a genuine innovation, since screw-nut systems are generally only used to stop equipment. The result: the screw-nut device and cable form a lightweight, silent, compact, high-performance jack. Once linked to a motor, this device becomes the core component of a highly "transparent" force-feedback system, i.e. a system which is very sensitive to external forces applied at the end of the actuation chain. And it achieves all this without a single force sensor!

"Invented for remote operation in the nuclear field, the cable-actuated jack quickly demonstrated its potential for other applications, such as helping individuals", says Philippe Garrec. By using longitudinally mounted, remote motors, located close to the joints, our researchers have developed a lightweight, force-feedback orthosis that is able to deliver a large force with only a small amount of inertia and friction. Having motorising the arm and the shoulder with a module located in the back, we are currently developing corresponding devices for the lower arm and the wrist. In the next version, ABLE will be anthropomorphic, with seven axes of freedom, and more adjustable to enable greater adaptability.

With its close resemblance to human anatomy, thanks to the elongated shape of the cable-actuated jack system, the ABLE orthosis is also designed with an open architecture. The user places his forearm in the intended indentation which is shaped like a half-cylinder. He is not required to thread his arm inside the orthosis as he would for the majority of systems of this type. "This makes ABLE more convivial and more acceptable to patients, who prefer to retain a degree of independence from the device", says Philippe Garrec. Some tests have already been successfully carried out by non-handicapped people as part of the Brahma project. That project was performed in collaboration with the Institute of Intelligent Systems and Robotics (ISIR-Université Pierre et Marie Curie/CNRS), the Laboratory of Neurophysics and Physiology (Université René Descartes/CNRS), the Laboratoire de traitement de l'information médicale (laboratory for processing of medical information) at Inserm and the company Haption. A new protocol for handicapped individuals will be put in place during 2009. Our researchers are already considering future improvements, such as intended-action sensors, which will be able to anticipate the movements of the user.

Embedded Systems

From transport to communication devices, from home technologies to health technologies, the presence of embedded systems is continually on the rise. These genuinely, intelligent devices incorporate both high performance architectures and advanced software.

As experts in both these areas, the LIST Institute develops the technological building blocks for embedded systems, intended for all areas of application. Controlling dependability and reliability, improving quality and reducing design costs are all among the challenges that have been addressed by LIST researchers, who combine skills in the fields of architectures and software.

Recent advances in multicore microprocessors and their spread throughout embedded systems have led LIST to develop new architectural paradigms and innovative algorithms in order to ensure consistency. The success of the technologies developed (detection of pedestrians, multicore programming models, security codes, etc.) has enabled the institute to strengthen its partnerships with industry. Multiplication of its bilateral contracts, notably with Kalray, Delphi, Airbus and ST Microelectronics, has created real opportunities for applying these discoveries. In parallel to this, the institute has continued its open-world policy for its “libre” (Open source) software, by carrying out several of its technological developments in this environment.

Over the coming years, this two-pronged strategy, which guarantees both optimal industrial application and high international visibility, will be made more durable and extended to new areas such as the security of goods and people.

Philippe Gasnier (Delphi)

Director of the Passenger Compartment Electronics and Safety Business

What is the aim of collaboration between Delphi and CEA LIST?

In 2006, Delphi launched the Oasis Automotive research programme with CEA LIST to demonstrate the feasibility of transferring a technology originally developed for nuclear safety to the automotive sector.

> *"We've saved at least two years in R&D time."*

What are its ambitions?

The activities of the OASIS Automotive programme are carried out in the System@TIC cluster (Num@tec Automotive project) in close cooperation with Sherpa Engineering. Its first goal was to develop a motor vehicle demonstrator meeting three objectives: first, provide a technologically and economically feasible solution to the increasingly complex demand for improved reliability in passenger compartment computers; second, comply with the ISO 26262 standard; and third, build a device compatible with the Autosar standard architecture used by manufacturers. The feasibility phase has now been completed and we have demonstrated that this technology can be transferred to the automotive sector. Our ambition now is to make Oasis Automotive a standard that can – and will – be used by all manufacturers around the world.

What happens next?

April 2009 will see the official creation of a consortium comprising Delphi, CEA, key French SMEs in the tooling sector and OEMs. CEA LIST's development work on this technology saves time for us and proves that our work is scientifically reliable. Although Delphi does business all around the world, it considers that a close relationship with industry is very important; innovation is instrumental in achieving this. Public-private technology transfers significantly boost the success rate in research, guarantee a quick return on investment and stimulate the development of company skills. It is undeniable that by working together with CEA, we saved precious time... at least two years! It also helped us gain a foothold here. Lastly, we are working on a new project on connectors concerning a tool for detecting and locating power cuts and faulty connections.

Embedded Systems

Software tools

Success of the "Algebraic Topological Methods in Computer Science III" conference

From the 7th to the 11th of July 2008, in Paris, LIST successfully organised the third international conference on "Algebraic Topological Methods in Computer Science", in association with the fifth European Congress of Mathematics. This was the occasion chosen by the MeASI research team, made up jointly of members from CEA, CNRS (French National Centre for Scientific Research) and the Ecole Polytechnique, to present their work on modelling and verification of complex industrial systems using algebraic topology methods. These methods enable the study of the safety of a collection of parallel processes by calculation of topological invariants. The conference, which brought together around one hundred participants, was financed by LIST with the help of Digiteo, the Informatique Mathématiques research group, the ANR project Inval, the Ecole Polytechnique, of Université Paris 7 and the Danish National Sciences Research Council.

LIST joins the international Autosar consortium

This year, LIST became the first European research partner to become a member of the international consortium, Autosar (Automotive Open System Architecture). This international initiative, which brings together all the major players from the automotive sector (including Ford, Renault and Volkswagen), aims to define a standard, open architecture for all software modules deployed in vehicles, in order to facilitate their integration. The major objective of this standardisation is to reduce the time and costs of equipment design. The admission of LIST as an Associate member of Autosar, supported by Core member, Continental Automotive France, is recognition of our skills in the area of automotive systems and software. It coincides with the launch of the Edona platform (Environnements de Développement Ouverts aux Normes de l'Automobile - Open development environments for automobile standards) of the Num@tec Automotive project, which is being carried out by the System@TIC competitiveness cluster. Edona, which aims to integrate various compatible components with Autosar at the national level, already incorporates five key LIST technologies. This convergence must continue, since LIST has applied to become a Premium Member and is investing, with its partners, in the creation of an Autosar center of excellence which will be open to industry.

