UNIVERSIDAD DE CHILE
FACULTAD DE CIENCIAS FISICAS Y MATEMATICAS

2030

A New Engineering for 2030

A New Engineering for 2030 Universidad de Chile

2030

A New Engineering for 2030

Contents


ESCUELA DE INJENIERIA

Introduction

The Faculty of Physical and Mathematical Sciences of the Universidad de Chile (FCFM), is one of the leading higher-education engineering institutions both nationally and regionally, as shown by: its research record (ranking fourth in Latin America QS Ranking), the quality of its students, (selected from the top 3% of high school students according to the national admission test), the number of graduate programs and students (reaching 23 Master and 12 PhD programs), the high competitiveness in raising funds from national agencies (95% of faculty have an external research grant), the renewed infrastructure (Beauchef Poniente project will provide an additional 40,000m2 in 2014, resulting in a total of 120,000m2), its history of curriculum change (with the early adoption of the CDIO initiative) and its record of innovation and entrepreneurship.

Yet, the picture of national success somewhat fades when displayed against the wider world background, as our thorough process of benchmarking that included trips of team members to eleven universities, showed: despite our good and rapidly improving national results, our research does not have the impact that others achieve, we do not pursue as many multidisciplinary topics and do not innovate as much as others, we are not as recognized internationally as others, and we do not teach our students a broad set of skills as others do.

This led FCFM to state a clear vision for this project: the goal is to become a world-class institution recognized by its leadership in science, technology and innovation, driven by multidisciplinary cutting-edge research that addresses both global and national challenges, and that provides an outstanding and broad educational experience, being engaged with the society and industry. By 2030, FCFM will be among the best 100 engineering schools in the world and top 3 in Latin America.

This vision will be achieved through a strategy of organic institutional change together with a policy of strong alliances with prestigious partners, geared towards improving research, education and impact on the Chilean economy, through innovation and entrepreneurship based on Scientific and Technological knowledge (i+e ST). The benchmarking process clearly showed that the pursuit of meaningful i+e does generate these positive effects; moreover, the important stress we place on innovation being based on ST knowledge is because, as boldly stated by the Chilean Academy of Sciences

"those innovations are the ones that, in the end, create more wealth for society. (...) Innovation based on scientific knowledge is a young phenomenon (in Chile), but is the one with an elevated potential for transforming productive processes".

Our strategic plan for change considers actions that will:

1

Spur multidisciplinary research and education in order to increase the relevance and potential impact of our activities.

2

Move FCFM towards a teaching methodology with more projects, multidisciplinary work and CDIO approach, thus allowing the formation of world-class students with improved skills in innovation and tools for entrepreneurship.

3

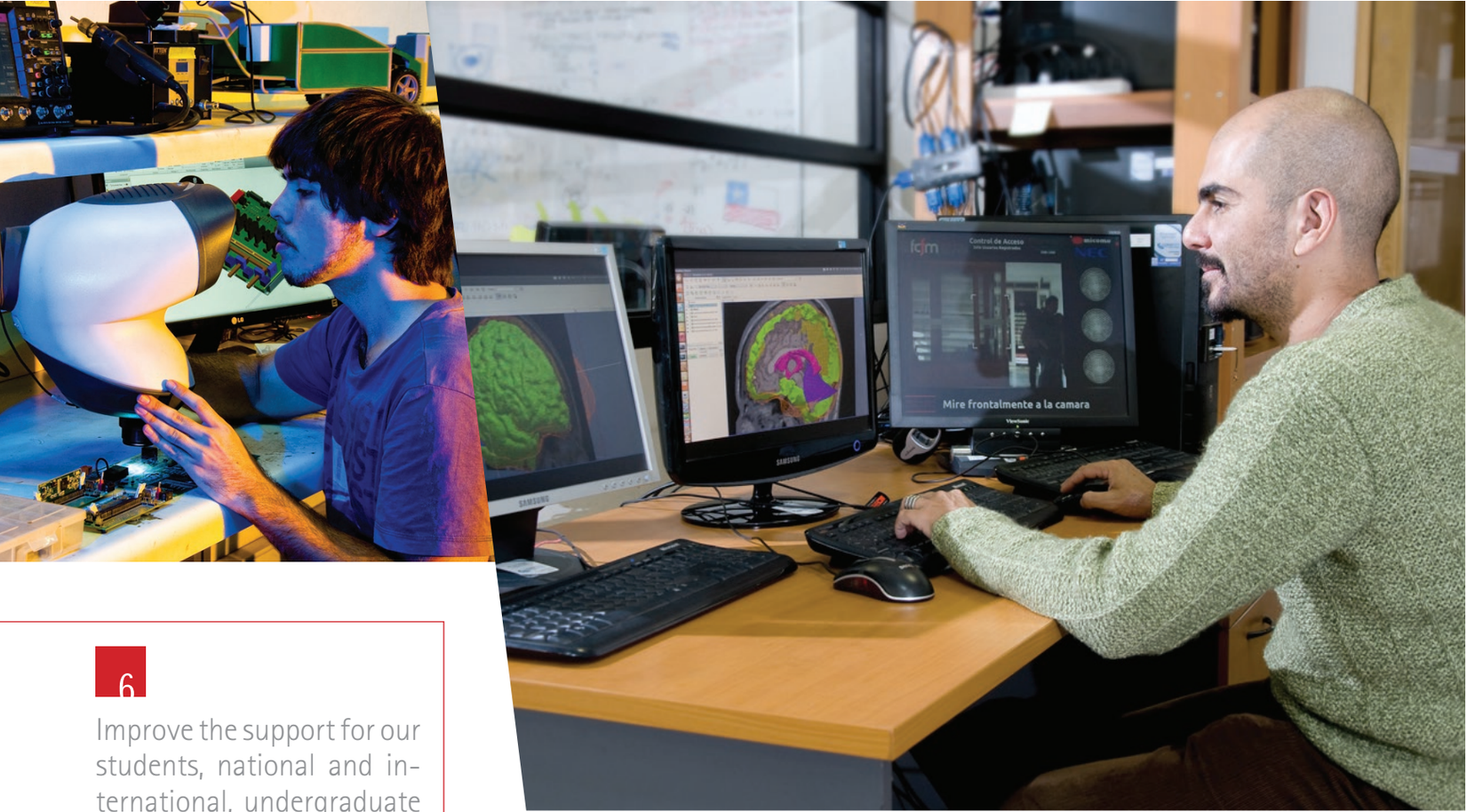
Strengthen our graduate programs by enhancing the graduate school, increasing the number of graduate students and by promoting dissertations in multidisciplinary topics in connection with industry.

4

Push for a profound cultural and organizational change to foster i+e ST at all levels, by means of an Associate Dean for Innovation and Technology Transfer, and a Scientific-Technology Innovation and Entrepreneurship Laboratory, that will help to provide the necessary hands-on experiences with i+e activities to both faculty and students.

5

Improve our internationalization and engagement with society by means of an *Associate Dean office for External Affairs.*



6

Improve the support for our students, national and international, undergraduate and graduate, by means of an *Associate Dean office for Student Affairs.*

7

Lead to agreements with prestigious partner universities that will support our plan. Specifically, our key partners will be the University of Manchester (UK) as a global role model of a public university that followed a steady and successful path of improvement, MIT (USA) for i+e ST and leadership education, and Cornell NYC Tech (USA) and Technion (Israel) as models for high-quality technology innovation ecosystems.

Notably, Technion and Cornell are partners for a new applied sciences and technology campus to be built in New York City. Therefore, they are pivotal for our longer-term goal of building a new scientific-technological campus at the Laguna Carén valley, which will be planned as a Latin American hub of academia, technology and business networks. The Laguna Carén site, an area of nearly 2,500 acres, is next to the international airport in Santiago, 15 minutes from downtown Santiago and an hour from Valparaiso.

Crucially, our bid is not just wishful thinking but is, on the contrary, supported by two key factors: (i) our unique current situation, with a large set of disciplines being cultivated and high-quality faculty and students; and (ii) a recent history of successful change, as shown by the 2000 FCFM plan that enabled renewal of the academic staff to foster research, the CDIO curriculum change and the strong increase of the quantity and quality of our infrastructure.

Our project is undoubtedly ambitious, but it is feasible and will provide very large returns to our country and the Latin American region, establishing, in the next 6 years, solid foundations for building a truly international and collaborative university-based innovation and entrepreneurship ecosystem. Through the "FCFM New Engineering for 2030" project and its installation in the Laguna Carén site, extraordinary opportunities await to establish a technology village: a place of meeting, exchange and generation of ideas, a space for applied research, development and technology transfer, innovation based on R&D, opportunities for wealth creation between university partners and industry, a source of welfare for our society, a unique experiment in the region that allows for a new vision of taking on the challenges of the century.

Mission and Vision

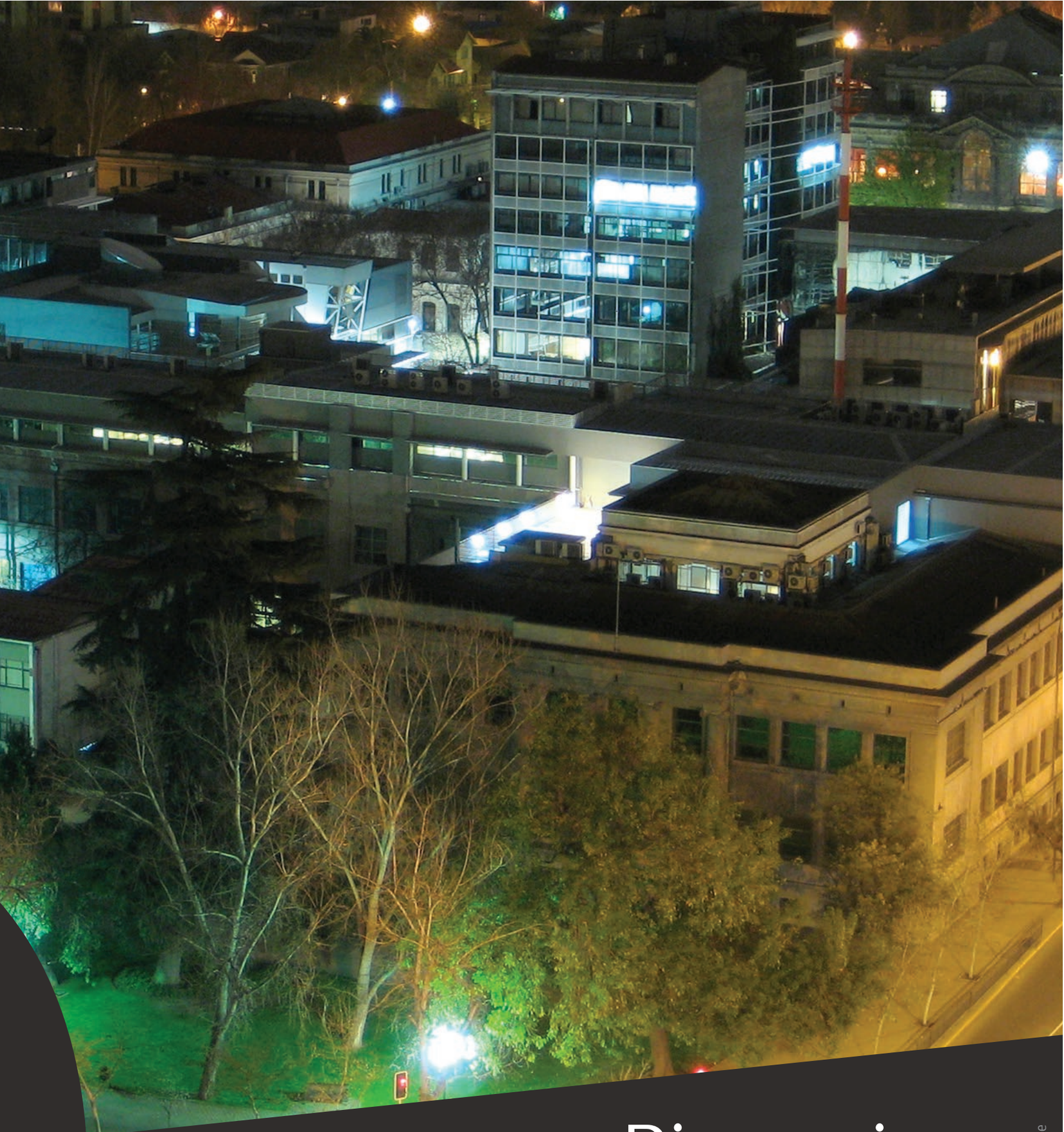
Mission:

We propose to overcome the old style, twentieth century like approach to engineering and science at FCFM by deeply transforming and strengthening our academic, management and R&D+i+e structures. These structural changes will emphasize multidisciplinary research, active education, internationalization and engagement with society and industry. Thus we expect to provide an outstanding and broad educational experience for our students, encouraging them to become leaders and meet the national and global challenges facing society. Also, we shall notably improve our standing in the world ranking of distinguished academic institutions and establish ourselves as a technology and science based innovation and entrepreneurship hub for the Latin American region.

Vision:

To be a leader in Science and Technology, becoming a pool of talent recruitment within the Latin American region, a world class institution that is well respected and is known for its outstanding contributions to the advancements of society and public welfare. The FCFM model for sustainable academic progress and productive involvement with industry becomes a standard for developing countries: being the best, not the largest, with intelligence to exploit limited resources, undertaking targeted tasks rather than addressing general challenges, where sustainability means wealth, caring for people and the environment. By the year 2030, FCFM will be among the best 100 engineering schools in the world and of the top 3 in Latin America.


2020



Diagnosis

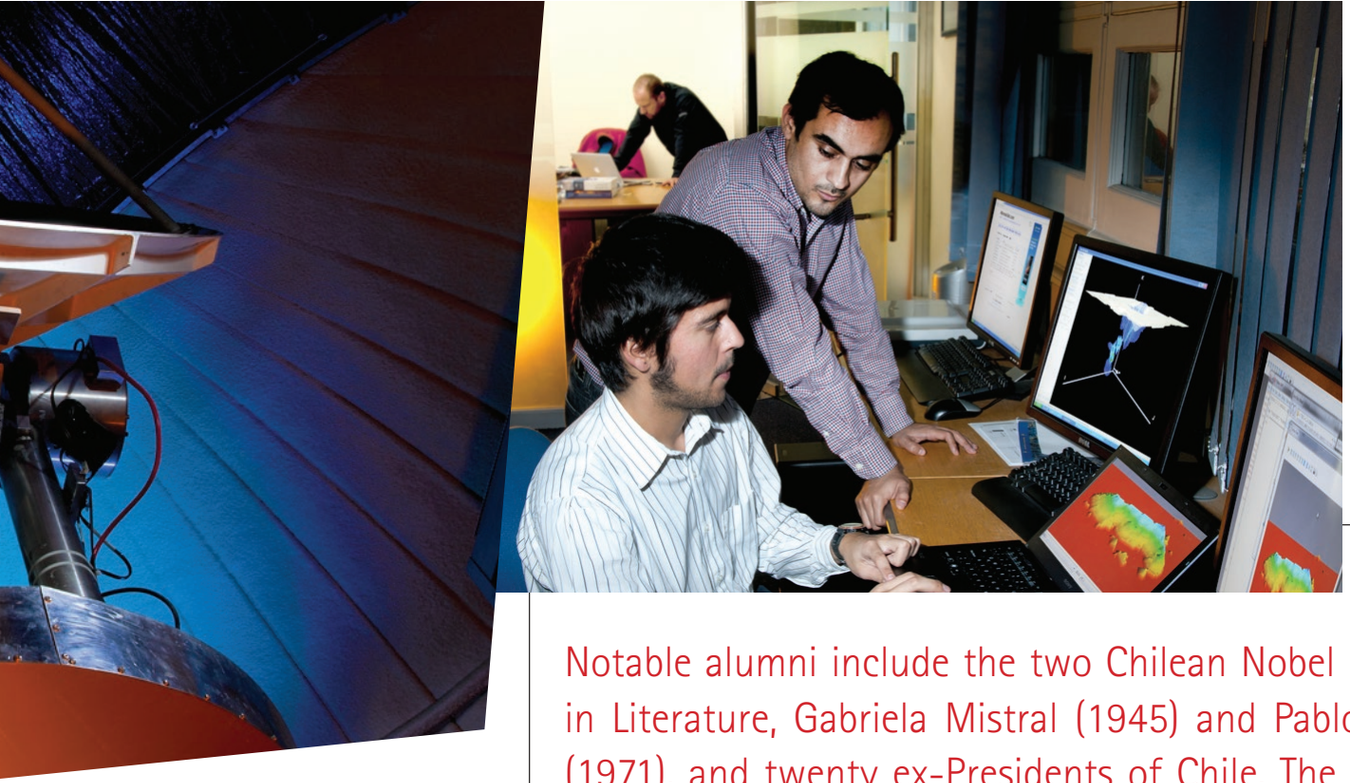
1. Description of the current situation

A short profile of the Universidad de Chile and the FCFM

The Universidad de Chile (UChile for short, www.uchile.cl) is the oldest and main higher education institution in the country. Established in 1842, its mission is to provide education and scholarship of the highest quality, through teaching and research across the fields of Science and Technology as well as Humanities and Arts, while interacting and collaborating with the relevant cultural, social and economic participants in society.

From the beginning, UChile has tackled key national problems such as education, the justice system, the prospection of natural resources (mining, forestry, water), horticultural development, public health issues, geophysical studies, earthquake-resistant engineering, energy and public infrastructure, to mention a few. It has also contributed to the formation of the leaders and intellectual elites of the country. Alumni have played prominent roles in academia, business, culture and politics. Notable alumni include the two Chilean Nobel laureates in Literature, Gabriela Mistral (1945) and Pablo Neruda (1971), and twenty ex-Presidents of Chile. The UChile is one of the only two universities fully accredited in the country (maximum 7 years in each area of competence, period 2011-2018, www.cnachile.cl).

Today, UChile is organized in 14 Faculties, 4 interdisciplinary Institutes and 1 clinical Hospital, which are located over 5 campuses in Santiago. It has nearly 28,700 undergraduate and 9,600 graduate students, and over 4,000 faculty members, a third



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being full-time professors. The President (Rector in Spanish) is the highest authority, elected by faculty to chair both the University Senate and the University Council for a 4 years period.

The Faculty of Physical and Mathematical Sciences, FCFM for its initials in Spanish (Facultad de Ciencias Físicas y Matemáticas, www.fcfm.uchile.cl), is the largest (number of students, research activity and output, economic resources) unit of UChile. It is located at the Beauchef campus in downtown Santiago, with an infrastructure reaching 120,000m2 of buildings for a population of nearly 4,700 undergraduate students, selected from the top 3% of high school students according to a national test for admission to higher education, 1,200 graduate students, 330 academics (including 206 full-time professors, 95% with a PhD degree), 50 scientists, 100 postdoctoral fellows and 1,600 employees making up the collaborative staff (1,200 work for external projects and services).

Under the direction of an elected Dean as the executive authority and the Faculty Council as the regulatory body, FCFM hosts one undergraduate school, one graduate school, 13 academic departments, 8 multidisciplinary centers for advanced studies, and 3 centers for technology transfer. The undergraduate school currently provides a 4+2 years long professional track in engineering (4 years for the equivalent to a bachelor degree) with 9 majors (biotechnology, chemical, civil, computing, electrical, industrial, mathematical, mechanical and mining), as well as an undergraduate program in geology and three 4-year long bachelor's degrees in science (astronomy, geophysics and physics). In turn, the graduate school also offers 35 degrees in science and engineering: 23 Master and 12 PhD programs.

The UChile record in research is quite remarkable, with the enthusiastic support from FCFM. Indeed, UChile is responsible for nearly 25% of the scientific publications of the whole country and the FCFM contributing with over 5%. UChile is the national leader in Excellence Research Centers and associative projects (40% of the national total granted), most hosted at FCFM. UChile ranks first in initiation and postdoctoral competitions of CONICYT (the National Commission for Scientific and Technological Research, www.conicyt.cl), most being FCFM young researchers. UChile ranks first in terms of R&D grants and Innova projects from CORFO, most conducted by FCFM faculty. UChile is placed among the 500 best institutions in the Academic Ranking of World Universities (ARWU - Shanghai Jiao Tong University), and it is the only Chilean university ranked top 10 in the Latin-American Ranking of Research Institutes (SCImago Research Group, Spain). In engineering research (citations per paper and H-index), UChile ranks fourth in Latin America according to the QS University Rankings.

1.1. General Background Information

1.1.1. The FCFM today: an overview on institutional commitment, recent actions and outputs on critical elements

In the year 2000 an initiative to evaluate and study the performance of the faculty was directed by the Dean of the FCFM. After that exercise, in 2001 the Faculty Council approved the Dean proposal to pursue three major lines of action: the renewal of the academic staff to foster research, a curriculum change to diversify the teaching offer and improve professional skills and a strong upgrade of the infrastructure to enable better education experiences and enhance research.

FCFM is one of the leading Chilean institutions in research, teaching and technology transfer in the fields of Basic Sciences, Earth Sciences, Engineering Sciences, Business, Economics and Management, contributing significantly to place UChile as the main national institution in scientific and technological research. Its unique design, having the engineering sciences as the core activity while integrating knowledge from related disciplines, multidiscipline at its best, allows us to provide state of the art training for the future engineers and scientists. At the same time, we can successfully face the complexities of modern research; it has also proved very positive to meet the diversity of demands from industry and the public sector.

Today, FCFM is working to become a truly world-class higher education institution in engineering and technology during the next decade. This is indeed a major challenge for a Chilean university, but we believe FCFM is in an exceptional and unique situation to embrace it. Such an enthusiastic perspective is based on one of the main characteristics of FCFM: a systematic and long-term effort for the implementation of continuous improvement strategies in relevant areas together with the political will and technical capacity to induce and implement radical changes, as we next show.

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As consequence, starting in 2002, several actions were taken on critical elements with the following outputs:

Increased productivity of academics in the field of research: In the year 2000, the faculty consisted of 176 full-time professors and 250 part-time lecturers. After changes were implemented in the selection and promotion criteria, in 2012 there were 206 full-time professors, resulting in a 17% absolute increase and a 50% replacement of the original members. The number of papers went from 215 annually to 333 during the same period, representing a 55% increase in total production. This leads to an average of 1.68 ISI papers published by full-time academics in the last five years. Published papers obtained more than 9,000 citations in 2012 and over 50% of them were published in journals belonging to the

top 25% according to their impact factor (Q1 category).

Increased quantity of foreign professors and post-doctorates: There has been an increase of foreign full-time professors over recent years, leading up to 12% in 2012 (from 5% in 2002). Post-doctorate research positions have experienced rapid growth resulting in 80 active positions in the year 2012 with only 37% held by Chileans. Fifty post-doctorates and twenty-four full-time academics are foreigners.

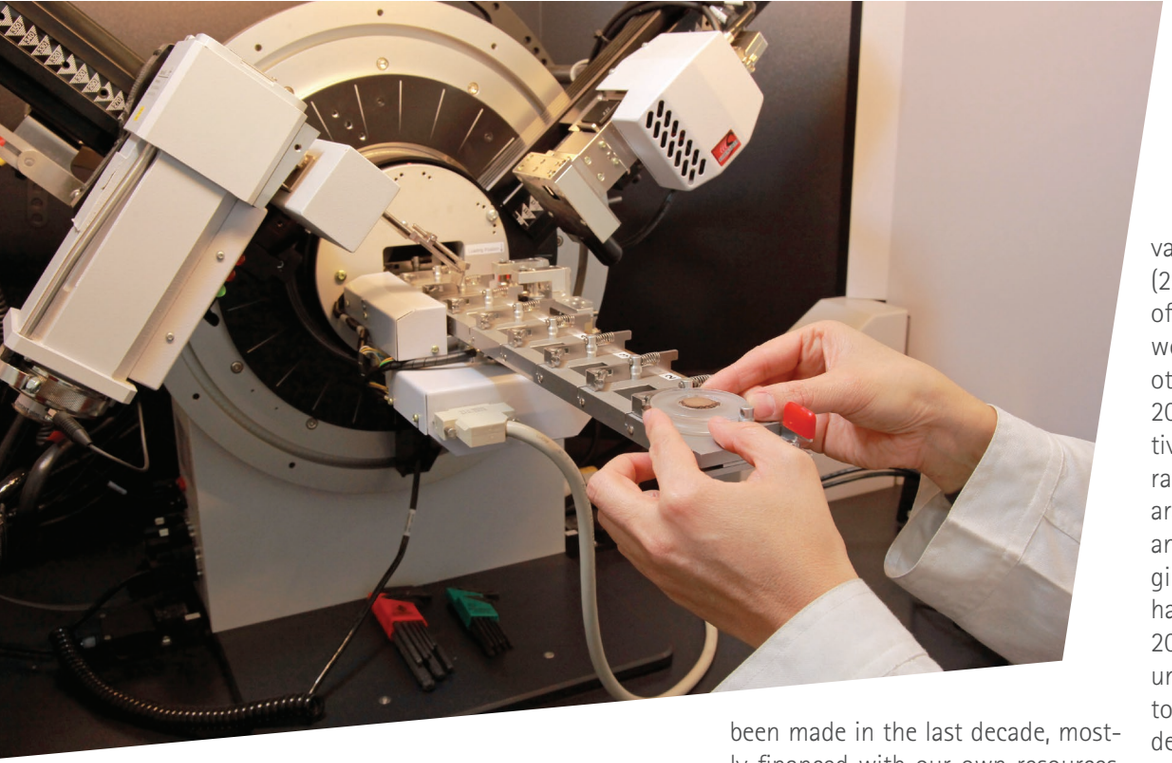
Growth in postgraduate and international student registration: In the year 2002, there were 434 master and 89 doctorate students. In a decade, doctoral programs documented a significant 152% increase with 224 people registered in 2012, of which 27% were foreign doctoral students. During the same period, registrations of master students also increased by 90%, with 13% being foreigners. In general, there were 1,050 postgraduate students in the FCFM in 2012 for which 164 were foreigners, representing 16% of total.

