Twenty-Year History and Current Status of LIMMS:
CNRS-UTokyo Joint Laboratory

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Abstract

LIMMS, Laboratory for Integrated Micro Mechatronic Systems, is a joint laboratory between French CNRS and The University of Tokyo with special support from JSPS (Japan Society for the Promotion of Science). CNRS researchers and French postdoctoral fellows supported by JSPS come to LIMMS and perform research with their Japanese counterparts in 16 hosting laboratories. They typically stay around two years. Their total number exceeds 160 from the creation of LIMMS in 1995. They have written 221 journal papers and presented 327 conference papers. The collaboration was extended from French-Japanese to EU-Japanese in 2011 when we obtained an EU-FP7 project for 4 years. Latest development of LIMMS aims to create a similar joint laboratory in France. This paper overviews its historical development and current status.

1. Introduction

LIMMS (Laboratory for Integrated Micro Mechatronic Systems) is the first French-Japanese joint laboratory on MEMS (micro electro mechanical systems). It was established in 1995 between French CNRS (National Center for Scientific Research) and The University of Tokyo. Though it is physically located in Tokyo, it turned into an official unit of CNRS with a UMI (International Mixed Unit) status in 2004. Then it was upgraded to the first international research unit of the EU in Japan via an EU-FP7 program in 2011.

Unlike typical international collaborations operated then in Japan, LIMMS is characterized by its unique operation protocol by hosting a critical mass (10-20 people) of researchers from France in Japan to let them conduct substantial research with Japanese partners over a few years. LIMMS is not a nominal framework of collaboration or a virtual entity. It operates through the direct interaction of researchers at work in the same place on the same topic. Thanks to the fruitful scientific outcomes and the established administrative support, LIMMS has been in functional operation over the exceptional long time of more than 20 years. This paper aims to give an example of protocol towards a successful international collaboration for those new starters who wish to create another “LIMMS” in their own fields.

2. History of LIMMS

2.1 Dawn of LIMMS

LIMMS was established for the mutual benefits of two parties in France and Japan who wished to start a new international collaboration in the emerging field called MEMS. MEMS is the technology to fabricate micro mechanisms on silicon chips by IC processes. In 1992 the French CNRS sent a delegation to places where MEMS R&D was actively performed. The Institute of Industrial Science (IIS) in the University of Tokyo was one of the destinations of the delegation led by Dr. Jean-Jacques Gagnepain, and they found a research group called RGOE (Research Group of Excellence) on Micromechatronics, which was a virtual network of laboratories to enhance their presence and visibility. The RGOE was operated by five IIS faculty members, headed by the author, with a strong support from the General Director of IIS, Professor Fumio Harashima. The two parties visited each other a couple of times, and finally concluded an agreement to start an international collaboration called LIMMS in 1995. The IIS was to host researchers from three founding institutes in CNRS participated in the program, including LPMMO in Besancon, IEMN in Lille, and LAAS in Toulouse.

The first reasons why the IIS was chosen as a place for LIMMS is that IIS was known as an institute focused on international collaboration. Before LIMMS, there were other international collaborations going on such as civil engineering for natural disaster prevention. The IIS had been always exposed...
to such international activities and had experience and know-hows in international protocols.

The second reason was the IIS’ interdisciplinary research policy. Activities covering different disciplines were encouraged to create a new field. MEMS is a good example of a result of this scientific policy, combining Mechanical and Electrical Engineering.

The third reason was complementarity. IIS is the largest university-affiliated research institute in Japan. More than 100 laboratories in IIS could provide enough experimental facilities and complemental knowledge for French researchers who were experts in each particular area, e.g. bio or RF, but not in MEMS. Also the French and Japanese ways of research were complemental. Generally speaking, Japanese are good at making things and French are good at theory and simulation. Besides such academic reasons, Tokyo had plenty of social supports for foreign researchers and their families. Tokyo has more options in the international schools for children.