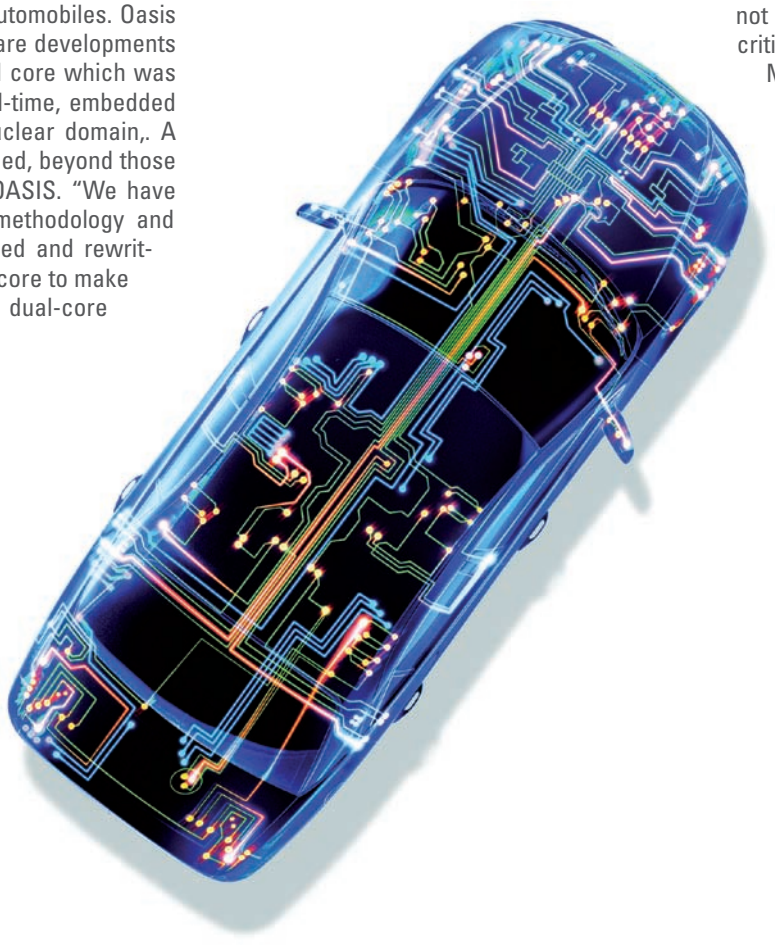
Usine Logicielle illustrates the "cluster effect"

The Usine Logicielle project, in which LIST has participated alongside numerous companies and academic laboratories, came to an end this year. Launched in 2005 as one of the first projects of the competitiveness cluster System@TIC, its objective was to bring together innovative software engineering tools, in particular those intended for embedded systems. In this collaborative context, LIST completed and presented its partners with several such technologies, including the UML profile, Marte, accepted by the OMG (Object Management Group), the UML2 editor, Papyrus, the middleware architecture, C3M, (in collaboration with Thales), the tests generator, GaTEL, and the statistical analyser, Fluctuat, evaluated by Dassault Aviation and Esterel Technology, and even the IT platform simulator Unisim, tested in production by MBDA. Numerous technology-transfers and skill-exchanges between the academic and industrial teams have made the Usine Logicielle a perfect illustration of "the cluster effect".

OASIS is improving the security of automotive electronics

Electronics have invaded the automobile, taking over everything from simple functions, such as controlling the lights or the air-conditioning, to the most complex functions such as the brakes and, perhaps soon, the steering too. The increasing numbers of processors being used should be accompanied by specific measures to guarantee their security of operation in all conditions. During 2008, LIST completed the first phase of the D2OS project on this topic, which has been performed over the last two years in collaboration with equipment manufacturer, Delphi. Its objective was to redesign Oasis for use in automobiles. Oasis is a suite of software developments and its associated core which was developed for real-time, embedded systems in the nuclear domain,. A new patent was filed, beyond those already filed for OASIS. "We have taken the Oasis methodology and adapted, redesigned and rewritten the execution core to make it suitable for the dual-core processors used in the automotive industry and to meet their typical application requirements", explains project leader, Christophe Aussagùes.

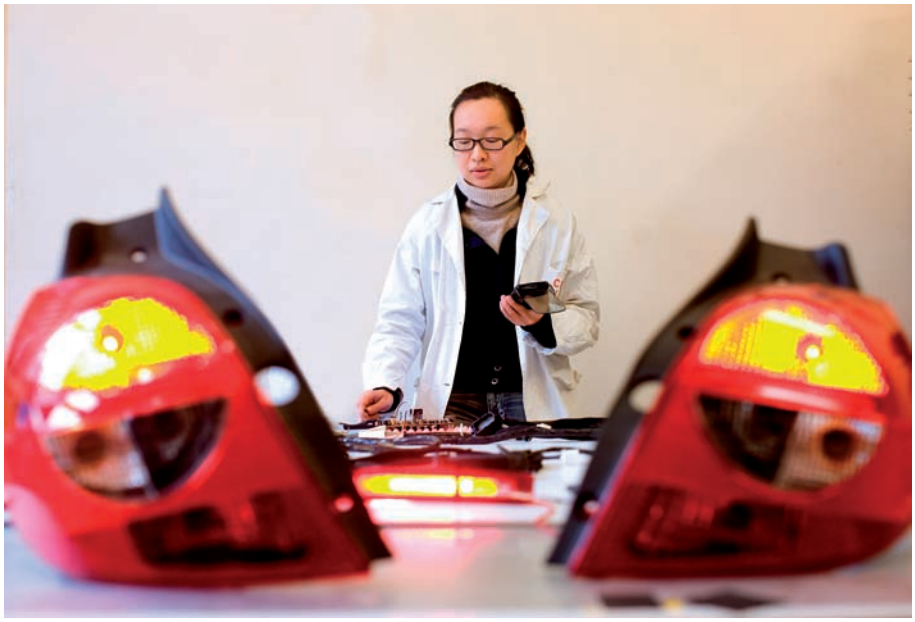
In particular, whereas the response-rate of the OASIS core is entirely regulated by time, some tasks performed by automotive processors must be regulated by rapid external events. We needed to segment the core and develop an interface which was capable of separating, in a secure way, the parts regulated by time from those regulated by rapid external events. Next, to guarantee a high level of availability of the processors, it was necessary to develop confinement units which ensure that, if one task fails it does not then affect all of the others. Hence the programmer defines "failure groups". These groups may contain just a single specific task, if he so wishes. If a task does not execute correctly, firstly the other protected groups continue their execution and secondly only those tasks which also belong to the same failure group are restarted, in a manner coherent with the rest of the application. In short, this ensures that failure of one integral function does not spread to all the other, possibly critical, functions of the vehicle. Moreover, this security of operation improves the performance of the processors. "We have demonstrated the value of our solution to our partner", declares Christophe Aussaguès. "It's now up to us to apply this technology with Delphi"