High competitiveness in raising funds from national agencies for science, technology research and innovation: Annually, various national agencies grant USD$21 million in financial support for research through programs such as FONDAP (4), BASALES (3), FONDEF, NUCLEOS, ANILLOS, (names in Spanish, www.conicyt.cl), etc. The UChile is the only institution that has created Millennium institutes in the engineering field with the Millennium Institute on Complex Systems Engineering (http://www.sistemasdeingenieria.cl) and the Millennium Institute for Cell Dynamics and Biotechnology: a Centre for Systems Biology (www.icdb.cl). Resources obtained through Millennium Institutes, Fondecyt, and postgraduate financing, reach USD$11 million annually. On the other hand, FCFM has a strong relationship with CORFO, which is the main government agency that promotes innovation, entrepreneurship and technological transfer. FCFM is the main local partner for the installation of 2 out of the first 4 international centers financed by CORFO (CSIRO and INRIA). Also, FCFM has sponsored about 20 Innova-CORFO projects in the last 3 years, including the recent program called "Go To Market: From the idea to the marketplace".

Partnerships with productive and public sectors: With business oriented initiatives and services such as IDIEM (the Institute for Research, Development and Innovation of Structures and Materials), NIC-Chile (the Network Information Center responsible for .CL domain name allocations and directory services), the National Seismic Center, among others, our faculty is able to maintain an important link with productive and public sectors, yielding an annual turnover of USD$50 million approximately.

Curricular change and leadership of CDIO in Latin America: In the year 2002, work began between academics, students and representatives from the profession and industry to design a new syllabus for the bachelor degree (4 years). This change, implemented in 2007, focused on competences rather than the more traditional knowledge based syllabus using the CDIO methodology (Crawley, 2001): Conceive, Design, Implement and Operate. The new plan includes a period equivalent to a semester of courses that the student freely selects to complete his/her training in science and technology and it gives the opportunity to complete a secondary field or minor. In 2009, reforms were applied to different disciplines, establishing the leadership of FCFM as a center of studies and dissemination of the CDIO initiative. This is the newest result in a long and consistent history of innovation in education. This ability to review and dare to try different training philosophies and techniques is fundamental when transforming schools to become world-class.

Significant improvement of infrastructure: With respect to infrastructure, several large investments have



been made in the last decade, mostly financed with our own resources. Some highlights from this venture include a modern classroom – the Galileo room – that enables an active learning environment for physics, the remodeling of an old building to foster electro-technologies laboratories, the building of a large laboratory for digital fabrication (FabLab) and a modern new facility setting new standards for campus life. Thus, the FCFM has 85 laboratories dedicated to teaching and research purposes, with equipment valued in several millions of USD. The so-called Beauchef Poniente project adds 40,000m2 of construction to reach a total of 120,000m2. This results in an additional 50% of space, with a value of USD$80 million. The project includes facilities for academics and students, offices for departments, laboratories, classrooms, common areas and sports facilities. These new facilities will be fully operational by the end of 2014.

Leadership in diversity and gender balance: Diversity is a fundamental value of UChile and FCFM and we make our best efforts to attract students of different genders, cultures, opinions, perspectives and skills. For instance, our students come from private schools (46%), subsidized private schools (30%) and public schools (24%). Concerning gender, only 20% of our undergraduate students are women; the situation is not better in other Chilean engineering schools. In 2013, FCFM decided to take affirmative actions to explicitly and deliberately improve gender equality. We are running a campaign to promote and celebrate talented women in engineering and science. In addition, we have implemented a program in the 2014 selection process of first-year undergraduate students leading now to a 25% share of women in the student population and to reach a 30% in the next years.

The strategy followed since 2000, characterized by a harmonious development of Basic Sciences, Engineering Sciences, Earth Sciences and the Sciences of Management and Economics, have fostered a unique environment in training, diversity and richness of options that these interactions have brought about. They generate different perspectives where knowledge is transformed to generate new solutions required by the society. Importantly, in particular for a project such as the one presented here, these changes were worked out in a harmonious, paced and inclusive manner, where the whole community was involved. There has been no significant resistance to change, but the contrary: a reflective thinking based on a positive questioning attitude.

We can be proud of what we have achieved until now, but this is not enough. The environment in which we are operating is challenging and continuously changing, and in some areas we cannot be satisfied with the speed or scale of our progress, especially concerning innovation and entrepreneurship based on science and technology.

1.1.2. Diagnosis: A critical analysis of the current situation

The conclusions presented in the next section were obtained after thorough critical analysis of data gathered by the project team, from both national and international sources, and from interviews, discussions and surveys of both national and international stakeholders and international experts. The data sources considered are: the Web of Knowledge, FCFM data basis, QS World University Ranking by Faculty 2013- Engineering and Technology and Academic Ranking of World Universities.

Internal stakeholders were faculty members and students. Faculty were approached for discussions within each department and in the Faculty Council; there was one meeting organized for each department. Students were selected for interviews and, in addition, student representatives attended the project meetings.

External stakeholders were divided into alumni and employers. When selecting the alumni to be interviewed some priority was given to those that showed initiative and an innovative and/or entrepreneurial mind, and to alumni working as engineers abroad. As for employers, we interviewed all engineering associations, all the relevant Ministries, the most important engineering consulting offices and large public and private companies where engineers play a central role; industry was thoroughly covered.

Finally, international experts, namely leading international university officials and professors as well as large global employers, were interviewed in person during their visit to our Faculty and, most importantly, during the visit of project team members to their home institutions.

Currículum

1) The engineering training at FCFM has a significant national prestige.

The prestige that FCFM has in the national picture is evident. At the initial stage, among the best students apply to our School of Engineering and Science: we select students from the best 3% graduating yearly from high school and participate in the national university entrance examination. At the exit stage, employers hire our graduates preferably: the employability of our graduates reaches 96% (average for all programs) during the first year after graduation. Also, a significant number of our graduates continue doctoral studies in prestigious universities abroad through scholarships, with high performances in the corresponding selection tests.

Local employers follow a rather traditional pattern in their hiring schemes. Thus, traditional academic programs such as civil engineering, industrial engineering, mechanical engineering and electrical engineering, together with other traditional academic programs, earth and space sciences, physics and computer sciences, continue to be the pillars of the School of Engineering and Science. Nevertheless, a consistent effort is made to develop training alternatives in less demanded fields. Engineering in Biotechnology is an example of an early program (1996), interesting student demand but slow industrial growth.

2) A solid background in basic sciences that trains them in rigorous reasoning to solve challenging problems is what characterizes FCFM engineers.

Theoretical understanding and technical breadth are the most important skills that our graduates have.

Our paradigm is to attract talented students, provide the basic science knowledge and tools in their first two years and then let them surf among the intricacies of the disciplines until they recognize one, or a mix, as their own. There are no quotas for each discipline. A program thus designed is optimal in terms of opportunities and personal satisfaction for the students but probably far from optimal in terms of management and resources. Our reward is to educate great people.

Our undergraduate professional programs are currently 12-semesters long. The syllabus consists of a common core (for all the programs) of four semesters, followed by another four semesters to complete a bachelor's degree. Afterwards, there are four more semesters remaining before obtaining the professional degree, which is required to practice engineering. The common core consists mainly of fundamental mathematics and classical physics courses, which are supplemented with project courses that aimed at fostering professional skills, inducing early contact with engineering problems and strengthening teamwork as well as basic knowledge from applications. After the common core, the students have the possibility to pursue a bachelor's degree and then a professio-

In 2007, a new plan of studies was introduced, based on the CDIO model (Conceive, Design, Implement, Operate)

nal engineering degree in one of the following areas: electrical, mechanical, mining, chemistry, biotechnology, civil, mathematical, computer, or industrial. In addition to this set, the FCFM also offers bachelors in geology, geophysics, physics and astronomy. Also important to mention is that of the requirement (though modest) in humanities, social sciences and art courses to complete the curriculum.

Employers and engineering associations identify theoretical understanding and technical breadth as the most important skills of our graduates. According to them, a solid background in basic sciences and a rigorous reasoning mindset to solve challenging and complex problems, even in international settings, is what characterizes our engineers. They further comment that this is the case even when compared to engineers from other countries (mainly from Europe and Asia).

Also, there is an agreement among our graduates that are considered entrepreneurs and innovators in their fields, that without this solid initial training it would have not been possible for them to innovate or to have an entrepreneurial mindset. Professors, employers and alumni all agree that the common core is crucial in achieving a high technical proficiency. However, it seems that this is not clear to our current students and, therefore, they need to be reassured and convinced of the value and relevance of the subjects taught in the common core trough the practice of real-life engineering problems.

3) Inter and multidisciplinary training with a hands-on approach should be a fundamental part of world-class engineering training. The FCFM has made important progress on this subject but more needs to be done.

The 2000 initiative to evaluate and study the performance of the faculty led to the conclusion that inter and multidisciplinary training with a hands-on approach is a central aspect of good engineering training. It was also concluded that FCFM was in a very good starting point to conduct both research and teaching in most of the more relevant engineering subjects, and therefore, a multidisciplinary approach was indeed possible.

Specific advances in the curricular redesign of the engineering program have seen an important push in the FCFM. In 2007, a new plan of studies was introduced, based on the CDIO model (Conceive, Design, Implement, Operate), which had its genesis in three Swedish universities and the Department of Aeronautics and Astronautics at MIT. Without impairing traditional strengths in basic engineering sciences and professional training, it incorporated a set of curricular and methodological innovations whose most direct effects are a cycle of studies that are more attractive to students, resulting in a minimal dropout rate and improved

career advancement which has fortified the design of the program. In addition, the number of project courses during the first two years of the programs was increased from one course to four courses. These are a key element of the change, since it is in these courses where most of the professional skills are integrated with the basic knowledge obtained from the lecture courses. In following this path, the FCFM became a region leader of the CDIO paradigm. Further, the reform asked for departments to create 'minors' at the 4-year long B.Sc. level; clusters of four courses that students from other departments could take during their bachelor studies, with the goal to create bridges between disciplines.

The first graduates of this new program completed their studies in December 2012. For this reason, no significant information has been yet collected from employers on the performance of these graduates to evaluate the impact of the curriculum change. This is as part the national accreditation process of our undergraduate programs that is being conducted this year 2014. We have constructed a database consisting of alumni and employers that are being consulted during the evaluation process currently in progress.

In turn, faculty academics maintain differing opinions with respect to the pertinence and results of the implemented changes. Some of them have the perception that the project courses in the first years have positively impacted student development in a positive way. They even argue that the credits for these courses should be increased, because these courses count for only half of the credits of lecture courses, which might send the wrong message to students about the relevance of these courses. Yet another group argues that these courses are of little value and they take credits away from basic lecture courses.

Despite the efforts made in implementing the CDIO approach, there is a gap between the common core and the last years of the major programs. During the two years of studies for the professional degree there are several project courses including a one-semester thesis, yet during the previous two years of the bachelor degree there are no project courses. This is something that is being handled in many of the academic departments.

The minors were aimed at solving another issue, which is that even though the students had the flexibility to take courses from other programs to promote inter- and multi-disciplinary training, they frequently were not able to build connections between disciplines. Twelve minors were formally declared, and the sequences of four courses were carefully analyzed for consistency and depth. Yet, despite the fact that each minor looked very appealing and were well designed, they were not as successful as desired. In practice, a sizeable number of students is taking non-related optional courses rather than following the proposed minors. Although some possible explanations have been proposed for this, this issue is still being evaluated as part of the national accreditation process currently in progress.

A third action aimed at fostering hands-on and multidisciplinary experiences during engineering formation has been the permanent support of the Faculty to large technology initiatives driven by the students. Examples of these initiatives are: the construction of an ultra light airplane in 2003, the participation in the RoboCup since 2004, the construction of the first solar car in Chile in 2007 (the Eolian project that is now in the fourth prototype), the powering -for the first time in Chile- of a small village in northern Chile with just renewable energies in 2010 (the Huatacondo project) and the construction of the first Chilean small (1 liter) satellite, since 2011 to present (SUCHAI project). Yet, although these initiatives have been of great impact for participating students, they cover just a small fraction of the total number of students.

The last major action taken to increase the project oriented education in the FCFM is the construction of a FabLab, a standardized laboratory of digital fabrication which allows students to conceive, design and build prototypes and devices much faster, even enabling students to instantaneously share their designs with other FabLabs around the globe (see http://fablab.uchile.cl/).

4) Our engineers would benefit from improved professional non-technical skills

Employers have a general perception that our graduates would benefit from improved non-technical skills, not related to basic sciences, such as: communication, project management, leadership, entrepreneurship and team working. Very importantly, everyone who was consulted warned us that this should not occur at the expense of the solid theoretical background that characterizes our graduates. Instead, improving those skills should be carried out starting in the first years of training and in multidisciplinary engineer projects. This will help reduce the gap between the above-mentioned skills –which have to be improved– and the solid theoretical training in engineering sciences.

Research and postgraduate studies

1) FCFM is a national leader in research and holds a prominent place in Latin America. FCFM has not yet achieved a leading international prestige in terms of research, even though some individual researchers or research groups have.

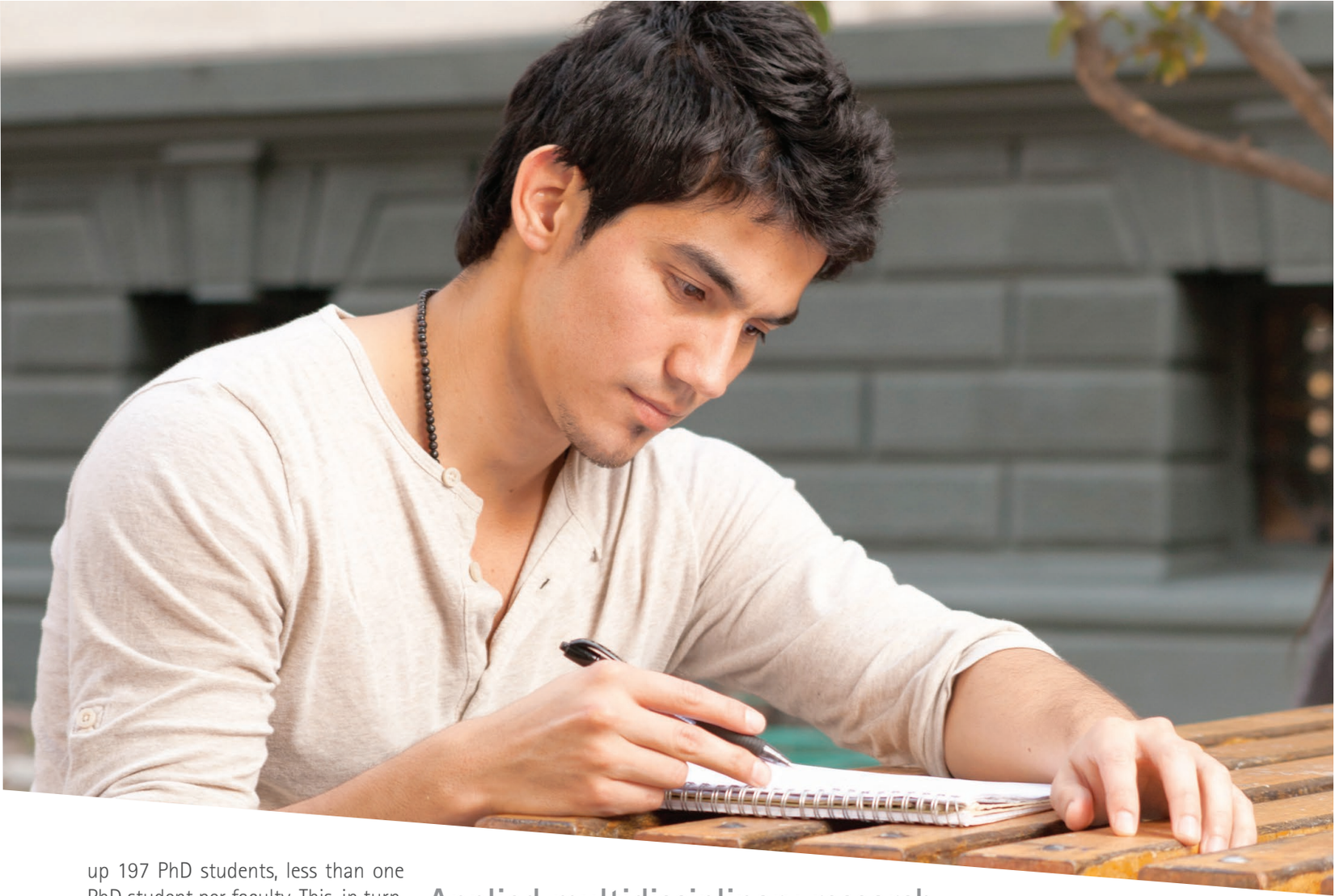
The UChile is among the top universities of Latin America. In the ARWU ranking UChile as a whole is ranked close to the 500th position. In this ranking, the FCFM does not appear because engineering subjects are showed just until the 200th position and the FCFM is positioned below that for all and each subject. On the other hand, in the QS ranking – which weights research and its impact as well as the reputation of the institution–, the FCFM ranks above the 200th position in five engineering subjects although four of these are rather close to the 200th position. Earth and marine sciences stand out particularly with the 75th place. It is relevant to highlight that there are cases where the FCFM has larger research and impact numbers, but less reputation numbers than other universities of the region, which dampens the results. At the national level, the FCFM currently holds 37% of the largest national funded research projects (Basal, Millennium Institutes and Fondap). These are seven projects that, all together, manage a total budget of USD$18 Million annually. Researchers within FCFM currently hold 17 middle size projects (Anillos and Fondef) and near 160 smaller (individual) projects (Fondecyt), as well as in 20 Innova-CORFO projects in the last 3 years, showing clear leadership within the country. Over 95% of the faculty of the FCFM is participating in an external research grant.

...considering the 358 papers published during the 2013, 50% of them have as co-author, a faculty member of a foreign university. About 25% of these collaborations can be described as multi-disciplinary.

As explained before, in the last decade the FCFM has made significant progress in academic hiring policies including a serious assessment of the number and quality of publications. Together with converging disciplines, we have focused on the formation of an academic body that achieves standards in training and self-purpose of an outstanding university: 95% of our full-time academics have doctoral training, probably a postdoctoral position at least and collaborate with their international peers. They are highly competitive in research and technology transfer. The quality of infrastructure that hosts our Faculty permits us to favorably compare ourselves with other prestigious institutions. However, there is also a cause for concern: our advance in scientific and technological productivity (measured in the number of papers, impact and number of citations) the growth rate has weakened in the last couple of years, despite the fact that resources have increased steadily at rates of about 10% yearly. To further characterize our scientific output, we can add that considering the 358 papers published during the 2013, 50% of them have as co-author, a faculty member of a foreign university. About 25% of these collaborations can be described as multi-disciplinary.

2) FCFM has PhD programs that look strong as compared to others in the country, but are rather weak in the global concert.

In relative terms, the FCFM faculty is not as productive in research as those from more developed countries. This might be attributed to the still small size of our PhD programs. All the PhD programs of the FCFM add



up 197 PhD students, less than one PhD student per faculty. This, in turn, could be attributed to a small number of students from abroad; even though the Chilean economy is in apparent good health and the FCFM has a good reputation within the region, only 10% of the PhD students are foreigners. One of the reasons for these low numbers, relative to the best universities in the world, is that there are few available scholarships and the granted funding is low when compared to the cost of opportunity of engineering graduates. Moreover, the domestic labor market does not value postgraduate studies in the field of technology. In addition, this shortage of PhD students might be caused, in part, by Chilean fellowship policies that impose severe constraints on foreign students while providing strong incentives for Chilean students to pursue their PhD studies abroad.

Applied multidisciplinary research, technology development and innovation

1) Although improving, FCFM research has to be closer to the national problems or those of the Chilean industry and global society.

Although for Chile and the Latin American region our level of research is acceptable, it has had limited impact on the Chilean (and regional) economy, with a few exceptions. One of the main problems is that our research has been rather atomized, without sustained collaboration between researchers to solve the larger problems currently being faced by the country and global society. Grant policies and promotion procedures indeed encouraged this individualistic behavior. It is imperative to promote a much more multi-disciplinary approach to research, which might produce not only higher and wider impact, but also a stronger relation with the industry.

During the last years, and due to the availability of specific government funds that promoted the formation of multidisciplinary research centers within universities, the scenario changed dramatically. Nowadays, the FCFM has eight multidisciplinary centers where collaboration between researchers is strongly encouraged. These fields are usually defined according to our national challenges or particularities of the country that facilitates research. Particularly strong

is our technological research in mining, energy, water, infrastructure resilience and complex engineering systems.

2) Although there has been some examples and progress, FCFM does not have a strong culture to support and foster innovation and entrepreneurship, and the i+e local ecosystem is underdeveloped.

We do recognize that FCFM does not have a strong culture to support and foster innovation and entrepreneurship; the previous cases of success –see section 1.1.3. below- have been more the result of individual or group initiatives by bright and motivated members of the FCFM, rather than the result of an explicit policy. In that sense, just as in the case of research, our numbers in i+e are good for the national level but are still far from the international standard to really stand out globally. The culture of our Faculty is not explicit to support innovation and entrepreneurship. Most of our efforts are oriented to the generation of relevant, high level research.

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Beyond the changes in the way the government funds applied and multidisciplinary research, the geographic isolation of Chile and the small local market, together with the lack of venture capital in the country still define the environment as "challenging" for innovation and entrepreneurship based on science and technology. UChile is now in the process of defining policies to promote i+e, however, the approach so far has been focused on standard metrics such as the number of patents, spin-offs, licenses and/or income generated from them. Those metrics (outputs) are poor in our Faculty for international standards. However, given that we have an increasing engagement with the industry through joint R&D initiatives within the multidisciplinary research centers, we can foresee a promising future in both entrepreneurship and innovation.

3) All FCFM stakeholders –students, faculty and alumni– strongly believe that a culture of entrepreneurship and innovation has to be created. But, very importantly, in a school like ours, entrepreneurship and innovation must be strongly linked to actual scientific and technological knowledge advancements, and not only to creative business.

There is agreement in the FCFM between students and faculty about the importance of developing a culture of entrepreneurship and innovation in technology. However, entrepreneurship and innovation is not explicitly included within the goals of our programs and policies. For this reason, there is little attention from the faculty on this subject, with almost no incentive for students and professors to develop innovation and entrepreneurial skills. The community of the faculty as a whole (leaders, students, professors and staff) believes that it is a good time for promoting a cultural change to foster technology innovation and entrepreneurship. They consider that the specific characteristics of this school –research and teaching in a large number of technological disciplines– are powerful drivers to foster this change and make an impact in the Chilean industry. The technology university-based entrepreneurship and innovation ecosystem within the country has a reasonable level with a good quality of life and local government support with increasingly economic resources.

Internationalization

1) FCFM undergraduate students are trained in English language to develop the basic communication skills to study or work abroad.

All undergraduate students are required to pass the Michigan Test of English Language Proficiency, a language certificate measuring students' English ability as a second or foreign language. Its primary purpose is to assess a learner's English language ability at an academic or advanced business level. FCFM provides five levels of English courses to ensure that all of our graduates have the necessary communication ability to study or work abroad. About 1.100 students per semester enrolled in an English course offered by our School, representing 25% of undergraduates.

2) FCFM undergraduate students are rather shy in seeking or exploiting opportunities to spend time abroad as part of their training.

The FCFM-UChile has implemented 3 mobility programs that are currently available for its undergraduate students. These are: (i) the Student Mobility Program of FCFM which includes agreements of the FCFM with prestigious universities in the world, (ii) the International Internships for Engineers program (IIE), which allows students of our school to make internships in senior foreign companies, and (iii) the Central student Mobility Program of UChile (PME-Central), which is managed centrally at the UChile Foreign Relations Office and encourages student mobility of both UChile students travelling abroad and foreign students coming to Chile. However, very few of our students, less than 1%, have used these programs in the past years. An important part of the problem is the lack of funding for students to travel when they hardly make ends meet at home.

