INSTITUT ARCHIMÈDE

Acronyme du projet : Archimède

Titre en français / anglais : Archimède / Archimède

Responsables du projet : Emmanuel Godard (PR), Xavier Roulleau (PR), Cécile Capponi (MCF HDR)

Aide totale demandée : 16 044 696 € sur une période de 10 ans.

Nom de l'établissement coordinateur : Aix-Marseille Université (AMU), statut : EPSCP

Ce projet est conçu au sein d'une IDEX: A*MIDEX

Établissements partenaires :

- *Établissements d'enseignement supérieur :*
  - Aix-Marseille Université (AMU), EPSCP
  - Université de Toulon (UTLN), EPSCP
  - École Centrale de Marseille (ECM), EPSCP
- *Organisme de recherche :*
  - CNRS, EPST

Unités de recherche impliquées :

- **CIRM** – Centre International de Rencontres Mathématiques
- **CPT** – Centre de Physique Théorique – UMR 7332
- **I2M** – Institut de Mathématiques de Marseille – UMR 7373
- **LIS** – Laboratoire d'Informatique et des Systèmes – UMR 7020

Ecole doctorale impliquée :

- **ED 184** – Ecole doctorale en Mathématiques et Informatique de Marseille

Champ scientifique du projet : Sciences du Numérique et Mathématiques

Contents

1 RÉSUMÉ

La révolution technologique actuelle portée par le "numérique" puise sa source dans les mathématiques parfois les plus fondamentales et trouve son effectivité dans le développement de concepts et de solutions informatisées. On peut mentionner l'utilisation effective des Théorèmes de Bayes (1763) et Perron-Frobenius (1912) pour le calcul du *pagerank* du moteur de recherche Google. On peut aussi citer la construction du plus grand artefact technique qu'est Internet, dont la sécurité d'utilisation, notamment des paiements en ligne, repose en grande partie sur des protocoles cryptographiques. Enfin, la photographie actuelle est rendue possible par les nouvelles techniques algorithmiques de traitement d'images qui permettent la miniaturisation des optiques.

La communauté maths-info de Aix-Marseille est en première ligne de cette révolution scientifico-technologique. Elle est le berceau de la théorie des ondelettes qui permet la compression d'images et vidéos, ainsi que du langage *prolog* d'Alain Colmerauer, préliminaire de l'intelligence artificielle dès les années 1980.

En outre, le récent rapport de prospective de l'INS2I au CNRS indique que, si les mathématiques sont le langage historique des sciences, au 21e siècle, l'informatique est en passe de devenir également un langage universel. Notre conviction est que l'enjeu n'est donc pas seulement de développer à Aix-Marseille deux disciplines mais également de participer à la construction en cours du nouveau langage pour les sciences et les technologies : le langage "math-info".

Par ailleurs, comme le souligne l'académicien des sciences Gérard Berry, le verrou majeur dans la plupart des domaines scientifiques n'est plus dans l'acquisition de données mais dans leur traitement et analyse. Par conséquent les mathématiques et l'informatique sont amenées à être au coeur de la pluri-disciplinarité.

Pour toutes ces raisons, l'Institut ARCHIMÈDE en mathématiques-informatique a un rôle de premier plan à jouer dans la communauté AMU et au-delà. L'Institut se donne comme objectif de former de nouvelles générations de scientifiques et d'experts en mathématiques, en informatique et leurs interactions[1], innovants dans les deux domaines.

Le projet d'Institut s'appuie sur le succès des 8 ans du Labex Archimède qui a initié la collaboration inter-disciplinaire maths-info sur Aix-Marseille. L'entente entre les deux communautés est singulière

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1 Dans ce document « informatique » désigne non seulement la discipline per se mais aussi les domaines en interaction étroite tels que l'automatique, la théorie du contrôle et le traitement du signal et d'image; de même, « mathématiques » doit être compris de manière générale, c'est-à-dire comme recouvrant tous les domaines des mathématiques fondamentales et des mathématiques appliquées, y compris la modélisation et la simulation numérique.

dans le paysage national et donne une réelle avance à Aix-Marseille Université. L'Institut souhaite capitaliser et intensifier ces collaborations pour amplifier significativement les réalisations du Labex.

Le projet repose principalement sur les deux plus gros laboratoires d'AMU, l'I2M (Institut de Mathématiques de Marseille, 300 membres dont 160 permanents) et le LIS (Laboratoire d'Informatique et Systèmes, 375 membres dont 190 permanents). Il repose également sur une partie du CPT (Centre de Physique Théorique, pour 30 permanents). Ces laboratoires sont de tout premier plan, l'I2M est le laboratoire d'AMU avec le meilleur rang au classement de Shanghai. Au niveau national, selon un récent classement[2], l'I2M se classe au quatrième rang national, c'est-à-dire au premier rang hors Paris, en ce qui concerne le h-index. Si l'Informatique n'est pas sur les premières marches comme l'I2M, le LIS se situe dans les tous premiers centres en province. Archimède forme donc un ensemble maths-info très cohérent, homogène et qui pourrait permettre à terme à Aix-Marseille de se situer dans les trois ou quatre meilleurs sites de France sur le domaine.

Le quatrième partenaire, le CIRM (Centre International de Rencontres Mathématiques), est le premier centre mondial de conférences en maths-info, accueillant chaque année 4000 participants. Les mathématiciens du monde entier connaissent Marseille au moins à travers le CIRM.

Avec ce consortium et dans le cadre des objectifs scientifiques énoncés précédemment, ARCHIMÈDE propose un projet ambitieux, pensé pour articuler les programmes de formation au niveau Master/Doctorat et les activités de recherche internationalement reconnues en mathématiques et informatique à Marseille. En plus de travailler à cette articulation entre formation et recherche, nos efforts seront dédiés à

1.   approfondir la relation inter-disciplinaire entre Mathématiques et Informatique,

2.   favoriser les mobilités entrantes et sortantes d'étudiants,

3.   articuler et structurer les relations avec les autres laboratoires de AMU autour de la problématique des données scientifiques,

4.   resserrer les liens entre le monde académique et le monde socio-économique.

Tout en approfondissant la relation inter-disciplinaire mathématiques et informatique, l'Institut s'attachera particulièrement à développer les interactions au delà. Commençons par noter que les quatre thèmes scientifiques majeurs développés à l'I2M, au LIS et au CPT sont

•   Analyse, Modélisation, Optimisation

•   Statistiques, Théorie du signal, Apprentissage automatique et Automatique

•   Systèmes dynamiques, Géométries, Probabilités

•   Algorithmiques, Logiques, Théorie des nombres

Les axes prioritaires pour les interactions mathématiques et informatique sont les suivants:

2 QS World University Rankings 2019.

- sciences des données, IA et apprentissage statistique (traiter et analyser des données complexes et/ou massives)
- fiabilité, sûreté, et sécurité (concevoir, prouver et déployer des systèmes complexes et/ou massifs)

Ces axes sont tout à fait cohérents du point de vue mathématique-informatique et correspondent également à une forte demande socio-économique. L'adéquation à celle-ci des formations par la recherche se concrétise par un taux d'insertion à 2 ans de 95% pour nos étudiants en emploi de niveau cadre.

Les interactions pluri-disciplinaires porteront sur les thèmes suivants

- santé et biologie
- énergie, transport
- sécurité, communication
- numérique et multimédia

Les actions d'ARCHIMÈDE sont organisées en six programmes, qui seront détaillés dans le reste du document :

- Visibilité Internationale
- Programme de Master
- Programme Doctoral
- Valorisation & Transfert
- Programme de Recherche
- Popularisation & Vulgarisation.

Soulignons les points les plus spécifiques de notre projet. Concernant la visibilité internationale, le CIRM et la chaire Jean Morlet seront des atouts majeurs. Concernant la valorisation et le transfert, nous nous appuierons sur une cellule de développement logiciel et sur une plate-forme technologique associée.

Notre communauté a également été à l'origine, ces dernières années, de la création de 4 startup et de nombreux logiciels dans le domaine maths-info. Nous comptons poursuivre et encourager ces initiatives en nous appuyant sur la SATT sud-est. Enfin concernant la popularisation et la vulgarisation, c'est une vraie spécificité de la communauté marseillaise. Les actions Maths Pour Tous et Pi-Day ont reçu le prix d'Alembert pour la vulgarisation des mathématiques en 2014 et 2016.

ARCHIMÈDE a déjà reçu le soutien de partenaires internationaux : Ecole Centrale Casablanca (Maroc), CIMPA UNESCO, IMPA (Brésil), Université Sfax (Tunisie), HSE Moscou (Russie), IRSN, LIA Roma (Italie).

Pour conclure, en offrant une plate-forme institutionnelle claire pour les unités de recherche (I2M, LIS, CPT) l'école doctorale (ED 184), le CIRM et l'ECM (Ecole Centrale de Marseille), ARCHIMÈDE aura un rôle déterminant, grâce au soutien conjoint d'A*MIDEX (AMU) et du CNRS, pour la structuration de toutes les activités de formation et de recherche liées aux mathématiques et à l'informatique à Marseille.

2   CONTEXT AND PREVIOUS ACHIEVEMENTS

2.1   CONTEXT AND SCOPE OF THE PROJECT

Training high-level experts in Mathematics and Computer Science. The technological transition that we have been witnessing for roughly two decades, with the advent of the Internet as a communication medium for expert and non-expert users, is pivotal. It has been spurred by the widespread access to information technologies (IT) and accompanying devices (e.g. mobile devices) and it has had an impact on many fields, far beyond those that are directly connected to IT such as, to name a few, biology, medicine, physics, arts, literature... It is fundamental to understand that mathematics and computer science are at the core of this transition, and that many (if not all) the major advances have hinged upon original models and/or algorithms proposed by experts in the fields, either from academic institutions or from the socio-economic world. It is therefore of the utmost importance for the sustained development of new technologies and knowledges to train experts in mathematics and computer science: this is the central purpose of ARCHIMÈDE. Indeed, the ARCHIMÈDE Institute is designed to provide a platform for those who want to engage into research careers or research and development careers, be it in an academic institution or in a company. In particular, ARCHIMÈDE proposes an ambitious project that offers a fine-grained organization of the training programs at the graduate and doctoral level and the research actions in mathematics and computer science that exist in Marseille. The project builds within extremely favorable conditions: the natural connections between the fields of mathematics and computer science, the way these connections have already been implemented in Marseille (especially from the research perspective through the LabEx Archimède, which is aimed at fostering all the actions pertaining to mathematics and/or computer science), the renowned quality of the research units where mathematics (I2M[3], CPT) and computer science (LIS) are studied, an attractive international meeting facility (CIRM) and a doctoral school (ED184) dedicated to those doctoral students aiming at a PhD either in mathematics or in computer science. ARCHIMÈDE brings together all these ingredients to give them a visible, understandable and unite structuring where training and research (in mathematics and computer science) work hand in hand.

3Lexicon. *ED 184:* École doctorale Mathématiques et Informatique de Marseille ● *I2M:* Institut de Mathématiques de Marseille ● *CPT:* Centre de Physique Théorique ● *LIS:* Laboratoire d'Informatique et Systèmes ● *CIRM:* Centre International de Rencontres Mathématiques.

We now devote time to explain how the context in Marseille may be particularly beneficial for an Institute in Mathematics and Computer Science.

Researches in Mathematics, Computer Science, and their complementarity. Research in mathematics has always been motivated by strong conjectures or deep questioning generated either by the mathematical community or by interactions with other domains (such as physics, computer science, biology...). The answers to these questions are very often found thanks to the coupling of approaches, ideas or reasoning originating from various fields of mathematics or outside. Research in computer science is deeply related to mathematical approaches, a tendency more and more strengthened with the recent developments of complex digital environments. A specificity of research in computer science is the question of generation of algorithms and the associated question of complexity. Even if mathematics and computer science appear clearly in France as different academic fields, the separation inside the research area is blurred: graph theory, numerical simulations, statistical learning, control theory or signal processing are examples of domains connected to mathematics as well as to computer science; discrete mathematics or logic are considered as building blocks of theoretical computer science. And even more, it is now the whole set of mathematics that is involved in modern research in computer science: analysis, statistics, probability, geometry, algebra... By their ability to describe, explain, model and simulate complex phenomena revealed by real life or interaction with other fields, mathematics and computer science take a major place in our every day life. Moreover, each step forward inside complexity triggers new questions and problems requiring mathematics and computer science research.