Embedded Systems

Vision systems and architectures

Wiring diagnostics on track for industrialisation



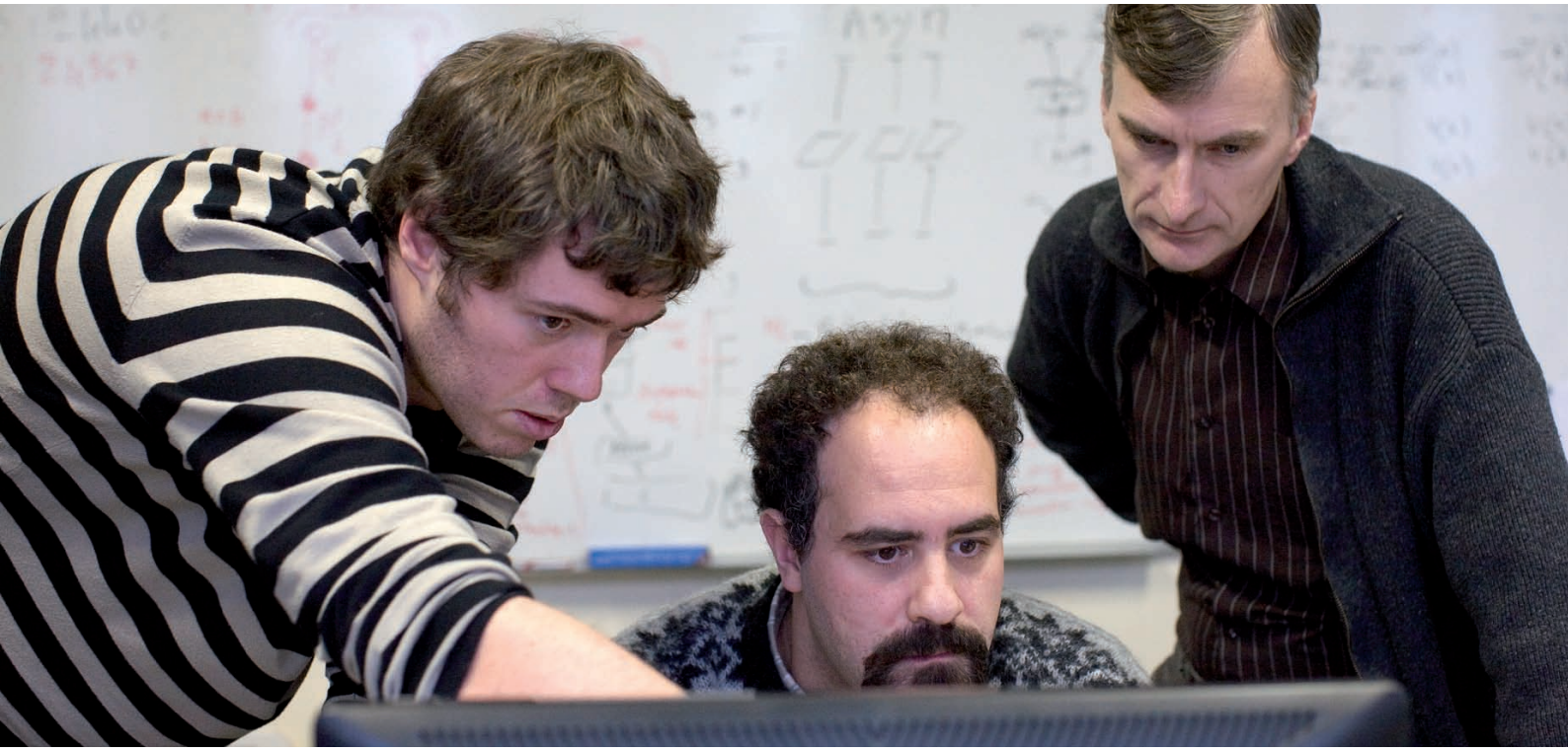
The cable-loom diagnostic tool, developed by LIST during the collaborative project, SEEDS, is now the subject of a technology transfer to the company Delphi.
This system, based on reflectometry, makes it easy to locate and identify faults in the cable-loom of light passenger or commercial vehicles and trucks. A signal is sent along the loom and its reflection, which is returned when it encounters a discontinuity such as a fault or simple branching, is analysed. This provides information on the position and nature of the possible anomaly. Hence, verification of the integrity of the cabling, in a vehicle for example, will now take no longer than between ten and thirty minutes; a huge time saving for mechanics. The system has been successfully tested under real conditions at Delphi's auto-mechanics training centre in Warwick (Great Britain). Delphi is an automotive equipment manufacturer and, convinced of the value of this system, its division, Delphi Solutions Products and Services, is investigating the possibility of commercialising this technology. For its part, LIST will develop new, higher performance, versions which respond to requirements expressed by future users and which have, for example, improved location of anomalies.

Thales and LIST are working together on vision systems

In 2008, Thales and LIST created a joint research team, working in the area of vision systems. The decision to set up this venture, followed their fruitful collaboration in the SIC project (Sécurité des Infrastructures Critiques - Security for critical infrastructure), part of the System@tic cluster, which related to detection of people via a camera network. The combined team, which will eventually consist of around twenty people in the "Vision Lab", will be investigating automatic systems of video analysis, to improve security of goods and people.

Mobile phones ready for HD

Today, most of mobile phones are embedded CMOS image sensors equipped. However, in these sensors, number of pixels keeps on growing when the pixel size decreases, due to silicon surface costs. As a consequence, the processing performance need is always more important, in order to maintain satisfying image quality. Several digital proceedings are therefore carried out, from soundproofing to image colour reconstruction. Currently, processing is performed by dedicated, low-energy, surface systems, but these do not allow the product updating with new algorithms throughout its lifetime. To overcome this obstacle, we have developed a new image processing architecture, named eISP (embedded Image Signal Processor). This, completely programmable, modular architecture has been patented. The device produced, which is made up of six "tiles", each of which contains six processing cores, completely matches with industrial needs, with a 250 mW electrical energy consumption and a 1.3 mm2 silicon surface using 65 nm technology. With the ability to withstand a 25 images per second high definition video (HD 1080p), this architecture will highly enable image quality improvement, specially for mobile phones.



Start-up: Kalray plans to produce parallel integrated circuits

The goal of the Kalray start-up is to produce a new generation of completely programmable, integrated circuits, equipped with functions for massively parallel processing. Kalray was created in July 2008 after being incubated for 2 years at CEA LIST. The technologies employed have been developed using LIST expertise in the areas of execution models and innovative programming for parallel architectures. LIST has played an active role in design of the language, the software tools and the architecture, with support from LETI on behalf of the design partner NoC (Network on Chip). Moreover, a joint laboratory has been created with Kalray, which houses around fifteen LIST research workers who are endeavouring to adapt state of the art technologies to meet market requirements, in the optimum manner. "Michel Harrand, who founded Kalray together with Joël Monnier, spent two years at LIST, directing the work which aims to define the principles and concepts of this new product", says Vincent David, the LIST-Kalray joint-laboratory manager. The final product will constitute a genuine "all-in-one" solution, since the chips will be delivered complete with all the software tools required for their programming. The user will be released from worrying about the complexity of the machine – which will behave like a hundred microprocessors – and be able to concentrate on his own applications. Those applications will primarily concern the embedded systems, such as video-surveillance, detection of pedestrians, multimedia, telecommunications, etc.

