June 2016

2012-2016

France Life Imaging mid-term report

Contenu

1 Introduction

The France Life Imaging – FLI- network was launched in 2012 to create a harmonized network of *in vivo* imaging research laboratories and platforms. The network's goal is to promote high technological innovation in biomedical imaging and to offer a convenient access to the academic and industrial communities to state-of-the-art *in vivo* imaging technologies and integrated services.

FLI gathers 25 imaging platforms organized in 6 regional nodes and distributed over the French territory. This network of coordinated platforms is open to collaborations with external partners, both academic and industrial. To support for population studies through the network, FLI has set up an additional transverse structure coordinated by the Information Analysis Management- IAM- node to provide a database management and information processing.

The imaging platforms are linked with research laboratories with a known expertise in imaging-related methodology and in translational and medical imaging. As such FLI aims at coordinating research efforts into four fields (and via 4 workpackages): molecular imaging agents, instrumentation and innovative technologies, interventional imaging, and image processing. Figure 1 presents the FLI network.

Starting from 6 regional nodes of *in vivo* imaging platforms and one node for information analysis and management linked to research laboratories and units, we specifically aimed:

- To propose an harmonized network including the set-up of a unique national access through a web portal, the set-up of a quality management plan to guarantee robustness, reproducibility, and high scientific value added of service activities, the progressive set up of a business plan adapted to FLI;
- To offer an optimized training for students in imaging and to coordinate training courses for continued education at the FLI platforms;
- To develop networking approaches in 4 core scientific activities to face the technical challenges in imaging more efficiently;
- To make strategic and complementary investments to improve the national offer in all imaging modalities. A total of 26M€ have been invested to acquire new imaging systems (+15% of the existing FLI installed based) or upgrades (5% of the existing FLI installed based is concerned)
- To propose the setting up of a national node for information analysis and data management
- To reinforce exploitation of nodes by funding running costs during the first years to allow the progressive set-up of the business plan.

The establishment of this network is expected:

- To boost innovations and research on critical issues on biomedical imaging: imaging agents, instrumentation and innovative technologies, interventional imaging and image processing thanks to the coordination of the research in these domains;
- To achieve optimal practices thanks to professional training, common methods for pricing and a shared quality policy;
- To accelerate the technology transfer to industry for their own development;
- To create jobs opportunities, especially for young scientists;
- To improve the visibility of the French research in biomedical imaging on the international scene thanks to a coordinated research.

Figure 1: FLI network of imaging platforms and research laboratories involved in FLI (in yellow, laboratories involved in the WP "molecular contrast agents" - WP1, in pink, the laboratories contributing to the WP "instrumentation and innovative technologies" - WP2, in blue the laboratories contributing the WP "interventional imaging" – WP3, in green the laboratories involved in the WP "image processing" – WP4, in red the regional nodes.
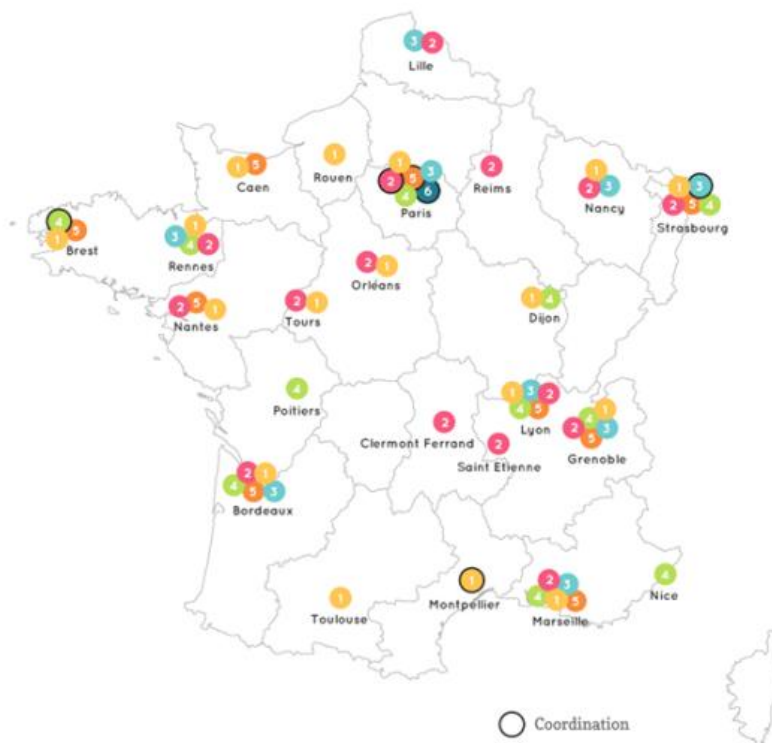
A total of **37,000 k€ were granted to FLI to build a harmonized network of imaging** platforms opened to partnerships. 26,762 k€ were transferred over the 2012-2015 period and 24,937 k€ were invested for**:**

- The acquisition of 49 pieces of heavy state-of-the art equipment (on the 52 planned);
- The recruitment of 3.5 full time person.year for the management at both national and regional levels (communication, quality policy, service offer and business development, training development, coordination of Grenoble and Paris Centre node);
- The recruitment of 358 person.month for setting up solutions for data analysis and processing (458 person.month were initially planned);
- The organization of 18 networking events to reinforce the links between academic, clinicians and industrial partners and build a strong community committed in *in vivo* imaging in France; 5 events in the scope of diffusion through training, 1 national seminar to assess in vivo imaging strengths and gather for the first time all the community in one single event, 2 national seminars on US and optical imaging, 9 thematic workshops organized by scientific leaders in the four domains already described: imaging agents, instrumentation and innovative technologies, interventional imaging and image processing.