Mathematics and Computer Science In Marseille From a local point of view, collaboration between computer science and mathematics in the Marseille area started at the very beginning of the start of computer science. A recent study of the mathematics institute of CNRS (INSMI) revealed that the Provence-Alpes-Côte d'Azur (PACA) area is the French leader in term of interactions between mathematics and computer science. There are interactions between mathematics and computer science in many local structures such as the Ecole doctorale or the LabEx Archimède. Researchers of both fields collaborate inside specific domains such as logic, information theory, big data, machine learning etc, processing through research groups or seminars. New trends and extensive collaborations between researchers of CPT, I2M, LIS are numerous and diverse: mathematicians and computer scientists share graduate and undergraduate programs as well as PhD supervision. We plan for the Institute ARCHIMÈDE to enhance the synergy between the research units involved in the project.

CIRM: a pivotal research facility The specificity of Marseille is also due to the presence of CIRM, a residential meeting center for mathematics located on the campus of Luminy. Welcoming around 3500 participants per year, CIRM is a real opportunity for local researchers to invite and meet researchers from the whole world. Even if it has a national mission, CIRM plays a key role in research in mathematics and computer science in Marseille area and is deeply involved in many local structures. The development of wavelets theory, for which Yves Meyer has been awarded the 2017 Abel prize, has widely benefited from CIRM's facilities.

2.2 MAIN PREVIOUS ACHIEVEMENTS

The ARCHIMÈDE Institute is supported by three research units: the Institut de Mathématiques de Marseille (I2M), the Laboratoire d'Informatique et Systèmes (LIS), and the Centre de Physique Théorique (CPT). These research units participate with the CIRM to the LabEx Archimède. The LabEx has significantly enhanced collaborations between mathematics and computer science, as well as links with CIRM. These are specific strengths of the Marseille site, to which is added the very favorable position of I2M in the last ranking of Shanghai of mathematical laboratories. Figure **1** summarizes the architecture and collaborations between the actors involved in the Institute project.
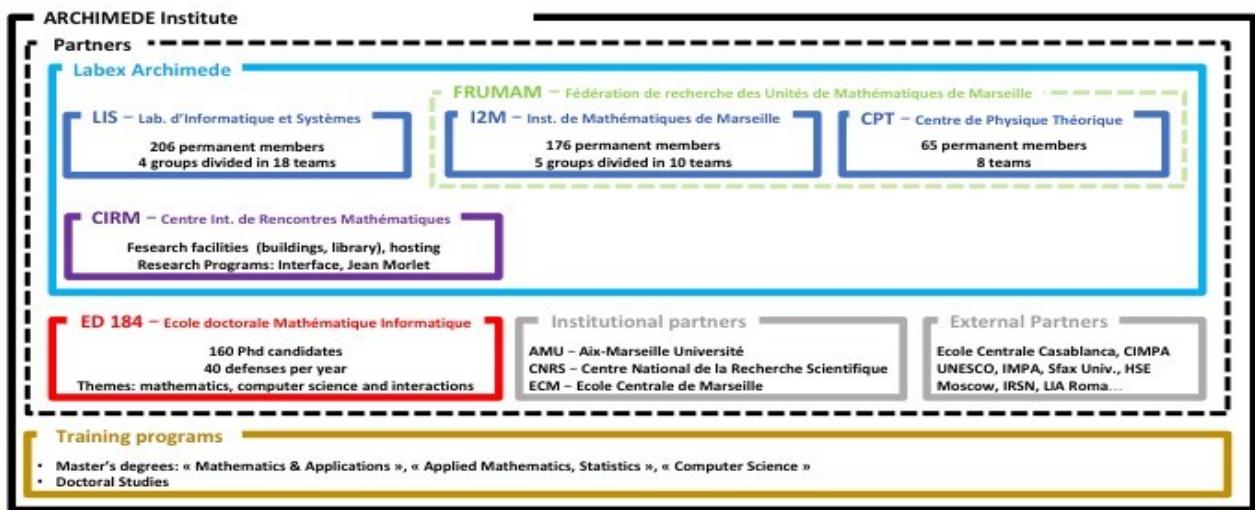

Figure 1: Architecture of the ARCHIMEDE project.

Graduate and Doctoral training. Every year, there is a significant number of graduate students from our training programs that are willing to engage into a PhD program in Marseille. Part of these students may have benefited from a financial support from the LabEx Archimède for their Master's degree. This is one of the very positive insights regarding the attractiveness of our site for studies in Mathematics and Computer Science. We hope the ARCHIMÈDE Institute will help us amplify this success.

All PhD students working in the field of mathematics or computer science are registered at the ED184 doctoral school. As such, they follow a set of common syllabus and are gathered together to conduct projects such as popularization initiatives (π-day, Treize Minutes Marseille Jeunes, see below). We hope for the ARCHIMÈDE Institute to enhance the doctoral program with new actions and to have it be accompanied by a Master program (see Figure **1).**

Awards and distinctions. The international recognition of I2M, LIS and CPT is evidenced by, among other things, the numerous prizes and distinctions awarded to its members, invitations as a keynote

speaker, the organization of international and national congresses. Some awards and distinctions attributed to the members of the ARCHIMÈDE Institute project:

- The CNRS innovative medal 2017.
- The d'Alembert prize 2016 of the SMF to the π-day association, coordinated by PhD students of the I2M.
- The Sofia Kovalevskaya prize 2015 of the Russian Science Academy.
- The d'Alembert prize 2014 of the SMF to the Maths pour Tous (Maths for all) association, supervised by a researcher of the I2M.
- The Gay-Lussac Humboldt prize 2013 of the Académie des Sciences.
- The Grand Prix Jaffé 2012 of the Académie des Sciences.
- The Paul Langevin prize of the Société Française de Physique 2009
- There have been 4 senior IUF and 5 junior IUF member nomination over the 2011–2017 period.
- Two members of the I2M have been laureate of an ERC Starting Grants during the same period.
- 4 members of the I2M have been laureate of a projet d'excellence A*MIDEX.
- A member of I2M is one of the "Highly Cited Researchers" (Thomson Reuters) in 2014.

Organization of international and national congresses. Proximity with the CIRM greatly encourages the organization of scientific activities (Morlet chairs, thematic months, international conferences) and members of I2M know how to take advantage of this opportunity. Over the last few years, they participated in the organization of more than 70 international conferences at CIRM, including 5 thematic months and benefited from 7 Morlet chairs (see below, for a description of Morlet chairs). Other conferences with large audiences have also been organized by members of the ARCHIMÈDE project. Examples of organized events:

- In 2014, the colloquium of the GDRI (Euro-Maghrebin of mathematics and their interactions) was held, which is an associated international research group of CNRS, which gathers together more than thirty-five research units from the Maghreb and France. This is in line with our aim at strengthening our connections with Mediterranean Countries and Africa;
- In 2016, LIS and I2M co-organized CSL 2016, the 25th EACSL Annual Conference on Computer Science Logic. It was partially funded by the LabEx Archimède and pertains to the research counterpart of the shared master degree IMD that will be a significant training action of ARCHIMÈDE.
- Also, in 2016 and 2017, there had been workshops on Quantum Computing, a research theme of interest for members of LIS, CPT and I2M; this may be one ambitious direction of research that we hope will benefit from the favorable framework offered by the institute by, for instance, offering a graduate course dedicated on the topic.

National and international collaborations. All teams of the project are involved in numerous national and international projects. Over 2011-2016, we have identified over 150 funded projects, involving most of the members of ARCHIMÈDE. The list of these projects would probably be of no use but, together with the other actions mentioned before, it reflects the extreme vitality of ARCHIMÈDE's national and international cooperation and its influence. To these cooperations under calls for

tenders or formalized agreements are added many bilateral scientific collaborations (with a list of countries that is very wide: from Europe through Mediterranean countries and Africa to Americas, and Asia).

The LabEx Archimède and its structuring effects. The LabEx Archimède, which gathers CPT, I2M, LIS and CIRM on research actions mainly dedicated to the graduate level and beyond is a fundamental achievement on its own. Funded in 2011, it has had a crucial effect on structuring all research activities pertaining to mathematics and/or computer science. The main actions of the LabEx Archimède have revolved around funding for international mobility (incoming essentially) and for the welcoming of doctoral and postdoctoral researchers. It is the purpose of the ARCHIMÈDE Institute to intensify the beneficial effects of the LabEx to add more pronounced actions towards graduate students, the socioeconomic world, and incoming and outgoing mobility. The LabEx Archimède will end In December 2019 and one goal of the Institute is to create a smooth continuation and amplification of the LabEx.

3 DESCRIPTION OF THE PROJECT

3.1 PROGRAM OUTLINES, VISION, AMBITION, EDUCATIONAL STRATEGY

Challenge. The need for people with expertise in Mathematics and Computer Science is an evidence in our every day life. Todays upcoming of new technologies (e.g. web, mobile devices) and their widespread use requires relevant models/algorithms from mathematics and computer science to be developed. Cybersecurity or data science are examples of new fields that have emerged with the aforementioned popularization of technology. The design of appropriate tools to answer the numerous questions posed in both fields requires the expertise of researchers from mathematics and computer science that are capable of producing appropriate new results possibly at the frontier between mathematics *and* computer science.

Objective The main objective of the ARCHIMÈDE Institute is to train those of the future experts in mathematics and computer science that wish to engage into research careers, either in academics, or in other public or private socio-economic sectors. The main actors or the ARCHIMÈDE Institute are therefore naturally the students and their teachers.

Opportunity Marseille is certainly one of the most natural places in France to build such an Institute in mathematics and informatics. Indeed, to reach its objectives, the Institute will leverage on two major specific advantages:

- the favorable scientific ecosystem in Marseille that has favored the gathering of mathematicians and computer scientists for more than two decades,
- the presence of the CIRM (Centre International de Rencontres Mathématiques) which hosts more than 3500 mathematicians each year in Marseille; the CIRM is indeed a perfect structure to organize events dedicated to the students and the researchers of the ARCHIMÈDE Institute.

The ARCHIMÈDE Institute model. The model of ARCHIMÈDE is to take advantage of all the training facilities (e.g., the syllabus, and CIRM), the research units involved in the project together with the strength of their collaborations. To implement actions towards incoming/outgoing (national and international) mobility and towards transfer from/to socioeconomic partners. More generally, ARCHIMÈDE is to institutionalize actions (e.g. fundings, partnership agreements, transfer) models/algorithms from mathematics and computer science to be developed. Cybersecurity or data science are examples of new fields that have to be further developed with respect to the aforementioned popularization of technology. The design of appropriate tools to answer the numerous questions raised in both fields requires the expertise of researchers from mathematics and computer science that are capable of producing appropriate new results possibly at the frontier between mathematics *and* computer science.

Structuring effects and impacts. For over two decades, there have been fruitful collaborations between mathematicians and computer scientists in Marseille. These connections have hinged upon common research topics, shared undergraduate programs, PhD candidate co-advisorships, and joint participation to funded projects (e.g. ANR projects). From a structural standpoint, mathematicians and computer scientists have been working in the same (or close-by) buildings in the various campuses of Marseille. It has to be noted that a large part of the mathematical community in Marseille will move from Château-Gombert to the historical campus of Saint Charles in 2021. This move will amplify the collaborations between all the members of the Institute and simplify greatly all the teaching and research activities.

The doctoral students all belong to the same doctoral School (ED 184). Mathematicians and computer scientists are both the primary beneficiaries of the internationally renowned CIRM. The tight bonds between mathematics and computer science amounted to the creation, in 2011, of the LabEx Archimède aimed at structuring the collaborations just mentioned. The project ARCHIMÈDE will strengthen the variety of research opportunities offered by Archimède and will improve the quality and visibility of the master and doctoral studies. In particular, building upon the success of LabEx Archimède and continuing it's actions, the ARCHIMÈDE Institute aspires to :

1. enhance the connections between teaching and research with a focus at Masters level programs and beyond,

2. significantly increase the number of high profile foreign students in the Masters and research units of ARCHIMÈDE and provide facilities that would be on a par with the high-level, international ranking and therefore, attractiveness, of mathematics and computer science in Marseille;

3. tighten the relations between academics and companies.

