



## Model of knowledge: EPFL's Master in Computational Science & Engineering

↳ The newly created Master in computational science & engineering (CSE) is an interdisciplinary degree including courses in high-performance computing, numerical mathematics, multi-scale and multi-physics modeling combined with various elective applied courses. The program is directed by Professor Assyr Abdulle, director of the Mathematics Institute of Computational Science and Engineering. Currently, the CSE Master includes 42 students on different academic and career trajectories.

Nik Papageorgiou  
Journaliste, Faculté SB/SV

Simulation has become an essential tool for engineers that can be integrated into mathematical modeling, numerical algorithms, and large-scale databases of observations, often leading to new paradigms. The CSE Master responds to the growing need for computer science in engineering by employing EPFL's wide range of research competencies in the field. Students gain outstanding skills in computer simulation, modeling and applied mathematics while developing their knowledge in an area of their choosing. The course equips them to deal with tomorrow's computational challenges in industry, but also prepares them for PhD programs in the basic sciences and engineering.



### Flash caught up with Professor Abdulle to discuss the CSE Master:

#### How did the course begin?

→ Around 2009, EPFL became involved in several new activities in the computational science. The "Centre européen de calcul atomique et moléculaire" (CECAM) had just established its headquarters on the campus, and the Centre for Advanced Modeling Science (CADMOS) – a joint initiative between UNIL, UNIGE, and EPFL – was created.

In simulation-based engineering, computer simulations and numerical algorithms play an unprecedented role for scientific discovery and technology development. The Lemanic region was growing into an international pole of excellence in CSE, and the three partner universities saw a unique opportunity to also develop an educational program around it.

#### What is the course's mission?

→ The new program aims to educate graduates with Bachelors in Engineering, Physics or Mathematics in the interdisciplinary field of simulation-based engineering and science. This Master constitutes the educational part of a vigorous initiative at EPFL to develop a world-leading center in CSE.

#### What challenges has the course met?

→ It is fair to say that the Master program had a slow start. As there is no CSE Bachelor degree at EPFL, local students have to leave their bachelor field in order to enroll in the Master. Then we met with some resistance on campus from teachers who believed that their own Master courses provided adequate CSE education. That debate is over; the Master is one of the most successful CSE programs in Europe, with more than 70 applicants from EPFL and around the world each year. Enrollment is very selective,

but it is open to Bachelors in the Natural Sciences or Engineering. Moreover, we recently created a double degree with the Politecnico di Milano that attracts outstanding applicants.

#### What makes the course special?

→ It is much more than just adding "a little simulation" into existing engineering or natural sciences programs. It is an interdisciplinary program designed to provide students with a combination of skills in many areas. The real gain is an integrated and multifaceted education that combines algorithms, modeling, applied mathematics, and computer science. Such skills are essential today in chemistry, biology, and civil, environmental or mechanical engineering. They open doors to new ways of pursuing scientific discovery or addressing computational challenges in industry, where such profiles are very much in demand.

The CSE Master also includes a compulsory internship, and we currently have 177 internship

offers from industry for CSE students. Companies are enthusiastic about working with them, and often extend their collaborations.

#### The course attracts students from different disciplines and scientific backgrounds. How does this impact it?

→ The diversity of the Master students is always a challenge, so the first semester centers on core courses e.g. scientific computing, numerical methods, software engineering, image processing and multiphysics modeling. In addition, there are courses that each student chooses with the program's coordinator, Dr Simone Deparis. Together, they build a coherent curriculum by which the students specialize in their desired field, but also reach the level required for mandatory core courses. This requires flexibility but it is also very rewarding, as CSE students show openness towards interdisciplinary projects, which is much appreciated by EPFL researchers.

## STUDENTS SAY:

**BENJAMIN PACCAUD:**

My CSE Master project was about analysis of contact mechanics between two solid rough surfaces. Contact between surfaces is hard to evaluate experimentally, so simulations are helpful to try and get an idea of what is going on.

The main interests are in the electric conductivity, the permeability across the contact surface or the friction forces. My project used the Finite Element library developed by Professor Molinari's Computational Solid Mechanics Laboratory to evaluate how the real contact area

evolves if the two solids deform plastically – this refers to irreversible deformations, like when you bend a piece of metal and it stays that way.

The CSE Master is great because of its diversity. There are a lot of courses to choose from, and if you don't like one, there is almost always another one available. On the other hand, if you see a course that is relevant but not in the course book, you can always ask to have it added! I was able to strengthen my programming abilities and my math background while discovering new fields where I could apply the techniques I learned. I still don't know exactly where I want to work, but I feel like many doors are now open.

**MARINE FROIDEVAUX:**

For my CSE Master project, I am working with the numerical mathematics group at TU Berlin. My project focuses on analyzing non-linear eigenvalue problems, which arise in a wide range of applications in engineering, e.g. the reduction of noise created by high-speed trains, or the dynamic analysis of structures.

Model equations arising from real applications typically contain Hermitian matrices or other kinds of matrix structures. Taking into account these special symmetries, I am developing and implementing an algorithm for solving

quadratic eigenvalue problems more accurately on computers (i.e. in finite precision arithmetic).

The Master in CSE is a good complement to my Bachelor in Physics. I learned how to combine the modeling of physical systems from different fields of application with the mathematical techniques and coding tools needed to simulate their dynamics numerically. For example, as part of my Master, I did an internship in a company responsible for the design of ventilation systems in road and railway tunnel networks. There, I created a model of thermo- and aero-dynamics in tunnel networks, developed an algorithm for approximating these dynamics numerically, and finally implemented it into simulation software.

All in all, I like that the interdisciplinary program of the CSE Master opens a variety of doors in academic research as well as in industry, where the coding and modeling skills you acquire are valuable.

## Swiss Space Center



## Space technologies studies: to demonstrate Swiss competences

↳ On February 16<sup>th</sup>, the EPFL hosted the presentation of results of the "Space technologies studies 2014" organised by the Swiss Space Center.

Grégoire Bourban  
Swiss Space Center

This event was dedicated to the presentation of the ten studies funded under the third call for proposals "to foster and promote Swiss scientific and technological competences related to space activities" issued in 2014 by the Swiss Space Office of the State Secretariat for Education, Research and Innovation of the Swiss Confederation (SERI/SSO).

Over 100 participants from Swiss industries and laboratories and the European Space Agency (ESA) had the opportunity to discover the projects conducted over 15 months by the selected consortiums.

The importance ESA places on this type of national activities for space technology development was highlighted by the presence of Mr. Franco Ongaro, ESA director of Technical and Quality Management. In his speech, Mr. Ongaro confirmed the relevance of the project selected with respect to the agency needs for future missions. He congratulated the SSO, the Swiss Space Center and the beneficiaries for the rapid implementation of such activities with a presentation of results just 2 years after the launch of the call for proposals. He welcomed this kind of public presentation for space technology developments by acknowledging the fact that in Europe

"we are excellent in savoir-faire but extremely bad in the faire-savoir".

Mr. Urs Frei, Deputy Head of the SSO, reminded everyone of the importance of Switzerland. ☰



Franco Ongaro, ESA director of Technical and Quality Management.

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