"This product solves one of the major difficulties encountered by applications designers, which is how to control a hundred or so processors in an efficient manner", explains Vincent David. This product will be particularly suitable for dynamic applications. It is based on intelligent algorithms which adapt during data-handling execution, defining, "in-flight", the nature and control of the processes to be accomplished. Such complex algorithms, already used in the processing of certain video data flows and in video-surveillance, tend to become widespread.

To ensure high performance processing, whilst guaranteeing maximum control of the machine, the LIST workgroup has designed an innovative architecture known as MPPA-(Multi-Purpose Processor Arrays). This is based on a hierarchical control-and-communication structure which ensures effective management of multiple equipment resources and a high-performance connection between the processors and the memory. The originality of the approach stems, in particular, from the joint exploitation and optimisation of the parallel computing component of the applications during both the compilation and execution phases. Technology transfer between CEA and Kalray has involved no less than 17 patents. The new chips, produced in small and medium series, should be commercialised in the next two or three years. A demonstrator version, intended to confirm the technological leap constituted by these new chips, will be produced in 2009.

Sensors and Signal Processing

Designing new sensors and their associated intelligent instrumentation, as well as developing software and hardware architectures for real-time processing of large volumes of data, etc.

These are two, core specialist areas of LIST which have seen genuine successes in 2008, in particular in the field of health, with the successful culmination of projects on imaging by mass spectrometry (Computis), radiotherapy (Maestro) and diagnostic aids (Human Diag). Buoyed by these successes, LIST teams have taken on new national and international projects, covering subjects as varied as security (Uncoss), transport (Picasso), health - notably in genomic analysis and predictive medicine (ReadNA) - and metrology, in particular for radiological protection applications (Oramed).

Using its expertise in radiation metrology and in radiotherapy, LIST will be leading a new and ambitious project – Doseo – which will create a standard platform for radiotherapy technologies on the Saclay plateau.

New opportunities appeared in 2008 with the emergence of two new strategic fields: energy and the environment. Researchers from LIST want to become involved in measurements of trace-level pollutants and in water management in arid regions, notably through the use of tracers to analyse the evolution of water courses. They will also be participating in several projects from EU Framework Programme-7, which are aimed at improving the efficiency of renewable energy sources (the Concerto-Temunde and Solaire Duo projects) and at distributing energy over electricity distribution networks, in particular for automobiles (E-vehicle in the grid).

Questions for Dominique Maraninchi,
Chairman of the French National Cancer Institute

On the right, Dominique Maraninchi with the radiotherapy team of French National Cancer Institute

What does the French National Cancer Institute actually do?

Set up by the Public Health Act of August 9, 2004, the INCA is a national health and science agency dedicated to Oncology. Through concerted action and incentive initiatives, implemented in line with an interdisciplinary approach, its goal is to reduce the number of deaths due to cancer in France and improve the quality of patients' lives. It actively supports access not only to screening and treatment but also to research and innovation.

Has the INCA developed links with the CEA?

Invaluable links. We work with major research operators within the framework of partnership projects. Such projects cover three areas: biology, clinical medicine and human and social sciences. In launching calls for projects, we hope to attract the skills of organizations such as the CEA and pool their knowledge and medical expertise.

Are you currently working with CEA-LIST on a major project?

We are actively involved in the new radiotherapy platform, Doséo. Of the 320,000 cases of cancer diagnosed every year in France, 180,000 are treated using radiotherapy. This is a key technique in treating curable forms of cancer because it can now target affected areas with incredible precision, without touching healthy tissue. Thanks to Doséo, we will have access to a reference center for technology in this field.

What exactly are you hoping to achieve with this platform?

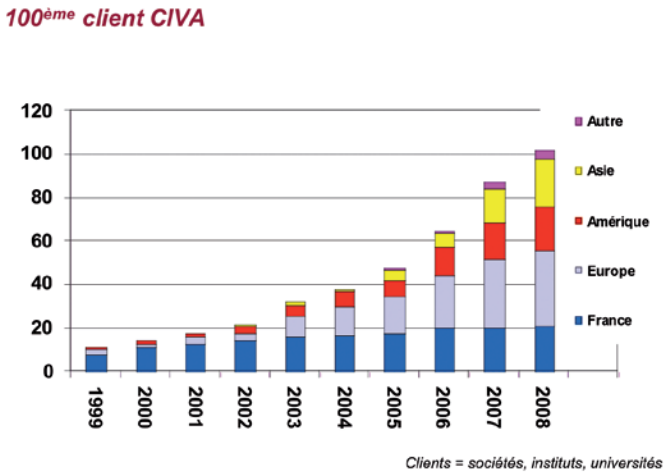
Since France launched its "Cancer Plan" in 2003, half the country's radiotherapy facilities have been renewed. We are now entering a transition phase leading up to full application, in 2011, of the quality criteria defined following certain accidents that have occurred in the past, notably at the hospital in Épinal. The INCA committed to the Doséo project at a very early stage because the platform paves the way for an effective response to what we want, in terms of the performance of radiotherapy techniques and in terms of training for the healthcare workers using them. Our investment – 2 million euros in 2008 together with monitoring the project – is perfectly in line with the Institute's goals.

Are CEA-LIST teams involved in any other projects?

Yes. For example, we could mention the projects focusing on prostate cancer genetics, led by Professor Olivier Cussenot, at Tenon Hospital in Paris. His team recently identified risk variants for this form of cancer, together with variants associated with aggressive forms. The idea is to improve the predictive values of diagnostic tests. Thanks to its expertise in complex systems, CEA-LIST is involved in developing these new diagnostic tests. The CEA is also deeply committed to research in this area, through its National Genotyping Center , which is working on the large-scale sequencing program for 58 different tumors, for which we provide support.

Sensors and Signal Processing

Non-destructive testing



100th CIVA licence granted

In 2008, the CIVA software package, developed by LIST, signed its 100th licence agreement. This simulation platform for non-destructive testing is now promoted by seven distributers and is being used in 23 countries, from the United States to Japan, including South Africa, India and Australia. Among the new customers are the North American Space Agency, NASA, and companies Petrobras in Brazil, Barc in India, Rotek in South Africa, Sumimoto in Japan and Eon in Great Britain, as well as four universities in Brazil, Greece, Japan and Korea.

Catiemon makes rail networks reliable

As part of the European Catiemon project (Catenary interface monitoring), set up to improve the reliability of transnational rail networks in Europe, we have developed novel Bragg grating sensors, in order to characterise the pantograph-catenary interaction and so optimise maintenance. This development has been accompanied by developments of more dependable installation protocols, whatever the meteorological conditions, and of sensor calibrations, notably with respect to the speed of trains and the contact force between the pantograph and the catenary. Measurements have been carried out using test locomotives supplied by the Swiss company, BLS, and more than 200 passenger and freight trains have been characterised by the optical inspection gantry. The signatures of the trains thus obtained, have made it possible to detect “non-standard” convoys. Thanks to this technological advance, our teams are planning to extend the prototype to the European railways infrastructure.