The ARCHIMÈDE Institute has been set up so that each action be coherent with the others and add a benefit to the whole training program, be it in terms of excellence, international mobility or professional integration. A by-product of ARCHIMÈDE will be the increase of research collaborations and the overall visibility, international influence of the research in mathematics and computer science

produced in Marseille. From a broader perspective, ARCHIMÈDE Institute, by offering a clear institutional platform for the departments of mathematics, computer science and the research units I2M, LIS, CPT, the ED 184 Doctoral School, CIRM and ECM (École Centrale de Marseille) and with the joint support of the A*MIDEX initiative of Aix-Marseille University and CNRS, is bound to be a pivotal piece for structuring all the activities pertaining to mathematics and computer science in Marseille.
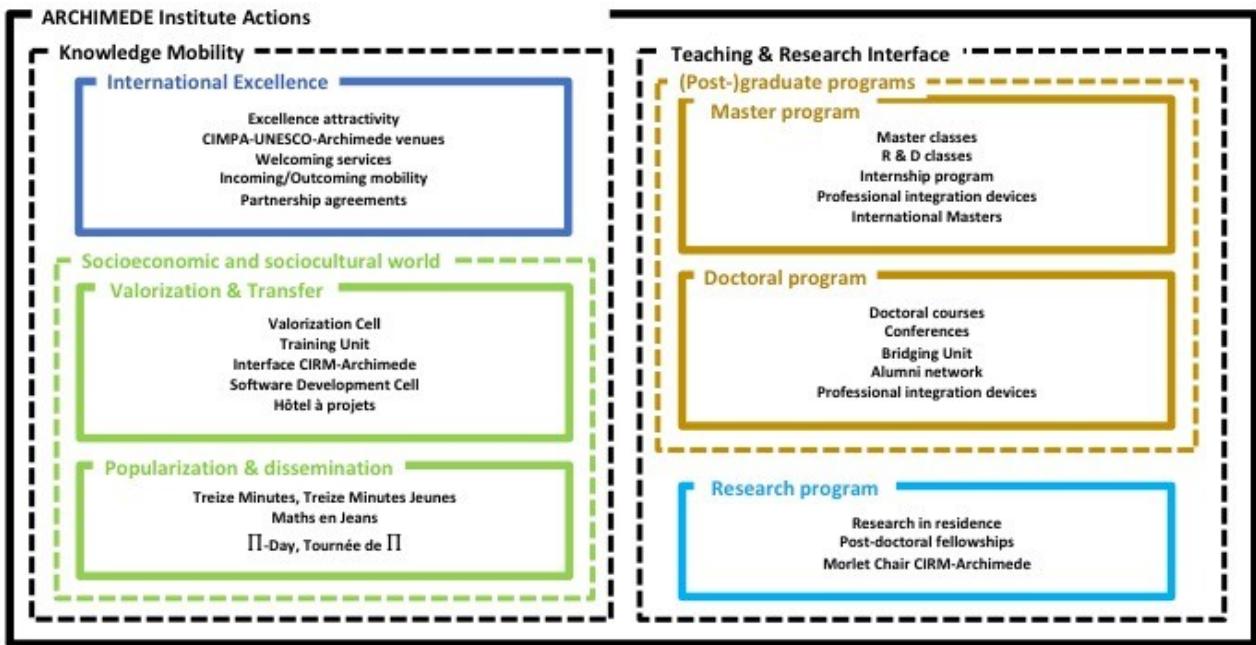

Figure 2: Programs and actions of the ARCHIMÈDE Institute. The blue and purple squares put by the side of an action indicate that it is already part of the Archimède LabEx (blue square) operational plan or the CIRM operational plan (purple square). The ARCHIMÈDE Institute will provide these actions with even larger audience and visibility. Some of these actions are already implemented.

3.2 SCIENTIFIC SCOPES AND CONTENTS OF THE PROJECT

The main objective of the ARCHIMÈDE Institute is to train those of the future experts in mathematics and computer science that wish to engage into research or research and development careers, either in academics, or in other public or private socio-economic sectors. It will also foster relations between Computer Science and Mathematics.

I2M is the only research unit in mathematics in Marseille; it comprises some 300 members, including 170 permanent researchers. LIS has approximately 330 members, including 180 permanent researchers. CPT has 85 members, including 50 permanent researchers; 58% of the permanent staff (4 out of the 8 CPT research teams) will contribute to the ARCHIMÈDE Institute project.

The ARCHIMÈDE Institute will amplify the achievement of the LabEx Archimède between Mathematics and Computer Science. AMU harbors the IDEX Project A*MIDEX and two of the five

national Convergence Institutes: ILCB (Institute for Language, Communication and Brain) and CenTuri (Centre Turing des systèmes du vivant).

The four major scientific themes developed in I2M, LIS and CPT are given below (together with the full-time equivalents for permanent positions):

- Analysis, Modeling, Optimization.
- Statistics, Signal theory, Machine learning, automatic.
- Dynamical systems, Geometries, Probabilities.
- Algorithms, Logic, Number Theory (65 full-time equivalents).

The first theme has 83 full-time equivalents, with a scientific production on year average of more than 90 publications in international journals. The second theme has 103 full-time equivalents, with a scientific production on year average of more than 180 international publications including 85 journals. The third theme has 95 full-time equivalents, with a scientific production on year average of about 75 publications in international journals. The fourth theme has 65 full-time equivalents, with a scientific production on year average of more 95 international publications including about 70 journals.

These constitute the strengths of the learning curriculum that is depicted thereafter and will be the backbone of the various programs supported by ARCHIMÈDE. Even if they might be considered from a purely fundamental perspective, these areas of research may have a huge impact on the following application fields:

- Biology, Health;
- Security, Communication, Data Science;
- Energy, Transportation, Safety.

These application fields and the recognized ability of the members of the Archimède Institute to provide significant advances therein may help define priority programs of development. These priority programs of development will be the opportunity for the Archimède Institute to focus on a particular topic, on a limited period of time within the major scientific themes of the institute, through specific calls. The

Data Science, Artificial Intelligence, Machine Learning. These entangled fields will be put forward for the first period of the Archimède Institute. There have been shared master's degree syllabus on machine learning, statistics, data analysis and, starting September 2018, a newly revamped syllabus is in force, that further focuses on the recent advances of AI/Machine learning, and aims at having courses dedicated for engineers from companies. This goes with the tentative creation of a Clarke-Turing Chair project at CIRM, centered on artificial intelligence/data science/machine learning and security. These projects will extend the renowned research activity in the relevant fields at I2M, LIS and CPT.

Security. We consider also to put an emphasis on (cyber-) security for similar reasons: there are joint master's programs on the foundations and the practice of the field. The mathematical and computer science research expertise in that field is undeniable (in particular, there are teams dedicated to cryptography and software verification in the research units). A master program has recently received the SecNumEdu quality label of Agence Nationale de la Sécurité des Systèmes d'Information (ANSSI). There is a clear potential to strengthen this area in high demand. It will up to the external Advisory Board to help decide, every two years, the themes that will be put forward by the Archimède Institute.

The full time equivalents for the previous priority themes are 70 and 37 respectively.

Growing Master's and PhD students. Over 10 years, the ARCHIMÈDE Institute aims to double the number of Master students in Mathematics and Computer Science, and to increase up to 25% the number of defended PhD thesis, according to our capabilities. The Ecole Centrale Marseille aims that 25% of its students obtain a PhD, against 15% now.

3.3 THE ARCHIMEDE INSTITUTE AND OTHER DISCIPLINES.

Mathematics and Computer Sciences have always developed collaborations with other fields, from the research to the applications level. The Institute will foster such interdisciplinary collaborations, and in particular aim to organize some of the collaborations of strategic importance to AMU's scientific community.

In this direction, it is worth mentioning more explicitly the area of scientific data. Data are of the uttermost importance as is realized in many businesses and in many fields. The same appears to be true for the vast amount of data that are produced by scientific experiments, by medical protocols, by research in many other fields like humanities. Moreover, one of the richness of AMU is the diversity and the quality of the fields that are present in the University. Mathematics and Computer Sciences are at the heart of this new evolution.

The Institute aims to be the "first stop" for data research at AMU. With the experienced researchers in these fields both present at I2M, LIS and CPT, and with the numerous master's programs devoted to data, the Archimède community can play an invaluable role in developing this area. The institute will take special care to address or help the needs in data processing from researchers within AMU. It will have a dedicated deputy director for "transfer" with special attention for the laboratories of AMU. This deputy director will help categorize the needs emerging (IT aspects, data analysis, data science, research collaborations or specific benefits) and direct our colleagues to the right stop, which can be a specific master's program, a pool of teams within the Institute, the technological platform, etc. A particular focus will be put on organizing meetings between our master's students and AMU's units so that they can also envision a career in a scientific environment (from IT to research).

Archimède Institute perimeter does not include a data storage facility, although we think AMU would benefit from a transverse structure that could be associated to the Mésocentre to computationally handle data (storage, databases, etc.). This structure should mostly have engineers, without a research component, with facilities to interact with the transfer director of the Archimède Institute.

Other projects in the area of data at AMU we are aware of are the AMSE Big Data project, the 3IA project. We will collaborate with any such structure at the following levels when appropriate:

1. Archimède researchers in Data Science will take part in Scientific Committees
2. Technical courses will be organized toward scientsts in other fields either through the technological platform, teaching programs, Hôtel à projets or research programs;
3. Joint research programs
4. Joint supervision of PhD candidates
5. Joint master theses.

3.4 DESCRIPTION OF THE LEARNING CURRICULUM

Until 2018, AMU offered one master in Mathematics and one master in Computer Science. The master of mathematics mainly relies on the research expertise of I2M which has a strong international visibility, while the master of Computer Science relies on the research expertise of LIS. Some specialties also use expertise from other laboratories and specialized lectures are given by people coming from industry. Research-oriented specialization are opened to students of ECM who get a double degree: an MSc. degree from AMU and the engineering degree from ECM. Masters curriculum changed in September 2018, the new curriculum are described in the next section.

3.4.1 The Previous Learning Curriculum (until September 2018)

Master in Mathematics : data

Number of students in the master in Mathematics.
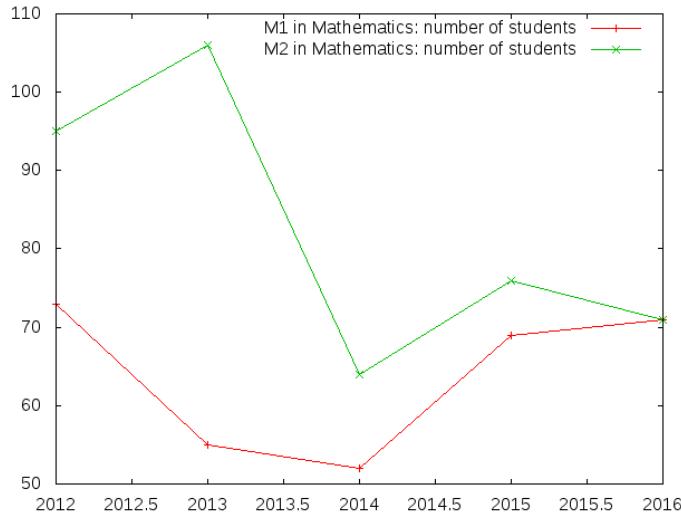
The drop in the number of students in year 2014 partly comes from the fact that students willing to be a teacher in mathematics at school follow a different curriculum organized by the ESPE (a faculty of AMU whose goal is the formation of school teachers).

Number of students in the master of Mathematics according to specialization.
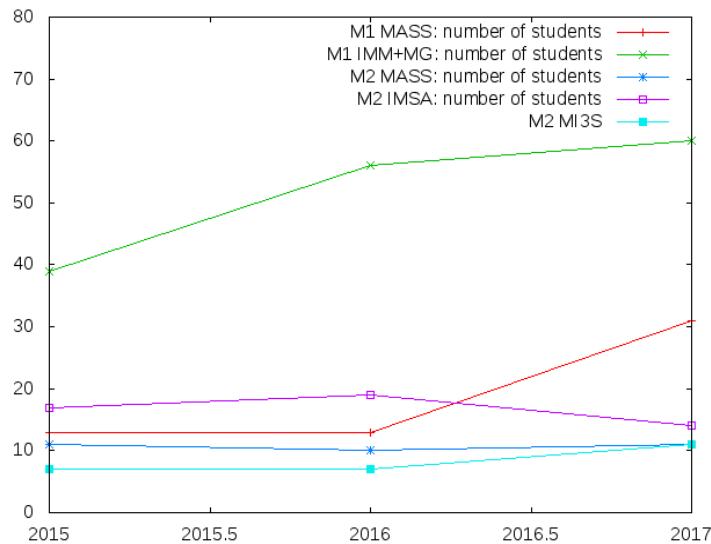
In 2016-17, 37% of M1 students came from foreign countries and 63% of M1 students came from France (mainly from AMU). According to the study performed by OVE, the local department investigating the professional insertion, 85% of graduates have obtained a position in companies or follow doctoral studies within 3 months.

Graduate students may continue in a PhD program in the doctoral school ED 184 (especially graduates from MG, MDFI, PS, EDPCS) or apply for a position in companies (mainly MI3S, IMSA, EDPCS, MASS).

Master in Computer Science The master in Computer Science was organized in the following specializations.