- The creation of 10 new trainings and the training of 1160 professionals;
- The award of 35 starting grants to 40 laboratories to foster collaborations and exchanges of know-hows to boost the French competitiveness;
- The support of 5 projects submitted to H2020 European calls since 2014 and the current set-up and support to 3 proposals to the 2017 H2020 *Innovative Training Network* call.

2 International visibility and involvement in European funded projects

Since its creation, FLI is strongly Europe-oriented. Important actions of FLI thus focused on (1) updating the equipment in *in vivo* imaging enabling the availability of state-of-the-art systems and innovative systems and (2) training to improve the French positioning in the European landscape.

FLI puts strong efforts in training professional and students especially in the scope of **European educational** programs and applications to H2020 calls; As such, 5 training actions were organized in English; FLI also supported 70 students and professionals to attend international trainings abroad; Additionally, FLI is partner of the European Molecular Imaging Doctoral School network (EMIDS) leading to the support and enrolment of 3 French PhD students in this program.

To further enhance the commitment of French researchers in Europe, FLI is coordinating the responses to Marie Sklodowska-Curie, Erasmus calls that should be leading to 3 *Innovative Training Network* (ITN), submissions in 2017.

Taking advantages of the availability of novel equipment and related expertise in the laboratories, FLI supported building collaborative projects between laboratories, platforms or sub-networks to apply to H2020 calls.

Since 2014, seven applications to H2020 calls for projects were financially supported by FLI. One was granted, and 2 are under revision.

- Taking advantage of the innovative spectral CT scanner funded by FLI and installed in Lyon in 2014, a project for the development of a new quantitative imaging system combining spectral CT and new contrast agents for molecular imaging in human led by the University of Claude Bernard Lyon 1 and granted 6.4 M€, was selected under the "Horizon 2020" European Research and Innovation program. The project involves Erasmus University of Rotterdam, (The Netherlands), University of Turin (Italy), King's College London (UK), Cliniques universitaires Saint-Luc of Brussels (Belgium), Philips Medical Systems Technologies (Israel), Philips Research (Germany) and Bracco Imaging (Italy). It will last 48 months from January 2016 to December 2019. Research projects for a fully functional spectral CT acquisition system are still in progress, including detector developments and data processing, but also energy dependent image reconstruction, development of target-specific contrast agents dedicated to a large spectrum of applications particularly in neurology, cardiovascular and imaging in small animals for the first two years and in larger animals and in humans for the last two years of the project. This will prepare the evolution of this technology towards non-radioactive intrinsically simultaneous anatomo-molecular imaging with CT in humans as a cost effective and safe new imaging modality. The expected gains for both patients and the

health system are considerable, cardiology and neurovascular diseases representing over 20% of health costs.

- In 2015, three applications were submitted; one to the FET-open Research and Innovation call focusing on the evaluation of new material for the design of coils for ultra-high field MRI and involving FLI through the CRMBM (Marseille), Institut Fresnel (Marseille)[1] and NeuroSpin (Saclay / Paris Sud) teams, one ERC Consolidator 2015 with CRMBM Marseille - NeuroSpin (Saclay /Paris Sud) and Institut Fresnel[1] and one application to an EINFRA call with a project aiming at providing a **scalable and flexible Virtual Research Environment** to researchers that will adapt to their needs and involving IAM node as a partner. The first project was rejected at the second phase of application while the second project was rejected at the first phase.

- In 2016, three proposals were submitted. One project coordinated by the IAM node was submitted in response to the EINFRA-22-2016 'User-driven e-infrastructure innovation' call launched in December 2015. The aim of the latter is to provide solutions for data management and analysis. The second proposal was sent in response to the INFRAIA-02-2017 ERAMMIT call and focuses on the preparation of an ERIC in nuclear sciences for medical imaging applications. And the third application was to the FET open 2016 lead by the Institut Fresnel (Marseille) and involved the CRMBM – and NeuroSpin as partners.

The involvement in European actions was one of the main objectives of FLI since its creation and it remains even though FLI is no longer a partner of the European Euro-BioImaging Infrastructure on the ESFRI roadmap and this since 2014. This decision was taken regarding the insufficient perspectives of the *in vivo* imaging with the framework.

3   Strong governance

FLI established strong governance to face two main challenges. The first one is related to the size of the network, which today includes 25 imaging platforms and 100 associated research laboratories. The second one relies on the need to rapidly update the imaging platforms and harmonize the practices of the platforms to boost the set-up of partnerships.

FLI is bound by a consortium agreement since March 2014 to resolve any contractual issues related to the consortium, keep-up with national regulations and implement such regulations if they involve work conducted within the consortium.

FLI is coordinated by Franck LETHIMONNIER, and assisted by an operational manager, a national level management office, and a national steering committee.

The national management office is composed of a manager in charge of the quality deployment, a responsible for partnership and two partial-time persons (20%) for the communication management and one for administrative and financial affairs. All in all, 2 persons were recruited by the institutions involved in FLI to ensure the coordination at regional and national levels, one by the CEA at Paris-South node and one by Bordeaux University (Bordeaux node).