CIVAmont-2012 is launched

In order to stimulate technological advances and breakthroughs in the field of non-destructive testing simulation, we wanted to involve our academic partners more deeply in the construction of CIVA–2012. Launched under the Carnot Institutes programme, the CIVA development group includes more than fifteen French and foreign laboratories at the forefront of research on signal processing and modelling. Five workgroups have been set up: ultrasound and bulk acoustic waves, guided waves, electromagnetic methods, inverse models and radiography. The modules developed in this programme will be added to the CIVA platform.

Non-destructive testing boosted by electromagnetic methods

In recent years, electromagnetic methods for non-destructive testing have experienced a genuine renewal of interest. Such techniques enable the integrity of metallic parts to be checked in a "clean" way because they remove the production of waste liquids which are a by-product of traditional "dye-penetration" testing techniques. LIST is continually proposing increasingly innovative solutions in this area. "Our research concerns two different types of sensor: flexible eddy-current sensors and Giant magnetoresistance (GMR) sensors", explains Philippe Benoist, LIST industrial-testing, programme manager.

The first type of sensor induces a magnetic field inside the part under test. This field causes electrical currents, referred to as eddy-currents, to appear. These are sensitive to their environment and they generate a secondary magnetic field. It is this secondary field which provides the information on the integrity of the structure being analysed. Currently, the majority of eddy-current sensors are capable of probing the surface of parts having simple geometries, with a resolution on the order of millimetres. The LIST teams have been working to improve this type of device and on methods for integrating them into kapton® films, a flexible polyimide. It then becomes possible to inspect large surface areas rapidly, even if the geometries are complex. A matrix containing around one hundred sensors has already been produced and several patents have been filed.

Although they are powerful, these systems nevertheless have their limits, particularly in terms of spatial resolution and depth of imaging. To overcome these limits, the LIST team has joined with CNRS and a number of companies, including EADS and Thalès, in the ANR Imagine project (Imagerie Magnétique pour l'Inspection à l'aide de Nanostructures Magnétiques- Magnetic imaging for inspection employing magnetic nanostructures). The goal is to develop integrated GMR sensors, based on the Giant magnetoresistance effect discovered in 1988 by the French Nobel laureate, Albert Fert. This phenomenon, which is observed in multi-layer structures composed of conducting and ferromagnetic materials, is manifest in the form of strong variations in electrical resistance which result from changes in the applied magnetic field.

Because they have much greater sensitivity than the usual magnetic sensors and are very small in size, these GMR sensors are able to achieve much greater spatial resolution. Using an optimised electromagnetic sensor, researchers at LIST and their partners designed a probe containing around a hundred elements. The probe has a spatial resolution on the order of a tenth of a millimetre and can probe the surface to a depth of around ten millimetres. The project will be completed during 2009. Already researchers are planning future developments, in particular, integration of these GMR sensors onto flexible substrates.

Sensors and Signal Processing

Instrumentation

Microsensors moving with the players

Our institute is collaborating with CEA Léti and with the Movea start-up, specialists in portable movement microsensors, at the joint laboratory, Motion Lab. Our researchers are developing movement analysis algorithms for the next generation of interactive video games, which will enable the user to steer the movements of his avatar in the game by simulating the walk or path. In fact, the real-time movements made by the player's feet are registered by microsensors installed on the shoes, and these are then used to simulate the movements on his screen. Measurements of the frequency, amplitude and the stealth of the player's movements enable very precise control over the virtual movements. Integrated into a genuinely "fun" environment, in the form of a demonstrator, this system will enable Movea to offer videogame editors an extremely rich interactive mode, with much higher performance levels than those achieved by current, commercially available, devices. These technological developments also underpin application projects in other areas, in particular sport and health.

Diamond is invading the world of transistors

Researchers at LIST have developed a process which makes it possible to deposit thin layers of diamond, 100 nm thick, with a heterogeneity that is less than 5% over an area with 5 cm diameter. This technique enables production of Silicon on Diamond (SOD) structures. Designed in collaboration with partners from the ANR Diatherm project, including CEA-Leti, at Grenoble, and the company PicoGiga, this SOD technology offers increased thermal conductivity and so provides a significant improvement in performance over SOI (Silicon on Insulator) components. The first international manufacturer was Soitec, a spin-off company of CEA. With this increased thermal conductivity, SOD components are finding applications in power electronics amongst others. A patent application has already been filed.

GPU processors for X-ray micro-tomography

For several years our teams have been developing new image reconstruction techniques, which make it possible to rebuild an object in three dimensions using images obtained from X-ray projections. These new, high-performance methods, nevertheless, require calculation times which are too long when performed on standard processors. Their memory is not large enough to permit data manipulation for real-time estimation required by the algorithm. To adapt our methods for massively parallel processing, the LIST researchers had the idea of using the technological capacity of a GPU (Graphics Processing Unit). Using these graphics cards in an alternative manner to their intended use (Tesla cards with 128 processors, manufactured by NVidia), high resolution reconstruction of 3-D images, with reasonable calculation times, is now foreseeable. This technological advance has been achieved within OMTE (Opération de Maturation Technico-économique - Operation for technical and economic maturation) of the Digiteo RTRA.