- Informatique Fondamentale (IF) / Sciences de l'Information et Systèmes (SIS). These are oriented towards research in Computer Sciences (IF) and Control and Automation (SIS).
- Fiabilité Sécurité Informatique et Logicielle (FSIL). This is oriented towards conception of applications, software quality and security issues.
- Génie Logiciel (GL). This is oriented towards Software Engineering.
- Sytème d'Information Répartis (SIR). This is oriented towards Distributed Data Bases.
- Informatique Décisionnelle (ID). This is oriented towards Business Intelligence and Operational Research.

In 2016-17, 48% of first-year (M1) students are foreign students and 52% of M1 students come from France (mainly AMU).

Number of students in the master in Computer Science.

Number of students in the master in Computer Science according to specializations.
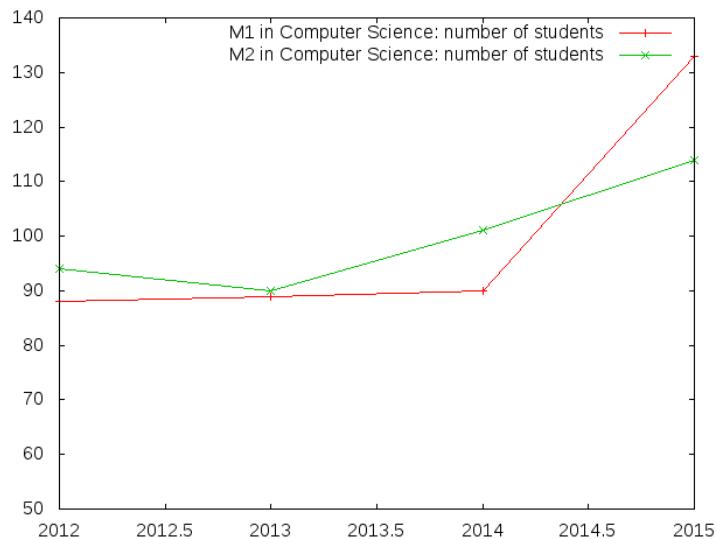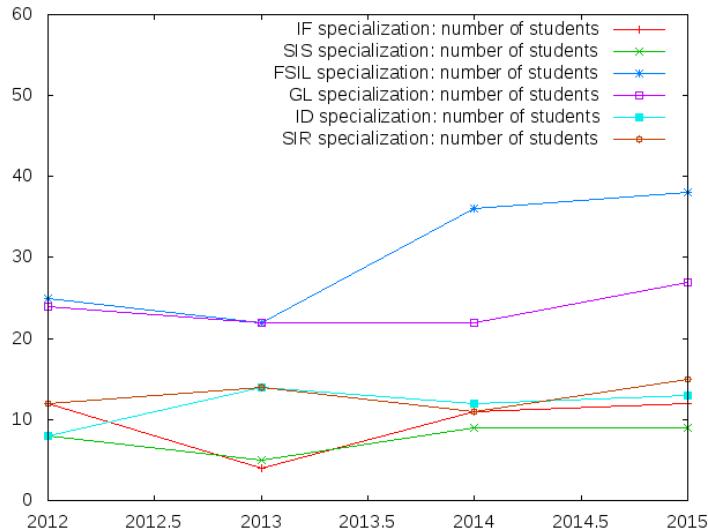
Many graduates obtain a job immediately after graduation (more than 50%) and 84% have found a position 12 months after graduation (according to the local study realized by OVE over the last three years).

Relations with Companies Both masters have strong connections with large companies (AXA, Airbus, Bull, Cap-Gemini, DCNS...) or research centers (CEA, IRD...). These connections are set up via the mandatory internship at semester 4 and more formal agreements have been signed between AMU and some companies (Bull, Cap-Gemini). For instance, AXA offers scholarship for students of the IMSA specialization (3 to 5 students a year) and engineers from Bull have given conferences to second-year students of the Computer Science master.

Attractivity and International Cooperation Students of ECM can enroll in the 2nd year of research specialization of the master of Mathematics or of the master of Computer Science and obtain the corresponding master. After graduation, several of these students have engaged in a PhD program in AMU. The Archimède Labex offers scholarships for second-year foreign students since 2012 (6 scholarships a year in average). These grants have attracted students from China, Vietnam, Lebanon, Senegal... I2M has an official collaboration with Roma 3 university (Italy) and Italian students have regularly attended the Master in discrete mathematics and computer science specialization for many years. Erasmus cooperations are very active and we regularly have students from European countries attending one or two semesters in our masters. The applied Master in social sciences specialization has agreement with the Department of Demographics of Montreal university (Canada) and Université catholique de Louvain (Belgium) which has led students to do their internship (Semester 4) abroad.

Doctoral Studies The average number of doctoral students in ED 184 is 150 with half of them coming from foreign countries and the other half from France. Around 25 to 30 PhD thesis are under the so-called co-tutelle status (each student has two advisors, one from AMU, the other from his university abroad).

	2013-	2014-	2015-	2016-	2017-	2018-
PhD defense	33	40	39	33	47	30

The number of grants given by ED184 is 8 in average, the Labex Archimède has given up to 3 grants (down to 1 in 2017 due to budget constraints), and other grants come from CIFRE contracts or grants given by ANR projects.

3.4.2 The Learning Curriculum (since September 2018)

The new learning curriculum of Aix-Marseille started in September 2018. It is planned to last for the next five years.

Bachelor curriculum The students enrolling in one of ARCHIMÈDE's programs are expected to hold a classical BSc degree in Mathematics or Computer Science of AMU or a similar degree from France or abroad. Furthermore, we expect some students to come from the "Licence MPCI" (MPCI stands for Mathématiques, Physique, Chimie, Informatique) and Licence "Sciences et humanités" programs: these two three-year undergraduate programs have been labeled "Académie d'excellence" by A*MIDEX; they enroll high-profile students selected after the baccalaureat. Several members of ARCHIMÈDE are very active faculty staff of these degrees. A new degree (parcours Mathématiques-Informatique in the Licence d'Informatique) designed for students interested both in Mathematics and Computer Science opened also in 2018 at the BSc level.

CMB syllabus The Computational and Mathematical Biology (CMB) syllabus is an international specialization of the masters in Mathematics and Computer Science. All lectures are given in English. The CMB specialization attracts bachelors in Mathematics, Computer Science or Biology. It is supported by the Centuri Convergence Institute which gathers mathematicians, computer scientists and biologists on problems of modeling complex systems and image processing.

Masters in Mathematics There are two masters in Mathematics named according to the official national denominations *Mathématiques et Applications (MA)* and *Mathématiques Appliquées, Statistique (MAS)*. The MAS acknowledges the recent important growth of the applications of statistics in many aspects of society and the need for a specific training of experts in statistics in relation with applications. The master MA addresses a wide spectrum of mathematics, both from their theoretical and applied aspects, and their multiple applications in other sciences and in technological fields. These masters correspond to two different ways of learning and using mathematics: the master MA attracts students more interested in foundations and theory, while the master MAS is chosen by those who prefer to study the applications, the tools required in these applications and are interested by the field of statistics. The master *Mathématiques et Applications (MA)* is organized as follows:

- Mathématiques Fondamentale. This specialization is focused on theoretical domains of mathematics;

- Mathématiques Appliquées CEPS. This specialization is focused on the theory of applied mathematics mainly probability theory, partial derivative equation and scientific computation;
- Informatique et Mathématiques Discrètes, shared with the master of computer science (see below) ;
- Two syllabus for Mathematics and Teaching;
- CMB specialization.

The master *Mathématiques Appliquées et Statistique (MAS)* is organized as follows:

- Mathématiques Appliquées et Sciences Sociales (MASS). This specialization is focused on the application of mathematics in social sciences;
- Ingénierie Mathématiques et Sciences Actuarielles (IMSA). This specialization is focused on mathematics of risk management, with applications in insurance and finance;
- Data Sciences (DS), shared with the master of computer science (see I3A below);
- CMB specialization.

Master in Computer Science The master of Computer Science is organized as follows:

- Fiabilité et Sécurité Informatique (FSI). This specialization is focused on security and software quality issues. It has the *SecNumEdu* label from Agence Nationale de la Sécurité des Systèmes d'Information.
- Géométrie et Informatique Graphique (GIG). This specialization is focused on Computer Graphics and Geometry.
- Ingénierie du Logiciel et des Données (ILD). This specialization is focused on software engineering and data organization (data bases, data mining...)
- Informatique et Mathématiques Discrètes (IMD). This specialization is focused on mastering mathematical tools required for modeling and solving problems in Computer Science.
- Intelligence Artificielle et Apprentissage Automatique (I3A). This specialization is focused on Artificial Intelligence and Machine Learning.
- CMB specialization.

The IMD and I3A specializations are shared with the master MAS and more details are found in the next section. Each specialization relies on the skills of research teams from LIS or I2M.

Common Learning Curriculum in Mathematics and Computer Science The links between mathematics and computer science in Marseille have led to two common specializations for students from either Mathematics or Computer Science.

- Informatique et Mathématiques Discrète syllabus (IMD). The relation between Computer Science and Mathematics is especially strong in area like logic and its applications (semantics of programming language, modeling and verification) and discrete structures (graphs, algebraic structures) and algorithms. IMD offers a specialization in these topics to students who have obtained a first-year Msc Degree in either Mathematics or Computer Science.

Data Science syllabus (master of Mathematics) and I3A syllabus (master of Computer Science). These two curricula are not identical but share many teaching units. They are specialized into the use of statistics and machine learning for analyzing complex systems described by observational data.

Computational and mathematical biology (CMB) specializations in Mathematics and Computer Science share many teaching units but focus on different angle to investigate complex biological systems.

Interaction between Mathematics and Physics Links with the Master of Physics are provided by means of a few courses on the use of mathematics in modeling physics (mathematical description of physical laws, in particular those for fundamental interactions), the use of combinatorics in computer science for dynamical systems (chaos and non linearity) that are attended by graduate students in Mathematics or in Computer Science. In particular, mathematical physics, as developed in AMU, can lead to a double Master graduation and we expect fruitful collaborations at the PhD level, particularly through the CenTuri Convergence Institute around the interdisciplinary topic of complexity in biology. Some mathematicians at CPT are within ED184. In the framework of ARCHIMÈDE, CPT volunteers to propose seminars, internships or PhD proposals in mathematical physics or neighboring areas connected with fundamental mathematics.

Interactions with companies We plan to strengthen the links between companies and ARCHIMÈDE by cooperation agreements. Internships offered by companies are a way to establish or strengthen interactions. ARCHIMÈDE gives an opportunity to reinforce these interactions with scholarship and PhD subsidized by companies as it is already the case with AXA company. Many PhD have been supported using CIFRE contracts, some of them given by small companies or startups in hot topics like Machine learning. For instance, 3 PhD students from LIS are now employed by the EURANOVA company which plans to set up a local antenna in Marseille. ARCHIMÈDE is an opportunity for obtaining more formal agreements between companies and AMU like what has been done with Bull and Cap-Gemini. ECM has a long tradition of interactions with companies and ARCHIMÈDE will benefit from this experience for internships propositions or CIFRE PhD subsidized by companies. ARCHIMÈDE is also expected to spin off start-ups that will employ master or PhD students, like the LED's CHAT company which started from a 1st-year master project or the LINXO company (one of the co-founder is a former student of AMU in mathematics and computer science).

Doctoral studies ED184, the Doctoral School of Mathematics and Computer Science of AMU ensures doctoral studies in mathematics, computer science and automation for AMU and ECM PhD candidates. The doctoral supervision is provided by researchers and lecturers from I2M, CPT and LIS. Out of almost 150 researchers and research professors who hold the habilitation (HDR), 146 have supervised a thesis in the last five years. In this high-quality scientific environment, ED184 hosted 156 PhD students in 2015-2016, almost all of which were funded. The number of students is stable over the period 2010-2016, as they range from 154 to 158 doctoral students. Approximately 70 % of them have obtained their master's degree outside the Marseille perimeter, a quarter of them abroad. More than twenty nationalities are represented. Each year, some 40 theses are defended, for example 38

during the calendar year 2015. A PhD student takes on average between 3 to 4 years to his/her defense. Drop-outs represent 6 % of a year class over the period 2010-2016.

Apart from the research work, the doctoral training of a PhD student is 100 hours equally divided between scientific training and transversal and professional training. The training offered by ED184 and the doctoral college ranges from master's courses, advanced courses to participation in the dissemination of scientific culture, seminars for doctoral students, training courses… At present there is a need for students to develop training in English as well as courses in English. This need should be fulfilled by the ARCHIMÈDE.

A mandatory check-up is organized every year of the PhD thesis in front of a committee gathering researchers and representatives of PhD students. This permits to verify that the PhD goes smoothly and will result in a PhD within the three-year schedule.