The steering committee is composed of the regional representatives of the platforms, the scientific leaders in key domains identified by FLI and the training manager. It meets once a month, eleven

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[1] Leader of the application

times a year since April 2011. It addresses the strategic orientations of the infrastructure, monitor the performance of the network and the actions of the workpackages, and set-up the communication strategy. Figure 2 presents a sketch of the steering committee.
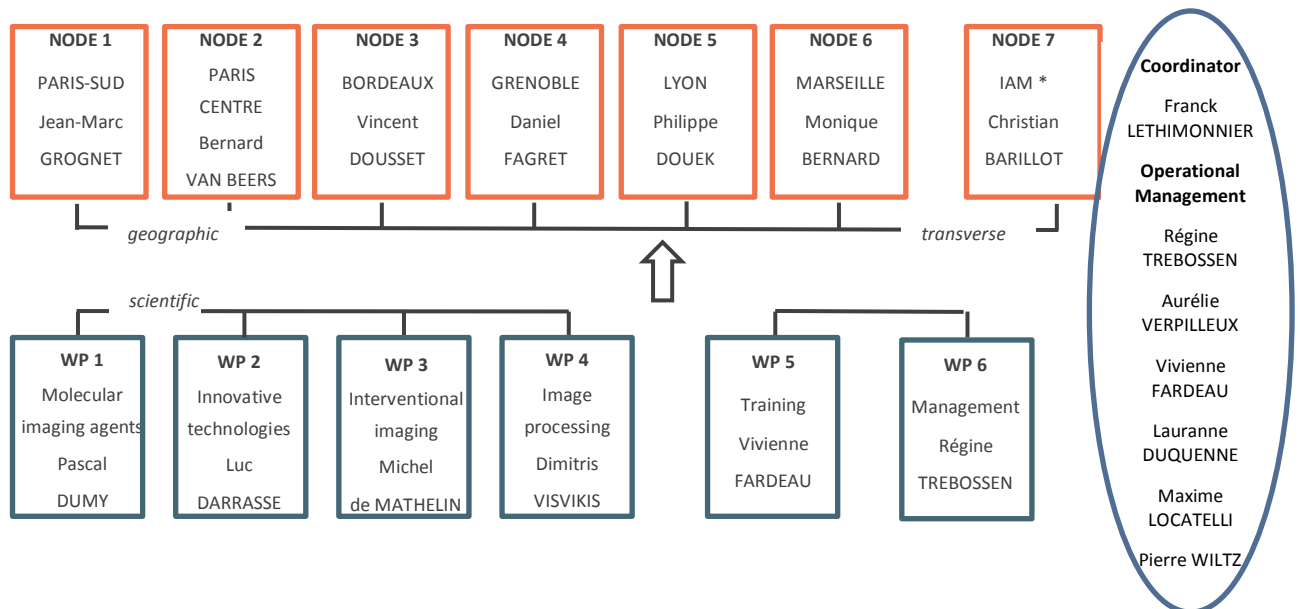

NODE 1	NODE 2	NODE 3	NODE 4	NODE 5	NODE 6	NODE 7	Coordinator
PARIS-SUD Jean-Marc GROGNET	PARIS CENTRE Bernard VAN BEERS	BORDEAUX Vincent DOUSSET	GRENOBLE Daniel FAGRET	LYON Philippe DOUEK	MARSEILLE Monique BERNARD	IAM * Christian BARILLOT	Franck LETHIMONNIER

geographic — *transverse*

scientific

WP 1	WP 2	WP 3	WP 4	WP 5	WP 6
Molecular imaging agents Pascal DUMY	Innovative technologies Luc DARRASSE	Interventional imaging Michel de MATHELIN	Image processing Dimitris VISVIKIS	Training Vivienne FARDEAU	Management Régine TREBOSSEN

Operational Management
Régine TREBOSSEN
Aurélie VERPILLEUX
Vivienne FARDEAU
Lauranne DUQUENNE
Maxime LOCATELLI
Pierre WILTZ

Figure 2: sketch of the steering committee and the operational coordination of FLI.

The steering committee is advised by an international Scientific Advisory Board (SAB) that met twice in 2013 and in 2015. The board gathers international key-opinion leaders in the field of medical imaging and research and medical applications[2]. Its role is to evaluate the strengths and weaknesses of the infrastructure, and to propose new avenues for research and development.

3.1 Strategic commitment in the French ecosystem

The Steering Committee, advised on many points by its scientific advisory board, launched several strategic actions to set FLI as a major actor in the French ecosystem and compete in H2020 applications.

Without FLI, most of the structuration actions would not have taken place.

We aimed at bringing closer the academic research on imaging and the industrials, to create job opportunities, and facilitate technological transfer. FLI and the radiologists and nuclear physicians aimed at working together to facilitate the validation of the new technological development and novel applications of innovative devices, and set up population studies and multi-centric studies.

The French strengths in *in vivo* imaging were assessed during a three-day seminar organized by FLI in cooperation with the French societies of biomedical imaging and the Paris-Region competitiveness

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[2] The SAB is coordinated by Pr. Richard Frackowiak and is composed of Pr. Silvio Aime, Pr. Sam Gambhir, Pr John Mazziotta, Pr. Oliver Speck, and Pr. David Townsend.

cluster MEDICEN (innovation for health). The seminar was held in February 2016 and welcomed 250 participants and fifteen industrials.