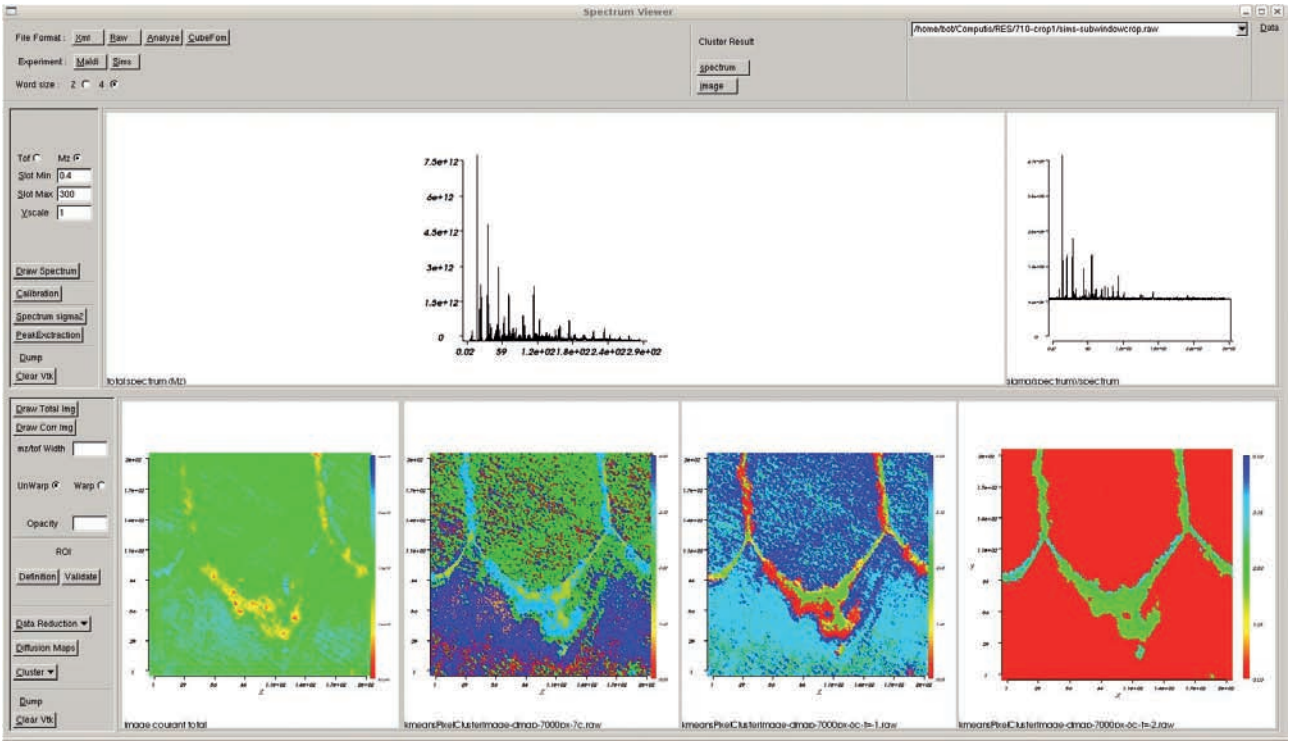
Algorithms in perfect health

Over the last few years, constant improvement in the mass spectrometry techniques that are used to identify molecules, particularly in the life sciences, has given rise to an corresponding increase in the volume of data to be processed, which can sometimes be as much as several Gigabytes. However, although these technologies are currently proving to be very powerful, the same cannot always be said for the analysis software which accompanies them. The skills which our teams possess in the areas of signal processing and gamma spectra analysis have led us into new areas of application, particularly in biology.

"Although the techniques are different, our gamma spectrometry solutions often prove to be relevant for mass spectrometry", says Olivier Gal, the Stochastic Processes and Spectra team leader at LIST. The first version of a data processing software platform, for molecular imaging by mass spectrometry, was delivered during 2008, as part of the European project Computis. Launched in 2006, this project brings together six partners together with LIST, including two industrial companies, to develop new methods of biochemical analysis based on this very special imaging technique.

"The principle is to construct a map of the constituents of a biological sample without recourse to markers which are usually employed in this field, such as fluorescent molecules", explains Olivier Gal. Two processes are employed: secondary ion mass spectrometry (SIMS) and matrix-assisted laser desorption/ionisation time-of-flight spectrometry (MALDI-TOF). During the point by point ionisation of a slice of the biological sample, by an ion beam (SIMS) or by a laser (MALDI-TOF), the detached ions are sent to a spectrometer. "Hence we obtain an image for which each pixel contains tens of thousands, or even hundreds of thousands, of independent channels, forming a complete mass spectrum", explains Olivier Gal. It is therefore possible to identify and to localise hundreds of molecules contained in the sample.

All that remains is to analyse the enormous volume of data generated. This is where the software developed by LIST comes into play. The first version is not only capable of finding relevant mass spectra, which give the structure to the image, but it can also compare these spectra with each other in order to rearrange them into classes. Hence, a biologist is able to see on the image, the areas where the greatest similarities occur in terms of composition. From 2009, the software will be able to use the spectra to automatically identify the molecules present in a sample. "Tested by our partners, in particular ICSN (Institut de chimie des substances naturelles - The Chemical Institute for Natural Substances) at CNRS, Genethon and Novartis, our software has provided a real benefit in imaging time for mass spectrometry." In addition to this work, our teams are also planning other applications for this software, in particular in the fight against biological and chemical risks.

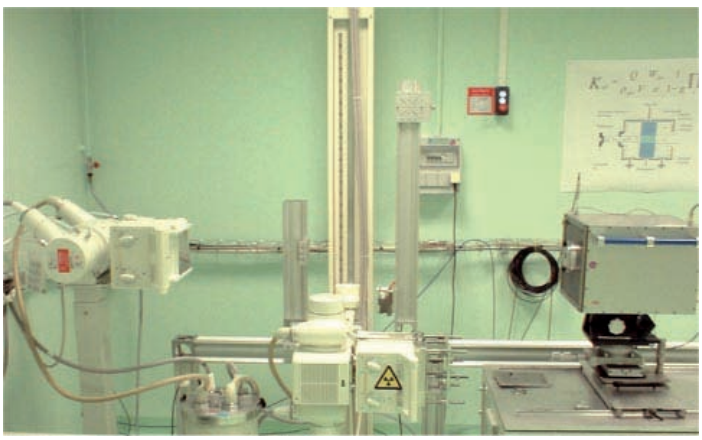


Sensors and Signal Processing

Ionizing radiation metrology

LIST are taking part in three European metrology projects

The Laboratoire National Henri Becquerel of LIST, continued to follow its European deployment strategy in 2008, by participating in three, large scale, research programmes. The first, Oramed, was launched as part of the first Euratom call for projects under FP7. The project has a duration of 36 months, is coordinated by the Centre d'études de l'énergie nucléaire (Nuclear energy research center) at Mol (Belgium) and brings together twelve partners. It aims to optimise radiological protection of medical workers by performing, in particular, dosimetry at the extremities and on the eyes of medical personnel.
The two other programmes were set up as part of the IMERA-Plus project (ERA-NET Plus, FP7) coordinated by Euramet, the European association of national metrology laboratories. Within the External Beam Cancer Therapy project, coordinated by the German national metrology institute (PTB), LNHB is leading the workgroup on Primary standards for IRMT. The objective is to establish dose absorbed to water, primary standards for small radiation fields (up to 2 x 2 cm^2) comparable to those used in intensity-modulated conformal radiotherapy. The dose standards currently in use were defined around twenty years ago. In agreement with international dosimetry protocols for radiotherapy published at the time, a standard was adapted for radiation fields of 10 x 10 cm2, much larger than the fields used today. LNHB is also taking part in a Euramet workgroup on Increasing Cancer Treatment Efficacy using 3D Brachytherapy, coordinated by the Italian national metrology institute (ENEA). Currently, dosimetry standards for radioactive sources used in surgery are defined in terms of air kerma. This time, it will be a question of establishing a primary standard in terms of the absorbed dose to water, i.e. in a medium more representative of biological tissue, whether healthy or tumorous.