2.2 Inauguration of LIMMS

A short version of the LIMMS history is shown in Figure 1. The old campus of the IIS was located in Roppongi at the time of LIMMS inauguration in 1995. The first Agreement was signed in Paris by CNRS Director, Dr. François Kourilsky, and President of The University Tokyo, Prof. H. Yoshikawa with Dr. Jean-Jacques Gagnepain, the Director of the Engineering Science Department (SPI) of CNRS and the Director General of IIS, Professor Fumio Harashima.

The founding core members of LIMMS were Prof. T. Masuzawa and the author, who served as the first Japanese Director of LIMMS from 1995 to 2001, in IIS and Dr. Michel de Labacherie and Dr. Dominique Collard, senior researchers from LPMO and IEMN with CNRS. Before signing the Agreement, it took almost a year to define the content of research contract as well as the procedure for transferring funding from France to Japan. The strong support from Dr. Gagnepain and Prof. Harashima finally made it happen.

The operation funding was provided by both parties. The CNRS gave funding for expenditure and small equipment based on the number of researchers sent in to IIS. IIS provided micromachining facilities and space. The faculty members had their own research funds from IIS, as well as from external funding agencies, the part of which was used as an operation budget for LIMMS.

In addition to these, the Japanese funding agency JSPS (Japanese Society for the Promotion of Science), agreed to provide IIS its fund called Inter-Research Centers Cooperative Program (IRCP), between 1994 and 2004, mainly for the international travel expenses that were essential to pursue the activities of LIMMS. JSPS also agreed to acknowledge LIMMS initiative and increase the possibility for hosting international post-doctoral fellows through their program, JSPS Postdoctoral Fellowship for Foreign Researchers, on a competition basis. Candidates to the Postdoctoral program were first recommended by CNRS through their evaluation process, and granted as a postdoctoral fellow with full coverage of travel costs to Japan and living costs. Upon additional application to the research fund, they were also granted to have their own budgets to conduct their research activities.

Dr. de Labacherie served as the first Director of LIMMS during the preparation of the agreement and the inauguration. Shortly after, Dr. Dominique Collard took the position over and began the real research activities by inviting CNRS researchers and French Postdoctoral Fellows (Figure 2). Those researchers worked in the laboratory of each IIS faculty member jointly with their counterpart, i.e. staff members and students in the lab. When LIMMS started, there were five host laboratories for LIMMS researchers. For this reason, the LIMMS framework is a network in the IIS to conduct international research on micromechatronics through the administrative support provided.
by a LIMMS office, where a permanent staff of CNRS, French/ Japanese speaking, was appointed.

Based on the active international collaboration in LIMMS, CIRMM (Center for International Research on Micro Mechantronics) was established in IIS in 2000, where the core member of ex-RGOE and other MEMS-related faculty members participated. CIRMM keeps an office in Paris where a French Professor, Alain Bosseboeuf, with a secretary maintains good information exchange with CNRS and coordinates NAMIS, an international network, described in the next section.

2.3 Development Phase toward Official CNRS Lab

After operating for nearly 10 years since 1995, the visibility of LIMMS was enhanced due to the large number of researchers hosted in IIS (16 CNRS researchers and 36 postdocs) and the publication list (178 publications: paper and conference) to a level which was good enough to justify its eligibility to receive the official UMI (Unité Mixte Internationale) status of CNRS. Benefits from being a UMI include the continuity of financial support from the CNRS as an official entity, through which the laboratory could plan a long range research project over a few years. It is also beneficial that a UMI is eligible to apply to national funding programs in France as well as in the EU. The UMI status gives more visibility to LIMMS to attract more attention from potential researchers who could participate.

LIMMS was successfully granted as the UMI status of CNRS in 2004. The four-year UMI contract requests LIMMS to have an intermediate evaluation in the 2nd year and a final evaluation before contract renewal. LIMMS has successfully renewed the contract twice in 2008 and 2012, and is now on the 3rd phase of the UMI. At the same time, LIMMS was promoted as an International Collaborative Research Center in IIS, and LIMMS members became eligible to apply to Japanese funding systems such as Grant-in–aid-for Scientific Research given by JSPS.