3.1.1 Networking actions with the industrial partners: a close collaboration with MEDICEN competitiveness cluster.

Two actions toward the community of ultrasounds imaging and therapy, and the community of optical imaging were initiated respectively in 2014 and 2015, in coordination with MEDICEN Paris Region competitiveness cluster. As the first step, a seminar bringing together the community assessed the needs of structuration in 2014 for the US and in 2015 for the optical imaging. This action is ongoing and the second stage is under discussion.

Imaging and therapeutic US (2014)

The first seminar gathered 160 participants; half of them from academic laboratories, more than ¼ from 20 SME and TPE and the rest were radiologists and clinicians. The majority were in favor of the creation of a club bringing together the three communities. This action is actively pursued in close collaboration with MEDICEN competitiveness cluster and the club may be launched during next meeting scheduled at the end of the year.

Optical imaging (2015)

The *in-vivo* optical imaging field is large combining several technologies with different characteristics, scales, and applications. Numerous French small companies are developing systems. The 2-day seminar organized by FLI with the support of MEDICEN competitiveness cluster in September 2015 gathered 100 persons and 20 small companies and partially exhibited the huge diversity of the technologies and their fields of application. This meeting was also an opportunity to establish ties of cooperation with an innovative company[3].

3.1.2 Bring the communities of academic research, radiologists and nuclear physicians closer

FORCEimaging: French organization of research on imaging at hospital facilities

FLI wished to establish close relationships with the French societies of radiologists and nuclear physicians. As thus, FLI was strongly committed to the creation of a network of clinical research in Hospitals, FORCEimaging. Its objective is to enhance the quality of data acquisition, storage, and analysis of the data acquired in the context of clinical research to warranty the re-use of the acquired data. The network proposed a white paper summarizing the objectives of quality and sent it to the French Health Authorities. The role of FLI in FORCeimaging network is to support the development of solutions of data management and analysis filling the requirements of clinical research in hospitals and solutions for enhancing multicentric studies and to translate its quality policy to the clinical research. A working group has just been set up to harmonize the data acquisition on human MRI scanners for population imaging and multicentric studies with the support of FLI. This initiative will benefit to both FLI and FORCEimaging.

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[3] For example, First Light Imaging, a small company developing optical imaging systems for astrophysics applications, presented its devices and its ambition of applying this technology to very high resolution small animal imaging. The company recruited a former doctorate of FLI network met during the meeting and asked FLI a letter of recommendation for applying to a grant to sustain its R&D on optical systems for small animal imaging applications.

3.1.3 Joint actions with other INBS

We set up working groups with France Bio Imaging (FBI) and the Institut Français de Bioinformatique (IFB) in the objectives of sharing technological solutions for data analysis and management.

If *in vivo* imaging is pivotal for research diagnosis and therapeutic evaluation in areas such as brain, cancer, heart and metabolism explorations, it is still emerging in infectious and inflammatory diseases. We get close to IDMIT (Infectious Disease Model and Innovative therapies) and organized a workshop in 2015 and in 2016 to prepare joint projects on specific themes.

3.2 FLI business model

A major objective of FLI is to establish an easy access to state of the art equipment and expertise based on an operational business model. FLI steering committee thus launched and followed the set-up 2 working groups, one dedicated to the implementation of a common methodology for pricing accounts (§3.2.2) and one to the achievements of a common quality policy (§3.2.1). The infrastructure is committed to provide high quality services to the external partners and the same high quality whatever the platforms.

3.2.1 A common quality policy

The platforms and the imaging system managers agreed to comply with the following standards:

- To offer reliable and advanced systems with a large panel of imaging modalities and expertise in the national context of FLI;
- To carry out projects on the devices under the supervision of an identified and trained staff, committed in a scientific and technological continuing watch;
- To carry out the project in accordance with the good laboratory practices or other guidelines and guidance if required;
- To contribute to activities and animation of the infrastructure by organizing training and scientific events;
- To provide a main access point for collaborations and services via the website of the infrastructure: www.francelifeimaging.fr.

For the platforms wishing for high quality standards, FLI offered to support the process of ISO 9001 and NFX50-900 certifications.

So far, Marseille CRMBM platform is certified and the Institute of myology in Paris is proceeding with the NFX50-900 certification with the help of FLI.

3.2.2 A common methodology for pricing

A working group involving accounting Managers, accounting Controllers and Platform Managers was set up since 2013.

A three-stage plan was then implemented:

(i) A common methodology for Operating Account (OA) has been agreed by the platforms and synthesized in a methodological guide;

(ii) The platforms implemented OA, allowing the calculation of the full cost for each modality or activity; some difficulties were also highlighted, such as the impact of the depreciation time differences in this cost (figure 3);

(iii) Pricing practices were discussed and harmonized for all type and nature of possible collaboration.