LNHB is equipped with a multi-pulse X-Ray generator

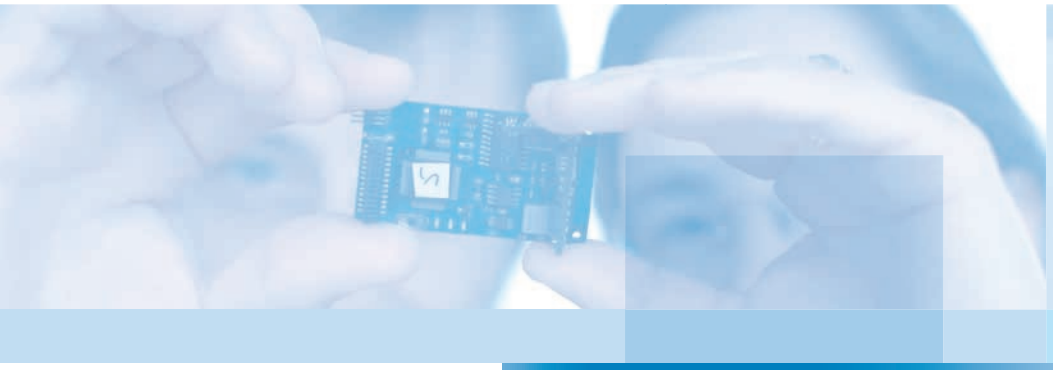
These days, some operations which are referred to as interventional surgery, require the use of radiological equipment emitting X-rays, even though medical personnel are working in close proximity to the patient. In order to be able to test and calibrate individual dosimeters worn by such professionals during these operations, the Laboratoire National Henri Becquerel (LNHB) has equipped itself with a multi-pulse X-ray generator, identical to those used by the medical services. Acquired as part of the European project, Oramed, it delivers beams with energies that can be varied between 40 and 120 keV, with currents from 4 to 1000 mA and frequencies of between 2 and 30 pulses per second. It can also be used to test new dosimeters designs for manufacturers, such as those developed by the company MGPi for Oramed.

Reflex, the final step on the road to a primary standard for X-rays

X-ray detectors are used in a large number of fields; metrology of radionuclides, astrophysics, microscopy, etc. How can they be calibrated, however, when there are only a few natural X-ray sources in the low energy regime, less than 10 keV? In order to resolve this problem researchers at LIST's Laboratoire National Henri Becquerel (LNHB) have equipped themselves with SOLEX (Source Of Low Energy X rays), an apparatus that emits a monochromatic beam of X-rays, with energies adjustable between 1 and 24 keV. However, to be capable of acting as a standard, the emitted beam must also be precisely characterised. This is the role fulfilled by REFLEX (RÉférence de Flux pour SoLEX - Flux reference for Solex) an innovative X-ray counter, developed entirely at LNHB. "Designing and building this counter ourselves, enabled us to control all of the components and so to determine their effects on the flux measurement. This would have been impossible with a commercial piece of equipment because the industrial secrets linked to the manufacturing processes would have prevented us from having access to all the characteristics of the equipment", says Johann Plagnard, the developer of Reflex.

Physically, Reflex is a gas counter. X-rays pass through, and ionize, a mixture of 90% argon and 10% methane. A change in voltage, proportional to the energy of the X-rays, is then observed between two electrodes immersed in the gas. Counting the number of changes in the voltage enables the quantity of X-ray photons which have interacted with the gas to be determined. "The difficulty with this highly classical style of detector, lies in the requirement for an exact knowledge of the proportion of X-rays absorbed by the gas", remarked Johann Plagnard. "Part of the energy does not interact with the gas and this increases the difficulty of the measurement" Obviously it is possible to calculate this absorption and to correct the resultant flux, but that approach would introduce too many uncertainties for it to be usable as a primary standard. This is where the original idea for Reflex arose. It makes possible direct measurements of both the incident flux and the absorption by the gas. Instead of simply having an entry window for the beam, the detection chamber for this counter also has an exit window. Hence, the portion of the beam which has not interacted with the gas can traverse and exit the chamber. This solution also makes it possible to eliminate the effects of parasite phenomena produced in the walls of the counter. A second detector, usually a silicon based semiconductor, located next to the Reflex exit-window, enables the emerging flux to be measured. All that is then required is to retract the counter, mounted on its motorized platform system, so that the semiconductor detector can measure the incident X-ray flux. Comparison of the two values, with and without the counter in the path of the beam, gives the rate of X-ray absorption in the gas directly. Additional measurements, based on the same method, enable the preliminary results to be corrected for the absorption within the beryllium, entry and exit windows. Hence, using this counter, an exact value is determined. The final component for this device is its automatic control software, which manages both positioning of the detector and performance of the various measurements. Using Reflex, it is now possible to completely characterise the energy and flux of the Solex beam. This was the final step required in order to turn Solex into a primary standard for X-ray radiation.