3) FCFM has not reached its full potential to attract international students.

Although the FCFM has a strong reputation within the region (Latin America), the number of international students is extremely reduced within undergraduate programs; only 1.5% of 4,700 students are international students. This can expected since university fees ran at USD$10,000 per year, a major amount for students coming from Latin-American countries with basically free university education. On the other hand, there are 104 foreign master students and 60 foreign PhD students in the FCFM, representing 13% and 27% respectively.

4) FCFM has increasingly become an attractive place for international researchers seeking an academic career, but there is still plenty of room for growth in this direction.

The number of foreign full-time faculty has increased in recent years reaching 12% in 2012, and a very interesting phenomenon has occurred with postdoctoral positions in the FCFM: The number of postdocs has witnessed fast growth with around 80 active positions for 2012, where only 37% of them are held by Chileans; another 27% is from Eastern Europe, 24% is from South and North America and 12% is from Asia.

1.1.3. A review of FCFM initiatives on technological innovation and entrepreneurship

FCFM has a number of examples of knowledge-based innovation and entrepreneurship activities, which place it at the very top nationally, yet far from international best-standards. For instance, in the recent book "Innovación basada en Conocimiento Científico"[1] (Innovation Based in Scientific Knowledge), edited by the Chilean Academy of Sciences, the reader may find 6 out 15 examples of successful innovations that were carried out by FCFM faculty (and three other examples include other UChile professors). This book was commanded by the Ministry of Education to the Chilean Academy of Sciences and is the result of the work of 32 scientists and 21 representatives from industry.

As the book from the Academy of Sciences boldly says: *"without a strong and productive basic science, most of which is carried out in a few Universities, there would be no chance of innovations based on scientific knowledge. And those innovations are the ones that, in the end, create more wealth for society".* They further argue that "innovation based on scientific knowledge is a young phenomenon (in Chile) but is the one with an elevated potential for transforming productive processes".

In what follows we present and briefly describe some of these examples; they clearly show that FCFM can have a strong impact on i+e based on knowledge creation in science and technology, as opposed to pure business-oriented initiatives.

A few examples of i+e successes based on science and technology

EOLIAN. The first solar vehicle in Chile; it was built in 2007. The initiative was born from a group of students and researchers at FCFM leaded by Prof. Rodrigo Palma, who had experience with electrical vehicles. Eolian 1 competed in the World Solar Challenge 2007, obtaining the 14th place after travelling, autonomously, 1862 kilometers. Eolian was followed by Eolian 2 in 2011.

DOCODE(http://www.docode.cl/?lang=en). It is software created to make easier the process of originality analysis of digital documents, with particular attention to education. The managing team and developers are researchers at the Web Intelligence Research Centre at FCFM, directed by Prof. Juan Velásquez. It is based on original research and was the winner of the 2011 PAN competition (Uncovering Plagiarism, Authorship, and Social Software Misuse), where 14 different teams participated. The FCFM team was the only one from South America.

Band 5 Receivers for ALMA - Millimeter-wave laboratory: (http://www.das.uchile.cl/lab_mwl/index.html). ALMA band five covers the frequency window from 163 to 211 GHz including the water line of 183 GHz. The Band 5 receivers are under construction at the Group of Advanced Receiver Development (GARD) on Chalmers University. The first receiver is getting ready for integration at the European Front End integration Center (EuFEIC) in UK, and it was delivered to ALMA on 2011. The Department of Astronomy (DAS) is part of the consortium for the development of the first 6 receivers providing skilled engineering labor at the EuFEIC and GARD. DAS will be responsible for the integration and verification of the receivers in Chile.

Mathomics (http://www.mathomics.cl/). It is a collaborative research group of the Center for Mathematical Modeling (CMM) and the Center for Genome Regulation at UChile, created to play a central role in the development of biotechnological projects, providing state of the art bioinformatics and mathematical modeling tools, allowing to face these problems from the point of view of Systems Biology. Mathomics works forming strategic alliances around projects with universities, research centers, public or private companies.

Micro and nano composites innovation. Led by Profs. Fernando Lund and Raúl Quijada, researchers grouped in CIMAT (a Center for Materials Research) investigated the use of micro and nanocomposites to improve the mechanical characteristics of different plastics. Their innovations include using eggshells (cheap and clean), obtaining nanocomposites to form clays and manufacturing a compatibilizer to enable an adequate chemical combination between the material and the additive. Three patents were obtained.

Use of nanometric copper in polymer matrices. By using copper based nanoparticles as filler in different polymer matrices, several kinds of antimicrobial materials can be developed. This methodology allows the production of high active materials due to the high surface/volume ratio of the nanofiller without changing the main characteristic of the matrix. The innovation involved in this field, led by FCFM faculty, is going to have a large impact in two very relevant areas; first, salmon production, where plastic cages will be manufactured that do not suffer from biofouling – that is, the formation of organic layers on the plastic cages –, dramatically decreasing production costs; and second, hospital care, where polymer matrices with nanoparticles of copper will be used to create antibacterial hospital furniture. Two patents are currently in process to be licensed.

Cube Land (www.citilabs.com/products/cube/cube-land). It is commercial software that forecasts land use and land price by simulating the real estate market under different economic conditions. For a user-defined scenario, Cube Land forecasts the supply and the demand for different types of properties, and estimates the location of households and non-residential activities. Cube Land uses a rigorous microeconomic approach that was pioneered by Prof. Francisco Martínez, to find an economic equilibrium between land supply and demand. The process also considers perceptions of the real estate market, market restrictions, and regulations. Cube Land was originally developed for Santiago City, under the name of MUSSA (Modelo de Uso de Suelo de Santiago), but is now being commercialized by Citilabs Corporation. It is in use, for example, in Minneapolis.

Seismic energy dissipators. The first application of seismic energy dissipators to the Chilean reality occurred in 1992, when a building using this technology was built in the Andalucía community in Santiago. The project was supported

by the Ministry of Housing and Urban Development of Chile, the company VULCO, and led by Profs. Mauricio Sarrazín, María Ofelia Moroni and Rubén Boroschek. This building was monitored together with a second identical building but without the dissipators, something that yielded invaluable data for both research and practice. The technology was then adapted to the conditions and legal specifications of Chile, and subsequently, adopted broadly.

Mobile ecographer. Profs. Carlos Conca from the Center of Mathematical Modeling (CMM), Manuel Duarte and Nicolás Beltrán, from Electrical Engineering led a team that innovated on mobile ecographers. The resulting prototype is being tested these days with very good results. This ecographer is lighter (800 grs), smaller and cheaper than other alternatives; has a two-hours autonomy and images are looked in a specific goggles set. It is likely to be used massively by doctors working on zones with bad accessibility and/or limited access to resources.

The El Teniente Converter. This is an emblematic case of technological innovation in mining. Hermann Schwarze, an engineer from FCFM, led a group of professionals to design and build a new fusion process, which was subsequently called El Teniente converter after the name of the mine where it was first used. It was patented in 1997. Starting in 2001, a number of studies using advanced applied mathematics, fluid dynamics and material sciences were carried out by teams from IM2 (Codelco) and CMM of FCFM. All this eventually lead to a capacity increase of 25%. To date, El Teniente converters can be found in many mines along Chile and also in Zambia, Perú, México and Thailand.

ASICAM – PLANEX – OPTICORT. These are three operations management models that evolved into software and that optimize production of forest companies by planning harvests, machinery location and truck scheduling. They were developed by a team led by Profs. Andrés Weintraub and Rafael Epstein, of the Industrial Engineering Dept. Weintraub and Epstein won the Franz Edelman prize in 1998, Weintraub won the Premio Nacional de Ciencias Exactas in 2000, while Epstein was Chilean Innovator of the year in 2008, mostly due to these innovations. This software is in use in Chile, Brazil, Uruguay, Argentina, Colombia and South Africa.

Business and commercialization initiatives

NIC Chile (www.nic.cl). NIC Chile is a spin-in that was created 25 years ago, at FCFM, by faculty from the Computer Science Department. NIC Chile, which still depends on FCFM, is the organization in charge of managing and registering web sites with domain .cl, and to operate the technology that enables these sites to work safely and efficiently. NIC Chile and its developers have an impressive record of milestones on the history of Internet in Chile: to name a few, they were the first to connect ever Chile to the web and they installed the first web server of Latin America.

Fundación para la Trasferencia Tecnológica (UNTEC) (www.untec.cl). It is a spin-off that was created in 1989. Its goal is to promote and execute all class of activities leading to a better use of scientific and technological knowledge, for the social, cultural and economic benefit of the country. UNTEC carries out applied research and development projects as well as technical consulting, for the public and private sector. Mostly, researchers from FCFM work in these projects, with the help from both external professionals and FCFM students. The *Novos Business Incubator (http://www.novos.cl)* was created by UNTEC, where it operated between 2008 y 2011, mostly related to initiatives of FCFM.

The Toha System (www.sistematoha.cl). It is an innovative technology for depuration of residual waters created and developed by Dr. José Tohá Castellá, at the biophysics lab of FCFM. It received the ALCATEL award for innovation in 2000. The technology is used both in Chile and abroad. It was patented by UNTEC, the Foundation for Technology Transfer associated to UChile. AccesNova (www.accessnova.cl). This spin-off was born as a strong collaboration effort of the Department of Electrical Engineering with Japan for information and communication technologies. It was established in 1994 in cooperation with the Nippon Telegraph and Telephone Corporation (NTT). Under the terms of the AccessNova Program, FCFM and NTT Laboratories have jointly carried out testing and performed milestone experiments on high-speed network and broadband applications, including the first multimedia videoconference between Chile and Japan. It carried

out a large number of projects and added –over time– several other partners, such as NTT Research Laboratories, National Astronomy Observatory Japan (NAOJ), University of Tokyo, Waseda University, Keio University, Codelco, Telefonica and Universidad Técnica Federico Santa María of Chile.

YAHOO Labs Latin America. Yahoo Labs Latin America, based in Santiago, was the first Yahoo Lab established outside the United States, as a result of an agreement with UNTEC in 2006. Hosted in the Engineering School of the UChile at Santiago, this lab focuses on research in the areas of Web search and mining, harnessing the strengths of the Latin American academic search community through collaborations and joint projects, in particular with the Center for Web Research of the Computer Science Dept. In addition to a large number of papers, the lab has presented eight patents in the US.

i+e in education and outreach

U-cursos (www.u-cursos.cl). This was the first national web platform for managing communications between, professors, students and institutions, and that enables on-line collaboration for educational purposes. The first version of U-cursos was developed by FCFM in 2001. In ten years of development, the number of processes that U-cursos allowed has grown exponentially, going from simple one-to-one communications, to allow surveys, coordination of group studies, classroom assignments, document preparation support and so on. To date, all UChile Schools and Faculties use U-cursos, by two high schools and by the Instituto de Estudios Bancarios. Altogether, U-cursos has more than 30,000 users and this keeps growing a steady pace. U-cursos is today offered as a paid service by FCFM.

C5 (http://www.c5.cl/). The Computing and Communication Center for Building Knowledge of the FCFM offers the opportunity to support innovation and change in schools through curricular integration of Information and Communication Technologies (ICTs) in different contexts. In collaboration with the Ministry of Education of Chile, it has designed an evaluation process of schoolteachers ICT skills. Based on the results obtained, the teacher can define training routes that allow him/her to identify strategies for better integration and pedagogical use of digital tools and resources available. Another interesting project now is the application of a national university selection test for blind people. The technology used is the result of nearly 20 years research in Audio and Haptic Interfaces.

Math Education Lab (http://www.cmm.uchile.cl/?cmm_labs=cmm-e). The CMM-E is an Education Lab targeted at researching on the areas of Math Teaching and Learning at the high-school level. It was formally established in 2013, but all of its members have led many projects on the subject before, including (i) designing the new national standards for math teachers (ii) REFIP (led by Prof. Salomé Martínez, Director of E-CMM), project that, for the first time, provides texts and multimedia materials to help teachers and education students to comply with the new standards (iii) edition of 14 texts that include case studies and materials for high-school teachers. See http://refip.cmm.uchile.cl/textos.

Comunidad InGenio (www.comunidadingenio.cl). Comunidad InGenio is a program of Scientific and Education Outreach. It belongs to the Complex Engineering Systems Institute, hosted by FCFM. Ingenio is a very large program; among other things it has: (i) helped create more than 3 case studies (based on research) that can be used by high-school teachers to teach from optimization to transportation, (ii) created a program to prepare math high-school teachers on using advanced teaching techniques; 30 teachers are trained each year (iii) has a microeconomics course for social sciences teachers, who in addition to attending seminars receive materials that help their teaching in their own classrooms (iv) organized the GoCup contest where high school students compete on solving an actual problem (transport system; delivery system) on a computational platform (v) organize ten to twelve talks each year, where one researcher goes to a high-school to talk about engineering and how research can have a strong impact in real-life problems.

Física del Desorden (http://colegios.dfi.uchile.cl). This is a project from faculty from the Physics Department at FCFM. It offers materials to help teaching physics in high school. These professors have designed a number of experiments that can be easily replicated in classrooms, at low cost, and that show day-today phenomena that require physics to be understood.

a) Metrics description

Research, applied research and technology development, faculty development and interaction with industry, public sector and society.

The following metrics allow us to measure the impact of our research:

- PhD students: Number of students enrolled in the year.
- Full-time faculty: Number of full-time faculty members in March of each year.
- Papers: Number of papers in the year. Source: http://wokinfo.com/
- Citation of papers: Numbers citation in the year. Source: http://wokinfo.com/
- QS position: Position in the Engineering and Technology QS ranking.
- Top 200 subjects: Number of subjects related to the FCFM in the top 200 position of the QS ranking.

The following table presents the evolution of these metrics from the year 2002 to 2012:

Table 1.1. FCFM Research capacty. Source: FCFM database.

Variable	Year 2002	Year 2012	Variation
PhD students	88	224	155%
Full-time faculty	176	206	17%
PhD students/Faculty	0.5	1.1	117%
Papers	215	333	55%
Papers/Faculty	1.2	1.6	32%
Citation of papers	--	9,000	
Qs position	--	225	
Top 200 subjets	--	5	

There are 5 subject matters in the QS World University Rankings for which FCFM ranks above the top 200 position in the world.

Table 1.2. FCFM subjects ranked according to the QS World University Rankings.

QS World University Rankings by Subject 2013	QS-Rank
Earth & Marine Sciences	51-100
Engineering - Civil & Structural	151-200
Computer Science & Information Systems	151-200
Mathematics	151-200
Environmental Sciences	151-200

In the QS Ranking by Faculty 2013 - Engineering and Technology (see Table 1.3) we can see that there is a university in Chile that, while having lower results on H-Index and citations per paper, it has better indicators of academic and employer reputation. Therefore we have chosen these 4 variables to improve our international standing: Academic Reputation, Employer Reputation, Citations per Paper and H-Index. The hypothesis is that our level of research will allow us to enhance the reputation and thereby enhance international recognition. Consequently in the fields of research, applied research and technology development, faculty development and interaction with industry, public sector and society, we will use the QS Ranking by Faculty- Engineering as one of the relevant metrics.

Table 1.3. Top 10 QS Ranking by Faculty 2013 – Engineering and Technology, Latin America.

Position	University	Country	Overall	Academic Reputation	Employer Reputation	Citations per Paper	H-index Citations
93	Universidade de Sâo Paulo (USP)	Brazil	72	67	79	74	68
183	Universidade Estadual de Campinas	Brazil	67	64	67	75	64
191	Universidad Nacional Autónoma de México	Mexico	66	64	69	73	60
205	Universidad de Buenos Aires	Argentina	65	62	73	73	52
221	Pontificia Universidad Católica de Chile	Chile	64	63	74	62	49
225	Universidad de Chile	Chile	64	60	69	72	55
247	Universidade Federal do Rio de Janeiro	Brazil	63	61	63	73	58
267	Universidade Federal de Minas Gerais	Brazil	62	53	62	80	68
282	Universidade Nacional de Colombia	Colombia	61	58	68	67	52
291	Tecnológico de Monterrey (ITESM)	Mexico	61	62	76	51	39

On the other hand, the relationship with industry and the public sector have generated incomes that are similar to those obtained by fees from undergraduate and postgraduate programs and research, as can be seen in Table 1.4. In 2013, the FCFM total income, without research grants, was about USD$90 million, where the academic programs provide $42 million USD ($24 million USD related to undergraduate programs, $8 million USD to postgraduate programs and $10 million USD research subsidy from government). Thus, $48 million USD corresponds to contracts and services for the industry and public sector.

Table 1.4. Income from undergraduate, graduate and provided services. Source: FCFM.

Type of Income	Millions of USD		
	Year 2011	Year 2012	Year 2013
Undergraduate programs	$20	$24	$24
Postgraduate programs and continuing education	$8	$9	$8
Government subsidy for research	$10	$10	$10
Services	$46	$42	$48
Total	$75	$85	$90

Our faculty has a significant relationship with CORFO, which is the main government agency that promotes innovation, entrepreneurship and technological transfer. On the one hand, out of the first 4 international centers that CORFO has promoted, 2 were established with participation of FCFM (CSRIO and INRIA). On the other hand, FCFM has received funding for nearly 20 different projects supported by CORFO. The following table presents the amounts of funding received from Innova-CORFO instruments in the last 3 years.

Table 1.5. Innova-CORFO grants obtained by the FCFM between 2011-2013.

Innova CORFO Projects	Period 2011-2013 Millions of USD
Installation of international centers: CSRIO and INRIA	$34
19 projects along five lines of support instruments	$5
Total Innova-CORFO grant	$39

Innovation. Number of patents. Source: INAPI.
The following Table 1.6 presents a summary of FCFM patent applications and number of patents accepted during the years 2005 and 2013. Although there are not many patents applications, there are a few very successful cases, an example is the spin off "Sistema Toha" which has generated more than a million dollars, www.sistematoha.cl.

Table 1.6. Number of patents per year. Source: INAPI.

Item/Years	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of Patent applications.	3	2	3	3	4	4	3	5	4
Number of Patents accepted.	1	1	0	2	1	1	0	2	2

Quality of our students and graduates

The last student accepted into our undergraduate program had a score of 718 out of a maximum of 850. This score is in the top 3% of the national admission test. Our graduates have the highest employability and income of all professions in the country, as Table 1.7 shows.

Table 1.7. Employability for the first year FCFM Engineers. Source: http://mifuturo.cl/

Major/Engineering UCHILE	Employability in the first year
Biotechnology	91.40%
Chemical	100.00%
Civil	98.30%
Computing	98.90%
Electrical	96.80%
Industrial	97.80%
Mechanical	95.10%
Mining	98.40%

Student International experiences.

The FCFM has 3 Student Mobility Programs available to students: The Student Mobility Program FCFM (PME-FCFM), which includes agreements of the FCFM with prestigious universities in the world, the International Internships for Engineers program (IIE), allowing students of our school to do internships in senior foreign companies, and the Central student mobility Program of the University of Chile (PME-Central), which is managed in the Central House of the University of Chile and allows mobility of students from University of Chile and of foreign students that want to study in Chile. As presented in the table below, between 2007 and 2011, 156 Engineering students of University of Chile used these programs. In the same period, 98 foreign engineering students studied a semester in the School of Engineering of the University of Chile.

Table 1.8. Students who had an exchange experience. Source: FCFM.

Students who studied a semester in another university or had foreign internships. 2007-2011	IIE-Internships	PME-Central	PME-FCFM	Total Students with foreign experience
Students of foreign university who studied a semester in FCFM	0	55	43	98
FCFM Students who studied in any foreign university for a semester or had foreign internships	90	36	30	156

FCFM has multiple student exchange agreements. IIE (International Internships for Engineers) is the FCFM program for international internships. Thanks to this program, students from different specialties of the FCFM have the option of paid internships in foreign companies. The following table presents only the number of student exchange agreements that have been in operation between 2007 and 2011, and it summarizes also the countries in which the FCFM have internships agreements with companies.

Table 1.9. Number of universities and foreign companies with FCFM agreements (exchange and internship)

Country	N° of universities with student exchange agreements	N° of foreign companies with internship agreements
Australia	0	1
Belgium	1	0
Canada	1	0
Finland	1	0
France	13	1
Germany	1	1
India	0	1
Italy	1	0
Malaysia	0	3
Singapore	0	6
Spain	2	8
Sweden	1	0
Total	21	21

As shown in the table 1.10 below, 106 FCFM students went for an internship abroad between 2007 and 2012.

Table 1.10. Number of FCFM's students who had an internship abroad.

Country/Year	Spain	France	Malaysia	Singapore	Germany	Australia	India	Total
2007	32							32
2008	16							16
2009	8	1	4	5				18
2010	3		3	2				8
2011	2		5	7	1	1		16
2012	2		6	7			1	16
Total	63		18	21	1	1	1	106

The number of foreign undergraduate students spending a semester at the School of Engineering of UChile has increased. In the year 2012, 21 foreign undergraduate students studied in FCFM, as reported in Table 1.11.

Table 1.11. Number of foreign undergraduates students who studied a semester in the FCFM.

Number of foreign undergraduate students who studied a semester in the FCFM	Number of foreign students
Autumn 2007	1
Spring 2007	5
Autumn 2008	1
Spring 2008	2
Autumn 2009	1
Spring 2009	8
Autumn 2010	4
Spring 2010	9
Autumn 2011	5
Spring 2011	7
Autumn 2012	11
Spring 2012	10
Total	64

On the other hand, there is an increasing amount of FCFM students who choose to spend a semester abroad:

Table 1.12. Number of FCFM´s students who studied in a foreign university for a semester.

FCFM Students who studied in any foreign university for a semester	Number of FCFM Students
Spring 2007	3
Spring 2008	5
Spring 2009	4
Spring 2010	8
Spring 2011	7
Autumn 2012	1
Spring 2012	18
Total	46

Student multidisciplinary experiences

From 2003, FCFM has developed the 6 innovative multidisciplinary projects in which the students participated voluntarily, as described in Table 1.13.

Table 1.13. Number of participating students in emblematic multidisciplinary projects.

Emblematic multidisciplinary projects	Beginning year of the program	Number of participating students
Ultralight aircraft	2003	15
Formula i	2003	30
RoboCup	2004	63
Eolian	2007	30
Fab Lab	2013	20
CMS	2002	1.000

- Ultralight aircraft: In 2003 a group of students and academics of the FCFM designed and built an ultralight aircraft from scratch.
- Formula i: The "Formula i" started in 2003, as an electric cars competition where cars were built by engineering students. Many groups of FCFM students participated in this competition during the years 2003 and 2005 (the last year of the competition).
- RoboCup: The RoboCup is an international robotics competition; the name is a contraction of the competition's full name, "Robot Soccer World Cup". Since 2004 the FCFM actively participates in the RoboCup competition.
- Eolian: Eolian is the name of a series of solar vehicles designed and constructed by students, staff and faculty of the Universidad de Chile. Up to now, three versions of the Eolian (solar car) have been made.
- Fablab: The Digital Fabrication Laboratory (FabLab) at FCFM provides modern tools for invention. It aims at producing a new type of working atmosphere were research, creativity, art and innovation meet together to produce new concepts, products and real engineering designs. During 2014 we will move our Fab Lab to a new 450 square meters space at Beauchef 851 building.
- CMS: is a social entrepreneurship, which has featured over 1.000 engineering students as voluntaries. http://www.construyendomissuenos.cl/

Curriculum

At present, during the common core (first 2 years) there are 3 project courses aimed at improving student teamwork skills, and communication and engineering design. In the next 2 years (bachelor's degree) there are no project courses. There are not mandatory courses in innovation and entrepreneurship in the undergraduate school.

Table 1.14. Number of project-oriented courses before and after 2007.

Type of courses	Before 2007	After 2007
Mandatory project-oriented courses in common core (first 2 Years)	0	3
Mandatory project-oriented courses in Bachelor degree (Years 3 y 4)	0	0
Mandatory courses in i+e based on scientific and technological knowledge	1	0

The FCFM has several courses related with innovation and entrepreneurship in a broad sense; 25 courses were taught in 2013 with 514 students. The following table presents a summary of the courses in innovation and entrepreneurship by major. Eight courses were taught by electrical engineering with 86 students. Although the specialty with more students taking courses related to innovation and entrepreneurship is industrial with 247 students.

Table 1.15. Number of innovation and entrepreneurship courses for majors.

Number of courses innovation and entrepreneurship/ Major	Autumn 2013		Spring 2013		Total Students Year 2013	Number of Courses Year 2013
	Number of Students	Number of Courses	Number of Students	Number of Courses		
Industrial	15	1	232	6	247	7
Electrical	44	4	42	4	86	8
Engineering School	17	1	45	1	62	2
Mechanical	32	2	25	2	57	4
Mining	12	1	19	1	31	2
Civil	0	0	23	1	23	1
Biotechnology	0	0	38	1	8	1
Total	120	9	394	16	514	25

About 1,100 students per semester enrolled in an English course, representing 25% of undergraduates. There are five levels of English required to ensure that all of our graduates have the necessary communication skills to study or work abroad. The number of students enrolled in each level during 2013 was as follows:

Table 1.16. Number of English students in the FCFM per semester and level.