Figure 3 illustrates the full cost of a one-hour clinical research MRI examination accounting for centre-to-centre equipment depreciation time.
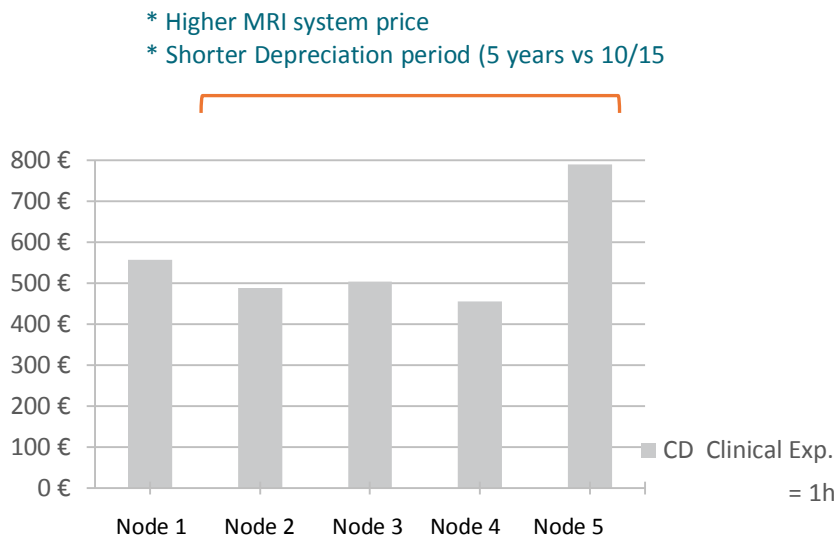

Figure 3: Illustration of the impact of the centre-to-centre difference in equipment depreciation duration on the full cost of 1 hour clinical MRI examination.

3.2.3 Service offering

The FLI service offer is built on a privileged access to the technologies and facilities, a support in setting up and developing projects and partnerships with the research teams of the network, and training programs on the different aspects of biomedical imaging.

The facilities, where the technologies and equipment are gathered with the scientific, medical and technological expertise, constitute preferred sites for research in biomedical imaging, and are at the core of the FLI network. Those facilities are dedicated to the needs of preclinical and clinical imaging research, whether diagnostic or interventional. Moreover, they provide a unique environment for training, both students and professionals.

The major thematic fields are covered throughout the involvement of almost one hundred research laboratories. FLI coordinates four major research themes, namely molecular imaging agents, instrumentation and innovative technologies, interventional imaging, and image processing.

The structural link between FLI facilities and the clinic naturally feeds a translational approach. FLI fits into the clinical research continuum, focusing on early stage studies, advanced methodology for diagnosis and therapeutic follow-up and first in-man studies. A consistent fraction of the equipment is installed within the hospitals in Paris, Orsay, Bordeaux, Grenoble, Lyon and Marseille, and the network involves experts and key opinion leaders in the biomedical imaging of specific therapeutic areas, such as neurology, cardiology and oncology.

Table 1 summarizes the expertise and the main leaders of FLI in the three main therapeutic areas of expertise of the laboratories.

Table 1: Expertise and corresponding platforms and laboratories in three main therapeutic areas.

Brain Imaging	CIREN – **Sainte Anne Hospital and CENIR, Paris**
✓ Neurodegenerative disease	IMNC – **Paris-Saclay University, Orsay**
	MIRCen – CEA, **Fontenay-aux-Roses**
✓ Cognitive neurosciences	NeuroSpin – CEA, **Saclay**
	IMN, GIN –Grenoble - Alpes Univ.
✓ Stroke	INCIA - GIN - U Inserm U1049, Neurocentre Magendie, **Bordeaux Uni.**
✓ Assistance to neuro-surgery	Visage - **Rennes**
	CRNL, team BIORAN and CMO, Fondation Neurodis, **SBRI – Lyon**
	INMED, INT, CMRBM U7339, **Marseille**

Cancer Imaging	IMOTION, **Bordeaux Univ.**
	Institut Albert Bonniot U823 - **Grenoble - Alpes Univ.**
✓ High frequency Ultrasounds	IPHC-ImaBio, **Strasbourg**
	CRCL- Leon Bérard Centre, **Lyon**
✓ Tumour characterisation	CRI, Centre for research on Inflammation - Laboratoire des Biomarqueurs en Imagerie, **Paris**
✓ Assistance to surgery	LIB, équipe ITD, **Paris**
	IMNC, Paris-Saclay University, **Orsay**
	IMB, UMR 5251, **Bordeaux**
	CERIMED. **Marseille**

Cardio-metabolism imaging	Centre de recherche radio thoracique **de Bordeaux**
	IHU Liryc, **Bordeaux**
	LVTS, Inserm U1148 équipe Cardiovascular imaging, **Paris**
✓ Cardiovascular disease	PARCC, équipe Imaging of microcirculation, Georges Pompidou Hospital, **Paris**
✓ Cardiac rythmology	IMB, UMR 5251, **Bordeaux**
✓ Atherosclerosis	CarMeN, **Lyon**
✓ Metabolism	Creatis, **Lyon**
	PIMPA, **Paris**
	CMRBM U7339, **Marseille**

FLI set up an easy access to the resources and expertise of the field, from a national perspective, as a complement to the existing local links between the laboratories and the companies through a web portal (www.francelifeimaging.fr/en/service-offer). The detailed knowledge of the French biomedical

imaging research environment, the involvement of experts and key opinion leaders and the comprehensive perspective of the sector enable FLI to guide and assist its partners, whether they seek for an expertise, want to build a research partnership (whatever its form), or need a training in some imaging technique.

4 Impact on the French *in vivo* imaging landscape

Starting from 6 regional nodes, 1 transverse node dedicated to the data analysis and management, all linked with 100 laboratories and / or research units in July 2012, FLI is now a network with:

- A unique web access to a wide range of biomedical equipment and integrated services (www.francelifeimaging.fr);
- Improved practices (common methodology for cost imaging calculation and a common quality policy);
- A training offer for professionals and specific actions toward the students and young researchers;
- An operational business plan;
- Harmonized research activities in key-domains (molecular imaging agents, instrumentation and innovative technologies, interventional imaging and image processing). Actions are coordinated by four scientific workpackages;
- A significant contribution to the French ecosystem;
- A common commitment to European funded research (§2).