3.5 ARCHIMÈDE SPECIFIC TRAINING PROGRAM

The actions implemented to reach the goals of ARCHIMÈDE range from pure training programs at the (post)graduate level to transfer and exchange actions: more specifically, scientific knowledge should be transferred from academy to the socioeconomic world (and back), and exchanges should be developed between our university and other universities. These actions are structured along six programs, depicted in Figure 2:

- International Excellence Program;
- Master Program;
- Doctoral Program;
- Research Program;
- Valorization and transfer;
- Popularization and dissemination.

The three first programs are explained hereafter, and the three last ones are described in the following section (Research-Learning interface). As shown in the previous sections, the masters and PhD curriculum are designed to fully integrate these actions.

3.5.1 International Excellence Program

The high level of Mathematics and Computer science developed at I2M, LIS and CPT, and the excellence of the Master and PhD training makes AMU a worldwide attractive place to study Mathematics and Computer Science. One of the main objectives of ARCHIMÈDE is to organize the incoming mobility of the best students at international level.

3.5.1.1 Excellence Attractivity

To attract high profile foreign students, we aim to create scholarships for each level of the Master program and PhD scholarships.

At the Master level, the scholarships will be granted by an ad-hoc committee upon evaluation of the applications and oral interview (or video conference for foreign students). A pool of excellent candidates exists: the number of applications received by the LabEx Archimède for graduate, doctoral and post-doctoral fellowships was roughly multiplied by 4 in 4 years, and reached 50 per year for each level, more than one third were excellent students. At present only 7 masters scholarships are granted. With sufficient resources, the Institute could attract more than 20 students.

The majority of the students benefiting from the LabEx Archimède scholarships have been later enrolled in a PhD program either in AMU/ECM or elsewhere, and this is expected to last with the ARCHIMEDE Institute. Of course, the scholarships given by ARCHIMÈDE will be also a strong incentive for excellent students to apply to our Master. If our project is accepted, these scholarships will be supplemented by 4 scholarships from Sfax University (Tunisia) for Sfax students to follow the master course in ARCHIMÈDE, for a total amount of 16 000€ per year. An agreement with ENS Lyon to enroll in our master bright students who have presented the difficult competition to enter this school and at the limit of being admitted. The visibility of ARCHIMÈDE will increase the number of students on the research track at ECM following both a master of ARCHIMÈDE and the engineering cursus of Centrale Marseille.

The Master lectures supported by ARCHIMÈDE will be given in English.

At the PhD level, ARCHIMÈDE will supplement the grants given by ED184, which are very few compared to our supervising capabilities. The ARCHIMÈDE label is expected to attract companies willing to offer CIFRE contracts for PhD. Candidates for grants are selected according to their academic records, the relevance of the subject and the skills of the advisor, after an interview with a selection committee.

ARCHIMÈDE is also an excellence label that will attract students from Ecoles Normales Supérieures (ENS Lyon, Ulm, Paris-Saclay) to pursue their PhD in I2M, LIS, or CPT with the specific grants that they hold; both I2M and LIF have already hosted such students (6 in 2015-2016).

Existing international research cooperations help building connections at the teaching level. For instance: the group supporting the GIG specialization in the Computer Science Master has many collaborations with Cornell Tech, ETS Montreal and University of Montreal and plan to organize exchange of master students (both incoming and leaving); researchers from I2M give lectures in masters in mathematics in Senegal, Ghana, Ivory Coast and attract the best students in Marseille for a Master 2 or a PhD.

ARCHIMÈDE will also support the research internships for non-scholarship 2nd-year master students, thereby attracting more students in the master program itself, or in the research semester. If funded, these students are likely to start a PhD in a unit of ARCHIMÈDE.

3.5.1.2 CIMPA-UNESCO-ARCHIMÈDE venues, Master 2 in west Africa

Each year, CIMPA co-organizes and sponsors Research Schools in developing countries. We will create one common ARCHIMÈDE - CIMPA research Schools per year; an expected by-product is to bring to the ARCHIMÈDE Institute the best Master or PhD students from developing countries.

In the same direction an international Master program has been runned for three years in the area of Probability, partly funded by CIMPA.

The ARCHIMEDE Institute will expand this program to other fields of Mathematics and Computer Science.

The initial observation is that quite a few French speaking countries of sub-saharan Africa (in particular Benin, Ivory Coast, Burkina Fasso, Mali, Senegal, Togo) have good or very good programs up to the Master 1 level and then they have difficulties to maintain a good program at the M2 and PhD levels. Each of those Universities does not have researchers covering a large enough range of advanced topics. The project is to establish a few Master 2 programs, each covering a specific field and gathering students from different countries in one campus for a six months period. The idea is to select very good students in each of these countries with an entry exam. The selected students obtain a "local grant" that covers local travels and expenses allowing them to spend six months in one selected university. In case of the already functioning program, it is the University Félix Houphouet Boigny in Abidjan (Ivory Coast). During the first three months, local professors gives preparatory courses and then professors from outside (either French or from other African universities) complete the program with more advanced courses.

The students then prepare their Master thesis in a laboratory, most of the time in France. For the last 3 years the output of the already existing international Master program has been quite impressive. Each year there was 5 to 8 students following the program and, at this point, about 10 of them are in a PhD program, three of them in Marseille.

3.5.1.3 Welcoming Services

ARCHIMÈDE Institute will offer accompanying services for foreign students (e.g. immigration paperwork, lodging, French classes via the FLE – Français Langue Etrangère – program, English classes). This action should be implemented in coordination with other internationally-oriented programs of AMU and with the Doctoral College.

3.5.1.4 Incoming/outgoing mobility

The ARCHIMÈDE Institute will:

- enhance the outgoing international mobility of students by offering Master and PhD students from Marseille the possibility to participate in international summer schools or conferences,
- provide financial support for PhD students and post-doc for research stays in other countries and/or laboratories,

- support the short term incoming mobility of international Master students through its Master classes program at CIRM.

3.5.1.5 Partnerships agreements

ARCHIMÈDE will institutionalize the existing cooperations that have brought excellent students in, and it will initiate new ones. We intend to prioritize our effort to initiate new collaborations with Mediterranean countries and Africa and to reinforce the existing well-established programs with Africa (Dakar University in Senegal, Ecole Centrale Casablanca in Morocco). Among other existing cooperations, one may quote the following countries: Brazil, China, Tunisia, Chili, Colombia, Morocco, Vietnam, Mexico, several countries from Eastern Europe. Several Institutions have already signed up an intention letter with ARCHIMÈDE to establish partnerships, such as IMPA (Rio, Brasil) and HSE Faculty of Mathematics (Moscow). As a by-product, new research and teaching collaborations will naturally emerge from these intensified cooperations.

3.5.2 Master Program

3.5.2.1 International Master classes at CIRM

Master classes are a pivotal action of ARCHIMÈDE, mixing teaching, research, and internationalization. We have planned two-week long master classes at CIRM and revolving around a teaching team led by a renowned researcher from abroad. The theme taught, in English, is intended to be one theme from the master programs hosted by ARCHIMÈDE and the audience will consist of local master students together with (selected) students from other universities (who will benefit from fundings by ARCHIMÈDE). These Master Classes will count in the assessment of students.

3.5.2.2 R&D Classes

This action is intended to have master students work over an eight-week span on a research and development project submitted by a company. The model is to have the students work in teams of 4 to 6 members over a period that is dedicated to the project in close connection with a project manager from the company and to have them deliver a project (a report, and possibly, a prototype program) at the end of the program. This cooperation model between university and companies exists in many engineering schools but it is not necessarily centered on research and development, which is the peculiarity of our proposal; yet, we plan to borrow the economic model implemented elsewhere and invite the companies involved to finance, through ARCHIMÈDE, the execution of the projects. These "classes" will count in the assessment of students for graduation. Also, they will give a larger place to research in companies and they will facilitate the professional insertion of students as R&D engineers or as jointly funded (ARCHIMÈDE and the company interested) PhD candidates.

3.5.2.3 Internship in Units

Master 2 students (especially in mathematics) will be welcomed to do their first research internship in a laboratory during up to three months. They will receive a stipend by ARCHIMÈDE for that work, according to the law, and to recognize their first contact in research.

3.5.2.4 Professional integration devices

- Participation to professional conferences such as AMIES,
- interdisciplinary courses such as scientific English, bibliography, data bases.
- Participation to scientific culture dissemination by tutorial of students in Maths en Jeans and Hippocampe programs (Dissemination and popularization Program)
- Participation in Interface program or Training units (Valorization & Transfer program).

interdisciplinary courses such as scientific English, bibliography, data bases.

3.5.3 Doctoral Program

3.5.3.1 Doctoral courses

We will organize lectures given by experts of the domain solicited by ARCHIMÈDE for doctoral students based on their needs under proposition of their supervisors. These propositions will be examined and selected by the ad hoc scientific committee of ARCHIMÈDE. All these courses are given in English and will prepare the students to participate to international conferences.

The PhD students will also benefit from the Master classes given at CIRM (see Master program) and will be encourage to attend some conferences during their PhD years.

3.5.3.2 Bridging units

French university students often experience difficulties to find jobs that correspond to their competence and skill level. In scientific domains, this is partly due to the existence of grandes écoles, which train students at a lower level (5 years after baccalauréat), but are more efficient in terms of connection with industry. The Bridging Unit aims at facilitating the employability of young students with a degree in mathematics or computer science (even in very theoretical domains), at various levels: master, doctorate and post-doc. The bridging program will ensure their professional training, develop their expertise and initial training, and strengthen their position with respect to the job market. In addition to the courses provided by master degrees and doctoral schools, the bridging unit will essentially propose technical training (modeling, applied mathematics, computer science), based upon practical projects, under the supervision of researchers and staff members from the development unit. The students will work either on development projects defined by ARCHIMÈDE (funding provided by the institute) or projects proposed (and funded) by external partners. Specific PostDocs positions will be proposed by the program. PhD students interested in closer connection with industry will be assigned specific transfer missions ("mission complémentaire de valorisation" in the French PhD programs) by the bridging unit, under either ARCHIMÈDE or external funding. Master students will also be offered the possibility of internships to complete their degree.

3.5.3.3 Alumni network

An Alumni association will be created to support ARCHIMÈDE 's goals, and to strengthen the ties between alumni, the community, and the Institute.

3.5.3.4 Professional integration devices

They are the same as in the Master Program. In addition, PhD students may also take advantage of the Hotel à projets (Valorization & Transfer program) to carry out R &D consulting missions in companies (mission complémentaire de valorisation).

3.5.4 Research-Learning Interface

We describe here the three last specific actions of ARCHIMÈDE, namely:

- Research Program
- Valorization and transfer
- Popularization and dissemination, which pertain to the research area and which are related with the training programs depicted in the above section.

3.5.4.1 Research Program

Research in residence. This program consists of periods ranging from 2 weeks to 3 months of intensive research in the Marseille area for visiting scholars and members of ARCHIMÈDE on leading subjects. That project has been launched by the LabEx Archimède. Six projects took place or are scheduled to take place soon, with a total number of 140 participants and a cumulative duration of 10 months. Since the projects were successful for the LabEx, the ARCHIMÈDE Institute will encourage people to submit research in residence projects. It will also support activities and meetings at the CIRM organized by its members.

Post-doctoral fellowships. The purpose of the Fellowship is to make funding available to attract young excellent post-doctoral fellows to the University, to enable them to develop their own research skills and simultaneously promote research within ARCHIMÈDE.

3.5.4.2 Transfer & valorization program

This program initiated by the LabEx Archimède has been very successful and the ARCHIMÈDE Institute is expected to boost its realizations and impact for master and PhD students.

Interface CIRM-ARCHIMÈDE. Interface is a new original program created by the CIRM. It is aimed for acquiring and discussing mathematical, computer and numerical tools, and concepts relevant to industry: modeling, simulation and optimization. This is a graduate training hosted by the CIRM, aimed for the continuous training of engineers, managers and professionals. CIRM is mobilizing its network of high-level mathematicians to propose short programs (from 3 to 5 days). The ARCHIMÈDE Institute will fund this for its students, creating for them a great opportunity to meet professionals from companies, and possible future employers.

Valorization Cell. As mentioned earlier, the discoveries made in the field of mathematics and computer science, even if theoretically-oriented, have significant impact on real-world applications. The valorization cell will work on easing the transfer between academic work and these applications; it will coordinate much of the actions from the transfer and valorization program.

Training units. The role of the Training Unit is to develop and transfer to socio-economic partners scientific knowledge from the research units, through high level professional training sessions, in the expertise domains of the ARCHIMÈDE members. Specific sessions will also be organized under request from interested trainees. Training sessions will be proposed to :

- scientists from other fields, and from research units outside ARCHIMÈDE;
- industrial partners in application domains of mathematics and computer sciences (biomedical and pharmaceutical domains, physics, chemistry, aerospace, web, ecology...);
- socio-economic actors for whom mathematics and computer sciences are unavoidable (i.e. various observatories, finance, insurance) and more generally any partner searching for training in mathematics or computer sciences.