LIMMS soon became the most representative and successful case of international collaboration. It attracted attentions from other institutes that wished to start a similar international program. Besides the link with France, CIRMM had other international programs on individual basis with institutes such as Swiss EPFL, German IMTEK, and VTT Technical Research Center of Finland. CIRMM also had connections with Asian institutes such as Seoul National University in Korea and National Tsing-Hua University in Taiwan.

It is a natural consequence that those institutes were united to strengthen the research activities on MEMS by creating a network-type collaboration structure. NAMIS (Nano and Micro Systems) network was created in that purpose in 2005, and more than eleven research institutes from all over the world have been participating since then as shown in Figure 3. NAMIS regularly has an annual meeting rotating among countries for exchanging up-to-date information and for planning the international collaboration. It also organizes a one-week-intensive school for graduate students and young researchers.

The operating cost of NAMIS activities is supported by the participating institutes. On the Japanese side, IIS obtained a grant called ITP (International Training Program for Young Researchers) from JSPS for five years since 2009. This fund was mostly used to send young researchers and graduate students to the NAMIS institutes for their own training and research. On the French side, NAMIS is supported by CNRS as an International Research Network (GDRI – Groupement de Recherche International). Prof. Hiroshi Toshiyoshi served as the second Director (2002-2007) of LIMMS and led those developments.

2.4 Entering New Horizon as EU International Lab

The third Director of LIMMS was Prof. Teruo Fujii (2008-2014). Under his initiative, LIMMS put further steps of growth. The first task was to set concrete rules and build a working system as UMI. The LIMMS office hired some secretaries to help managing UMI-related issues. The official evaluation also requires very careful preparation. Statistic data on scientific and managing activities were collected and complied. Also the strategy how to keep the level of scientific activities among top institutions over the world should be clearly stated to convince the members of evaluation committee that LIMMS is important asset for CNRS. The varieties of LIMMS members were also widened. LIMMS started to accept Ph. D students and trainees in Master level. Competitive funding from French National Research Agency (ANR) and CNRS internal programs has also been obtained by the effort of members. Furthermore LIMMS encourages the members to conduct the collaboration research...
by connecting host laboratories and provides support by LIMMS internal projects.

Around 2008, CNRS began to emphasize not only scientific achievements but also contribution to society via solving local and global problems and introducing innovations. Therefore, patent applications obtained priority as well as paper publication. LIMMS responded to this policy change by setting up rules how to apply for patents jointly by CNRS and IIS. In addition, the collaboration with industrial sectors was established with L’Oreal in 2011 after a couple of years of negotiation.

LIMMS has been the most active and substantial node in the NAMIS network ever since its establishment. Thanks to the UMI status of CNRS, LIMMS is officially eligible as a partner to the EU-FP7 program and has obtained an upgrade status through the EU-FP7 program called INCOLAB, as part of which the EU institutes participate in the LIMMS framework. This is regarded as an open gateway for the EU institutes to access the collaboration with the University of Tokyo in exactly the same manner as French researchers come to Tokyo and stay, as illustrated in Figure 4. For this reason, the program name is EUJO-LIMMS i.e. EUROpe-Japan Opening of LIMMS to those new participating institutes. EUJO-LIMMS is the first international collaboration laboratory of the EU in Japan.

As a matching-fund to the EU-FP7, the IIS also received the JSPS C2C (Core-to-Core) program from 2012 for five years (on-going now). It must be a rare case that a single institute successfully benefits from a similar international grant without a break. Achievements of LIMMS both in science and administration seem to have been positively evaluated.

3. Current Structure and Operation

3.1 LIMMS Organization

Two Directors representing CNRS and IIS sides, now Prof. Collard and Prof. Hideki Kawakatsu, are the highest managers of LIMMS supported by an administrative director hired by CNRS. There are a few secretaries working for them and one specialist managing the EU project. All are good at speaking English and French, at least. The organization is summarized in Figure 5.