4.1 Equipment and expertise

Most of the fund granted to FLI was dedicated to upgrade existing systems, to invest in new equipment, and to develop solutions for information management and analysis. 49 novel systems were installed by the end of 2015 leading to the availability of the most up-to-date devices and to an increase of the number of available systems. As a consequence, these new equipment increased the capacity of imaging and figure 4 shows that in 2014 the actual system occupancy reached the level of 2013 maximum imaging capacity on the systems bought with FLI funding.
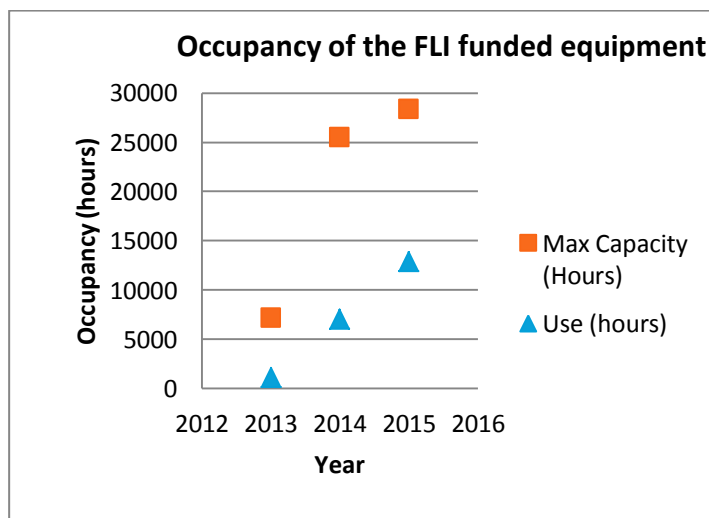
Figure 4: Maximum capacity and effective occupancy of the systems installed thanks to FLI funding

All in all, more than 160 pieces of equipment spanning all imaging modalities and multimodal systems are available now (figure 5).
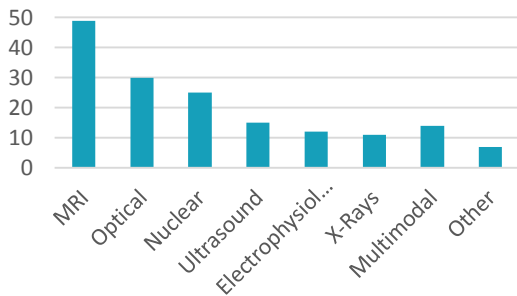

Figure 5. Pieces of heavy equipment available in FLI network.

Among these systems, some are under development and validation in the laboratories. This is the case for the multimodal PET - ultrafast ultrasound system for small animal imaging. Two spectral CT scanners are also developed, one in the framework of a European funded project coordinated by Lyon node (see §2) and one using a different design of detectors and installed in Marseille node. The performance of both systems will be compared thanks to funds granted by the French agency for research for that project. Some imaging systems are also prototypes such as the systems for optoacoustic imaging, the High Frequency Ultrasounds systems used for therapy under MR or US control (3 such systems).

Nearly 1/3 of the systems are dedicated to human research imaging (figure 6).

Figure 6. Imaging modalities for small animal (Left) and for clinical research (right).
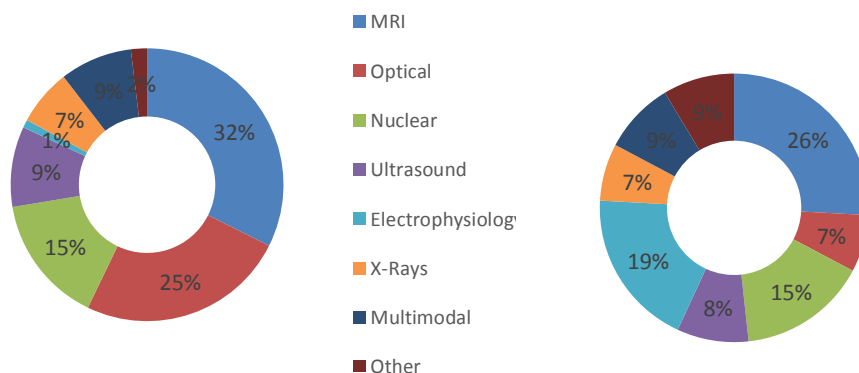
4.2 Data management and analysis

The role of data analysis is crucial for the improvement of the knowledge on the patho-physiological mechanisms of diseases The work performed by the IAM node is essential to provide to a large clinical community software for information management and analysis integrating the latest innovations, such as the integration of 'omic', biological imaging, and population imaging information. Used for the diagnosis and the patient follow up, such tools will enhance the precision of the diagnosis and the patient care. To facilitate the transfer, FLI and the societies of medical imaging are working together to bring the communities of academic research and medical doctors at hospital closer. The community bridging will have the other advantage of improving the set-up of large medical databases including imaging and all data collected about the patient.

FLI with its node IAM, proposed and evaluated image analysis and data management solutions allowing the interoperability between heterogeneous and distributed storage solutions implementing raw and meta-data indexing (e.g. through the use of semantic models or ontologies).