The training sessions will take the form of 2 to 5 days sessions, managed by ARCHIMÈDE members. At the end of the session, certificates from the Institute, the Universities and perhaps industrial partners will be delivered to the participants.

Besides, some specific courses from our masters will be adapted and proposed in the framework of the training unit. This will provide another way to favor exchanges between students, academics and companies.

Software Development Cell (from the LabEx Archimède). PhD students or researchers from the ARCHIMÈDE Institute units often develop very sophisticated mathematical or computer models, and algorithms. The goal of the Development Cell is to finalize the development of prototypes originating from research teams along the standards of professional software engineering, shape and test them before dissemination under appropriate license. The "products" of the development unit will be conceived so as to be exploited by the Archimedes members in their own research projects, and in the framework of the actions of the training unit, distributed to other academic institutions and laboratories. This will provide ARCHIMEDE an increased of visibility. Some of these "products" could be valued economically, for example in the framework of collaborations with industrial partners who would take care of the transformation into a commercial product. Such partnerships will be managed in collaboration with the SATT and/or the transfer units of the institutions.

The projects developed within the Development Cell will be selected among projects submitted by the ARCHIMÈDE Institute members, or by industrial partners (which will, in this case, participate in the funding of the project). It is to be noticed that several industrial partnerships exist (Orange Labs, IBM research, Airbus, PSA Peugeot- Citroën and regional SMEs such as SoNear, Novadem and Genesis). The core of the Development Cell will be formed by 3 research engineers hired on permanent positions by the institutions, who will advise young scientists hired on short term missions at the Post-doc, PhD and master level in the framework of the Bridging Unit. Part of this unit should integrate the technological platform leaned to Archimède, in such a way that the specific skills of its engineers can benefit others fields and companies. This cell will be partially integrated in the technological platform whenever development toward external partner are involved.

Technological platform.

It is worth mentioning that the training unit and the software cell will merge into a "technological platform", which is in preparation with the help of A*Midex and should be proposed in 2019. This platform should rely on the ARCHIMEDE Institute, elaborated on the experience of the LabEx Archimède "software development and training units" in relation with socio-economic partners. It is based on the development of scientific techniques and algorithms coming from researchers. It aims at offering services recruiting advanced skills in mathematics and computer science, to outside structures (other laboratories, companies, etc) with internal competences, and experiences from master students to researchers and engineers (current or to be hired). These services are expected to have a broad spectrum from developing quality software components and associate benefits, to professional training, specific consulting, etc.

These services will be payed by the outside structures (training, development, consulting) the tariffs will be defined latter and should allow to attain an economic self-sufficiency of this platform within the duration of the Institute.

Hôtel à Projet

The Hôtel à Projets is intended to provide companies with a hub to direct the R&D projects for which they require expertises that can only be found in ARCHIMÈDE. It will be a joint project conducted within the French MSO (Modeling, Simulation and Optimization) network of the Agency for Interaction in Mathematics with Business and Society (AMIES), a national organization aiming to develop the relations between academic research teams in mathematics and business. It is a founding member of the European network Eu-Maths-In. This project will have a leveraging effect regarding the connections between academics and companies and will provide the site of Marseille with an operational entity that already exists in other cities in France (e.g. Grenoble, Strasbourg, Versailles). Including the project within the scope of ARCHIMÈDE will provide it with all the assets (visibility, expertises in mathematics and computer science and the growing needs of expertises in these fields in companies) to be successful. As a positive by-product, we expect the involvement of more private partners in the funding of PhDs and post-docs.

3.5.4.3 Popularization & dissemination

The LabEx Archimède had bet on the relevance of some events dedicated to promote mathematics and computer science to an audience of laymen. The Institute will pursue the promotion of such initiatives, together with AMU (doctoral college, and the service for scientific culture).

Maths en Jeans. This is an innovative pedagogical project that was introduced and developed in our university in the 90's. The main goal of this project is first to initiate students to the methodology of scientific research by working on open problems of mathematics and then to initiate them to the popularization and dissemination of scientific culture.

Treize Minutes Marseille. The event *Treize Minutes Marseille* was launched in 2013, from the idea of several researchers in mathematics and computer science of the LabEx Archimède. Inspired by the homonym Paris event. It features 6 local researchers on a stage, each talking during 13 minutes on

their research, addressing a wide audience. Each year, at least a mathematician and a computer scientist are scheduled. In 2016, two sessions on the same day registered 570 attendees; the event is live-streamed, with hundreds of internauts.

In 2016, PhD candidates in math, computer sciences and other sciences created "Treize Minutes jeunes chercheurs" to promote and popularize the work of young researchers, with an equally great success.

Π-day. PhD candidates from the LabEx Archimède had initiated in Marseille the international Pi- day. LabEx Archimède was their promoter, but the dynamic PhD team gathered many other helps for organizing wonderful events gathering many types of audience, from 2015 to 2017 (http://www.piday.fr/).

Other events. LabEx Archimède researchers are involved in several large local events for the popularization of math and computer science, for example Nuit des chercheurs (2016, 2017). The LabEx Archimède granted some other smaller events, such as talks regarding the links between stochastic processes and a wide range of societal studies.

The year 2019-2020 will be the year of mathematics at CNRS. Many events will be organized and supported by ARCHIMEDE: workshops at CIRM for highschool students with activities like Maths en Jeans, mathematical forums, mathematical theater in partnership with the theater company «les n+1».

The ARCHIMEDE Institute wishes and encourages the promotion of any action towards the popularization of mathematics and computer science. ARCHIMÈDE is intended to pursue this, with relevant help, welcoming at any time news ideas, by encouraging/supporting the continuation of both existing activities and the creation of new concepts.

4   A*MIDEX GLOBAL STRATEGY (WRITTEN BY A*MIDEX FOR THE EUR PROJECT)

Co-leading institutions of the Institutes led by AMU, research organizations work in tandem in the framework of the monthly A*MIDEX Steering Committee and implement a shared strategy in their joint research units on the Aix-Marseille site. In order to prompt researchers to participate in the Institute's teaching offer, research organizations have agreed to encourage them to teach 64 hours (HETD) of modules a year, and to consider their involvement in the Institute as a significant selection criterion for PEDR bonus. In practice, Institute researchers will be involved in disciplinary teaching, but also in new modules. For instance, to upgrade the teaching offer of all Institutes and better prepare Master and PhD students for their future career in research, AMU intends to create practical modules to train students to submit grants, taking the EU Horizon 2020 program's calls for proposals as examples. Institute researchers are expected to participate in these modules and illustrate them through real case studies. Another aim is to foster the turnover of this pool of "teaching researchers" over time, in accordance with their individual wishes, to spread the culture of teaching among Institute's researchers. In this purpose, AMU and research organizations have agreed to experiment

with mutual provision of academic personnel, time-limited and on specific assignments, within the scope of the Institute.

5   PROJECT ORGANIZATION AND MANAGEMENT

5.1   PROJECT MANAGERS

For the time of the application, we envision a trio of project managers : Emmanuel Godard (as manager), Xavier Roulleau (as co-manager) and Cécile Capponi (as co-manager for valorization).

- Emmanuel Godard
  - Position: full professor at AMU (since 2015).
  - Research themes: distributed computing: distributed computability, topological methods, natural computing.
- Xavier Roulleau
  - Position: full professor at AMU (since 2016).
  - Research themes: Algebraic geometry: K3 surfaces, Surfaces of general type, Hyperbolicity.
- Cécile Capponi
  - Position: associate professor (HDR) (since 2018)
  - Research themes: Machine Learning: multimodal learning and ensemble-based algorithms for learning, Bioinformatics.

5.1.1   Capsule biography of Emmanuel Godard

- **Since 2018** Head of the *Fiabilité et Sécurité Informatique* Master curriculum
- **2016-2018** Head of the 2nd-year *Fiabilité et Sécurité Informatique* Master speciality
- **2015-2018** Head of the 1st-year Bachelor degree in Computer Science, on-line curriculum.
- **Board membership**
  - Member of the Ecole Doctorale 184 Board, since June 2016.
  - Member of the Centuri Institute scientific board, since Sept. 2017.
  - Elected Member of the LIS board since 2018

5.1.2   Capsule biography of Xavier Roulleau

- **2019-2020** Head of the Master II on the theme "Algebraic Geometry and Arithmetic" for year 2019-2020. It includes the organization of a Master class on Cryptography in Avril 2019.
- **February 2019** Co-organizer of the Thematic Month "Complex Geometry" to be hold in the CIRM (Luminy) during. There will be a one week Master Class followed by 4 weeks of conferences.
- **Board membership**
  - Member of the Scientific Council of the I2M

5.1.3 Capsule biography of Cécile Capponi

- **Since 2011** Deputy director for Valorization at Labex Archimède
- **Since 2013** Founding member of "Treize minutes Marseille"
- **Board Membership**
  - Member of Archimède board 2011-2019
  - Member of the Ecole Doctorale 184 Board, since 2018.

5.2 ORGANIZATION OF THE STAKEHOLDER ENTITIES

ARCHIMÈDE is based on the excellence of the research activities in mathematics and computer science developed on the Aix-Marseille site.

The department of Mathematics, the department of Computer Science of AMU and ECM have a longstanding tradition of cooperation at master level. Research-oriented common learning curriculum with ECM exist in mathematics and computer science and between the two departments. Relations with industry and welcoming foreign students (cooperation agreements with Brazil and China, foreign language course…) are strengths of ECM that ARCHIMÈDE will rely upon. ED184 is currently in charge of doctoral studies for Mathematics and Computer Science. ARCHIMÈDE will be the place to strengthen the interactions and actions supported by theses entities for master and PhD students.

5.3 COORDINATION FRAMEWORK

The A*MIDEX steering committee - which statutorily includes AMU's Research and Education Vice-Presidents - will hold yearly reviews of th e Institute achievements and be the Supervision Board of all Institute projects. A dedicated Institute's supervisor will be appointed at the A*MIDEX Foundation, as a point of contact to oversee organizational issues and facilitate steering of the Institute's action plan 2018-2027.

Moreover, to improve coordination, a single governance scheme has been set up by A*MIDEX for all Institutes, including:

- An Institute Steering Committee, which will be the decision-making body of the Institute, involving the participation of faculties' deans, doctoral schools' directors, the director of the doctoral collegium, and research units' directors,
- An Institute Executive Office with 3 deputy directors (research, education, innovation) around the Institute director, with the operational support of an executive manager,
- An Institute External Advisory Board, which will meet at least every other year and compulsorily before the projects' milestones at years 3 and 6.

GSRs Governance Scheme

GSRs Supervision Board: approval of strategy and yearly reviews of all GSRs (→)
Steering Committee: decision-making, coordination, implementation, and reporting (→)
External Advisory Board: recommendations and evaluations before the projects' milestones (→)
GSR Executive Office: GSR operational implementation
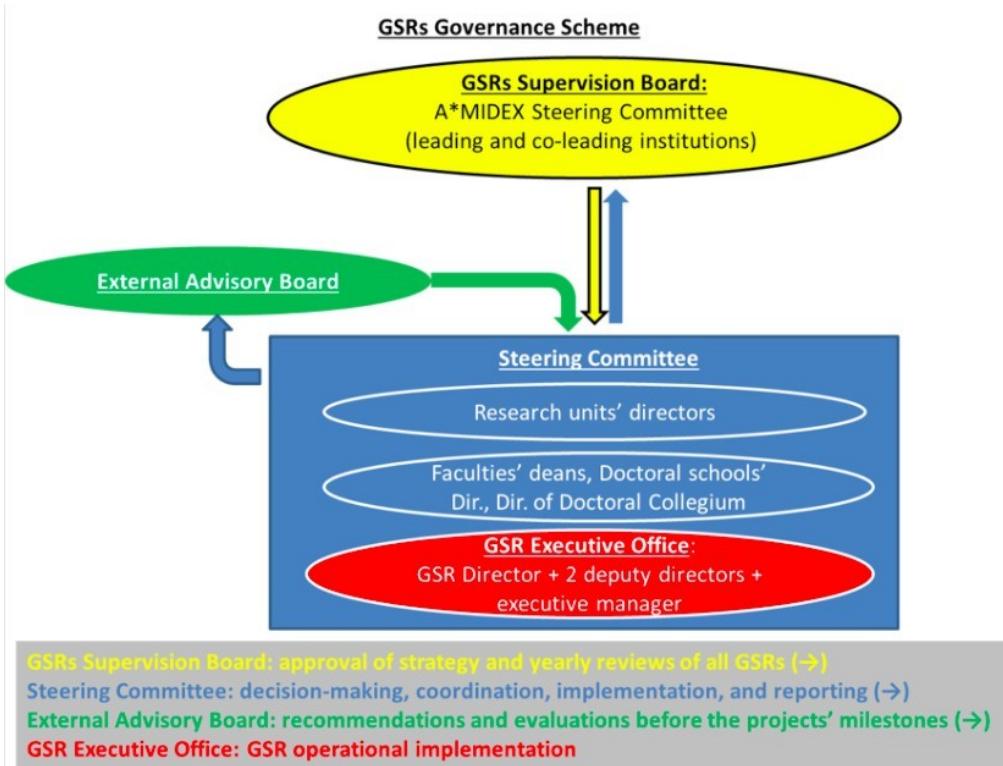
Last, this detailed organization and all terms and conditions of the partnership will be described in an Institute consortium agreements, which will be specific annexes to the A*MIDEX framework consortium agreement and refer to the latter, following the method formerly used to draw up LabEx consortium agreements.