Number of students in English Courses	Students Autumn 2013	Students Spring 2013
Level 1	81	110
Level 2	199	161
Level 3	275	237
Level 4	284	290
Level 5	265	302
Total students per semester	1,104	1,100

The number professors that were trained abroad in active education methodologies during the last three years are the following:

Table 1.17. Number of professors trained abroad in active education.

Professors trained abroad in active education		
Year 2011	Year 2012	Year 2013
0	3	0

Organizational Structure

The functions of technological transfer, international relations and student affairs are supported by the following structure:

Table 1.18. Number of persons and annual budget of the offices, which support the functions: Technology Transfer, External Affairs, and Student Affairs.

Position in the organizational structure / function	Full-time staff	Annual Budget
Associate Dean for Technology Transfer	0	0
Associate Dean for External Affairs	0	0
Office of Student Affairs (student support & international relations)	16	$ 0.5 Million USD

There is no office of Technology Transfer in FCFM structure. The Associate Dean Academic and Research, manages institutional international relations related to faculty development. The international relations functions in the Office of Student Affairs are limited to student mobility programs. This office has a staff consisting of 16 people in 4 areas: quality of life, individual student support, student organizations support and international exchange agreements.

b) National and international networks and relationships

UChile has signed thousands of collaborative agreements (general and specific) with 320 higher educational institutes and international organizations in 46 countries. It participates in more than 200 networks, consortia, associations and alliances in the world, such as: APRU, SYLFF, OUI, CNRS, OEA, UNESCO, ERASMUS ECW, European Union Frame Program (EURO), ALFA, among others. Around 1,800 academic short-term and long-terms stays abroad are reported yearly. UChile participates with foreign universities in thesis co-tutorship, double-degree programs, joint post-graduate programs, double professional title at the pre-graduate level, and in research activities. The University receives approx. 1,000 international professors and researchers per year to elaborate the before-mentioned programs and activities. The University receives 1,400 foreign students (pre-graduate and post-graduate level) yearly. There are also more than 70 student exchange agreements to study abroad. Likewise, yearly more than 200 students from the University carry out their studies abroad.

Around 1.800 academic short-term and long-terms stays abroad are reported yearly.

The International Relations Office is in charge of promoting, strengthening and expanding the international links of the UChile that benefit directly from the management and development of the strategic programs of the institution. For this reason they work in coordination with the academic units (faculties, institutes, professors and students in general) and with the central pre-graduate, post-graduate and research divisions.

Agreements and relationships with foreign universities

The Student Mobility Program (PME-FCFM), consisting of one or two semesters abroad, dual degree programs and international internships, coordinates most of the mobility programs for students. International mobility for students is granted via a large array of partnerships and networks with universities and institutions worldwide, which include the following international networks:

- *Ampère, Groupe des Écoles Centrales (GEC) and Groupe des Écoles de Mines (GEM) in France*
- *GE4 (Global Educations for European Engineers and Entrepreneurs) and Magalhaes/SMILE in Europe*
- *Bilateral specific agreements with international universities, such as Mc-Gill University in Canada and Université Lyon in France, offering over 20 universities with active double degree.*

In addition, the FCFM offers internships programs with over 20 international companies (IIE: International Internships for Engineers). Thus in average, 10 foreign undergraduate students per semester stay at the FCFM, and 8 undergraduate students per semester go abroad. These numbers are increasing at a rate of 1 student per year.

Relationships with the public sector and enterprises for providing services

IDIEM, NIC and CSN have a relationship with the public sector and enterprises for providing services for over $40 million USD a year.

The IDIEM is an institution of the Faculty of Physical and Mathematical Sciences, UChile. It was founded in 1898 as a workshop of Strength of Materials, under the School of Engineering of the UChile, with the main objective to test and verify the quality of the materials used in public constructions, becoming in this way the first Lab Technical Control Materials that existed in the country. In 2005 according to the Exempt Decree No. 001338 of the Dean of the FCFM, the unit was renamed Centre for Research, Development and Innovation of Structures and Materials. Currently the IDIEM is registered in the Official Register of Laboratories Technical Quality Control Construction, according to Supreme Decree No. 10 of the Ministry of Housing and Urbanism 2002, in addition to multiple accreditations to the National Institute of Standards (INN).

NIC stands for "Network Information Center", or Network Information Center, historic name used worldwide to define the organization responsible for administering domain names on the internet in any category. The world organization administering the Internet domain names, IANA (Internet Assigned Number Authority), in 1986, delegated the exercise of that function in the Department of Computer Science of the UChile, in order to allow creating domain names corresponding to our country, resulting in the ". cl suffix."

CSN is the national seismological center, CSN's mission is to provide to Chilean authorities, ONEMI and SHOA, seismic information that occurs in the country in a timely and accurate manner in terms of epicentral location and magnitude.

Center for Mathematical Modeling - CMM (http://www.cmm.uchile.cl)

The Center for Mathematical Modeling (CMM) is a national leading scientific center for research and applications of mathematics. It aims to create new mathematics and use it to solve problems coming from other sciences, the industry and public policies. It was created in 2000 by a group of researchers of the Department of Mathematical Engineering at UChile, with the support of FONDAP CONICYT. CMM is also an international unit of the National Center for Scientific Research (CNRS) of France, and has an important wide world network of counterparts. Over these two decades the Center has contributed to the innovation and solution of public and industrial problems in areas where mathematical modeling has shown to be essential, especially where the Chilean economy has advantages, like mining, astronomy, energy and natural resources. Nowadays it features six consolidated laboratories, four emerging labs, and another

four in exploratory phase, covering a wide range of application areas. The mission of the CMM is to create new mathematics and use it to solve problems coming from other sciences, the industry and public policies. Its aim is to develop science with the highest standards, which also guides its endeavors in industrial research and education. We envision CMM as a world-class center of excellence for research and advanced training in applied mathematics, internationally recognized as a platform for mathematical industrial modeling with the highest impact in innovation.

The International Scientific Committee (ISC) comprises selected worldwide renowned researchers in the areas actively developed at CMM. This board helps CMM in the evaluation of its strengths and weaknesses, and in keeping abreast of the new trends in fundamental and applied research activities: John Ball (President, Oxford University, UK), Jean Bertoin (Universität Zürich, Switzerland), Luis Caffarelli (University of Texas, USA), Ivar Ekeland (Université Paris-Dauphine, France), Martin Grötschel (Technische Universität Berlin, Germany), Masayasu Mimura (Meiji University, Japan), Olivier Pironneau (Université Paris VI, France), James Yorke, (University of Maryland, USA). On the other hand, the Industrial Advisory Board (IAB) advises CMM on industrial topics and the opening of the Center to new areas of applications and new business opportunities. The members of this board are the following: Yuji Inoue (former VP R&D, NTT; Chairman of the Board, TOYOTA Info-Technology Center Co. Ltd.), Maurizio Arienzo (former VP and Managing Director – Consumer Electronics at IBM; CEO, NovaWare Inc.), José Luis Daza (Founder and CEO, QFR Capital Management L.P.), and Álvaro Fischer (Chairman of the Board, Fundación Chile).

Complex Engineering Systems Institute - ISCI (http://www.sistemasdeingenieria.cl/isci/index.php?idioma=_en)

The Faculty of Physical Sciences and Mathematics (FCFM) is the only engineering school whose professors have been supported by the most important Chile government grant for applied research: the Millennium Institute Scientific Initiative. The Complex Engineering Systems Institute (ISCI) is a top scientific research center in the engineering systems area that manages problems of great size or special complexity. The ISCI works includes a continuum from methodological research; in disciplines like operation research, microeconomics, industrial organization and mathematics; to areas like transport, energy, mining, forestry, information technology, retail, production management and public sector, developing high country impact projects in the knowledge frontier. Relations to the industry and the government are vital for the Institute. The ISCI, through productive innovation, does research

on relevant unsolved industrial problems. Many of the Institute's researchers are involved in major projects of public agencies, including, among others, the Criminal Public Defender, JUNAEB, and different ministries and government institutions (transportation, environment, etc.). Its activities in the industrial sector include, among others, initiatives with the forestry, mining, salmon farming and retail sectors, with such companies as Compañía Sudamericana de Vapores, CMPC, Multiexport, and BHP Billiton, among others. The activities carried out together with industry have allowed a number of students and graduates to take part in different applied projects.

Today, the Institute has 33 researchers of the UChile and three other universities. They include outstanding researchers and young promises; all of them Ph.D. from renowned universities and authors of several publications in international journals with ISI standard. The Government of Chile, through ICM and CONICYT, funds the Institute in addition to industrial resources for applied projects. One of the main strengths of the Institute is the generation of synergy among the most diverse engineering areas: Industrial Engineering, Transportation Engineering, Mathematics Engineering and Electrical Engineering. This provides the tools to position itself in a privileged place within the academic world, becoming a national and international scientific research benchmark, able to create, from engineering, innovative and efficient answers to the most challenging current problems.

Other Advanced Research Centers

The FCFM has different advanced research centers that are part of national and international networks and partnerships, which include the following:

Advanced Mining Technology Center – AMTC (http://www.amtc.cl/?lang=en): the AMTC has established important cooperation agreements and joint research projects with scientists and world-class technology centers. Among its partners are Codelco and BHP Billiton, whose representatives are members of the AMTC board.

Andean Geothermal Center of Excellence – CEGA (http://www.cega.ing.uchile.cl/cega/index.php/en): This center works to generate and improve geothermal knowledge in Chile. CEGA is sponsored by the UChile and works in collaboration with the Catholic University of Chile (PUC) and the government (SERNAGEOMIN).

Solar Energy Research Center – SERC (http://www.sercchile.cl/?lang=en): The SERC is a joint center with the UChile, UTarapacá, UAntofagasta, U. Técnica Federico Santa María, U. Adolfo Ibañez, UConcepción and the Fundación Chile. The center has been sponsored by the Ministry of Energy, Enel Green Power companies, Minera Doña Inés de Collahuasi, Chile Abengoa SA and Minera Gaby Gabriela Mistral SPA of Codelco Chile Division.

Center for Climate and Resilience Research – CR2 (http://www.dgf.uchile.cl/CR2/?page_id=1550&lang=en): This is a world-class research center focusing on Earth System Science. This center is sponsored by the UChile and is associated with the UConcepción and the U. Austral of Chile.

Center for Astrophysics and Associated Technologies – CATA (http://www.cata.cl/index_en.php): This center is located at the UChile in the Department of Astronomy at Cerro Calan and its associated with the Department of Astronomy of PUC and the Department of Physics of UConcepción.

Association of CSRIO and INRIA with the FCFM

To transform Chile into the innovation hub of Latin America, CORFO invited various international centers of excellence to settle in our country with the purpose of developing new projects and technologies in strategic sectors for Chile; such as mining, food, computers and biotechnology. Two of the four selected centers chose the FCFM as a key partner: INRIA (France) and CSIRO (Australia).

CSRIO is one of the largest and most diverse research centers in the world, ranked top 1% in the world in 13 research fields. Thousands of companies utilize CSIRO innovations in their business. This center will be established in Chile in alliance with the Advance Mining and Technology Center (AMTC) of the FCFM. The objective is to integrate academia and industry to find solutions aimed at improving the efficiency of the national mining sector in Chile.

The INRIA center, which in Chile is called CIRIC – the Communications and Information Research and Innovation Center - is dedicated to research and innovation transfer in the ICT field. This program was established by INRIA the French institute devoted to research and technology transfer in digital technologies, and is executed with nine other Chilean universities. Created in 2012, it is scheduled to develop during ten years. Projects are developed in three strategic lines: Internet and Telecommunications, Hybrid Energy and Natural Resources Management.

1.2. Institutional commitment

In the organization of UChile, normative and strategic decisions lie in the Faculty Councils, chaired by the Deans, and for specific matters requiring high-level approval, in the University Senate and University Council, both chaired by the President of the University. The University Senate is a normative and strategic council, with representatives of faculty (60%), students (30%) and staff (10%), elected by their peers. The University Council is a collegiate executive board, composed of the Provost, school Deans and two external members appointed by the President of Chile. The Statute of the Corporation, in place since 2005, regulates the current system.

The initiatives are generated and studied at the local level by Department committees, School councils and Faculty boards, with recommendations sanctioned at the appropriate Faculty and University levels. Administratively, UChile is organized centrally in terms of its academic and educational projects, with general guidelines to be pursued by all the disciplines. Nevertheless, the organization is decentralized for managing the economic resources that are either yearly allocated by the central authorities or directly obtained through project funding and services. This scheme provides ample opportunities to each Faculty to best optimize the resources available and reach their goals.

There is an Institutional Development Plan (IDP), approved by the University Senate in 2006, which has became the roadmap designed for UChile. The IDP describes the vision of UChile as a higher education institution guided by international standards of academic excellence, which creatively and effectively responds to the conditions and challenges of globalization and the integration of Chile in the world, following a path that is consistent with the historical mission, state and national public nature and commitment of the university.

The task of reflecting on and proposing strategic plans to transform the FCFM School of Engineering and Sciences to that of a world-class organization is undoubtedly a major challenge that is entirely consistent with the IDP of UChile. Within this institutional framework, and motivated by the invitation to participate in the national effort proposed by Innova-CORFO to establish a "New Engineering for 2030" in Chile, a team composed of officials, academics and professionals have conducted a critical diagnosis and benchmarking study for the FCFM.

Through literature review, international consulting, interviews, local workshops, visits abroad and other activities, the team was able to conceive a comprehensive, ambitious and feasible strategic plan for the FCFM for the following years, touching upon several issues. This plan emphasizes the third mission of UChile and the importance for the country of applied research, development and technology transfer, innovation and entrepreneurship based on R&D. This project coincides with a major expansion of the FCFM in progress during the last decade, under the direction of the current Dean, Prof. Dr. Francisco Brieva, with an explicit commitment by the academic authorities to promote the renewal and change in the orientation of faculty research, teaching plans and methodology of our students.

This was reported to faculty, students and staff in public workshops held at the FCFM, both at the Faculty and Department level. The obtained feedback was incorporated in the identification of possible actions to address the main gaps. The Faculty Council has approved the key elements of this plan recently.

In knowledge of the "New Engineering for 2030" proposal from the FCFM, the President of UChile conveyed formally to the Dean his enthusiastic and determined commit-

ment for this initiative. Moreover, in addition to the local economic resources, academic and student contributions to the FCFM plan, *the President has assumed, with the objective of supporting this effort, the management necessary to foster the installation of a technology village at the Laguna Carén: a site of more than 2,000 acres that is located in the Lo Aguirre valley, east of Santiago, on Route 68 to Valparaíso and next to Santiago's international airport, 20 minutes by car from FCFM's Beauchef campus. This will allow establishing the centers for technological innovation and entrepreneurship serving as the basis for the development of a unique i+e ecosystem in the Metropolitan Region of Chile, with a major impact.*

This plan is the fundamental base for the proposal that has been submitted to Innova-CORFO. The current Deputy Dean has been appointed as Head of the Project and the starting multidisciplinary faculty team has been expanded to cover new areas of expertise and skills. The management and administrative actions of the plan will be performed essentially at the Faculty level. Considering the highly dynamic activity of projects undertaken up to now, the Faculty has years of experience in the management, implementation and successful completion of projects. Permanent staff is trained to meet the demands of projects, all of which are within the rules of the government that regulates our actions.

The expected added institutional value and associated impact are related to the engineer training with a renewed profile that allows them to take on the growing demand for innovation. The benefits that the FCFM expects to obtain are related to consolidating an outstanding institution in the world that fosters the liaison between the country and the global society development, being the architect to generate knowledge, products, ventures and human resources recognized on an international level. This makes up part of the vision of UChile, a representative characteristic of higher education provided by the state within the country. The School will guide student's research towards scientific and technological innovation in the major problem areas relating to engineering and the challenges of the nation in its path to development: energy, water, business

and global capital markets, infrastructure and resilience, science-technology-society, advanced manufacturing and digital manufacturing, big data networks, high-performance computing, to mention a few.

The institution will benefit from the increase in technology transfers, relations with the business world and the development of technological innovations in specific areas according to the needs of the nation. We will be the host to welcome and nurture corporations and reinforce our global concerns regarding resources, environment and the economy. Our major challenge consists of devoting significant creative efforts in order to respond to emerging needs. The general goal is to take this opportunity to establish us during this decade as a world-class institution in the field of engineering and within disciplines that sustain or interact with it. In the upcoming decade, with an environment of socio-economic development and availability of adequate resources, we will reach a prominent place in the world and serve as a national source of opportunity for development, innovation and entrepreneurship.

Through the "New Engineering for 2030" project and its installation in Laguna Carén, new extraordinary opportunities await to establish a truly valley of technology; a place of meeting, exchange and generation of ideas, a space for applied research, development and technology transfer, innovation based on R&D, opportunities for wealth creation between university-based ecosystems and industry, a source of welfare for our society, a unique experiment in the country that allows for a new vision of taking on the challenges of the century.

References

[1] Eds. Fernando Lund, Bernabé Santelices, Juan Asenjo y Tomás Cooper, Academia Chilena de Ciencias, 2013.

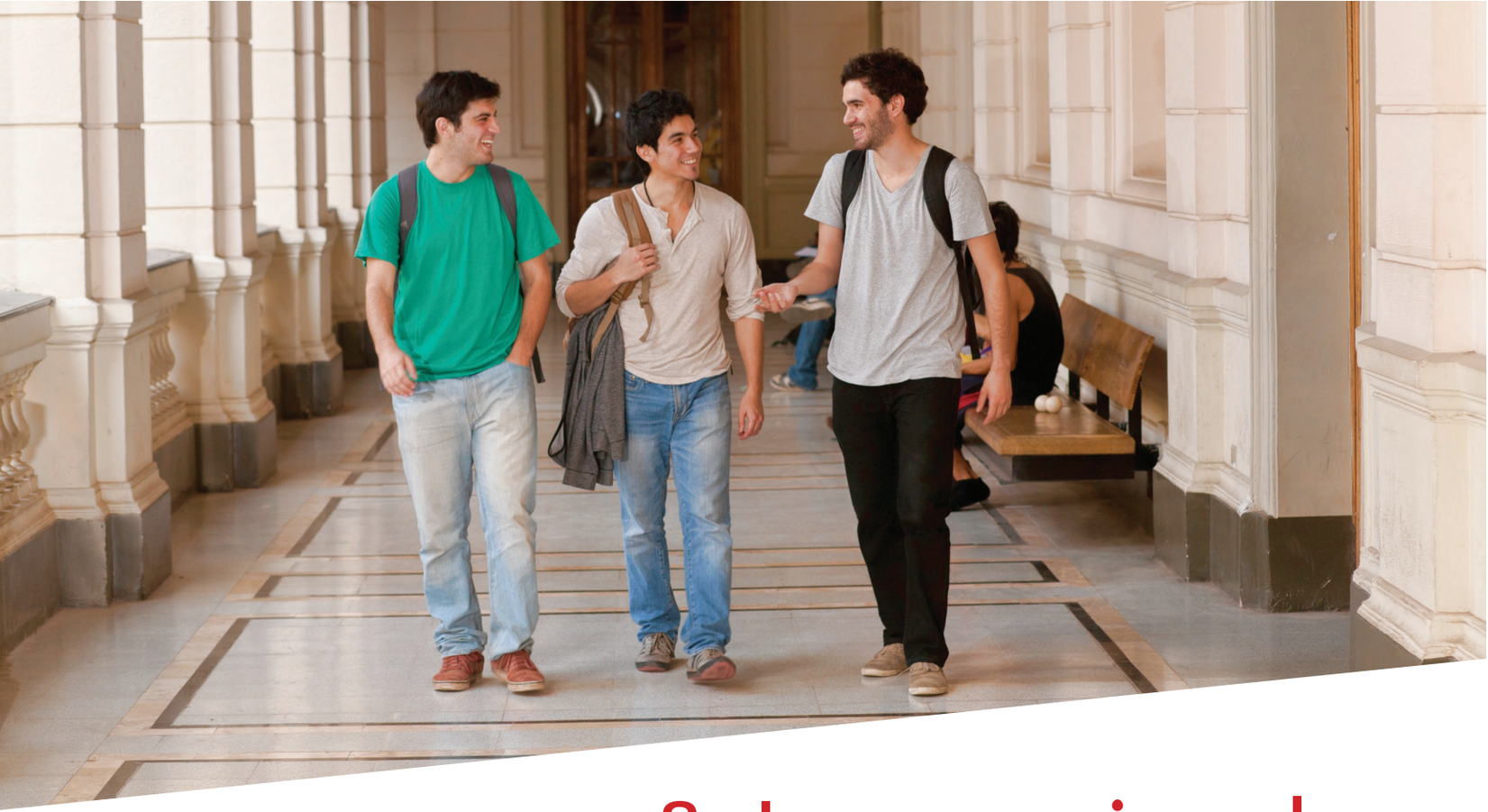
Interviews, surveys and workshop for diagnosis.

Institutions
Tomás Guendelman: President Institute of Engineers Fernando Agüero: President College of Engineers Mauricio Sarrazín: Engineers Academy President of Chile Jorge Atton: Deputy Secretary of Telecommunications. Chilean government Pedro Pablo Errázuriz: Secretary of transportation and telecommunications of the Chilean government Gloria Hutt: Deputy Secretary of transportation of the Chilean government
Companies
Antonio Hales: Head of Scientific Operations - ALMA (Atacama Large Millimeter/submillimeter Array) Guillermo Ugarte: Chief of Process. AMEC Gabriel Meruane: Projects Director. SQM Enrique Miranda: Manager. IIMCH
Alumni and Faculty
3 Interviews with alumni innovators 47 Interviews with alumni 2 Interviews with alumni who work abroad 97 Surveys with alumni 13 workshop with faculty of all majors

2030

A New Engineering for 2030

Benchmarking



2. International Benchmarking

The purpose of this benchmark study is to know first-hand the strategies followed by some world leader institutions that successfully went through changes in the areas of engineering education, research and development, technology transfer, innovation and entrepreneurship, and internationalization, or that have been leaders in some or all of these areas for years. In particular, we are interested in knowing the key factors that drive the change and what the critical elements and best practices for sustained success are.

It was decided to start with some meetings and workshops with international consultants in Santiago, selecting the most appropriate institutions for the benchmarking analysis. Then, every selected institution was contacted and 5 delegations of team members, including the Deputy Dean and the Associate Dean for Undergraduate School, were sent to visit them for personal interviews with authorities, managers, faculty, students and staff. Once back in Santiago, all gathered data and information were discussed in internal workshops of the project team, presented to the Faculty Council and then reported to faculty, students and staff in a public workshop held at the FCFM. Finally, the obtained feedback was incorporated in the conclusions and identification of possible actions to address the main gaps, which are presented here.

2.1. Benchmarked Institutions: Selection approach

In order to have a feasible plan for change, the institutions to be benchmarked cannot just be successful; in addition they have to bear some resemblance and connection with our own Institution. Indeed, according to the report presented by Graham (2013)[2], most successful change programs did conduct previously a brief benchmarking process; yet academic faculty members had a tendency to resist change when the institutions that were proposed as role models were dissimilar and unconnected to the real situation of their own institutions. Taking this into consideration, it was decided to perform the study by selecting as main case studies two institutions that (i) are public as FCFM is, (ii) have an administrative structure analogous to ours, (iii) include social responsibility among their goals and (iv) are world-leading research universities: the University of California at Los Angeles (USA) and the University of Manchester (UK).

In addition, it was decided to perform focused benchmarking exercises with institutions that are world-leaders in specific topics that are of interest to this project. These institutions, which were proposed by leading engineers, local community members and external advisors, are: Olin School of Engineering (USA), Massachusetts Institute of Technology - MIT (USA), California Institute of Technology – Caltech (USA), Chalmers University of Technology (Sweden), Karlsruhe Institute of Technology (Germany), University of Groningen (Holland) and University of Waterloo (Canada). During the benchmarking process, an important issue that was identified is the quality of the technology innovation ecosystems in which leading universities are operating. In this direction, Technion – the Israel Institute of Technology – was consistently cited as one of the most highly regarded university-based i+e systems operating successfully in challenging environments. Furthermore, Technion is the Cornell University (USA) partner for a new applied sciences and technology campus to be built on Manhattan's Roosevelt Island in New York City.

Table 1 below summarizes the institutions that were benchmarked, the activities conducted at each of them and both the reason for choosing the institution and the role it will play in this project. Details are provided in the following sections but it is very important to note that, in all cases, professors working on this project travelled to those institutions to hold meetings with high-ranked officials. Furthermore, in some cases consultants came to Chile for work meetings. Table 2 summarizes the universities regarded as reference institutions for the implementation of technology i+e university-based hubs. Table 3 summarizes the position of the considered institutions

> Olin School of Engineering (USA), Massachusetts Institute of Technology - MIT (USA), California Institute of Technology – Caltech (USA), Chalmers University of Technology (Sweden), Karlsruhe Institute of Technology (Germany), University of Groningen (Holland) and University of Waterloo (Canada).