Starting from the survey of the end-users needs from physicists (round table at the SFRMBM, Société Française de Résonance Magnétique appliquée à la Biologie et Médecine) to clinicians (round table at the JFR, Journées de la société Française de Radiologie), we selected three scenarios for our infrastructure utilization:

1) Software as a Service (SaaS) for clinical and preclinical distributed research where the user searches for an outsourcing solution (turnkey service) or hosting-type service where mono or multi-centre data are controlled, stored and processed following users specifications and final results can be provided (typical users, clinician, PI of a cohort study),

2) Platform as a Service (PaaS) i.e. an open resource for professionals which provides housing of data (DaasS) and processing pipelines defined for the need of a large (open) community of users (typical users, organizer of image processing challenges, PI wishing to disseminate data) and

3) Storage and Computing as a service (SCaaS). Basic cloud hosts solution for storage, processing and exchange (typical users, researcher for data management with a small group of collaborators). Such scenarios are supported by the architecture developed. A web portal was set-up and collaborative engineering work is currently performed respectively in Paris-Sud, Strasbourg, Rennes and Nancy to ensure interoperability between Shanoir, CATI, Archimed and MediBase. Dedicated workflows can be executed locally or on distributed architectures (VIP).

OntoNeurolog and OntoCati ontologies used in Shanoir and CATI respectively have been extended to deal with preclinical imaging data. The developed architecture will be used to organize a Multiple Sclerosis challenge at the next MICCAI conference in October 2016. It will consist in providing solutions to share common data (data to segment and corresponding gold standard) and execute 'participants' pipelines. This will demonstrate the technical force of our solution. In parallel, we started to define a specific business model to operationalize our solution and ensure it can survive beyond the FLI-IAM action.

A specific action toward IFB (Institut Français de Bioinformatique) and FBI (France BioImaging) is engaged for sharing expertise in complementary domains, to define interoperability between our platforms and envisage common actions and projects (§3.1.3).

4.3 External projects on the imaging platforms

FLI has already a significant track record with industrial and academic partners.

Figure 7: FLI track record of industrial partners.

Thanks to the partnerships, the income due to lease to others increased over the last three years while the research contracts decreased. All in all the income remained stable in a general context of decrease of the public investment.
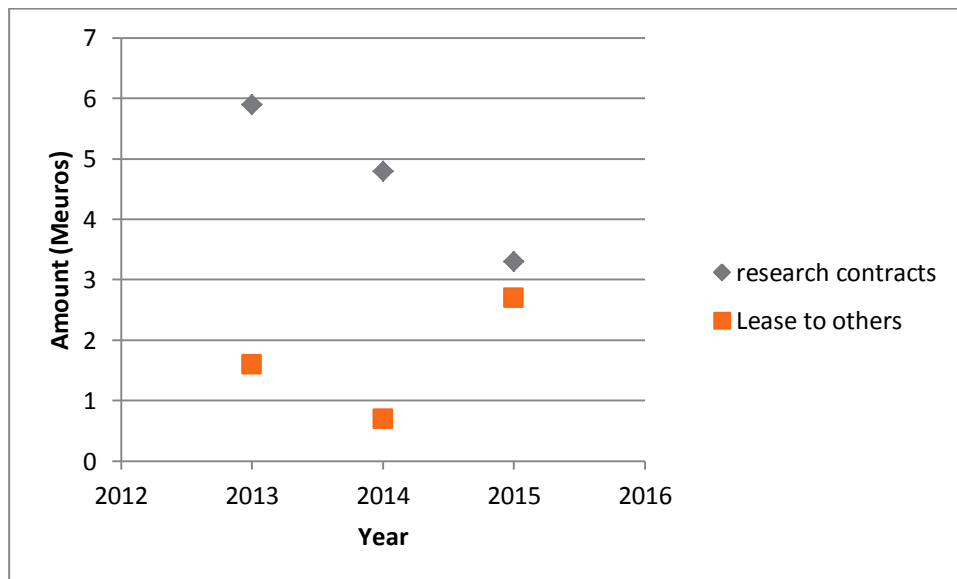

Figure 8: Revenues of the network.

FLI has the ambition of setting up ambitious partnerships with big pharmaceutical companies, and Healthcare product companies.

FLI signed an agreement with SANOFI and with Bruker, and through the Lyon node, FLI started a partnership with Philips for the development of a spectral CT scanner for human and new functionalities for molecular imaging with such a modality (§. 2).

FLI has signed an agreement with the pharmaceutical company SANOFI to access to the equipment and the expertise of the imaging platforms. Two projects were launched so far. For the first one, SANOFI was looking for an expertise in Parkinson's disease imaging and animal models. The second project dealt about molecular imaging using MRI. The set-up of a project based on ultrasound imaging is under discussions.

Bruker is a partner of FLI since the beginning of the project. Five small animal MRI scanners were bought to Bruker and the company indirectly supported the methodological research and development of FLI small animal MRI platforms by discounting the servicing.

Philips is a partner of FLI for the development of new features of the spectral X-rays scanner for especially for molecular imaging in humans through H2020 SPCT project.

5 Training of professionals and students

The aim of the training WP (WP5) is to ensure a high level of education in the field of biomedical imaging within, throughout and across the FLI consortium, for both students and professionals. Since the beginning of the project, WP5 has contributed to the training of 1160 students and professionals. The main achievements over the 1st four years are listed below.