5.4 INSTITUTIONAL STRATEGY

This application for the Institute Call falls within the strategy approved for the Aix-Marseille site in research, education and international relations by its partner institutions, grouped in the A*MIDEX Steering Committee (StC). Concretely, it was incited by the A*MIDEX StC, which gave a "Go" to the project after analyzing its letter of intent. ARCHIMÈDE Institute has indeed met all the expected criteria identified by the StC.

Furthermore, this Institute project is a new step building on the structuring achievements of LabEx Archimède in Mathematics and Computer Science, which is a key thematic priority for the Aix-Marseille site.

6 EXTERNAL PARTNERS

Marseille is a large Mediterranean city. AMU has a strong Euro-Mediterranean identity and is very active in Africa and in the French speaking world. The ARCHIMÈDE Institute should encourage the development of mathematics and computer science in other Mediterranean and African countries. We will also build on the existing bounds with other countries and international research units (UMI),

such as Rio de Janeiro, Pisa, Mexico, Santiago de Chili, Moscow. As is already explained above some join programs will also be developed with the help of CIMPA.

6.1 FUNDING PARTNERS

University of Sfax. The university of Sfax (Tunisia) will participate to the ARCHIMÈDE Institute and will give each year :

- 4 scholarships of 4000€ each for 2nd-year Master students doing their master thesis in Marseille;
- 2 shared scholarships of 3200€ each (2000€ for 2 months in France and 1200€ for the period in Tunisia all this during 3 years) for PhD students; for a total of 313 600€ along the 10 years.

The ARCHIMÈDE Institute will complete the financial support of the shared PhD scholarships with 2000 e per year. This will certainly increase the exchanges and cooperations between AMU and some Mediterranean countries.

Ecole Centrale de Casablanca. The Ecole Centrale Casablanca in Morocco will support one PhD scholarship every two years, in co-advisorship with the ARCHIMÈDE Institute. This will give a supplement of 367 200 € to ARCHIMÈDE.

6.2 OTHER PARTNERS

- CIMPA : Centre International de Mathématiques Pures et Appliquées, LabEx CARMIN, UNESCO
- IMPA : Instituto de Matemática Pura e Aplicada, UMI 2924 CNRS, Rio de Janeiro
- Laboratory Ypatia of Mathematical Sciences, LIA CNRS, Rome
- HSE: National Research University, Higher School of Economics, Moscow
- IRSN Institut de Radioprotection et de Sureté Nucléaire
- Center Solomon Lefschetz in Mexico,
- Centre de Modélisation Mathématiques in Santiago du Chili.

7 FUNDING JUSTIFICATION

Calculs basés sur une période de 10 ans, hors frais de gestion. La présentation est organisée selon 4 champs : formation, recherche, valorisation et gouvernance.

7.1 FORMATION

Bourses Master 1

14 bourses de 10 000 € / an	1 400 000 €
Renouvelables pour une 2ème année (14 bourses sur 9 ans)	1 260 000 €

Bourses Master 2

6 bourses entrantes de 10 000 € / an	600 000 €

Soit 14 bourses de M1 et 20 bourses de M2 / an

Gratifications de stage

18 stages de 3 mois, soit 54 mois de gratifications / an (base : 554,40 € / mois)	299 376 €

Master en Afrique

20 000 € de bourses / an	200 000 €
Ecole de recherche Archimède – CIMPA – UNESCO, 10 000 € / an	100 000 €

Cours en master et doctorats

- o Intervenants internes AMU : 2 000 h (base 58,80 € / h) — 117 600 €
- o Intervenants externes : 6 invitations par an pour 2 semaines
  - ▪ Cours 1 000 h (base 58,80 € / h) — 58 800 €
  - ▪ Missions (base 2 000 € / invitation) — 120 000 €

Master Classes

2 master classes / an organisées au CIRM (moitié prise en charge par le CIRM)	160 000 €

7.2 RECHERCHE

Bourses doctorales

7 nouvelles bourses / an, soit au maximum 21 bourses / an. Total : 56 bourses de 3 ans, sur base 95 000 € / bourse   5 320 000 €

Bourses post-doctorales

Moyenne de 6 bourses / an, base 45 000 € / bourse	2 700 000 €

Écoles d'été et conférences

20 000 € / an pour favoriser la participation de nos étudiants de M2 et doctorants à des écoles d'été ou conférences, comprenant frais de voyage et d'inscriptions (+ exceptionnellement l'hébergement si le laboratoire ne peut pas le prendre en charge)

200 000 €

Appel à projets « au fil de l'eau »

Projets financés dans la limite de 3 000 €, 40 000 € / an	400 000 €

Programmes de recherche en résidence

Projets impliquant au minimum 8 semaines d'invitation, 20 000 € / an	200 000 €

Convention de reversement CIRM

Reversement annuel de 80 000 € pour financer des semaines de conférences / mois thématique / chaire morlet organisés au CIRM

800 000 €

7.3 VALORISATION

2 ingénieurs de recherche « développement logiciel » (dont un CDI)   920 000 €
Fonctionnement de la cellule valo

Stagiaires, formations , frais de mission   50 000 €

AMIES + classe R&D

SEME, collaborations avec entreprises, avec participation financière du LabEx AMIES   200 000 €

Activités CIRM

Participations de 15 étudiants / an aux formations proposées par le CIRM, orientées vers les entreprises. Base :
1 500 € / semaine   225 000 €

7.4 GOUVERNANCE

Coordinateur/trice (CDI)   435 840 €
Management

    o   Décharges d'enseignement : 96 h / directeur, directeurs adjoint, soit 288 h / an
          120 000 €
    o   Frais de gouvernance : missions, réunions, achats de fournitures et de matériel de bureautique
        ou informatique   120 000 €
Communication et visibilité

Posters et stands événementiels, base 4 000 € / an   40 000 €

TOTAL du budget prévu	**16 044 696 €**

La contribution de chaque champ au budget total prévu est donnée ci-dessous.

Formation	26,9 %
Recherche	60 %
Valorisation	8,7 %
Gouvernance	4,4 %

Annexe 1 : Détail budget Institut Archimède

	Coût unitaire	Quantité par an	Durée (ans)	Total
FORMATION				**4 315 776 €**
Bourses de M1	10 000 €	14	10	1 400 000 €
Bourses de M2 - nouveaux boursiers	10 000 €	6	10	600 000 €
Bourses de M2 - boursiers M1 renouvelés	10 000 €	14	9	1 260 000 €
Gratifications stage	554 €	54	10	299 376 €
Master en Afrique / UNESCO / CIMPA	30 000 €	1	10	300 000 €
Heures intervenants internes AMU pour master / doctorats	59 €	200	10	117 600 €
Heures intervenants externes pour master / doctorats	59 €	100	10	58 800 €
Déplacements intervenants externes pour master / doctorats	2 000 €	6	10	120 000 €
Master Classes au CIRM	8 000 €	2	10	160 000 €
RECHERCHE				**9 620 000 €**
Bourses doctorales	95 000 €	7	8	5 320 000 €
Bourses post-doctorales	45 000 €	6	10	2 700 000 €
Ecoles d'été / conférences	20 000 €	1	10	200 000 €
Au fil de l'eau	40 000 €	1	10	400 000 €
Programmes de recherche en résidence	20 000 €	1	10	200 000 €
Convention de reversement CIRM	80 000 €	1	10	800 000 €
VALORISATION				**1 395 000 €**

Salaire ingénieur de recherche	46 000 €	2	10	920 000 €
Fonctionnement de la cellule valo	5 000 €	1	10	50 000 €
AMIES/ classe R&D	20 000 €	1	10	200 000 €
Activités CIRM - Programme Interface	1 500 €	15	10	225 000 €
GOUVERNANCE				**713 920 €**
Salaire ingénieur d'étude	43 584 €	1	10	435 840 €
Heures de décharges d'enseignement	41 €	288	10	118 080 €
Frais de gouvernance	12 000 €	1	10	120 000 €
Communication / visibilité	4 000 €	1	10	40 000 €
TOTAL				16 044 696 €

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Marseille, 11 juin 2019

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Objet : Réponses Institut Archimède Mathématiques-Informatique

Nous remercions le Board International d'A*MIDEX pour ses remarques constructives et ses questions auxquelles nous répondons dans ce document qui vient donc en complément et précise la lettre d'intention initialement soumise.

Cécile Capponi, Emmanuel Godard et Xavier Roulleau
porteurs du projet d'Institut *Archimède Mathématiques-Informatique*

Questions Générales

1. Description de la structuration progressive de l'Institut sur les cinq prochaines années en décrivant les postériorités issues du LabEx Archimede et les priorités (axes thématiques et forces) de l'institut, ainsi que les actions transverses Math/Info qui est une spécificité du site.

La structuration de l'Institut sera constituée progressivement. L'ambition est de construire un institut interdisciplinaire mathématiques-informatique de premier plan avec des axes prioritaires pour l'interdisciplinarité notamment mathématiques-informatique.

La gouvernance sera constituée selon le modèle proposé lors de l'appel à proposition. Cela pourra évoluer en fonction des discussions avec les tutelles. Le comité de pilotage est constitué des Vice-Présidents Recherche, Formation, A*Midex, du doyen de l'UFR Sciences, du Directeur du Collège doctoral, de l'Ecole doctorale et des représentants désignés par les EPST. Il sera constitué et réuni durant les 6 premiers mois. Le comité exécutif sera constitué de la direction (directeur, directeur adjoint, directeur adjoint à la valorisation) et du responsable de projet recruté pour l'Institut et des responsables des comités internes (recherche, formation,...).

Actions transverses :

Le rapport de prospective 2019 de l'INS2I au CNRS indique que, si les mathématiques sont le langage historique des sciences, au 21e siècle, l'informatique est en passe de devenir également un langage universel. Notre conviction est que l'enjeu n'est donc pas seulement de développer à Aix- Marseille deux disciplines mais également de participer à la construction en cours du nouveau langage pour les sciences et les technologies : le langage "math-info".

A Aix-Marseille, la collaboration entre mathématiques et informatique se déroule excellemment, nous souhaitons amplifier ces collaborations. En conséquence, tous les programmes de l'Institut Archimède présenteront une priorité pour les collaborations issues de deux laboratoires. Une partie d'entre eux seront entièrement dédiés à ces collaborations, en particulier sur les priorités identifiées de l'institut.

Deux thématiques prioritaires seront soutenues. Il s'agit de

— sciences des données, IA et apprentissage statistique
— fiabilité, sécurité et cryptographie

Postériorité du LabEx Archimède

Nous avons conservé le nom du LabEx pour l'Institut car ce fut une expérience extrêmement positive pour l'ensemble des communautés scientifiques impliquées. Le projet Institut Archimède est cependant très différent de celui du LabEx à bien des égards. Ce projet vise bien davantage à capitaliser sur l'héritage du LabEx Archimède qu'à le prolonger. Si nous conservons un programme de bourses de M2 attractif à l'international, ainsi qu'un petit volant de projets non fléchées financés au fil de l'eau, ainsi qu'un lien privilégié avec le CIRM, nous allons déployer l'Institut très majoritairement dans des directions et des actions différentes. Tout d'abord, en ce qui concerne la formation à et par la recherche, les actions (bourses, master-class, information et valorisation) s'étendront sur l'ensemble des années et des parcours de Master associés à l'Institut. Sur l'ensemble des actions de l'Institut Archimède, une proportion significative sera fléchée spécifiquement sur les thèmes prioritaires. Une nouvelle dimension internationale est également ajoutée avec l'ouverture du Master Afrique en mathématiques. Nous soulignons également que nous passerons une nouvelle étape en terme de valorisation avec une offre de services et de formations très novatrice.