Therefore, it was decided to include Cornell University (USA) and Technion (Israel), through their joint Cornell NYC Tech project, as reference institutions as well.

according to the QS World University Ranking 2013. As a reference, according to the QS ranking, the UChile ranks in the position 223 worldwide while FCFM ranks 225.

Table 2.1. Benchmarked institutions.

Benchmarked institution	Type of work conducted	Approach
University of Manchester	Interview with authorities and engineering campus visits.	Global Role Model. Partner in possible joint MSc program on i+e sc-t.
University of California at Los Angeles	Interview with authorities and engineering campus visits.	Global Role Model
The Franklin W. Olin College of Engineering	(i) During visit to Chile by consultants: a document was produced with the conclusions obtained after the meetings with stakeholders of the faculty. This document was used as input for preparation of diagnostic and benchmarking. (ii) Interview with authorities and engineering campus visits.	Focus: Engineering education Role: Consultants for teaching innovation.
Massachusetts Institute of Technology	(i) During visit to Chile by consultant: a document was produced with the conclusions obtained after the meetings with stakeholders of the faculty. This document was used as input for preparation of diagnostic and benchmarking. (ii) Interview with authorities and engineering campus visits.	Focus: i+e in Engineering education, i+e culture Role: Partners for entrepreneurship education in engineering; consultants for Improving CDIO approach; consultants for improving i+e culture and environment
Caltech	Interview with authorities and engineering campus visits.	Focus: R&D in the most challenging science problems Role: Model for R&D in science.
Chalmers University of Technology	Interview with authorities and engineering campus visits.	Focus: Engineering education, internationalization Role: Model for teaching and curriculum innovation, internationalization
Karlsruhe University of Technology	Interview with authorities and engineering campus visits.	Focus: Engineering education, internationalization Role: Model for teaching and curriculum innovation, internationalization
University of Groningen	Interview with authorities and engineering campus visits.	Focus: Engineering education, internationalization Role: Model for teaching and curriculum innovation, internationalization
University of Waterloo	Interview with authorities and engineering campus visits.	Focus: R+D+i+e Role: Model R+D+i+e; model for technology hub UChile

Table 2.2. Additional reference institutions for university-based technology i+e hubs.

Reference institution	Type of work conducted	Approach
Cornell University (NYC Tech campus)	Interview with authorities and engineering campus visits.	Focus: TT, innovation and entrepreneurship. Role: Partners for accelerating our start-ups and design of technology hub at UChile
Technion – the Israel Institute of Technology	Interview with authorities and engineering campus visits.	Focus: TT, innovation and entrepreneurship. Role: Partners for accelerating our start-ups and design of technology hub at UChile

Table 2.3. QS World University Ranking 2013 of all considered institutions

Institution	QS Worldwide	QS Faculty of Engineering and Technology
University of California at Los Angeles (USA)	40	16
University of Manchester (UK)	33	28
Olin School of Engineering (USA)	-	-
Massachusetts Institute of Technology – MIT (USA)	1	1
California Institute of Technology – Caltech (USA)	10	10
Chalmers University of Technology (Sweden)	202	55
Karlsruhe Institute of Technology (Germany)	116	33
University of Groningen (Holland)	97	-
University of Waterloo (Canada)	180	46
Cornell University (USA)	15	24
Technion (Israel)	183	123

The remainder of this section is structured as follows. Section 2.2 describes the current situation and the strategies and actions followed by the two main case studies, while Section 2.3 describes the same for the focused case studies. In both cases future relations with each benchmarked Institution are discussed. Section 2.4 described the Cornell NYC Tech + Technion reference. Section 2.5 contains a thorough analysis of differences and gaps between the current situation of FCFM and the benchmarked Institutions, identifying possible causes for those gaps and making a first assessment of actions. Section 2.6 contains a brief plan for updating the benchmark as time progresses.

2.2. Benchmarked Institutions: main case studies

Main Case Study 1: The Henry Samueli School of Engineering and Applied Science, University of California Los Angeles, Los Angeles, California, USA

An important figure is the high percentage of students (> 50%) taking part in junior clubs or engineering chapters of several associations, without credits.

Overview

The School of Engineering at University of California, Los Angeles (UCLA), with nearly 70 years of existence, is located within one of the largest public universities in California, USA. It is an institution devoted to leading research and teaching, with a special focus on biomedical and bioengineering sciences. The goals of UCLA's Engineering School are: 1) to impact with their research and work, the future lives of people in ways they cannot yet imagine, 2) to create a multidisciplinary environment for teaching and research, especially in the biomedical and bioengineering sciences and 3) to develop innovation and entrepreneurship within their community. The School of Engineering at UCLA holds a very good reputation in research with strong undergraduate programs (top 10% of students in the country). The administrative structure of the School of Engineering follows this scheme: the head of the school is the dean, supported by three associate deans (dean of academic and student affairs, dean of research and physical resources, the dean of international initiatives and online programs) and an assistant dean (CFO). The academic demographic is: 18% women and 39% of minorities. In 2012, 14,100 students applied to the undergraduate program and only 619 were accepted. The same year, the number of undergraduate students was 3,232, and the number of graduate students was 1,776 (M.Sc., 856, and Ph.D., 920). The ratio of full-time faculty to Ph.D. graduate students is currently 5.8:1 with 156 full-time (all with a Ph.D. degree) and 93 part-time academics.

Reasons for its selection

The Henry Samueli School of Engineering and Applied Science is similar to the FCFM in its administrative scheme, size (students and faculty) and research focus. It also has undergone a curricular and cultural change recently (2007), driven by the current administration, in order to develop and foster innovation and entrepreneurship following a multidisciplinary approach within the faculty. This change was motivated by the fact that their graduates were losing competitiveness in the local and global market: colleges and uni-

versities in California are highly driven by innovation and entrepreneurship, and UCLA's School of Engineering was lagging. Who was interviewed? Authorities of the UCLA's School of Engineering: Vijay Dhir (Dean), Richard D. Wessel (Associate Dean, Academic and Student Affairs), Adrienne Lavine (Vice Chair of Undergraduate Programs, Mechanical Engineering), Daniel Kamei (Associate Professor & Vice Chair, Bioengineering), Pirouz Kavhepour (Associate Professor, Mechanical Engineering).

Engineering education

The Henry Samueli School of Engineering and Applied Sciences offers 7 Engineering degrees (Biomedical Engineering IDP, Bioengineering, Chemical and Biomolecular Engineering, Civil and Environmental Engineering, Computer Science, Electrical Engineering, Materials Science and Engineering, and Mechanical and Aerospace Engineering) that last five years divided into quarters (3 quarters per year). The first two years are devoted to basic mathematical and physical sciences, with one course of chemistry and one course of biology. Student training is based on lectures, with a final seminar or capstone (2 quarters) at the end of the fifth year. Also, several groups of students of different degrees participate in the national and international competitions, such as the Seismic Design Competition (won twice in a row by Mechanical Engineering students) and National bioengineering undergraduate competitions (won twice in a row by Bioengineering students). An important figure is the high percentage of students (> 50%) taking part in junior clubs or engineering chapters of several associations, without credits.

Research and development

UCLA stands in the top 31 ranking (QS, 2013), in the 16th position in Engineering Sciences worldwide, with Mechanical Engineering in the 12th position and Electrical Engineering in 8th. In Engineering (2013) it ranks 9 in the undergraduate programs and 16 in graduate programs nationally (QS, 2013). In the Times Higher Education World University Rankings, it holds the 7th place, and in the Microsoft Academic Search for H-Index, it holds the 4th place in cited papers (2012). The school houses ten research centers and institutes, such as the Center for Cell Control, and the Wireless Health Institute. Regarding awards and recognition, the Henry Samueli School of Engineering and Applied Science distinguishes:

Number of National Academy of Engineering members: 23
Number of PECASE recipients: 7
Number of National Medal of Sciences recipients: 2
Number of National Academy of Sciences members: 4
Number of Turing Award winners: 2
Number of Nobel Laureates: 1

Knowledge and technology transfer, and licensing

The Henry Samueli School of Engineering and Applied Science has a longstanding tradition of TT at the core of their work. Some of UCLA's Engineering School Milestones are, for instance:

- Crump Institute for Medical Engineering (1980): technological innovations mixing engineering and

ving simulator, study of interface between transportation and land use planning in urban areas, study of automatic computers for traffic control, examination of the ecology of air transport, and the analysis of transportation planning for the development and management of national forests, to name a few.

Licensing policies of UCLA are as follows: the IP belongs to UCLA. When this is licensed, it is divided in thirds (one for the University, one for the School and one for the academic/student), but the license is preferably given to the company of the academic/student. The University/School demands 5% of the shares/stock of the company. Since the creation of the ITA (Institute for Technology Advancement), the number of licenses/patents/companies/startups has increased, according to the current dean.

medical sciences, spinning out a company (Frigitronics). Sensors, drug delivery and medical technology are their signature. The first artificial limbs were also developed in the School.

- The research of reverse osmosis and first saline water purifier.
- Institute for Transportation and Traffic Engineering, serious problems in Los Angeles, was first undertaken by UCLA's Engineering School, creating the initial schemes to try to solve such a large problem. Some of their studies were: the study of alcohol level and driving performance, automotive restraint analysis, adult harness and child safety belt tests, tested automobile headrests as a protection against whiplash, development of full-scale wide-view dri-

Since the creation of the ITA (Institute for Technology Advancement), the number of licenses/patents/companies/startups has increased, according to the current dean.

Entrepreneurship and innovation

Important curricular and culture changes occurred in 2007-2008, prompted by current dean of UCLA's Engineering School. These changes were driven by an assessment conducted by the dean and a board of

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industrial advisors, where they found low entrepreneurial and innovative skills among graduates. This is a similar and current concern at the FCFM. The graduates, though highly trained in technical skills, were lacking the connection of these skills with innovation and entrepreneurship. Thus, changes to the curriculum and culture were proposed, which are summarized in the following milestones:

- The reformulation of their curriculum, focusing on multidisciplinary training: for the completion of each degree in one department, 3 sequential courses of another department must be taken. Another scheme is to take 3 sequential courses in Technology Management (innovation and entrepreneurship) in collaboration with the Business School of UCLA.

- The creation of the Institute for Technology Advancement (ITA). The mission of the ITA at the UCLA Engineering Institute for Technology Advancement is to support the UCLA Henry Samueli School of Engineering and Applied Science in three coordinated areas. First, ITA helps enable the development of major new multi-disciplinary research efforts for UCLA, providing business development support and strategic direction to increase overall UCLA research funding. ITA helps identify new research opportunities and associated funding sources. ITA also provides facilities and funding to start and promote new companies. These spin-out companies leverage UCLA technologies to provide long-term benefits and returns to UCLA. The on-going Student Entrepreneur Venture Competition is one such example, where they are promoting and supporting students to leverage their ideas and inventions into new companies. In addition to starting new companies and helping UCLA to develop new programs, ITA also is commissioned to facilitate industry access to UCLA engineering expertise. In this role, they are direct proprietors of R&D projects to support near-term industry needs. This in turn helps faculty and students gain funding and experience with new and unique research opportunities that would otherwise not be available to them.

Internationalization

Internationalization within UCLA's School of Engineering has been historically important: in California, especially Los Angeles, the Latino community is quite large. The percentage of foreign students (graduate and undergraduate) is 20% and a significant number of foreign academics. On this line, actions have been undertaken to increase the internationalization scheme such as:

The graduates, though highly trained in technical skills, were lacking the connection of these skills with innovation and entrepreneurship.

- The creation of online Master's degree in every program of the School of Engineering.

- Creation of exchange programs (undergraduate) with Asian universities (such as the Peking University and Hohai University in China). In addition to these points, UCLA's School of Engineering has continuous relationships with almost 80 different schools of Engineering around the world, developing large collaboration programs with Asia and India.

Important curricular and culture changes occurred in 2007-2008, prompted by current dean of UCLA's Engineering School. These changes were driven by an assessment conducted by the dean and a board of industrial advisors, where they found low entrepreneurial and innovative skills among graduates.

Main Case Study 2: Faculty of Engineering and Physical Sciences, University of Manchester, UK

The University of Manchester is a public university created in 2004 by bringing together The Victoria University of Manchester and The University of Manchester Institute of Science and Technology,...

Overview

The University of Manchester is a public university created in 2004 by bringing together The Victoria University of Manchester and The University of Manchester Institute of Science and Technology, producing a powerful new force in British Higher Education. The Faculty of Engineering and Physical Sciences today comprises nine academic Schools, each with a powerful legacy of research and teaching success. The University of Manchester has as a driving goal to be one of the top 25 research universities in the world. It is oriented to become a place where all students enjoy a rewarding educational and wider experience, known worldwide as a place where the highest academic values and educational innovation are cherished. The research prospers and makes a real difference, and where the fruits of scholarship resonate throughout society. Its core goals are: World-class research, outstanding learning and student experience, and social responsibility.

Reasons for its selection

The University of Manchester is a public university with a structure similar to that of the University of Chile. Since its merge in 2004, it has gone through several structural and cultural changes to reach their driving goal of becoming one of the top 25 research universities in the world. These changes have been guided by two strategic plans; the first called "Advancing the Manchester 2015 Agenda", which established a blueprint for the newly formed University of Manchester in 2004, the second called "Manchester 2020", was created in 2011 and builds on the aims set out by its predecessor. According to the Academic Ranking of World Universities (ARWU), the University of Manchester was able to climb from position 89 in 2003 to 41 in 2013.

Who was interviewed?

Collin Bailey (Dean of Faculty of Engineering and Physical Sciences), K. Brown (Head of school of electrical & electronic engineering and former dean on education), Tony Walker (Director of Business Development and Business UMIP), Stephen G. Yeates, (Professor of Polymer Chemistry, member of OMIC).

Engineering education

The programs are based on bachelor (three years) and master (one year) degrees. To enhance the employability of their graduates, Manchester decided to improve the communication and team working skills of their students. Taking into consideration that engineers should be able to create and build solutions, three methodologies where implemented in the curriculum: 1) Individual or team projects at each year of the

program and each project with a one year duration, 2) Almost all courses have laboratory work and 3) A few project-based learning courses based on solving case studies. To improve the quality of life of their students, the faculty has made a significant effort to change the academic "culture" from a strong research focus to an educational one. To achieve this cultural change it was very important to give the same weight to teaching and research at the moment of the academic evaluation. Additionally, all new academics have to follow educational training lessons and have a mentor assigned to them, who can belong to any school. Time invested by the mentor is considered in his/her academic evaluation.

Research and development

Social responsibility is a crucial aspect of the research activity. The institutional research priorities are geared towards finding solutions to global challenges such as cancer, world poverty, carbon reduction, nuclear energy and social cohesion. There are more than 70 specialist research centers and groups in the Faculty, undertaking research in fields such as photon science, electrical energy distribution systems, neural-inspired computing architectures, the structure of the universe, nuclear science and technology, tissue engineering, alternative energy sources, global and local environment studies, lightweight materials for 21st-century fuel-efficient vehicles, medical imaging, aeronautical engineering, and nano-materials.

Based on the diagnosis that the faculty was becoming less competitive, the authorities decided to make a strong "cultural" change in their academics, promoting teaching, technology transfer and research impact. To this purpose, it was decided to focus the academic evaluation in four fundamental areas: 1) research, 2) teaching, 3) knowledge transfer and 4) leadership, management and media impact. Each area with the same importance, hence academics must have activities in these four areas. An example is that an academic with an exceptional publication rate, but with a non-satisfactory evaluation in the other areas, is not promoted. In addition, it is not enough to do high quality research in your laboratory, as collaboration is a requisite.

A strategy to enhance high impact research was driven by the need for multidisciplinary research. The first step was to detect areas where University of Manchester had competitive advantages over other universities. After this analysis, some key areas where selected from which different research institutes where created. These institutes bring together academics from different disciplines to solve the grand challenges. It is import to note that these key research areas and institutes were created from the top, and hence, decided upon by the authorities. In the faculty there are 5 research institutes with a strong multidisciplinary focus. These institutes do not belong to any particular school, but are transversal to all of

them, allowing interaction between researchers in different disciplines. A good example is the Manchester Institute of Biotechnology (MIB), the first college interdisciplinary research institute built for this purpose. It focuses on advanced quantitative methodologies for specific challenges in biotechnology, acting as an interface between biology, medicine, physics, mathematical and computing sciences. It is composed of 500 members, including academics, students and technicians, with 60 research groups, 120 postdoctoral fellows, and 300 graduate students. It has an annual budget of nearly 100 million euros. The MIB has a unique culture of pluralism and open research supported by world-class infrastructure. The MIB infrastructure does not belong to any researcher. Researchers can "rent" temporary space in an office or laboratory, which are all designed with open spaces, allowing integration between different groups.

...the participation of academics, even as a shareholder, is very relevant in the early stages of the business development, but is expected to decrease gradually, returning to a 100% academy dedication.

Knowledge and technology transfer, and licensing

The "University of Manchester's Intellectual Property Commercialization Company" (UMIP), is a company owned by the university that works independently, and whose mission is to promote the transfer of technology and knowledge. UMIP contributes to the purposes and objectives of the University as a place for knowledge transfer, carrying out activities related to intellectual property management and commercialization. Among other activities, UMIP performs: 1) an identification, protection, evaluation of the commercial potential of research within the faculty 2) intellectual property marketed via the most appropriate route: sale, licensing and spin-out. It important to note its "proof-of-principle" program that brings the research to a demonstrable and useful stage for later sale. UMIP also finances projects in their early stages. Also noteworthy is a "spin-out" guide, aimed at academics, and defines the steps to follow in this matter, since it is highly recommended by the UMIP. In this case, the participation of academics, even as a shareholder, is very relevant in the early stages of the business development, but is expected to decrease gradually, returning to a 100% academy dedication. Since 2004, the University of Manchester has generated more than 100 spin-out companies and obtained more than 200 technology licenses.

There are other methodologies to enhance knowledge transfer, as the "Organic Materials Innovation Centre" (OMIC) (www.omic.org.uk) and "Knowledge Centre Materials Chemistry" (www.materialschemistry.org). This Centre is independent and driven by both the university and the industry, to enhance knowledge transfer with joined projects. This is an example of government funded interdisciplinary research, focusing on promoting the chemical industry in areas that are a priority to the country.

With an active participation of local industry, the Centre has been able to develop short-term solutions to problems that are relevant to the industry without losing the science and research focus. A key factor in the success of the Centre was to hire researches with previous background in the industry.

Entrepreneurship and innovation

The University of Manchester has a global reputation for being at the forefront of innovative and enterprising research. To support entrepreneurial and innovative initiatives, the University of Manchester has the Innovation Centre (UMIC) with state-of-the-art incubator and an enterprise conferencing and networking center. UMIC provides high quality state of the art biotech and hi-tech facilities. Their vision is to provide a vibrant supportive environment for tenant companies allowing them the freedom to concentrate on their core business development. For this purpose it provides:

- High quality facilities and management services including turnkey laboratories and high spec office space.

- An innovative and entrepreneurial environment for start-ups, incubator tenants and SME's (small and medium-sized enterprises).

- Outstanding venue for conferences, events and meetings.

Internationalization

The University of Manchester currently has 16% of international students in undergraduate programs and 42% of international graduate students.

2.3. Benchmarked Institutions: focused case studies

A) Focused Case Study I: The Franklin W. Olin School of Engineering, USA

Overview

The Franklin W. Olin College of Engineering is a staple of the innovation in Engineering Education. Created in May 2006, it offers Majors in Electrical and Computer Engineering, Mechanical Engineering and Engineering. It has a highly selective admission process with emphasis on outstanding academic achievement, extracurricular activities, with special attention given to creativity, passion and enterprise. Admitted students are granted half-tuition for 4 years (more than $60 thousand US dollars in total, $20 thousand supplied by Olin's scholarship) and on-campus housing.

Reasons for its selection

The Franklin W. Olin School of Engineering is a staple of innovation in Engineering Education in the World (Bernard M. Gordon Prize for Innovation in Engineering and Technology Education holders for 2013), where curriculum, culture and education is devoted to innovation.

Who was interviewed?

Authorities: Mark Somerville,(Associate Dean for Faculty Affairs and Development Professor of Electrical

...another initiative similar to this capstone is given for entrepreneurial students, where a business aspect of Engineering is accessible, creating their own company to solve a problem not necessarily given by a sponsor.

Engineering and Physics), Jonathan Stolk (Professor of Mechanical Engineering and Materials Science), Debbie Chachra (Associate Professor of Materials Science), Jessica Townsend (Associate Dean for Curriculum and Academic Programs Associate Professor of Mechanical Engineering), Juliana Bernal-Ostos (Visiting Assistant Professor of Materials Science), and three senior class students.

Focus: Engineering education

Engineering training at Olin College lasts 4 years, based on an innovative hands-on curriculum. Olin's innovative curriculum is the result of broad-based efforts to update engineering education for the 21st Century. Among the reforms prompted by groups like the NSF (National Science Foundation – USA) and the leaders of the engineering community, was the increased emphasis on business, teamwork, interdisciplinary design and communication skills. Olin incorporated these reforms and other creative ideas into a new curriculum created from a clean slate with the help of 30 student "partners." The curriculum is based on the "Olin Triangle," a combination of rigorous science and engineering fundamentals, entrepreneurship and the liberal arts. In addition, there is the innate motivation of students, empowered through "Passionate Pursuits", a study of personal intellectual or artistic interests for credit. There is a deep commitment at all levels to active learning and interdisciplinary courses built around hands-on projects. A faculty devoted and motivated to innovation in Engineering Education is added to this curriculum. At Olin, "learning" and "doing", go together from the start. This real-world approach culminates in SCOPE (Senior Consulting Program for Engineering), a significant, year-long engineering project for an actual client.

Courses are given in student groups of 20-30, in fully equipped teaching rooms which serve as labs, heavily endowed with hands-on activities at every level with the mission of creating engineering innovators.

Olin College is ranked 4th in the US as an undergraduate school offering an Engineering degree. The College does not undertake research in Engineering (or if there is any, the amount is negligible), but on Education of Engineering, where they are the leading school in the world in innovation in Engineering Education, *winning the Bernard W. Gordon Award for Innovation in Engineering Education (2013).*

In 2013, 782 students applied to the undergraduate program and only 151 were admitted, enrolling 81 of them, after a selection from 210 applicants during Candidate Week. The ratio of full-time faculty to undergraduate students is 1:9 with 30 full-time (each with a Ph.D. degree) and 35 part-time academics. The demographics of academics is 43% women, with an 8% enrollment of foreigners (23 different countries). They have a 94% First-to-Second Year retention rate, and a 98% of employability (graduate school 19%, and entrepreneurs 5%). The Senior Capstone Program in Engineering (SCOPE), a yearlong project under realistic constraints of a corporation or other sponsor is a way to take students throughout a real engineering program. The sponsor supplies an authentic, challenging and real problem. The College provides a group of students (5 to 7), a dedicated space, a faculty adviser and access to technology base of the College. Besides the SCOPE chapter, another initiative similar to this capstone is given for entrepreneurial students, where a business aspect of Engineering is accessible, creating their own company to solve a problem not necessarily given by a sponsor. This is done in collaboration with Babson College (Business School).

As part of its educational mission, Olin College is committed to innovation and continual improvement. This commitment stems from the college's resolve to stay on the cutting-edge of engineering education so that the educational and intellectual experience remains fresh. The focal point for Olin's continual improvement and innovation efforts is the Initiative for Innovation in Engineering Education (I2E2), which was established by Olin's President, Richard K. Miller, in the fall of 2009 to embody this aspiration and to facilitate related programs. Professor Lynn Andrea Stein is its founding director; many Olin faculty members, staff, and students share in its activities.

B) Focused Case Study II: The Massachusetts Institute of Technology – MIT, USA

Overview

The mission of MIT is to advance knowledge and educate students in science, technology and other areas of scholarship that will best serve the nation and the world in the 21st century – whether the focus is cancer, energy, economics or literature. *The numbers of MIT are staggering:* over 11,000 employees, a faculty over 1,500 academics, 4,500 undergraduates and 6,700 graduate students in over 50 majors and Ph.D. programs. The reputation of MIT grows every year with recognition coming from its 78 Nobel Prize winners, 53 National Medal of Science winners, 43 MacArthur Fellows, 27 National Medal of Technology and Innovation winners.

Reasons for its selection

The Massachusetts Institute of Technology is the foremost institution in engineering education, research and development in the world. But, besides these distinctive positive attributes, the students, faculty and environment have posed the need for the development of professional skills that were not part of their curriculum and culture. These initiatives, which are rather recent, are trying to generate a cultural change among their students and faculty, generating the leaders of the future. It must be noted that other initiatives towards the enhancement of professional skills, such as the CDIO program, which started in the Astronautics in the late 90s, have also been applied at MIT.

Who was interviewed?