1. The **management** of the WP was ensured through: i) the organization of 3 to 4 management board meetings per year; ii) the periodic dissemination of the information on more than 60 training actions per year; and iii) the design of new promotional material and websites.
2. **The training and professional integration of students** was improved through: i) the allocation of 96 scholarships for students to take part in French and international trainings or congresses; ii) the financial support to 2 master programmes for the implementation of state-of-the-art lab work sessions on FLI core-facilities; iii) the organization of a yearly Workshop "Imaging your career"; iv) the implementation of the French Imaging Network of Young Scientists (FINYS) aiming at increasing the employability and visibility of the students and young post-doc among academic and industrial partners; and v) the communication actions toward the master degrees and doctoral schools coordinators.
3. The **coordination, support and update of the continuing professional development (CPD)** actions for the staff and users of the core-facilities was ensured through: i) the identification of the training needs of the academic and industrial scientific community; ii) the support to 7 ongoing training actions and the allocation of 30 supports grants to attend trainings; iii) the implementation of 3 trainings for the Industry; iv) the organization of 5 new trainings in Molecular Imaging, Ultrasound Imaging, ParaVision 5, MEG and fMRI for which ECTS and certificates are provided; v) the design of 2 additional CPD in Metrology and Optical Imaging; vi) the promotion and recognition of staff mobility and exchange within the FLI consortium leading to the mobility of 4 researchers; and vii) the contribution to the training of medical and paramedical staff with the support to the WP Training of FORCEi.
4. The **embedding of the FLI training actions in the scope of related European educational programmes** was achieved through: i) the organization of 5 training actions in English; ii) the

support to 70 students and professionals to attend international trainings abroad; the official collaboration with the European Molecular Imaging Doctoral School network (EMIDS) leading to the support and enrolment of 3 French PhD students in this program; and iii) the coordination of the responses to European calls (Marie Sklodowska-Curie, Erasmus) among the FLI network that should be leading to 3 ITN submissions in 2017.

5. The **effective communication among the partners and the scientific community** was improved through: i) the visit of all FLI core-facilities by the project managers to present the training actions; ii) the contribution to the FLI website; iii) the support to 4 FLI workshops organised by the scientific WPs; iv) the strengthening of translational research by organising a yearly 1 day training during the Journées Françaises de Radiologie for researchers and physicians gathering 150 participants over the last 3 years; and v) the contribution to 2 educational events organised by the Inserm.

Furthermore, the FLI partners are also directly involved in students' training by contributing to hands-on and MSc thesis (1300 BSc, MSc and medical students per year) and by supervising more than **300 PhD thesis**.

6 Research and development activities of the network

FLI is promoting the research and development leading to very innovative imaging systems such the multimodal Positron Emission Tomography and Ultrafast US device for small animal imaging, the spectral X-ray scanner designed with very high energy resolution detectors at CPPM laboratory in Marseille or the advanced optical imaging systems based on RAMAN spectroscopy and polarized non-linear imaging developed at *Institut Fresnel* In Marseille. Those projects were partly funded by FLI.

In order to successfully deal with the current challenges of *in vivo* imaging and remain internationally competitive, FLI chose to reinforce collaborations between laboratories with starting grants. The grant aimed to pool resources and skills to overcome barriers to technological, scientific, organizational and financial progress. For this purpose, 35 exchanges between laboratories were financially supported in the four research domains already described: molecular imaging agents, instrumentation and innovative technologies, interventional imaging and image processing.

Among those projects; one was the start of a larger project on new material for high spatial and time resolution acquisition coils in MRI that was submitted to an H2020 FET open call and unfortunately was rejected at second phase; two projects were submitted to a French research agency call but rejected.

In addition to funding starting collaborations, the scientific workpackages organized networking actions through nine thematic workshops. Future events will enable to assess the impact of these actions.

7 Perspectives

Most of the equipment funded by FLI is available and the implementation of the "first contact point" to enable everyone interested an access the imaging equipment and the expertise in France is open. FLI members are putting a strong effort to build projects in the perspective of applying to H2020 calls.

In the short term, a challenge to face for FLI is to enhance the validation of the technological innovations developed in the network and transfer them to clinical practice, an important step in the process of transfer to industrial partners.

Another important issue is the development of collaborations with industrial partners, in the technological domain but also in the field of clinical expertise. To date, FLI has signed two agreements (Sanofi and Bruker) and a research partnership (Philips). Our next challenge is to build ambitious partnerships with other pharmaceutical companies, but also with SME lacking a research and development department, for which FLI may provide them with R&D capabilities.

Advances in the understanding of pathophysiological processes will come from the integration of data at different levels, from the cells to the population studies stage. And the role of data analysis is also crucial for the improvement of the knowledge on patho-physiological mechanisms. The work performed by the IAM node is essential to provide to large clinical community software for information management and analysis integrating the latest innovations, such as the integration of 'omic', biological imaging, and population imaging information. Used for the diagnosis and the patient follow up, such tools will enhance the precision of the diagnosis and the patient care. To facilitate the transfer, FLI and the societies of medical imaging are working together to bring the communities of academic research and medical doctors at hospital closer. The community bridging will have the other advantage of improving the set-up of large medical databases including imaging and all data collected about the patient.

8   Publications

73 publications acknowledged FLI so far, 11 published in 2016, 44 published in 2015, 16 published in 2014 and 2 in 2013. These numbers may appear small compared to the number of researchers and PhD students gathered in the network. It took us time to spur everyone to do so but the increase over the year is an encouraging figure of merit.

List of the peer-reviewed publications

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