LIST Organization Chart



Direction

Director

Riadh CAMMOUN

Digiteo Labs Project

Jean-Louis PIERREY

Administration and PR

Jean-Yves HENRY, Adjoint au Directeur

Elisabeth LEFÈVRE-REMY, PR

Management control

Philippe LECESTRE

Programs

Deputy Director

Didier JUVIN

Transport

Xavier APOLINARSKI

Security - Defense

Raymond FOURNIER

Europe

Jean-Louis SZABO

Sensor and Signal Technologies Division

Head of Division

Alain PLUQUET

Monitoring/Control Systems and Simulation Division

Philippe BENOIST

Henri Becquerel National Laboratory

François DAMOY

Measurement Systems and Technologies

Laurent DISDIER

Programs

Industrial testing

Philippe BENOIST

Metrology

Bruno CHAUVENET

Instrumentation

Elvire LEBLANC

Intelligent Systems Technology Division

Head of Division

Denis PLATTER

Interactive Robotics

Jean-Marc ALEXANDRE

Architecture and Design

Thierry COLLETTE

Virtual Reality, Knowledge Engineering and Sensorial Interfaces

Arnauld LESERVOT

Software tools

Jan STRANSKY

Programs

Interactive Systems

Karine GOSSE

Embedded Systems

Fabrice DEREPAS

Delegate for Nuclear Affairs

Philippe DESBATS

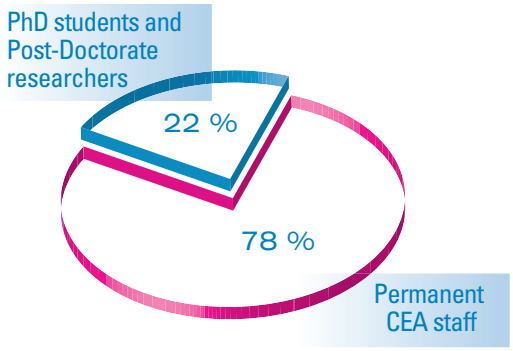
LIST, key figures 2008

Budget

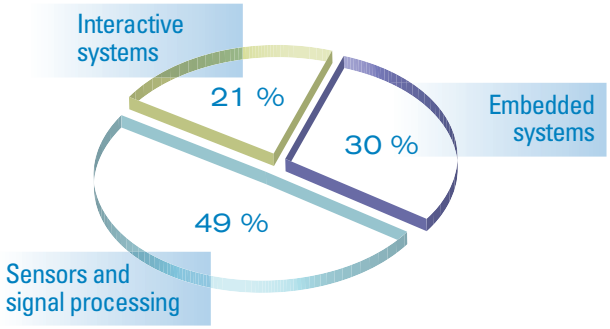
€50 million

Staff

530 researchers, including 115 students

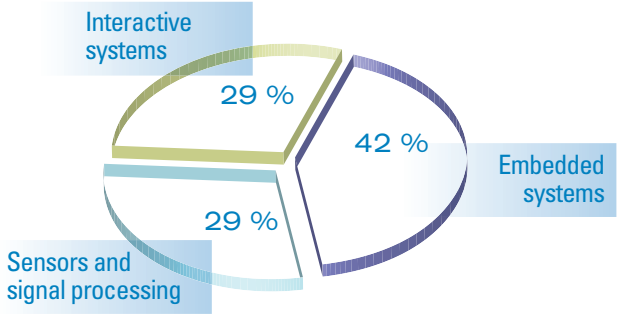


Distribution according to research area



Technology and Reasearch Transfer

Patents and licenses 2008



Patents and licenses 2008
176 active patents
38 patents filed in 2008
70 active licenses

Theses

Interactive Systems

- Control of shape of the bistable structures with distributed and discreet activation
- Study and realization of algorithms of interactive control of dynamic virtual human beings
- Analysis of vast corpuses of texts to give a synthetic vision
- Characterization and modelling of magneto-assets material for potential applications in actuators
- Geometrically exact approaches for the interactive simulation of models of cables and Cosserat surfaces
- On-line collaborative work for virtual assembly
- Sensitive tactile interface for a texture rendering
- Modelling and control of the manipulation in virtual reality
- Combining manual and automatic resources for the semantic analysis of texts
- Networks of pressure sensors on flexible substrates for the analysis of technical gesture
- Use of the force feedback in contactless laser micromanipulation
- Optimization calculations for intersections between straight line segments and a large number of mobile and complex 3D objects used in interactive radiation phenomena simulation
- Construction and use of a multimedia ontology in dialogue situations
- Propagation simulation of non-linear Volterra series: application to virtual reality (sound synthesis, haptic system)
- Interactive simulation of a NDT conformable sensor positioning on a piece of complex geometry
- Semiactive magneto-rheological suspension systems for cars
- Haptic and pseudo haptic feedback for virtual prototyping
- Knowledge management for virtual reality operation and robotics
- Multi-target optical trapping micromanipulation applications
- Tactile interfaces for gripping virtual objects
- New concept of inherently reliable micro-articulation using integrated actuator
- Autonomous navigation based on the principle of multi-sensory memory
- Automatic object caption from video information by a cooperative robot for disabled people
- Optimal synthesis, production and characterization of 3D flexible micro-joints integrating piezoelectric actuation and measurement for the "self-sensing" in microrobotics for health
- Synthesis of BioMEMS based on micro flexible mechanisms that allow nanometer moving and the measurement of nano Newton forces
- Potentialities of flexible structures with integrated actuator for the "self-sensing". Application to force feedback for microrobotics
- Force monitoring for control and safety in interactive robotics
- Autonomous closed-loop navigation by optical flow of a drone in unsure environment
- Control of a synchronous machine used for an effort-drived orthosis
- Designing an interface for operating a robot
- Algorithms for visual command and control of a drone
- Intrinsically safe design for man-cooperative robots

Embedded Systems

- Static analysis by abstract interpretation of memory manipulation
- Static analysis of descriptions of hardware components
- Static analysis by abstract interpretation of hybrid continuous discrete systems
- Static analysis of the physical subsystems of an industrial complex system
- Static analysis for the constraints test of C programs using dynamic memory management
- Model-driven engineering and design patterns for real-time embedded systems
- Validation by static analysis of digital programs
- Criteria for testing and generation of test sequences for synchronous reactive systems modelled by calculation data flow controlled by extended state machines
- Coupling UML models and data flow for the design of real-time systems
- Integration of heterogeneous models in a real-time system design methodology
- Active vision system for video surveillance applications
- Recognition of objects in video sequences, application to video surveillance
- Validation through formal methods in the Oasis development process
- Integration of primitives for self-adaptable circuit placement/routing
- Designing a flexible architecture for embedded vision systems

Theses

- Description language for fine-grained parallelism (thread) within tasks parallelism for MPSoC
- Odometry by vision for driver assistance applications in urban areas
- 3D reconstruction of non-rigid scenes
- Multi-camera multi-target monitoring: application to video-surveillance in a network of cameras
- Reconfigurable memory hierarchy for embedded architectures
- Definition and implementation of communication mechanisms for parallel embedded architectures
- Fault-tolerant architecture for Multi-processor on chip (CMP)
- Methods for on board car diagnosis for complex wire networks
- Integration of heterogeneous systems taking into account the level of security
- 3D scene repositioning through an embedded camera for augmented reality applications
- Event detection in a crowd by means of video-surveillance
- 3D reconstruction of manufactured objects from image sequences
- Self calibration of an on board vision system in a vehicle
- System-level reconfigurable platform for embedded applications
- Applications porting environment on the parallel vision platform
- Computing architecture for improvement of images produced by video CMOS sensor
- Low consumption reconfigurable processor for multiprocessor system on silicon

Sensors and Signal Processing

- Bio-functionalized photonic crystal fiber: a technological breakthrough in biophotonics for the development of chemically selective Bragg grating sensors
- Design and development of a reconstruction algorithm for microtomography used in micro-fluidic systems
- Establishment of the primary reference for X-ray low energy dosimetry
- Measuring methods of the input function of beta + tracer for PET imaging
- Study of the propagation and diffraction ultrasonic waves model for a diffusing metallurgical structure application to non-destructive austeno-ferritic steel testing
- Development of synthetic diamond gauges for the production of biosensors
- Development of a ultrasound reconstruction method for localization and characterization of defects.
- Coupling finite element and modal methods for non-destructive testing using ultrasonic guided waves.
- Calculation by artificial neural networks of the 3D dose distribution in a phantom patient for the treatment of cancer radiotherapy.
- Estimation of a distribution of very fast response time in molecular fluorescence and telemetry.
- Reconstruction in vivo of the 3D image of the received radiation dose during radiotherapy.
- Numerical and experimental study of a radiotherapy treatment planning system (TPS) incorporating a Monte-Carlo calculation - Applications to heterogeneities and small beams.
- 3D imaging through X-ray and vision data fusion
- Design of multielement transducers and techniques
- High resolution and high counting rates gamma spectrometry on sodium liquid generation 4 reactor primary circuit
- Construction of model pore network environment from fibrous tomography X. Application to the study of transport phenomena in the diffusion layers of a PEMFC type fuel cell
- Semi-analytical modeling of electromagnetic phenomena appealing during eddy currents testing of a 3D geometry mechanical piece
- Development of a numerical model for simulating a non-destructive testing process for ferromagnetic tubes by a leak flow sensor
- Simulation of ultrasound non-destructive testing in carbon epoxide

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