Prof. Joel Schindall (Director of the Gordon Engineering Leadership – GEL- program), Leo McGonagle (Executive Director of GEL program), Diane Soderholm (Education Director, GEL program and Instructional Designer at MIT-Skoltech initiative), Williams Lucas (Director of Research of GEL program and Assessment designer at Skoltech initiative), Leon Sandler (Executive Director of the MIT Deshpande Center), Maren Cattonar (Innovation Manager of the

MIT Deshpande Center), Kyle Judah (Program Manager, Martin Trust Center for MIT Entrepreneurship) and Ari Epstein (Lead instructor, Terrascope Initiative).

Focus: Leadership, innovation and entrepreneurship changes in a well-established institution

With respect to leadership in innovation and entrepreneurship, MIT has developed a new initiative towards this objective.

Several initiatives have been devoted at MIT to foster and enhance professional skills in their engineers. For instance, The CDIO initiative, which started in the Department of Aeronautics and Astronautics of MIT, is an innovative educational framework for producing the next generation of engineers. The framework provides students with an education that stresses engineering fundamentals set in the context of *Conceiving – Designing – Implementing – Operating (CDIO)* real-world systems and products. Throughout the world, CDIO Initiative collaborators have adopted CDIO as the framework of their curricular planning and outcome-based assessment.

The FCFM is one of these collaborators, organizing CDIO programs and workshops in South America as part of a large network of institutions around the world. With respect to leadership in innovation and entrepreneurship, MIT has developed a new initiative towards this objective.

The Bernard M. Gordon-MIT Engineering Leadership (GEL) Program develops next-generation technical leaders who are equipped to understand and address significant engineering problems in real-world situations. The program is committed to ensuring that MIT continues to lead the nation in graduating effective engineering leaders. The Gordon-MIT Engineering Leadership Program fosters new approaches that prepare the nation's young engineering leaders for productive and effective careers in engineering companies and continues MIT's rich, innovative tradition of engineering leadership. It is important to note that to develop the potential leaders of engineering innovation, invention, and implementation, the program works both with students enrolled at MIT and industries outside the institute. Students start engaging with GEL in their sophomore year, with UPOP, the Undergraduate Practice Opportunities Program. Setting the stage for GEL Year One, UPOP introduces students to engineering practice. Those in UPOP receive personalized coaching, a summer internship, post-internship reflective activities, and hone basic interpersonal proficiencies such as effective networking, building an impactful resume and other career-enhancing skills. Juniors and seniors who complete UPOP or who qualify on the basis of experience on an engineering project in an industrial or academic setting can apply for the GEL Year One program. Accepted students participate in interactive short courses providing frameworks, models, and cases on engineering leadership.

GELs apply and practice these approaches in weekly Engineering Leadership Labs (ELLs). They participate in guided reflection on their successes and discover opportunities for improvement. Mentors, ELP faculty and staff, fellow students and program alumni provide guidance in reflecting on and learning from lea-

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dership experiences. Students who successfully complete the first year program requirements may elect to apply for GEL Year Two. Students selected for GEL Year Two participate in a more intense manner and with additional leadership responsibilities in short courses, ELLs, mentored leadership development experiences and an InternshipPlus.

Beyond MIT, the program partners with industry to develop the leadership skills of their young engineers and with like-minded academic institutions throughout North America to advance the practical and pedagogical principles of engineering leadership. This internal and external focus allows the program to meet its mission, which is to educate and develop the character of outstanding MIT students as potential future leaders in the world of engineering practice and development; and to transform engineering leadership in the nation, thereby significantly increasing its product development capability.

C) Focalized Case Study III: The California Institute of Technology, USA

Overview

Located in Pasadena, California, The California Institute of Technology (Caltech) is a world-renowned science and engineering research and education institution, where extraordinary faculty and students seek answers to complex questions, discover new knowledge, lead innovation, and transform our future. Its mission is to expand human knowledge and benefit society through research integrated with education, while investigating the most challenging, fundamental problems in science and technology in a singularly collegial, interdisciplinary atmosphere, educating outstanding students to become creative members of society. Caltech possesses 6 academic divisions: Biology & Biological Engineering, Chemistry & Chemical Engineering, Engineering & Applied Science, Geological & Planetary Sciences, Humanities & Social Sciences, and Physics, Mathematics & Astronomy, with 26 academic options in a 4-year plan. The faculty, consisting of 300 academics and over 600 research scholars, lectures over 2,000 students (978 undergraduate and 1,253 graduate students) in a 40%/60% ratio of women to men.

Reasons for its selection

Caltech is a leading research and teaching institution in the world in technological and scientific innovation. Its size is small in faculty and students with respect to other institutions, but their quality is outstanding. A dominating factor in selecting Caltech is their trademark

culture of intertwining different disciplines with freedom to create impact in their local and global community in the most challenging and fundamental problems in science and technology.

The Caltech Center for Technology and Management Education provides proven techniques to successfully stimulate innovation in technology-driven organizations.

Who was interviewed?

Faculty: Carver Mead (Gordon and Betty Moore Professor Emeritus of Engineering and Applied Science), Michael Vicic (Chemical Engineering Laboratory Instructor). Entrepreneurs: Joanne Long (CEO at IORodeo), Julius Su (Visitor in Chemistry, co-developer of the SKIES Learning App), and two Chemical Engineering students.

Focus: Innovation and entrepreneurship in the most challenging problems in science

Caltech does not possess a driven culture towards the formation of spin-offs or start-ups, but rather a very laissez-faire spirit, where faculty, and mainly students can generate new and innovative answers to problems in science and engineering. As Prof. Mead quite strongly stated "if it is challenging, we solve it". This includes the problem of technological and scientific innovation, and its translation to entrepreneurial aspects. Thus, there is no focalized driven initiative towards i+e (there are some clubs, workshops and technology transfer initiatives, as in the case of the FCFM), but there are no constraints to generating start-ups or spin-offs: they are applauded and expected. An aspect that has become more and more important to the Institute is education of innovation. The Caltech Center for Technology and Management Education provides proven techniques to successfully stimulate innovation in technology-driven organizations. In their short courses and certificate programs, participants learn new strategies, approaches and tools for developing products, optimizing processes, and increasing cost and schedule performance. The programs help technical and nontechnical executives and managers take better advantage of innovations and technological breakthroughs. Caltech CTME instructors are chosen for their proven track record of implementing strategic and tactical improvements that benefit the bottom line.

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D) Focused Case Study IV: Chalmers University of Technology, Sweden

Overview

Chalmers University of Technology is a Swedish university located in Gothenburg that focuses on research and education in technology, natural science, and architecture. The vision of this university is for a sustainable future from its local national context and history. The mission is that of internationally acclaimed education and research combined with a professional innovation process, to become one of the world´s most attractive universities. It became a private non-profit university in 1994.

Reasons for its selection

Chalmers was one the founders of the CDIO approach. This approach was first developed in a 2000-2006 project funded by the Knut and Alice Wallenberg Foundation. The founding partners were Chalmers, Massachusetts Institute of Technology (USA), Linköping University and the Royal Institute of Technology (KTH). CDIO stands for Conceive – Design – Implement – Operate. The CDIO Initiative develops a new vision for engineering education, while stressing engineering fundamentals set in the context of the Conceiving – Designing – Implementing – Operating process, which engineers use to create systems and products.

Who was interviewed?

Dr. Johan Malmqvist (Department of Product and Production Development, Dean of Education), Dr. Mats Lundqvist (Director of Chalmers School of Entrepreneurship, Head of Division), Dr. Mikael Enelund (Head of Mechanical Engineering program, Department of Product and Production Development: Prototyping Lab.), Dr. Rikard Soderberg (Head of Production Area, Department of Product and Production Development).

Focus: Engineering education

In Chalmers, the different majors are not attached to departments but to programs, independent entities that buy course service from the departments, depending on demand and purposes. This has two main goals: to be independent of the focus of each department and to increase multidisciplinary collaborations.

This University has a strong focus on CDIO teaching system, especially in the departments of Mechanical Engineering and Product and Production Development. It features new student rooms, improving the workteam and new workshops - all very intensive in resources. Every year the students develop projects according to their knowledge level. Students learn security rules and basic instructions for operating the machines from the workshops needed for the projects. Students have open access to this equipment that allows them work more during non-office hours. These projects are a complement of the fundamental knowledge taught in regular lectures, and does not decrease the quality of the teaching. This methodology is a further way to integrate the different areas of the fundamental knowledge. As an example of this methodology, the students from the Master in Automotive Engineering have to build a whole racing car over the year, from scratch, utilizing the university's workshops. Each piece of the car is designed and built by the students.

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E) Focused Case Study V: Karlsruhe Institute of Technology – KIT, Germany

Overview

KIT is an institution of excellent international research and teaching in natural sciences and engineering. It was created in 2009 when the University of Karlsruhe (Universität Karlsruhe), merged with the Karlsruhe Research Centre (Forschungszentrum Karlsruhe). KIT was born to become the German role model for the 21 century that sets international benchmarks in research, teaching, and innovation. KIT goals are 1) attract the best experts from all over the world; 2) set standards in teaching and promotion of young scientists; 3) become the leading European center of energy research; 4) play a role in nanosciences that will be visible worldwide; and 5) be a leading innovation partner of industry.

KIT has a program named "Industry on Campus", offering space and facilities to people from industry for research within the KIT.

Reasons for its selection

KIT was selected because as a German institution its engineer programs have a very strong relationship with the local industry. KIT engineers are praised at being very practical, ascribed to the high quality of the apprenticeship courses they go through as part of their education. The quality of German engineering expertise has long been much vaunted, especially in the field of mechanical engineering. In addition, KIT has gone through a strong structural change after merging the University of Karlsruhe with the Karlsruhe Research Centre. The main reason for establishing KIT was to strengthen Karlsruhe's position in the German Universities Excellence Initiative, which offered elite universities grants of up to 50 million euros per year. The University of Karlsruhe was chosen for the initiative in 2006/2007. Who was interviewed? Dr. Michael Kurth (Head of Studies and Teaching), Dr. Klaus Dullenkopf (Head of President's Staff), Dr. André Presse (Institute for Entrepreneurship, Technology Management and Innovation, ENTECHNON).

Focus: Engineering education and knowledge transfer

Before the Bologna process (http://ec.europa.eu/education/higher-education/bologna_en.htm) engineering programs lasted 6 years. Changes have made the bachelor program a three-year degree and the master program a two-year degree. Both degrees culminate with thesis work. During the whole program, the students participate in different company internships. This is a key characteristic of the German engineering programs and the internship is well structured based on defined skills that are listed by the university. The first internships start at the onset of the program, before the first semester starts. With this, the engineers learn practical engineering skills. In general, they follow traditional lecture methodology with a high amount of students (around 600 per classroom). Based on the success of its engineers and on the reality of the German industry, they do not see the need to change the teaching methodology. However, they have formal elective lectures that focus on social communications and other engineering skills.

F) Focused Case Study VI: University of Groningen, Netherlands

Overview

The University of Groningen (Dutch: Rijksuniversiteit Groningen), located in the city of Groningen, was founded in 1614. It is one of the oldest universities in the Netherlands as well as one of its largest. The University of Groningen is in the top 3 of European research universities in the fields of: Ecology, Material Sciences, Chemistry and Astronomy. It has nine faculties, nine graduate schools, 27 research centres and institutes, and more than 175 degree programs.

Reasons for its selection

The Netherlands is home to one of the world's oldest and most highly respected systems of higher education, dating back to 1614. Universities in Netherlands are all public and highly controlled by the government. The 2012/13 QS World University Rankings include 13 Dutch universities - all within the world's top 500, and an impressive 11 in the top 200.

Who was interviewed?

Dr. F. Brustolin (International Relations, policy advisor. Faculty of Mathematics and Natural Sciences), Prof. Erik van der Giesse (Director of the Applied Physics Program), Prof. Gerald Jonker (Director of the Industrial Engineering and Management Program), Prof. Jacquelien Scherpen (Director of the Institute for Engineering, Technology and Management), Prof. Gert-Jan Euverink (Professor of products and processes for biotechnology in the bio-based economy)

Focus: Research and Knowledge Transfer

The great research areas from the Dutch universities are oriented by government policies, taking into account its strengths. This strategy tries to optimize the resources consi-

The programs have a very strong connection with the local industries and a third of the professors have an industrial background. Regarding the student selection, they have a state-regulated quota. Half of the students are rejected during the first year. In the first semester of a course, education tends to be theoretically oriented at KIT, with a high concentration of mathematics for engineering and natural science courses. It is possible to choose between practical and theoretical topics in later semesters.

KIT has a program named "Industry on Campus", offering space and facilities to people from industry for research within the KIT. The innovative industry-on-campus model attaches great importance to the exchange between academia and industry, which in this case, enabled the close cooperation of industry members and KIT in a joint and interdisciplinary team.

A relevant part of the funds come from industrial consortia, joining different companies with the university.

dering the size of the country, which maximizes the resources and avoids competition between institutions. Research at Groningen is structured in institutes. All academics belong to a research institute and are asked to teach courses in the different programs (there are no departments). Currently there are 12 institutes in Groningen.

An example is the "Institute of Technology and Management" created to improve the transfer between university and industry. While other institutes in the university focus on basic research, this institute does engineering research with a strong focus on application. A relevant part of the funds come from industrial consortia, joining different companies with the university. These consortia have funding from the government and the European community, imposing the requirement of working in a consortium, rather than with a particular company. The consortia structure facilitates the divulgation of the knowledge, as this does not belong to any specific company. Some of the research areas were defined based on the teaching needs of different programs. To improve the transfer, the institute hires external professors coming from industry that typically work one day per week in the university, not only doing teaching, but also doing research and training graduate students. These professors have a formal space and access to the facilities of the university, and can apply for government funding, as they are members of the university. The company finances their time dedicated to work at the university.

G) Focused Case Study VII: University of Waterloo, Canada

Overview

The University of Waterloo is a public, research university located in Waterloo, Ontario, Canada, founded in 1957. It has six faculties, 30,000 undergraduate students, 5,000 graduate students, 1,100 academics and 2,000 staff. It pioneered a co-op system of education that remains one of its distinctive features. Among Canadian universities, it has ranked "best overall" in 18 of the last 21 years, and "most innovative" in 21 of 21 years.

Reasons for its selection

Waterloo is widely regarded as a leading university in Canada in research-based innovation and entrepreneurship, and its graduates are in high demand among technology companies in North America. The university is also the focal point of an innovation ecosystem that has evolved in the surrounding area.

Who was interviewed?

Martha Foulds (Director, Planning, Faculty of Engineering), Dave Dietz (Director, Engineering Research, Faculty of Engineering), Anwar Hassan (Associate Dean for Research and External Partnerships, Faculty of Engineering), Jana Carson (Manager of Institutional Analysis and Planning) and Barry Ferguson (Associate Dean, Co-operative Education, Faculty of Mathematics).

Focus: Education, innovation and entrepreneurship

The University of Waterloo is a strong research and education institution, and is also a leader in Canada in innovation and entrepreneurship, with strong ties to industry. The main focus of this visit was to explore the critical success factors that explain UW's performance in i+e. Based on several interviews in the Faculty of Engineering and in the Faculty of Mathematics (where the School of Computer Science is located), and with the Office of the provost, it was consistently pointed out that the main success factors were:

1 The Co-Op Program. Waterloo was founded around the idea of a Co-Operative Education approach, where students are required to do six work terms in the course of their studies. Currently, 100% percent of the students in Engineering and 70% of those in Mathematics are enrolled in Co-Op. For students, this means having two years of real world work experience when they graduate, often in high-tech companies in Canada and the US, having earned from 6,000 to 40,000 dollars for each work term. For the university, it is a constant source of contacts with industry, a boost on their reputation and also a way to attract students that are independently minded and not afraid to take risks.

2 An education approach that encourages hands-on work. The most successful engineering programs, in terms of leading to innovation and entrepreneurship, are those that focus on design-implement courses. The Faculty of Engineering is currently encouraging this with the addition of a new building (E5) that provides ample workspaces for student teams working on projects. Some of this development has taken into account the experience of Olin College, though Waterloo is a much larger institution and not easy to steer in a new direction.

3 A generous intellectual property policy. The university has a unique policy, where all intellectual property rights belong to the inventor. This policy has encouraged professors and students to develop innovative products and create startup companies to take them to market. The university does not expect to get a financial return from those inventions or companies, but over the years, successful graduates and faculty members have provided generous donations that have become a key factor in its development. Two well known examples are David Cheriton, a Waterloo Ph.D. graduate and a professor of Stanford university, one of the early investors in Google, who provided a $25 million donation for the Department of Computer Science (now the David R. Cheriton School of Computer Science); and Mike Lazaridis, founder of Blackberry, who, during the most successful years of the company, provided funding to create the Center for Nanotechnology, as well as the independent, but connected, Perimeter Institute for Theoretical Physics.

4 An ecosystem to foster innovation and entrepreneurship. An entrepreneurial culture has developed within the university, and also in its surrounding, where many technology companies are located. The university operates several programs to encourage and foster the creation of startup companies by professors and students. Notable examples are the David Johnston Research + Development Park, that features an Accelerator Centre, the Velocity program, focused on educating student innovators, and that includes a residence, a "garage" and a startup fund, and the Conrad Business, Entrepreneurship and Technology Centre. Having many startup companies located near the university also provides an opportunity for having mentors and guest speakers with real world experience.

2.4. Reference institutions for new university-based technology hubs

The JTCII departs from traditional academic departments and is organized in three interdisciplinary hubs selected for their relevance to the New York City economy: Connective Media, which focuses on extracting and using information from a variety of media data sources; Healthier Life, which will create better health care information systems, mobile health care applications, and medical devices; and the Built Environment, which aims to increase the efficiency and sustainability of urban environments at all scales, possibly through the use of sensor-based data.

Through the benchmarking process and the literature review, it was highlighted that Technion, the Israel Institute of Technology, is one of the most successful institutions in technological innovation and entrepreneurship despite the challenging environment where it is placed. In particular, the high level of the undergraduate students and the research at Technion has been pointed out as key elements in the extraordinary rate of startups formation in Israel during the last few years.

At Technion, we specifically met with Dr. Iris Arbel (Executive Director, Knowledge Center for Innovation), Prof. Uzi de Haan (Director of the Bronica Center for Entrepreneurship and Director of the Joan and Irwin Jacobs Technion-Cornell Innovation Institute program), Dr. Harry Yuklea (Bronica Center for Entrepreneurship, international programs), Prof. Oded Shmueli (Executive Vice President for Reserach), Prof. Paul Feigin (Vice President for Strategic Planning), Prof. Avi Shaviv (Head of the Grand Water Research Institute) and Giselle Rotman (Marketing coordinator at the Technion International School).

In 2011, Cornell University and its partner, Technion, won a bid for a new applied sciences and technology campus to be built on Manhattan's Roosevelt Island in New York City. NYC Mayor Michael Bloomberg established the competition in order to increase entrepreneurship and job growth in the city's technology sector. The winning bid consisted of a 2.1 million square feet state-of-the-art tech campus being built on Roosevelt Island, which will have its first phase completed by 2017, with a temporary off-site campus opening in 2012. The New York City Economic Development Corporation awarded the project to Cornell NYC Tech rather than to Stanford University, in potential partnership with the City College of New York. Cornell NYC Tech began classes in January 2013 in temporary classrooms supplied by Google in its office building located at New York City's Chelsea neighborhood. See more details here: http://tech.cornell.edu/future-campus/

The Jacobs Technion-Cornell Innovation Institute (JTCII) plays a key role within Cornell NYC Tech, by offering interdisciplinary dual degree programs in the applied information-based sciences, and by bringing a global perspective to research and education with an emphasis on technology transfer, commercialization and entrepreneurship. The JTCII departs from traditional academic departments and is organized in three interdisciplinary hubs selected for

their relevance to the New York City economy: Connective Media, which focuses on extracting and using information from a variety of media data sources; Healthier Life, which will create better health care information systems, mobile health care applications, and medical devices; and the Built Environment, which aims to increase the efficiency and sustainability of urban environments at all scales, possibly through the use of sensor-based data. In addition to the academic faculty employed by JTCII, a dynamic Industrial Affiliates program provides a valuable source of local technology experts and seasoned entrepreneurial mentors.

In our visit to Cornell NYC Tech, currently at Google NYC headquarters, we specifically met with Craig Gotsman (Director of the Cornell NYC Tech initiative), Maurizio Arienzo (New York City advisor of innovation and entrepreneurship for the Cornell Tech initiative) and Uzi de Haan (Director of the Joan and Irwin Jacobs Technion-Cornell Innovation Institute program).

2.5. Analysis of differences: FCFM vs benchmarked institutions

This section contains a thorough analysis of differences and gaps between the current situation of FCFM and the benchmarked Institutions. In order to do this we first distill and summarize the main conclusions that we drew after interviewing the stakeholders at each School of Engineering. We then compare FCFM to the benchmarked institutions according to the five issues discussed in each case, namely, Engineering Education, Research and Development, Technology Transfer and Licensing, Innovation and Entrepreneurship and Internationalization. The comparison is made, in all five cases, against the two main case studies, and against the institutions whose focus is relevant, identifying possible causes for the gaps. We close this Subsection by making a first assessment of actions, which are treated in detail in the following Sections.

narking

2.5.1. Summary of conclusions from the benchmarking

1. The interviewed research institutions have chosen different paths for their development towards a set of goals *driven by the urgency of the local and global threats* to their graduates and programs. These goals are very clear and focused, and in order to accomplish them, new focalized initiatives and programs were created.

2. The new institutionalized initiatives and programs have not yet been evaluated using standard metrics, either because of their novelty or because of the short time frame for their implementation. Even so, the internal feeling of the performed change in the interviewed institutions is positive, and the sector of the community that does not agree, complies with the idea that the institutions are "better than before". From this point of view, *there are no "magical" or "correct" metrics to evaluate change* (either curricular, strategic or cultural), but rather through performance indicators and targets.

3. The chosen references prove that *world class scientific and technological innovation and entrepreneurship can be developed in unfavorable environments:* either with stern cultural and regulatory backgrounds, as in the case of complex public universities (The Henry Samueli School of Engineering and Applied Science of the University of California, Los Angeles, USA, and The Faculty of Engineering and Physical Sciences of the University of Manchester, United Kingdom), and in harsh environments where industry is not fully developed (Israel Institute of Technology, Israel).

4. Change towards the formation of innovation and entrepreneurship needs to stem from *the strengths of the institution. Successful change in these institutions has been observed to be top-down driven, but bottom-up in the implementation and transversal in all units of the institution.* Every single stakeholder needs to feel that he/she is a part of the proposed change, and important entity with regard to imposed goals. It is very important to *engage all participants in the need for change.*

5. Students can learn practical engineering skills by working in *individual or team-based projects related to engineering along the curriculum.* In these projects the students can analyze the different aspects of engineering from laboratories to practical design, acting as a complement of the fundamental knowledge taught in regular lectures

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and integrating the different areas of knowledge.

6. A successful change scheme possesses *incentives towards such change for all the community involved,* including new instruments (for instance teaching credits or merits, Ph.D. scholarships directed towards multidisciplinary approaches, new resources for student development, and awards for students, alumni or faculty). The objective of these incentives is to produce a *"cultural" change that promotes teaching responsibility, technology transfer and research impact.*

7. In the case of the complex research public institutions, *multidisciplinary projects and initiatives are chosen in every single case as the way to bridge the need for innovation and entrepreneurship.* This approach percolates towards every aspect of the development plan of these institutions: teaching, research, technological transfer and, innovation and entrepreneurship. There is an agreement that to face grand challenges it is necessary to build multi-disciplinary teams focused on priority areas, thus pushing the limits of traditional research. On this point, for research complex institutions, graduate schools have to be enhanced as a driving motor for technological and scientific innovation.

8. On the same point, both complex research public universities have developed very focused technology transfer schemes (ITA at UCLA and UMIST at the University of Manchester), where internal and external projects towards technological and scientific innovation and entrepreneurship are brought together. These TT schemes are sustained *as long-term initiatives by both universities, disregarding "red numbers",* as they feel that a successful TT scheme does not only and solely provide incomes.

9. *Making a meaningful and long-term impact in the local and global community, economy and society through different dimensions* (chosen specifically for and by each institution following their strengths) through Engineering is the most important driver of change towards innovation and entrepreneurship in every single institution interviewed.

10. Finally, *in order to enhance innovation and entrepreneurship through universities, engineering schools need to operate in a fertile ecosystem with a global perspective.* There are cases in the world where university-based innovation and entrepreneurship ecosystems have been developed despite the challenging environments, in particular in Israel with Technion. With an appropriate strategy applied to the Chilean reality, it should be possible to follow a similar path.

2.5.2. Gaps and difference analysis by issue

Engineering Education

Institutions compared with: UCLA, Manchester, Olin, MIT, Groeningen, Chalmers, Waterloo.

Many engineering schools have begun to move away from the traditional lecture style and have taken recently a very proactive approach in engaging students in hands-on, interactive, team-oriented learning experiences from year one within the curriculum to enhance the professional abilities of their graduates, namely teamwork, leadership, communication and self-efficiency.