2. Stratégie en terme d'emploi : planification pluri-annuelle des Ressources Humaines sur cinq ans en cohérence avec les choix stratégiques formation&recherche.

Sur les aspects RH, nous déploierons l'Institut dans ses différents facettes : direction, fonctionnement et communication ; aspects formations, valorisation et recherche.

Fonctionnement et communication de l'institut

Les besoins sont immédiats.

— Un(e) responsable de projet (niveau IGE/IGR)
— Un(e) chargé(e) de communication / community manager (niveau IGE) (à mutualiser avec les laboratoires)

Etant donné l'ampleur du projet, son fonctionnement et son animation devront être portés par un personnel à plein temps.

Concernant la communication, le site web du LabEx Archimède sera partiellement réutilisé afin de bénéficier de son référencement. Un accent particulier sera mis sur la communication et en particulier les réseaux sociaux.

Formation

Les formations de master ainsi que les doctorats sont gérés par les composantes et écoles doctorales et dotés en personnels de gestion.

L'aspect RH concernant l'Institut est essentiellement la partie qui concerne les bourses de thèses (d'excellence et sur projet de recherche), des financements destinés aux étudiants de masters sur critères d'excellence (attractivité nationale et internationale), des bourses de mobilité sortante pour les étudiants du site, entrante pour les étudiants du programme Afrique, et la gratification des stages que nous proposons de prendre en charge.

Nous soutiendrons également les deux programmes "Master Class" et "Interface" au CIRM par des volumes d'heures d'enseignements de 300h par an.

Nous appuierons également le développement du programme de formations professionnelles, donc les publics seront potentiellement tout à la fois issus de nos partenariat avec le privé que des besoins identifiés des laboratoires et instituts d'AMU.

Valorisation

Chaires industrielles

Les chaires industrielles seront génératrices de ressources RH (CIFRE, ingénieurs,. . .) financées par les industriels. Deux chaires industrielles au moins seront mises en place dans les 3 premières années. L'extension des relations avec ceux-ci peut permettre d'envisager la création une troisième chaire en 5è année.

Cellule Valorisation et plateforme technologique

Nous recruterons deux ingénieurs la première année, afin d'amorcer le catalogue de la plateforme technologique. Un troisième les rejoindra en deuxième année, les recrutements ultérieurs devront s'équilibrer avec les revenus générés par la plateforme.

Attractivité et rétention Nous soulignons ici à quel point il est important de prendre en compte la situation extrêmement tendue de l'emploi pour les ingénieurs informaticiens de haut-niveau et de définir une politique d'attractivité et de rétention afin de pouvoir et travailler et continuer à travailler avec les meilleurs talents. Privilégier les postes pérennes (CDI, postes statutaires) doit être une véritable piste de réflexion afin d'être compétitif sur ce marché.

Recherche

Nous voyons deux enjeux du point de vue recherche.

Chaires Nous envisageons que dans les 5 ans au moins trois chaires (senior ou junior) pourraient être mises en place sur les thèmes prioritaires de l'institut. Dans tous les cas il s'agira d'**attirer ou de retenir** sur le site un(e) chercheur(se) considéré(e) comme étant du meilleur niveau. En fonction des opportunités, nous prévoyons également de co-financer des chaires, comme celles qui peuvent être proposées par le PIA, sur, notamment, des thématiques prioritaires de l'Institut.

Ces chaires pourront soit accompagner un recrutement sur poste statutaire soit permettre un recrutement de type CDD (à convertir en recrutement statutaire ou non). Le budget complet pour une chaire est évalué à environ 150000€/an par chaire.

Le processus sera évalué au bout de 5 ans dans toutes les dimensions de l'Institut.

Projets conjoints La science des données (dont l'IA), la sécurité des données sont des enjeux majeurs pour le développement des laboratoires et Institut de AMU. Une collaboration renforcée est à mettre en place afin d'identifier et d'aider à évaluer les besoins en IE, en IR, en postdoc dans le domaine de ceux-ci.

En tant que hub mathématiques-informatique, dans l'objectif de travailler avec des personnels expérimentés en Informatique et Mathématiques appliquées,
l'Institut souhaite accompagner les instituts afin de leur faire bénéficier de notre expérience dans le domaine de l'implémentation d'algorithmes complexes, ou des pipelines avancés de traitement de données, tant d'un point de vue RH que d'un point de vue technico-scientifique.

3. Planification annuelle détaillée sur cinq ans, par action (formation, recherche, innovation, international, liens avec le monde socio-économique).

Les tableaux ci-dessous récapitulent les actions pour les 5 premières années, notamment en RH, pour nos différents programmes.

Formation

année	1	2	3	4	5
Bourses M1	6	10	14	14	14
Nouv. Bourses M2	6	6	6	6	6
Renouv. Bourses M2	0	6	10	14	14
Stages de Master	30	45	54	54	54
Master Afrique	1	1	1	1	1
Heures Intervenants Internes	50	100	150	200	200
Heures Intervenants Externes	25	50	75	100	100
Déplacements Intervenants	2	4	6	6	6
Master Classes CIRM	1	2	2	2	2

Recherche

année	1	2	3	4	5
Chaires	1	2	2	3	3
Bourses Doctorales	4	5	7	7	7
Bourses Post-Doctorales	3	4	6	6	6
Ecoles d'été / conférences	0	1	1	1	1
Projets au Fil de l'eau	40 K€	40 K€	40 K€	40 K€	40 K€
Recherche en Résidence	10 K€	20 K€	20 K€	20 K€	20 K€
Reversement au CIRM	80 K€	80 K€	80 K€	80 K€	80 K€

Valorisation

année	1	2	3	4	5
Ingénieurs de Recherche	2	3	3	4	4
Fonctionnement de la Cellule Valo	5 K€	5 K€	5 K€	5 K€	5 K€
AMIES / classes R&D	0	1	1	1	1

Gouvernance

année	1	2	3	4	5
Ingénieur d'Etude	1	1	1	1	1
Décharges Enseignements	288	288	288	288	288
Communication	4 K€	4 K€	4 K€	4 K€	4 K€

Formation

Dans une compétition internationale vis-à-vis des GAFA, la valeur ajoutée de institut concerne les enjeux de formation, qui sont peu appréhendés par les industriels. L'institut doit donc non seulement s'appuyer sur un socle de formation initiale mais également développer une offre de formation continue et professionalisante sur les thèmes prioritaires

Sans occulter une situation de compétition singulière avec les acteurs (grands ou non) du privé, l'Institut doit assumer la place qui est la sienne, au sein de l'Université, c'est-à-dire, produire et transmettre des connaissances. Au delà de la question concrète de l'organisation des formations, l'Institut s'attachera à produire les conditions concrètes du maintien et de la mise en place de formations ambitieuses et de haut niveau dans ces thèmes compétitifs. Ceci repose en particulier sur le maintien et le développement d'une expertise interne du plus haut niveau. L'Institut Archimède participe de manière centrale à ces conditions.

Une réflexion sera poursuivie autour des formations bi-disciplinaires. L'Institut accompagnera prioritairement celles-ci notamment en termes de bourses de Master.

Nous souhaitons mettre en contact une majorité de nos étudiants avec les laboratoires hors du périmètre d'Archimède, au même titre que les entreprises qui viennent se présenter auprès d'eux chaque début d'année.

Nous travaillerons au développement du catalogue de formations continues et professionnalisantes tant en direction des entreprises du privé que du monde académique. Nous souhaitons tripler en trois ans l'offre de formation (5 formations sont proposées actuellement). Nous évaluerons tout particulièrement le développement et l'adéquation de celles-ci au bout de ces trois années.

Recherche

1. Décrire les domaines de compétences/spécialisations, par conséquent les priorités thématiques et les forces en présences

Les quatre thèmes scientifiques majeures développés à l'I2M, au LIS et au CPT sont donnés ci-dessous (pour un total de 346 équivalents temps-plein).

— Analyse, Modélisation, Optimisation (83 ETP)
— Statistiques, Théorie du signal, Apprentissage automatique et Automatique (103 ETP)
— Systèmes dynamiques, Géométries, Probabilités (95 ETP)
— Algorithmiques, Logiques, Théorie des nombres (65 ETP)

Les thèmes prioritaires de l'Institut sont

— sciences des données, IA et apprentissage statistique (traiter et analyser des données complexes et/ou massives)

— fiabilité, sécurité et cryptographie (concevoir, prouver et déployer des systèmes complexes et/ou critiques)

Ces deux thèmes regroupent environ 110 ETP (pour deux tiers dans le premier thème, et le tiers restant dans le second). Nous nous appuierons sur les forces respectives – tant recherche que formation – de ces deux thèmes afin de les développer de manière optimale pour le site Aix-Marseile.

2. Renforcer la valorisation des thématiques qui différencient le site

Deux thématiques ont été identifiées comme précisé en introduction. Le développement de ces thématiques nécessite une grande interdisciplinarité mathématiques-informatique. De nombreux spécialistes sont présents tant à l'I2M qu'au LIS. En terme de traitement du signal, d'apprentissage automatique, les équipes de l'I2M et du LIS sont réputées. En cryptographie l'I2M possède ou a recruté récemment plusieurs chercheurs réputés. En terme de formation, le Master Informatique propose une formation labellisée en cybersécurité. Les actions que l'Institut mènera ont pour vocation de renforcer et valoriser ces points forts dans toutes leurs dimensions.

Une réflexion sur l'amont des besoins bidisciplinaires sera également menée afin d'identifier les actions permettant d'attirer et former les scientifiques maths-info de nouvelle génération.

La création de l'Institut permettra de rendre visible ces thématiques tant au niveau national qu'au niveau régional, pour l'ensemble des opérateurs de recherche.

3. Identifier des thématiques transverses prioritaires pour le site

Un travail particulier sera effectué sur les deux thèmes prioritaires (IA et données, sécurité). Les chaires industrielles ainsi que les chaires junior/senior seront fléchées vers ces thématiques. Le développement de ces deux thèmes n'étant pas identiques en l'état actuel, ils seront abordés de manière différentes. Les premières chaires seront pour le thème "IA et données".

Innovation

La *Cellule Valorisation* aura une place de premier ordre au sein de l'Institut. Les mises en relation avec des entreprises ou des laboratoires seront travaillées particulièrement à tous les niveaux de formation (master, doctorat), notamment au travers du programme Interface.

Par ailleurs, la propriété intellectuelle du logiciel sera considérée en amont de toute collaboration ou transfert, par la cellule de valorisation en accord avec les tutelles, et les partenaires ProtisValor et la SATT. En matière de type de licences logicielles, l'institut conseille les auteurs en prenant en considération (1) les recommandations des tutelles et partenaires, (2) le contexte du logiciel et des recherches menées autour de lui (nécessité ou pas, pour les chercheurs, d'une licence collaborative et/ou libre et/ou commerciale), et (3) la nature même du logiciel et son potentiel de diffusion. La politique d'Archimède est de favoriser la diffusion – scientifique ou industrielle selon le cas – des logiciels qui y sont développés. Ainsi, Archimède accompagne les chercheurs de l'Institut jusqu'à un accord avec les tutelles et partenaires de valorisation.

International

Nous maintiendrons un haut niveau d'attractivité et de visibilité pour le site. Nous vous informons en particulier que le projet de Master *Bobo - Abidjan - Marseille* vient d'être retenu par le Ministère des Affaires Etrangères.

Lien avec le monde socio-économique

1. Au regard du potentiel recherche et formation, l'institut doit établir une feuille de route pour

développer le partenariat avec le monde socio-économique

L'objectif est de constituer le *Hub Maths-Info Provence*. Ce hub se veut être le point d'entrée pour toutes les thématiques mathématiques-informatique (et en particulier pour les questions "IA et données") pour les industriels et les académiques de la région.

Les objectifs sont de

- — Doubler les bourses CIFRE
- — Maintenir le haut volume de diffusion scientifique
- — Création hôtel et plateforme technologiques
- — Recrutement initial d'ingénieurs pour l'amorçage de la plateforme

Nous nous appuierons sur l'ensemble des outils suivants, hôtel technologique, SEME et master class, formation professionnelle, programme Interface, cifre. Nous maintiendront le réseau d'alumni, ainsi que les liens avec le LabEx national AMIES autour des mathématiques et de l'informatique appliquées aux entreprises et à la société. Ceci devra s'articuler à la création et/ou promotion de chaires industrielles déjà mentionnées.

2. Créer l'hôtel & Plateforme Technologiques

Nous créerons la plateforme technologique dès 2020, après recrutement des deux ingénieurs. Après une préparation de l'ordre de 18 mois afin d'en identifier les meilleurs acteurs potentiels, nous ouvrirons l'hôtel technologique en janvier 2021.