LIMMS researchers are quite in variety. Tow CNRS research positions are allocated specific to LIMMS. CNRS assigns willing researchers to stay in LIMMS for two or more years. There are two research engineers who have Ph.D. degree and help other researchers in technologies such as MEMS fabrication or bio assay. Postdoctoral fellows are supported by JSPS, CNRS or some grants. Six French Ph.D. students are jointly supervised...
by French and Japanese professors and conduct research both in France and Japan. Short-term Master’s trainee students are also sent by CNRS. Their support comes from French side. EUJO-LIMMS members and industrial collaborators are also accommodated in LIMMS (Figure 6).

Now there are 16 host professors. They are mainly associated with CIRMM but some other professors in IIS and the Faculty of Engineering of The University of Tokyo are also invited to join LIMMS as host professors.

### 3.2 Achievement statistics: as of March, 2014

Since its creation in 1995, LIMMS has hosted 34 CNRS researchers, 63 JSPS Postdoctoral fellows, 6 IIS Postdoctoral fellows, 3 CNRS research engineers, 11 Ph.D. students, 1 CNRS administrative, 1 IIS administrative and 15 trainees. The number of Journal papers is 221, including ones in high impact journals such as Nature, Nano Letters, Lab-on-Chip, IEEE JMEMS and APL. The number of conference presentations is 327. All of them jointly co-authored both from French and Japanese sides.

In the meantime, LIMMS members have been awarded with 6 Grant-in-aid-for-Scientific Research from MEXT, 3 ANR projects and 1 INSERM-Plan Cancer. Also ex-LIMMS members who returned to France have continued their collaboration with host professors using SAKURA program, PICS and JSPS Bridge.

### 3.3 Collaboration partners

LIMMS now has 16 supporting laboratories in CNRS. Typical international collaboration between Japan and France had a bias that Japan was sending more researchers than hosting French researchers. LIMMS is, on the other hand, an exceptional case where many French researchers travel and stay in Tokyo for their research activities. From this point of view, LIMMS structure significantly contributes to the balanced researcher flow between the two countries.

In EUJO-LIMMS, EPFL in Switzerland, IMTEK with University of Freiburg in Germany, and VTT in Finland were original partners in 2012 in addition to CNRS. Then, MESA+ with Twente University in The Netherlands newly joined in 2014. Thirteen research institutions join the NAMIS network from 10 countries over the world (Figure 3).

### 3.4 Scientific Policy

The research activities of LIMMS have been long justified and protected by the strategy suggested by its founder, Dr. Gagnepain, which was to pursue scientific results of high visibility and impact rather than intellectual property rights (patents) for the first ten years. A high-risk-high-return type research proposal is more encouraged than in other institutes. On a clear understanding, LIMMS enjoyed precious financial and administrative resources from both countries. Prof. Harashima also expressed this policy as “LIMMS should pursue the peaks of scientific achievements”.

The initial scope of LIMMS was design and fabrication of MEMS; this was extended to application devices to nano and bio technologies in later years. Most research topics were operated in coherence with the scope of individual host laboratories. Since 2007, LIMMS has been expected to hold its own scientific policy as an independent UMI, and hence a new policy has been set in three different axes namely, Advanced MEMS/NEMS, NanoTech, and BioMEMS, by enhancing the collaboration beyond the boundaries of the individual host laboratories. The three axes, keywords and related host laboratories are schematically illustrated in Figure 7.

As an original policy of the IIS, interdisciplinary research is encouraged, and has been successfully implemented in the collaborations of the LIMMS framework.

Each LIMMS researcher has a host laboratory in IIS. He/she has at least one collaborator from Japanese side to make sure the language and custom barriers do not hinder research
practice. Therefore, the research topic must be interesting to both the researcher and the host lab; LIMMS French and Japanese directors are responsible in defining such a topic before the arrival of each researcher.

More than 20 LIMMS researchers always stay in IIS; this allows mutual help among them in terms of early settlement, learning necessary skills and getting information on expertise/equipment in different labs. This critical mass of researchers makes the life easy and the research activities more efficient.