The benchmarked institutions use a variety of schemes when training and educating future engineers. The timeframe of their degrees (3+2 years scheme of the Bologna agreement or the 4 years of the engineering schools in the US) is different from the one used by our faculty: 6 (2+2+2) years, where 2 years are for the common core, 2 years for the bachelor major and 2 for the professional degree. Following the diagnosis of the FCFM, this timeframe difference is not a very important one in the development of our students in their future workplaces, nor on their employability, as they possess strategic advantages given by the first two years of the common core, as already discussed.

A noticeable difference is the actual way we train our students. Traditional lectures, standard tests and evaluations, and regular curricula are mainly used by UCLA and The University of Manchester's engineering academics, either in the first two-three years of their bachelor degree or the following two years of their master degree, ending with a capstone at the end of the fifth year. On the other hand, institutions like Olin College base their educational approach on students doing project work throughout the curriculum, and Waterloo's signature co-op program provides two years of real-world work experience for students by the time they graduate. Many engineering schools have begun to move away from the traditional lecture style and have taken recently a very proactive approach in engaging students in hands-on, interactive, team-oriented learning experiences from year one within the curriculum to enhance the professional abilities of their graduates, namely teamwork, leadership, communication and self-efficiency. These experiences last one to two semesters, involving local and/or international stakeholders.

Beginning in 2007, our school has introduced a similar Introduction to Engineering course in the first year, following the CDIO paradigm (applied strongly in Chalmers and MIT), conceive, design, implement and operate processes and systems, followed by a project workshop in the second year, but there is a lack of design-build courses in the middle years of the curriculum. On the other hand our engineering education lacks the industrial and real-world approach from practitioners of the engineering profession. This gap is caused mainly by the success of our graduates as employees in their respective workplaces, which has not created the necessity of change. Another probable cause is a somewhat smaller importance given to education in our research-driven faculty. To achieve this cultural change it is important to give similar importance to teaching than to research, for instance in the academic evaluation, and to include teaching training as part of the academic career (training lessons, peer evaluation, mentoring).

Another aspect in the analysis of the difference between the bench-

marked institutions and our faculty is the culture of engineering education outside the curriculum. Extracurricular activities for students are fundamental in the future engineers: 50% of UCLA's undergraduate population partake in clubs related to their future engineering interests, and The University of Manchester's students follow the same path. Even more, Olin's "Passionate Pursuits" is a for-credit instance where students follow their interests outside of the scope of their majors. These activities help their students develop skills and abilities that cannot be stacked in the curriculum directly or that are not taken into account in traditional engineering education schemes, strongly emphasizing the "doing" part of the engineering education. Infrastructure is needed for this point, and our faculty has taken long strides since 2007 in this direction, but a gap can be clearly identified when the load of the curriculum makes it hard or even impossible for students and academics to partake projects outside of the traditional workload. The cause of this gap is related to the structure of the curriculum, where solid mathematical and physical background is sought in order to tackle engineering problems, thus filling up the workload of the students and academics, leaving little time to tackle interdisciplinary projects. A way to change this paradigm is to emphasize the importance of such project-based workload either in the curriculum (increasing the weight of such courses in the curriculum) or by giving non-academic incentives towards the development of projects outside the scope of the curriculum.

Research and Development
Institutions compared with: UCLA Manchester, Caltech.

FCFM stands very well in terms of R&D nationally, actually leading in all possible metric. But there is a clear gap between what we do here and the impact that the benchmarked institutions achieve. In fact, Manchester had a specific policy geared toward increasing impact. Some ingredients of that policy were to give priority at finding solutions to global challenges (such as cancer, world poverty, carbon reduction, nuclear energy and social cohesion), but also to do so through multidisciplinary research, in order to increase the likelihood of really novel findings. Moreover, Manchester decided, in a top-down move, to detect and foster those areas where it had competitive advantages over other universities. And all this can help explain the difference in R&D impact; while other universities have internal policies clearly oriented towards nurturing multidisciplinary research, FCFM has rested only on particular initiatives, some of which have been externally promoted through grants. The gap, though, can be addresses as FCFM has a great potential for multidisciplinary research –probable the largest in the country– as it cultivates many areas of engineering and sciences and the research culture is strong. Additionally, the policy carried put in the last decades to improve the quality of hired assistant Profs has –as shown in Section 1– proved to be fruitful. Thus, all ingredients to take a major leap are set.

Technology Transfer
Institutions compared: UCLA Manchester, Cornell, Technion.

The most important universities have a technology transfer (TT) office. In fact, the top ten engineering schools (according to the QS ranking) have one. In the particular cases of UCLA and The University of Manchester, they have well defined technology transfer units: the ITA (Institute for Technology Advancement) at UCLA, and the UMIP (University of Manchester's Intellectual Property Commercialization Company) at the University of Manchester. The FCFM, however, does not have a central unit to attend the requirements of individual researchers or groups of researchers related to TT, which makes it difficult to transfer knowledge to the industry; this is a clear gap. So far the issues related to TT are handled with the joint efforts of the Academic & Research Direction and the Project office. Although the University is doing some efforts in that direction, we think that having our own Technology Transfer unit is important to overcome this gap.

Innovation and Entrepreneurship
Institutions compared with: UCLA Manchester, MIT, Waterloo.

At the University of Manchester the Innovation Centre (UMIC) provides an innovative and entrepreneurial environment for start-ups, incubator tenants and small and medium-sized enterprises. The UCLA has the Institute for Technology Advancement, which provides facilities and funding to start ant promote new companies. At the University of Waterloo, a culture of innovation and entrepreneurship has developed, that includes a radical approach to intellectual property, a co-op program that places students in constant contact with leading companies, and an ecosystem that includes accelerators and many success stories from which students and faculty members can draw inspiration and guidance. At the FCFM, despite being successful at the national level with a number of successful cases of scientific-technological innovations, there is a clear absence of such an environment for i+e. On the other hand, we have a growing number of students that are nowadays looking to generate their own companies by the end of their studies. These students require special guidance in both innovation and entrepreneurship that is not currently provided at the FCFM. We have identified the following ways of overcoming this gap: first, include specific courses on innovation and entrepreneurship in the curriculum, and secondly, generate a Science-Technology Innovation Laboratory and an Entrepreneurship Laboratory (STIE Labs) to introduce the i+e culture into the FCFM environment.

Internationalization
Institutions compared with: UCLA Manchester, Karlsruhe, Groeningen, Chalmers.

Within the benchmarked entities, there is a transversal agreement on the importance of the internationalization of the undergraduate, gradua-

te, academic and staff levels to enrich and upgrade the local environment at the Engineering Schools. This is a point not present yet in our Faculty. In other words, we have not fully grasped the transversal concern that internationalization must be a part of the infrastructure, organizational administration and living culture of the Engineering schools. This concern is reflected on the number of foreign students on the curriculum of the benchmarked schools. The University of Manchester's Engineering school has over 15% foreign undergraduate students and 40% foreign graduate students. Similar numbers are displayed by UCLA's Henry Samueli School of Engineering. In this sense, a clear gap appears as the foreign student community within the FCFM is small (below 2% in the undergraduate level), although somewhat larger and increasing in time for postdoctoral fellows and academic staff. The main cause for this shortcoming is that FCFM as a whole is insufficiently known internationally, both in terms of Engineering rankings and in international companies related to technology, engineering processes or systems. This is somewhat a vicious circle: FCFM shows a deficiency in internationalization because it does not have enough international exposure.

Also, the benchmarked schools promote and take part in a strong policy of online master programs towards achieving worldwide visibility and impact, thus attracting the best and brightest students, researchers, professors and new stakeholders into their environment. This also serves the point to induce an active learning scheme, where local and foreigner students interact (in person or online) with each other. In our school, this type of program does not exist, although MOOCs are playing a small role in the development of new lectures and courses. This gap is related to the standard and classic way of teaching and learning in the FCFM, where building online tools is not taken into account in the academic evaluation as an improvement of the teaching role, or even viewed as a nuisance by some of the faculty. A way to overcome this gap is to give incentives to the faculty to use new learning techniques (through academic evaluations).

Student mobility programs (either to universities or industrial partners), academic sabbaticals, visiting professors acting on each school are viewed as important parts on the internationalization scheme of each faculty. Established programs on this respect are crucial to the development of strategic plans for the benchmarked universities (Manchester had a strong investment on the internationalization of its academic faculty, and Chalmers had a very strong connection with MIT academics that visit for long periods of time while developing the CDIO approach).

A cause of this mismatch between our school and the benchmarked institutions can, certainly, be traced back to the geographical isolation of our faculty. But, certainly as well, there are no well-established programs for international mobility of students and professors, in part because the institutional organization is not really conducive to this. To bridge this clear gap we propose on the strategic plan a change both on the cultural and organizational scheme of the FCFM to include an office of international affairs and of international mobility of students, which would establish formal (and funded) programs.

2.5.3. Possible actions to overcome identified gaps

In what follows, we briefly mention some possible alternative strategies to overcome the identified gaps and shortcomings. These are motivated by the actions and programs developed in the institutions considered here for this benchmarking study. Also, we have taken into consideration the conclusions and recommendations from the report entitled "The Innovative and Entrepreneurial University: Higher Education, Innovation & Entrepreneurship in Focus", U.S. Department of Commerce, The Office of Innovation and Entrepreneurship at the Economic Development Administration, 2013.

Engineering Education

There is an ever-increasing amount of technical knowledge that engineering students have to manage. There is also a growing recognition that young engineers must possess a wide range of personal, interpersonal skills. In order to give the engineering students both technical and personal/interpersonal skills, the FCFM has adopted the CDIO approach and implemented several activities of active learning. Despite that, the percentage of active learning activities in the classroom is still low; therefore, we are determined to increase the number of active learning activities in the classroom, as well as team work and multidisciplinary learning experiences.

Research and Development

Based on the benchmarking, we have identified multidisciplinary research as a way of improving our research impact. Although the FCFM has a great potential for multidisciplinary research, there is not a clear internal policy to promote coordinated, focused, multidisciplinary research. In order to overcome this gap, we propose coordinating the efforts of the Academic & Research Direction (A&RD), and the future Technology Transfer Direction to promote participation in multidisciplinary research and development projects. Both the A&RD and the TTD will identify "common problems" that need to be addressed through multidisciplinary research. In order to foster multidisciplinary research, the A&RD will incentive the application to external grants that require that kind of research, and will incentive the formation of multidisciplinary groups to tackle these "common problems".

Technology Transfer

The FCFM, however, does not have a central unit to attend the requirements of individual researchers or groups of researchers related to technology transfer, which makes it difficult to transfer knowledge to the industry. To overcome this gap we propose the creation of an Innovation and Technology Transfer (iTT) office or directorate, whose main objective is to propose and develop strategies to enhance the impact of our research in the industry and society. Such a unit should be adequately staffed with skilled professionals who are provided with the resources to effectively and efficiently perform their jobs. The iTT office should foster policies to maximize the societal and economic development benefits of discoveries, rather than maximizing revenues, and to encourage participation by our researchers and encourage engagements with potential partners (industry, entrepreneurs and venture capital investors). Also, it will strengthen strategic investments in university-industry collaborations aimed at advancing technologies of mutual interest and renowned research programs, designed to enhance market-pull of research.

Innovation and Entrepreneurship

A growing number of students are nowadays looking to generate their own companies when finishing their studies. This need requires special guidance in both innovation and entrepreneurship in order to prepare them and faculty to the new times, where i+e ST are expected to be more important than before. This requires an increase in the internal resources to promote i+e ST activities. To overcome this gap, i.e., that of not having a culture for scientific-technological innovation and entrepreneurship, we propose to implement a series of courses, tutorships and specialized counseling for students and faculty, along with a i+e ST Laboratory and an Ideas Accelerator to manage internal resources and set guidelines in the FCFM. On the other hand, we are planning to encourage faculty innovation through incentives, faculty industry sabbatical leaves, campus prizes and other forms of recognition. Also, we expect to create and expand programs that connect faculty and students to the resources they need: industry partners, entrepreneurial mentors, translational research and "proof-of-concept" funds, accelerator facilities and venture creation services, within the normative and legal framework of UChile. We propose to implement streamlining initiatives and encourage the reduction in internal reporting and compliance requirements, which would allow faculty to increase time spent on proposal writing and research.

Environment and engaging with local economic development efforts

FCFM is operating in a challenging environment, historically characterized by a local culture that does not support i+e: geographic isolation, underdeveloped technological industry, lack of human resources and a lack of venture capital. However, in the last years, thanks to multiple efforts, in particular through CORFO instruments, the ecosystem has been starting to change. In line with these efforts the schools of engineering in Chile, in particular the FCFM must play a central role to attract relevant actors to develop the Chilean ecosystem and globalize its activities in order to accelerate local initiatives. Specifically, it should be relevant to impulse a technology hub in Santiago (or Chile) and international partnerships with world-class institutions and international technology hubs. This will allows us to encourage the development of accelerators and public-private partnerships on or within close proximity to university-based ecosystems; and find ways to provide innovation services to new enterprises external to the university.

Internationalization

The FCFM has an average of less than one PhD student per full time professor, which, based on the benchmarking is considered low (e.g., UCLA has 5.8 PhD students per full time professor). Our challenge is to double the number of PhD students in the time frame of the project. In order to do that, we will increase the number and quality of scholarships and provide allocation facilities for foreign students and/or students coming from other parts of the country. This will contribute to the internationalization of the FCFM.

2.6. Plan for benchmarking update

The updating of the benchmark contains the following points:

1

Some specific programs of the above mentioned institutions will be consulted in more detail during the implementation of similar initiatives in the FCFM.

2

The essence of UChile establishes the need for public accountability of our actions and the use of the economic resources. Therefore, we will update the indicators section 1.1a of this document along with the parameters of our benchmarked universities annually and present our findings at different instances: web page, annual report and workshops.

3

There will be an external Monitoring Board recruited from our reference institutions. They should provide independent comments and recommendations to the project leaders and the university.

4

We will conduct qualitative benchmarking every 3 years for the two role models institutions (UCLA & Manchester), identifying when necessary other universities for in-depth review of our strategic plan's evolution.

5

We have considered including institutions from Asia in our benchmark process. Countries like Japon (University of Tokio), Korea (KAIST-Korea Advanced Institute of Science & Technology) and China (Beihang University) cannot be dismissed when setting the technological horizon at year 2030. In particular when they have followed or are following a path towards economic growth similar to ours.

Finally, we want to highlight that a number of the benchmarked institutions are either partners or consultants and, therefore, the update will be part of our agreements with them.

References

[1] Dr. Ruth Graham, "Technology Innovation Ecosystem Benchmarking Study: Key findings from Phase 1", MIT Skoltech Initiative, 2013.

"The Innovative and Entrepreneurial University: Higher Education, Innovation & Entrepreneurship in Focus", U.S. Department of Commerce, The Office of Innovation and Entrepreneurship at the Economic Development Administration, 2013.

narking

Interviews for Benchmarking.

Name and Position	Institution
Richard Wesel: Professor & Associate dean.	UCLA
Vijay K. Dhir: Dean.	UCLA
Adriene Lavine: Vice Chair of Undergraduate Programs, Mechanical Engineering.	UCLA
Daniel Kamei: Associate Professor & Vice Chair, Bioengineering.	UCLA
Piroux Kavhepour: Associate Professor, Mechanical Engineering.	UCLA
Teresa Alonso Rasgado: Director of the Latin American Program.	University of Manchester
Collin Bailey: Dean of Faculty of Engineering and Physical Sciences.	University of Manchester
K. Brown: Head of School of Electrical & Electronic Engineering.	University of Manchester
Tony Walker: Director of Business Development and Business UMIP.	University of Manchester
Stephen G. Yeates: Professor of Polymer Chemistry, member of OMIC.	University of Manchester
Mark Somerville: Associate Dean for Faculty Affairs and Development.	Olin College
Jonathan Stolk: Professor of Mechanical Engineering and Material Sciences	Olin College
Debbie Chachra: Associate Professor of Material Sciences.	Olin College
Jessica Townsend: Associate Dean for Curriculum and Academic Programs.	Olin College
Juliana Bernal-Ostos: Visiting Assistant Professor of Materials Sciences.	Olin College
Joel Schindall: Director of the Gordon Engineering Leadership-GEL-program.	MIT
Leon Sandler: Executive Director of the MIT Deshpande Center.	MIT
Maren Cattonar: Innovation Manager of the MIT Deshpande Center.	MIT
Kyle Judah: Program Manager, Martin Trust Center for MIT Entrepreneurship.	MIT
Ari W. Epstein: Lecturer. Terrascope. Office of Experiential Learning.	MIT
Leo McGonagle: Executive Director. Bernard M. Gordon MIT Engineering Leadership Program.	MIT
Diane H. Soderholm: Senior Instructional Designer. Skoltech Initiative.	MIT
William Lucas. Director of Research: Bernard M. Gordon MIT Engineering Leadership Program.	MIT
Eric Mazur: Area Dean of Applied Physics.	Harvard
Julie Schell: Postdoctoral Fellow Educational Research.	Harvard
Anas Chalah: Director of Instructional Laboratories. Lecturer on Engineering Sciences.	Harvard
Craig Gotsman: Director and Professor, Cornell-tech.	Technion- Cornell
Jaime H. Moreno: Senior Manager, Microprocessor Architecture.	IBM
Alain E. Biem: Research Staff Member. Business Design Research.	IBM
Maurizio Arienzo: President and CEO.	Nova Ware
Uzi de Haan: Professor, Faculty of Industrial Engineering and Management.	Technion-Israel

Name and Position	Institution
Eduardo Abeliuk: Entrepreneur, TeselaGen. Ph.D. in Electrical Engineering, Stanford University.	Stanford
Carver Mead: Professor Emeritus.	Caltech
Michael Vicic: Chemical Engineering Laboratory Instructor.	Caltech
Joanne Long: CEO at IORodeo	Caltech
Julius Su: Visitor in Chemistry, co-developer of the SKIES Learning App.	Caltech
Dr. Johan Malmqvist: Department of Product and Production Development. Dean of Education.	Chalmers University of Technology
Dr. Mats Lundqvist: Director of Chalmers School of Entrepreneurship, Head of Division.	Chalmers University of Technology
Dr. Mikael Enelund: Head of Mechanical Engineering program.	Chalmers University of Technology
Dr. Rikard Soderberg: Head of Production Area. Department of Product and Production Development.	Chalmers University of Technology
Pascale Kohler: International affairs.	Karlsruhe Institute of Technology
Dr. Michael Kurth: Head of Studies and Teaching.	Karlsruhe Institute of Technology
Dr. Klaus Dullenkopf: Head of President's Staff.	Karlsruhe Institute of Technology
Dr. André Presse: Institute for Entrepreneurship, Technology Management and Innovation.	Karlsruhe Institute of Technology
Prof. Petra Rudolf: Professor of Experimental Solid State Physics.	University of Groningen
Dr. F. Brustolin: International Relations, policy advisor.	University of Groningen
Prof. Erik van der Giesse: Director of the Applied Physics Program.	University of Groningen
Prof. Gerald Jonker: Director of the Industrial Engineering and Management Program.	University of Groningen
Prof. Jacquelien Scherpen: Director of the Institute for Engineering, Technology and Management.	University of Groningen
Prof. Gert-Jan Euverink: Professor of products and processes for biotechnology in the bio-based economy.	University of Groningen
Martha Fouds: Director of Planning, Faculty of Engineering.	University of Waterloo
Dave Diezt: Director, Engineering Research. Faculty of Engineering.	University of Waterloo
Anwar Hassan: Associate Dean Research and External Partnership. Faculty of Engineering.	University of Waterloo
Jana Carson: Manager of institutional Analysis and Planning.	University of Waterloo
Barry Ferguson: Associate Dean, Cooperative Education, Faculty of Mathematics.	University of Waterloo

2030

A New Engineering for 2030

Strategic Plan

3. Transformation strategy and plan

3.1. Strategic Approach, Main Goals and Implementation Plan

a) Mission, vision and description of the strategic approach to the transformation process of the school.

Mission and Vision

FCFM's vision as a higher education institution guided by international standards of academic excellence, which creatively and effectively responds to the conditions and challenges of globalization and the integration of Chile in the world, follows a path that is consistent with the historical mission, state and national public nature and commitment of Universidad de Chile. The goal is to become a world-class institution recognized by its leadership in science, technology and innovation, driven by multidisciplinary cutting-edge research that addresses both global and national challenges, and that provides an outstanding and broad educational experience, being engaged with the society and industry.
In this context, FCFM aims to be the most important center of the country in engineering and science, to be internationally recognized in the academic world in the areas of its competence, and be a major player in the process of adoption of science and technology in all areas of the national economy. It is essential to the FCFM mission to be involved with the generation, development, integration and communication of knowledge in basic sciences, engineering, earth sciences, economics and management sciences. It is the responsibility of FCFM faculty to significantly contribute to the advancement of these areas, addressing the problems and needs of the country and global society. Fulfillment of this mission is carried out through teaching, research and outreach activities, at different levels of complexity.

Methodology for the identification of gaps

The diagnostic process shows that FCFM has taken strong efforts to strengthen its research and education components over the last 15 years. The level of research and the quality of its alumni is well over an acceptable level in the Latin American region, but still lacks in comparison to that of developed countries. Quality (scientific merit, impact of research in terms of citations, international recognition) and impact (application and use of the research outside of the academia) must be improved.

Although present in FCFM, Technology Transfer (TT) and innovation & entrepreneurship based on Science and Technology (i+e ST), are identified as our weakest areas. There is no structure within the school of engineering to foster either i+e ST or TT at all levels (undergraduate and graduate students, post docs and faculty). In particular, a tendency to work individually and by disciplines appears to be a major obstacle in tackling more pertinent and challenging problems. The challenge is to develop innovative technologies that solve real-world problems, build viable business models and move them out of university labs into the market.

On the other hand, from the benchmarking process, it was established that public state-owned universities can be relevant actors in TT. Some important examples are those of the University of Waterloo (Canada), UCLA (USA), University of Manchester (UK) and Technion (Israel). In addition, international research universities have improved the impact and pertinence of research by addressing global problems in a collaborative way between disciplines (a multidisciplinary approach). They foster, either in a direct or indirect manner, multidisciplinary activities at all levels. During the benchmarking, different actors from MIT, Cornell and Technion highlighted the fact that research is a key element to innovation and entrepreneurship in Science and Technology. This evidence is also supported by the benchmarking performed by Skoltech [1], where the research capacity is identified as one of the success factors for i+e ST. Skoltech benchmarking [1] also shows a high correlation between high level research and the best ecosystems for innovation in the world. In addition, a study by the Kauffman Foundation [2] shows that most of the i+e ST is carried out mainly by a combination of professors, postdocs, PhD and business students. Research has been identified as a cornerstone, therefore, being a necessary condition to have i+e ST. However, this has proven to be insufficient.

From current literature [2] [4] [3] and our own benchmarking process, we identify the key elements of success for i+e ST:

(1) Institution rich cultural environment for i+e ST,
(2) Leadership within the university in i+e ST,
(3) The quality of research,
(4) The quality of life within the country and the university,
(5) Government support,
(6) Institution strategy, and
(7) Student-driven entrepreneurial activities.

Points (1), (2) and (7) are associated with the availability of courses, training and initiatives related with i+e ST and with valorization of i+e ST within the school (at all levels). We have grouped these success elements together in the so-called i+e ST culture. Points (3) and (4) are grouped into the so-called multidisciplinary work at the undergraduate and graduate level, and research and international collaboration. Point (3) is related to the pertinence and impact of the research, the multidisciplinary work among high level researchers and a qualified PhD program, appearing as the main drivers of high-level research. Point (4) is associated with proper infrastructure and support for national and international students and staff. Point (5) is considered as external and in some way, granted. The Chilean government has been fostering i+e in general with different instruments and in particular, with this specific grant from CORFO. For point (6) FCFM has developed and implemented a clear strategy of research quality improvement, demonstrating good results (in a number of publications, citations and with international recognition), being a key element for i+e ST. The development of the current strategy (for this grant) appears also to target point (6). Point (6) also refers to the direct or indirect strategy to foster i+e ST. At this stage we identify the i+e ST administrative structure as a strategic element. For these key elements to succeed in fostering i+e ST, we have identified the main specific gaps that FCFM should address:

I. Discipline rather than multidiscipline (at all levels). Besides external (large) grants, there is a lack of institutional incentives to perform coordinated, focused and multidisciplinary research. In particular, undergraduate and graduate programs

tend to individualize work in an atomized manner.

a. More active (project-oriented) education: The need for more active education and generation of assessment mechanisms of the new methodologies; in particular, based on the CDIO syllabus [3].

b. Focused Research: Most of the benchmarked universities identify the focus on research as a strength. FCFM has not identified strategic areas on where to focus and coordinate the work of the disciplines. Large External grants have proved to be an unofficial vehicle for such a purpose.

c. Stronger PhD Programs: The PhD programs need to grow in numbers, quality and should support multidisciplinary research in specific areas where Chile has strategic advantages.

d. Lack of coordinated relation with national/international industry: In particular, this pertains to the lack of high-level coordination for internships and joint projects with national/international industry.