### 3.5 Agreements and Contracts

LIMMS always prefers real research activities to paper documents. However, without written records on mutual understanding, collaboration work cannot sustain for a long time. Therefore, contracts of different structural levels have been signed between CNRS and the University of Tokyo since 1994, after the national level agreement between CNRS and the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) in 1990. An agreement at the higher level addresses the scope and spirit of the agreement, and those at the lower level of the institute describe the protocol for international operations including the procedure for funds transfer for instance.

Major agreements related to LIMMS include the agreement on academic exchange between the University of Tokyo and the CNRS (1994-), the memorandum concerning research and collaboration between IIS, University of Tokyo and SPI (1995-), Convention for the Creation of LIMMS-CNRS-IIS (UMI 2820) (2004) and collaborative research contract (1995-). The CNRS counterpart to IIS was initially SPI, and then according to structural change in CNRS became the Department of Science and Technology for Information and Communication (STIC). Now it is National Institute of Sciences for Engineering and Systems (INSIS) in CNRS.

### 3.6 Management support by LIMMS office

LIMMS has its own administrative office to operate the researcher’s accommodation program as well as the financial accounting for them. The four major axes in LIMMS administration: namely (1) human resource support, (2) accounting and financial planning, (3) France-Japan administrative operations, and (4) house-keeping LIMMS and supporting the daily-life of members. The administrative staff sometimes serves as a contact for intellectual properties (patents) between LIMMS researchers and patent law firms. The purpose of LIMMS office is to help researchers to minimize the lead time before starting research activity, to quicken their learning curve to reach their maximum potential as fast as possible, and also to push their potential up to the highest level.

The first function to minimize the lead time is to support researchers in their house-hunting for instance. Making an apartment contract is a time-consuming process even for Japanese due to the fact that the contract is written in Japanese and due to local customs on the real-estate market. LIMMS office supports researchers from the preview visit to the contract making phase. LIMMS office also provides help in opening a bank account, arranging a kindergarten for the family, and buying a health insurance policy for instance.

The second function to quicken the learning curve is to provide researchers with accounting help for their research funds for instance. Book-keeping of international funds requires specific skills in every phase from fund transfer to financial reporting due to bylaws of the two countries and the currency exchange rates. LIMMS also has a regular evaluation committee meeting, which is also managed by the LIMMS office. Most administrative documents from IIS are provided in Japanese, and it would be difficult to read for international researchers. LIMMS office give some support in such case to free in part researchers from cumbersome business.

### 3.7 Further development: SMMIL-E

Currently, LIMMS aims to open its mirror structure in Lille, France. It is named SMMIL-E (Seeding Microsystems in Medicine In Lille – European Japanese technologies against cancer) and targeting on the introduction of advanced bioMEMS devices into medicine, more specifically into cancer therapy. The partners are IEMN/CNRS, University of Lille I, and Oscar Lambret Center, a cancer hospital. Japanese professors and researchers visit and stay in SMMIL-E to test their state-of-the-art devices with medical doctors in the hospital. Japanese students will have the opportunity to experience foreign research environment and to be exposed to practical needs from medical doctors.

### 4. Conclusion

Since its foundation in 1995, LIMMS has actively conducted research by close collaboration between Japanese and French members. Financial, administrative, technical and mental supports from both CNRS and IIS of UTokyo are the key for the success. Timely funding aids from JSPS, MEXT, JST, ANR and EU work out effectively to accelerate and expand LIMMS toward a real international research unit on interdisciplinary micro and nano systems.

In order to keep such supports, LIMMS tries to maximize its performance by successive re-structuring, e.g. CNRS-UMI status in 2004, definition of three research axes, emphasis on patents...
and industrial collaboration, EU laboratory (EUJO-LIMMS) in 2012, and creation of its mirror (SMMIL-E) in France. The administration structure have also been grown from researchers’ support to full management of the UMI.

Of course, scientific “peak” achievements are the core of LIMMS strength. Two examples, the molecular tweezers and the TEM in-situ measurement system, can be named are described to demonstrate efforts toward “peaks”. This year LIMMS celebrated its 20-year anniversary. I want to appreciate the readers for their support and encouragement to LIMMS.

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