II. Lack of i+e ST culture (knowledge, value and support). In particular, FCFM lacks i+e ST strategy, courses, trainings, sponsored competitions, institutional and international support, an assessment instance and proper recognition of the work developed on this topic.

III. Lack of administrative structure to foster i+e ST and TT. FCFM lacks an institutional structure for generating, supporting and assessing Scientific-Technologic innovation and entrepreneurship and Technology Transfer.

IV. A challenging environment within the country and the Latin American region. The lack of i+e ST is not an issue either at a university level or at the engineering schools. Nevertheless, Chile is a challenging environment for i+e ST due to various factors, such as the geographic distance, small market and lack of venture capitals, among others.

These gaps have an impact on many of the areas of development at FCFM. Table 3.1 shows the relation between the gaps and areas. Quality research, education and internationalization experience are necessary conditions to foster i+e ST and TT, hence the reason deficiencies in these fields indirectly impact the level of i+e ST and TT.

Table 3.1. Identified gaps and their impact within the items defined by CORFO.

Identified Gaps	Education	Research	i+e ST	Technology Transfer	Internationalization
Lack of tendency (at all levels) to work in a Multidisciplinary manner	X	X	X	X	X
More active (project-oriented) education					
Stronger PhD Program					
Focused Research					
Lack of coordinated relation with national/international Industry					
Lack of administrative structure to foster i+e ST and TT		X	X	X	X
Lack of i+e ST culture (knowledge, valorization and support)	X	X	X	X	
A challenging Environment within the country and the Latin American region for i+e ST		X	X	X	

Trajectory and strategy to overcome the identified gaps

CORFO, based on international evidence, has defined four possible trajectories that engineering schools might choose for development and trajectory based on: (i) engineering education, (ii) research and technology transfer, (iii) industry relationship and outreach, and (iv) a combination of the previous three. On the other hand, CORFO has defined six strategies to tackle the selected trajectory with a strategy of: (1) organic evolution, (2) aggressive renewal of faculty personnel, (3) strong alliances, (4) a "build-operate-transfer (BOT) approach", (5) digitalization and social networks, and (6) a combination of the previous five.

In particular, since 1997, FCFM has followed the *research and technology transfer* trajectory, achieving measurable development gains in research, education, infrastructure and internationalization. The activities described in the diagnosis section suggest that the best overall strategy for FCFM in the following years is *the combination of organic evolution with strong alliances,* since most of the radical strategies were already implemented. Though we will develop all areas within the university in an organic manner, the commitment to change at FCFM is based on the opportunity to improve the level of research and education through i+e ST.

Therefore, *FCFM will drive a profound cultural and organizational change to foster innovation and entrepreneurship in science and technology (i+e ST).* The commitment of FCFM to i+e ST is closely related to one of its goals: pursuing new high-level knowledge for Chile, the Latin American region and the world. Most of the interviewed universities in the benchmarking process mentioned that successful universities pay close attention to i+e ST not only to profit from it, but also to improve the levels of their graduates and research. Specifically, paying attention to i+e ST aids in making research more pertinent, improving its impact and developing the professional skills of its graduates. In most of the benchmarked universities, high-level research is seen as a necessary (but not sufficient) condition for i+e ST. In that sense, as the benchmarking stage is now understood by the faculty, improving our level of i+e ST will have a positive effect on our research, our graduates and the impact and pertinence that research and graduates can have on society.

UK Royal Academy of Science carried out a study [5] where it was demonstrated that large and extended transformations are not usually the best option, especially for institutions with inertia and history, such as the Universidad de Chile. Instead, small and deep focalized transformations tend to keep the implementation simple and more effective, to achieve the desired results.

A simple effective action to improve our level of research, education and internationalization with emphasis on i+e ST and TT is to foster *multidisciplinary work.* Multidisciplinary work will be encouraged for research and graduate education, undergraduate education, and for the impact that our research and graduates have on society.

Figure 3.1 presents a scheme of how we see the role of multidisciplinary work in FCFM. The multidisciplinary profile of students and staff will be taught, encouraged and supported at FCFM and will be included as a desirable characteristic of our graduates, faculty and programs. Multidisciplinary collaboration with local and foreign institutions will also be encouraged and supported with specific activities.

> FCFM will drive a profound cultural and organizational change to foster innovation and entrepreneurship in science and technology (i+e ST).

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Figure 3.1. The strategic approach

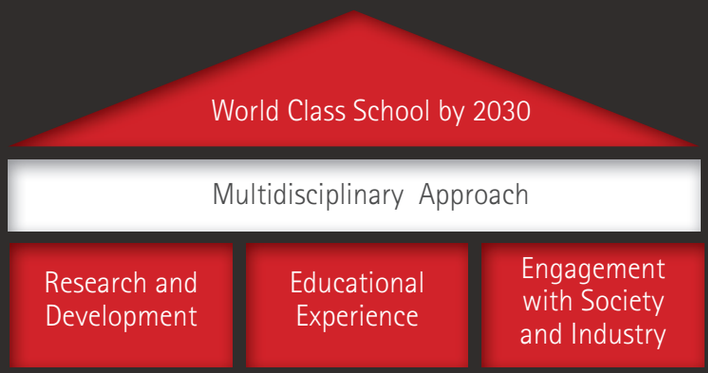


Figure 3.1. The strategic approach to improve the three major dimensions of our school, and in turn, to position FCFM among world class institutions in Engineering. By encouraging and supporting multidisciplinary work, engaging national and international industry, we will improve the pertinence and quality of our education, research and impact on society.

Multidisciplinary work appears as a simple means to improve our education, research and internationalization, which are key to fostering high-level i+e ST. However, it has to be fostered in conjunction and coordination with other high-priority macro actions, which will be conducted within this project (a more detailed description of the actions is given in section 3.4). The following are Macro-Activities which are proposed to bridge the identified gaps (Table 3.1).

I. The promotion of joint laboratories, project-oriented courses and strategic alliances.
II. A change in the institutional structure to foster, monitor and assess i+e ST and TT activities.
III. Creation of courses and degrees in i+e ST.
IV. Creation of the i+e ST Laboratories.
V. PhD program will be strengthened, in focus, multidisciplinary approach and size.
VI. Formation of institutional structure to foster student quality of life and internationalization.
VII. Strengthening CDIO curriculum and its assessment. Improving the professional and communicational skills by improving the Engaging and Outreach process.
VIII. Creation and development of International channels for i+e ST and TT – Cornell-Tech and REAP program from MIT Martin Trust Entrepreneurship Center - and cultivation of a national ecosystem: the Laguna Carén Technology Village.

The relation of these macro-activities with the identified gaps and their impact on the pertinence areas of the institution is presented in Table 3.2.

Table 3.2. Macro-Activities and their expected impact within the gaps and in the areas (items) of FCFM.

Identified Gaps	Education	Research	i+e ST	Technology Transfer	Internationalization
Lack of tendency (at all levels) to work in a Multidisciplinary manner	I, II, IV, VII	I, II, IV, V	I, II, IV, V, VII	I, IV, V	I, II, IV, V
Lack of administrative structure to foster i+e ST and TT		VI	II	II	VI
Lack of i+e ST culture (knowledge, valorization and support)	I, II, III, IV, VI, VII	I, II, III, IV, V	I, II, III, IV, V	I, II, III, IV, V	IV, VI, VII
Challenging environment within the country and Latin American Region		VIII	VIII	VIII	

Multidisciplinary areas for priority development

In order to improve our standing in the world ranking of distinguished academic institutions, FCFM must be recognized internationally as a focused excellent research unit. Academic prestige and global reputation will be attained by building capacities in priority development areas with a full use of our competitive strengths in multidisciplinary research. These areas are divided into three categories:

- The first category corresponds to advanced technologies for productive processes and wealth creation.
- The second category is composed of key ST issues related to the public interest and welfare.
- The third category is related to advanced technologies for cutting-edge basic research.

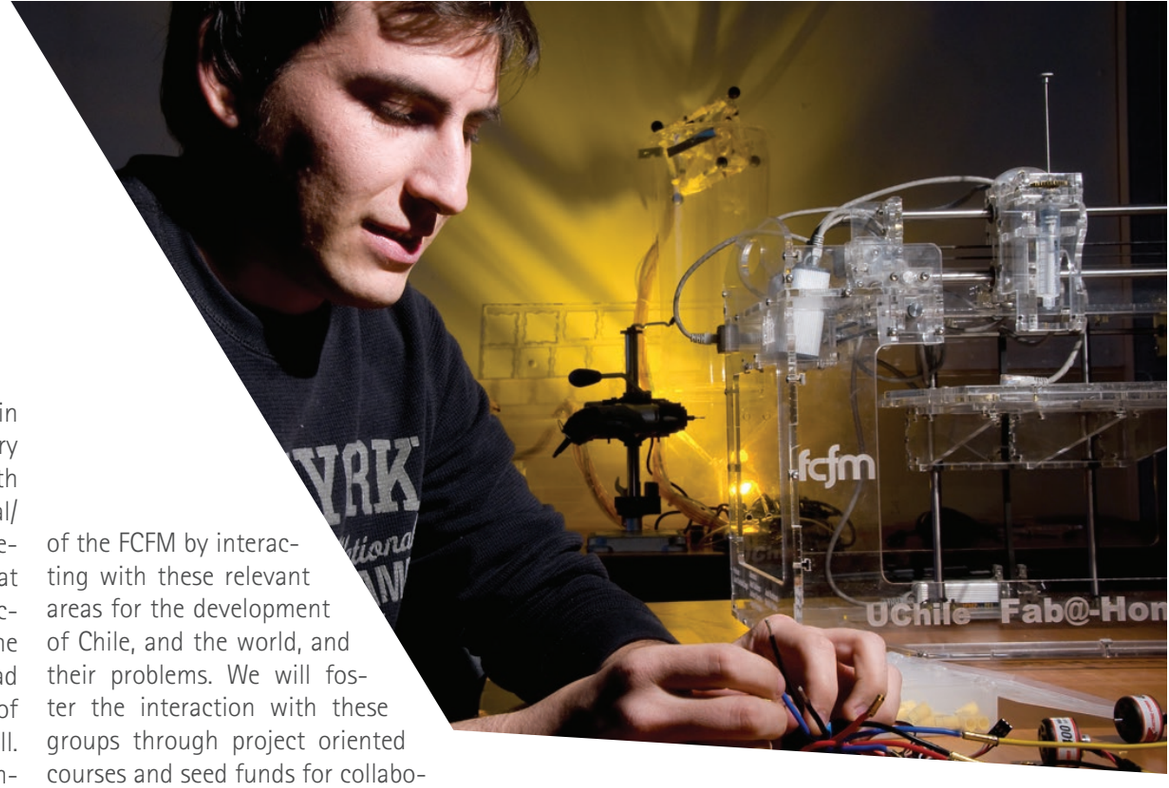
Faculty focus

The proposed selection of priority development areas does not exclude other emerging topics. But in the next 5 years these will be the areas where the 13 disciplines of the FCFM will look for problems and, in a coordinated way, collaborate to address them. The following table summarizes the priority development areas and some specific topics, based on our (FCFM) expertise and the necessities of our country.

Table 3.3. Selected areas for priority development.

Technologies for productive processes and wealth creation	Areas of public interest and welfare	Technologies for Scientific research
Energy • Solar • Electromobility • Geothermal • Fossil fuels substitution • Smart-grids • Electric storage systems	Resilience • Infrastructure • Natural Hazards: Earthquakes, Tsunamis • Climate change • Instrumentation and sensor networks	Astronomy • Radio astronomy instrumentation • Big data
Mining • Specific site operation technologies • Critical minerals • Productivity • Environment and Sustainability	Education • High-school teachers' standards • Learning technologies and methods	FBioengineering • Biological systems • Bioinformatics • Body area networks
Systems Engineering • Modeling • Optimization • Operative Research • Computational Model • Smart cities	These areas of priority development will be reviewed every 5 years, where the first review will be held in 2019. Based on the state of maturity, impact achieved and necessities of the country, the areas might be updated. The authorities of the FCFM and the external board will hold the review.	

University Focus



Outside the faculty but still within the university the multidisciplinary approach will be encouraged with two specific areas where physical/mathematical sciences and engineering technologies might have a great impact. We will encourage interaction with the Faculty of Medicine and the Hospital of the Universidad de Chile, and with the faculties of Agronomy and Veterinary as well. We expect to drive Scientific-Technology knowledge and innovation of the FCFM by interacting with these relevant areas for the development of Chile, and the world, and their problems. We will foster the interaction with these groups through project oriented courses and seed funds for collaborative research.

Proposed Transformation Plan

Improving our level of i+e ST will require changes and coordination improvements. In this section we explain in more detail the proposed transformation in structure, education, research and external engaging & outreach in order to foster scientific-technologic innovation and entrepreneurship.

The strategy plan will foster innovation and entrepreneurship in science and technology by enhancing the i+e ST culture (support, knowledge and value), which is correlated to the input, process and output nomenclature of the MIT Skoltech study on innovative ecosystems [1]. We will support i+e ST (input variables) by changes and optimization of the organizational structure as well as with improvements of policies and seed funds.

The knowledge will be foster with curricular and extra-curricular activities. The extra curricular activities place a key role not only to practice by applying what is learned in the curricular activities, but also to assess the methodologies used in the curricular activities.

Finally the value of i+e ST will be foster by valorizing these activities in our community and by leveraging, through different mechanism, the technology transfer activities. In this level our ambitious plan is to provide to Chile and the Region with a world class Technology Hub.

The activities of each level will count with the collaboration of specialized institutions, groups and experts for their development, implementation, operation and assess. Figure 3.2 shows a diagram of the strategic plan where the rows are the level of culture and the columns are the description of the proposed mechanism, the macro activities and the partners collaborating to implement the plan.

Figure 3.2. Diagram of our strategy plan

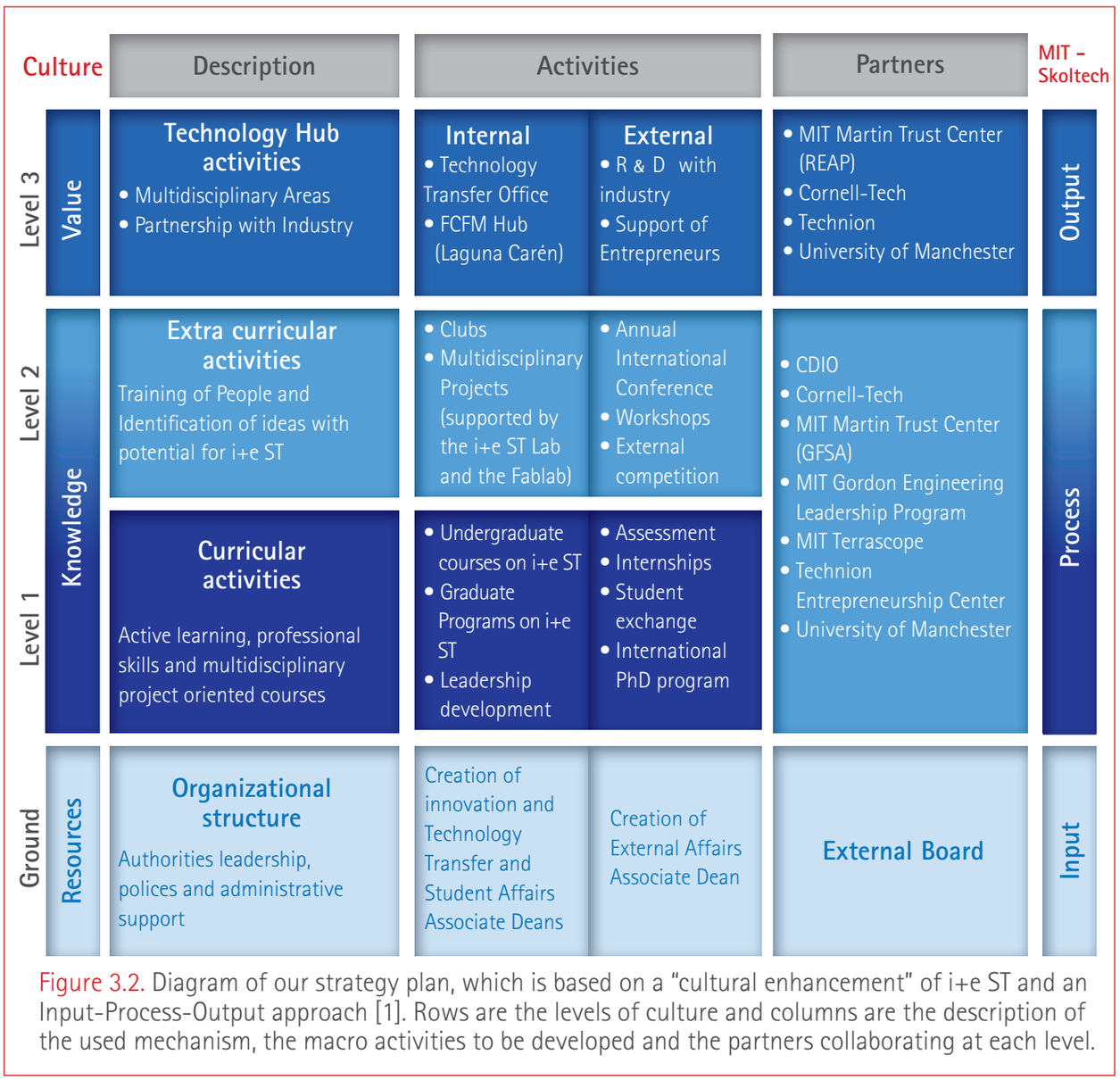


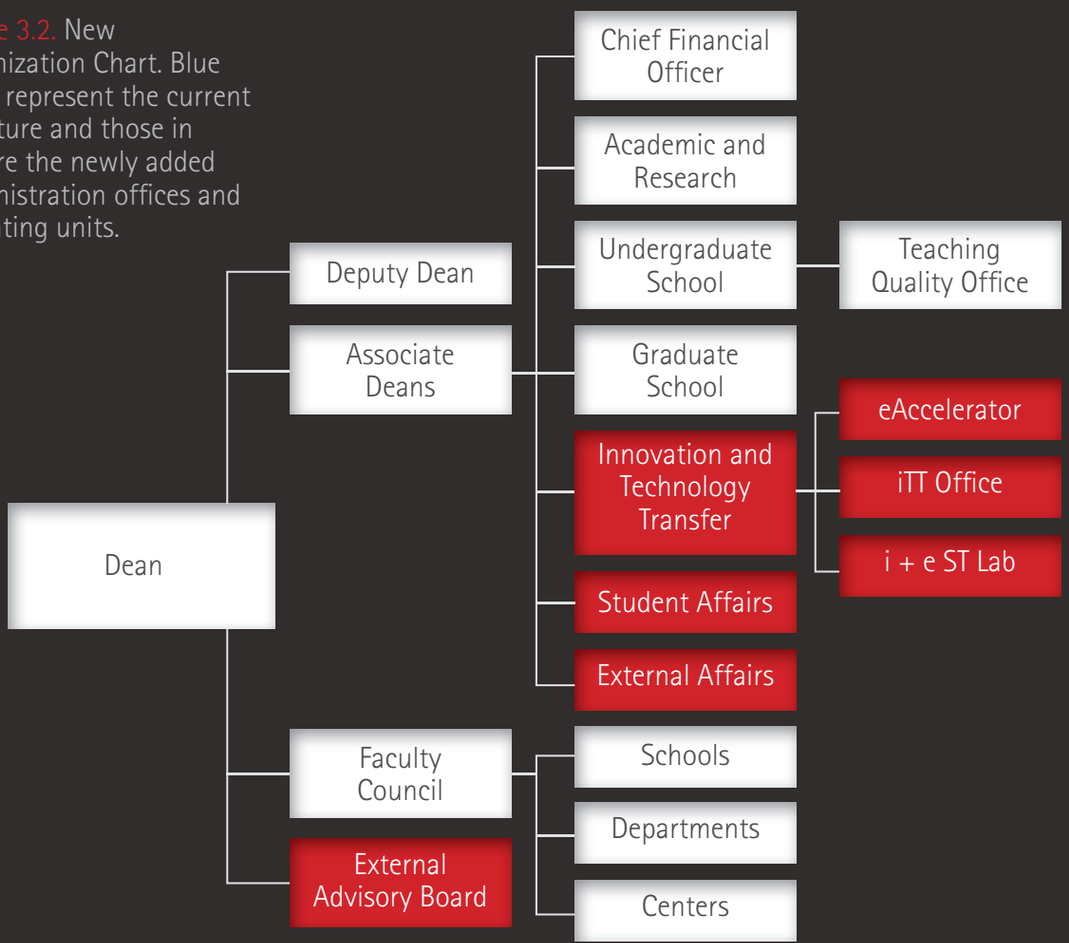
Figure 3.2. Diagram of our strategy plan, which is based on a "cultural enhancement" of i+e ST and an Input-Process-Output approach [1]. Rows are the levels of culture and columns are the description of the used mechanism, the macro activities to be developed and the partners collaborating at each level.

I. Change in the institution Structure

The main authority of FCFM is the Dean. Below the Dean is the Deputy Dean and there are currently four Associate Deans: Chief Financial Officer (CFO), Academic and Research, Undergraduate School and Graduate School. Coherent with the Universidad de Chile regulations, we propose to have three extra Associate Deans: *Student Affairs, External Affairs,* and *Innovation and Technology Transfer.* In addition we propose to have a *National/International Academic/ Industry Advisory Board* to collaborate with the strategic policies of the Faculty and the evaluation of their implementation. A schematic organizational chart is presented in Figure 3.2.

Figure 3.3. New Organization Chart

Figure 3.2. New Organization Chart. Blue areas represent the current structure and those in red are the newly added administration offices and operating units.



In particular, the *Deputy Dean* is in charge of the communication office, student relations and architecture office. The *Associate Dean for Academics and Research* is in charge of the academic quality control, related to external accreditation processes and overseeing Department progress. Academics and Research is also mandated to promote and coordinate the research developed at FCFM as well as seeking and identifying grant opportunities for both the Faculty and members of the community. The *Chief Financial Officer (CFO)* is in charge of the financial and accounting processes, human resources management and the legal support for FCFM. The *Associate Dean for the Undergraduate School* leads the undergraduate processes and their coordination. The teaching quality office, operative since 2006, handles the curriculum improvement and teaching training for professors and teaching assistants.

At present, the *Associate Dean for the Graduate School* is in charge of the quality assurance of the graduate programs at FCFM and the accreditation process. However, most of the diffusion and program management is carried out locally within each department.

Research in science and technology is usually a team endeavor. In this sense, good collaborative work by graduate students and their advisors fulfills a double role: first, it enables better research and therefore, S&T innovation; second, it enables the educating of high level professionals that had significant exposure to state-of-the-art knowledge in their fields, something that eventually leads to S&T transfer to industry. Major barriers to this process occurring fruitfully are: (i) poor knowledge in markets, nationally and internationally, of the programs we offer (ii) fractioned or incomplete information about curricula, fees, requirements

and overall life experience in Santiago, Chile, (iii) poor management of funds associated with programs, which ends up in inefficient allocation of resources. All three barriers can be surmounted with an adequate institutional redesign of the Graduate School, a change already in motion at FCFM for the centralized coordination and management of the graduate programs - a process that will be accelerated during this project.

In the new structure, the *Associate Dean for External Affairs* will be in charge of establishing, coordinating and assessing the external activities in FCFM at all levels and will interact with community. It will look for relationship opportunities with national and international industry and research/educational institutions. The *Associate Dean for Student Affairs* will attend to quality of life issues for undergraduate and graduate students, supporting and ensuring the quality of a multidisciplinary education with international visits and quality internships. The *Associate Dean for Innovation and Technology Transfer* will foster, support and assess the processes of i+e ST and TT at FCFM. This unit will have three new operative offices: the innovation *Technology Transfer (iTT) office* (Industry and TT externally financed projects), the *Accelerator of Ideas: eAccelerator and i+e ST lab.* The iTT office will have the research information and will foster application of these offices by helping with the connection between real world problems and the FCFM research capabilities. The eAccelerator will provide guidance and support to the commercialization procedures of FCFM innovations; world acceleration can be pursued through our international collaborators (Cornell NYC Tech).

Roles regarding i+e ST

The *Associate Deans for Undergraduate and Graduate Schools* and associated staff will be in charge of proposing, executing and monitoring curricular and extra-curricular activities for undergraduate and graduate students, which promote multidisciplinary education and the first structured approaches for the students in i+e ST, in coordination with the other Associate Deans. The curricular changes will have the collaboration and supervision of international collaborators (with advisors from MIT Gordon Leadership Group, MIT Terrascope initiative, CDIO, MIT Skoltech, Cornell NYC Tech, Technion among others).

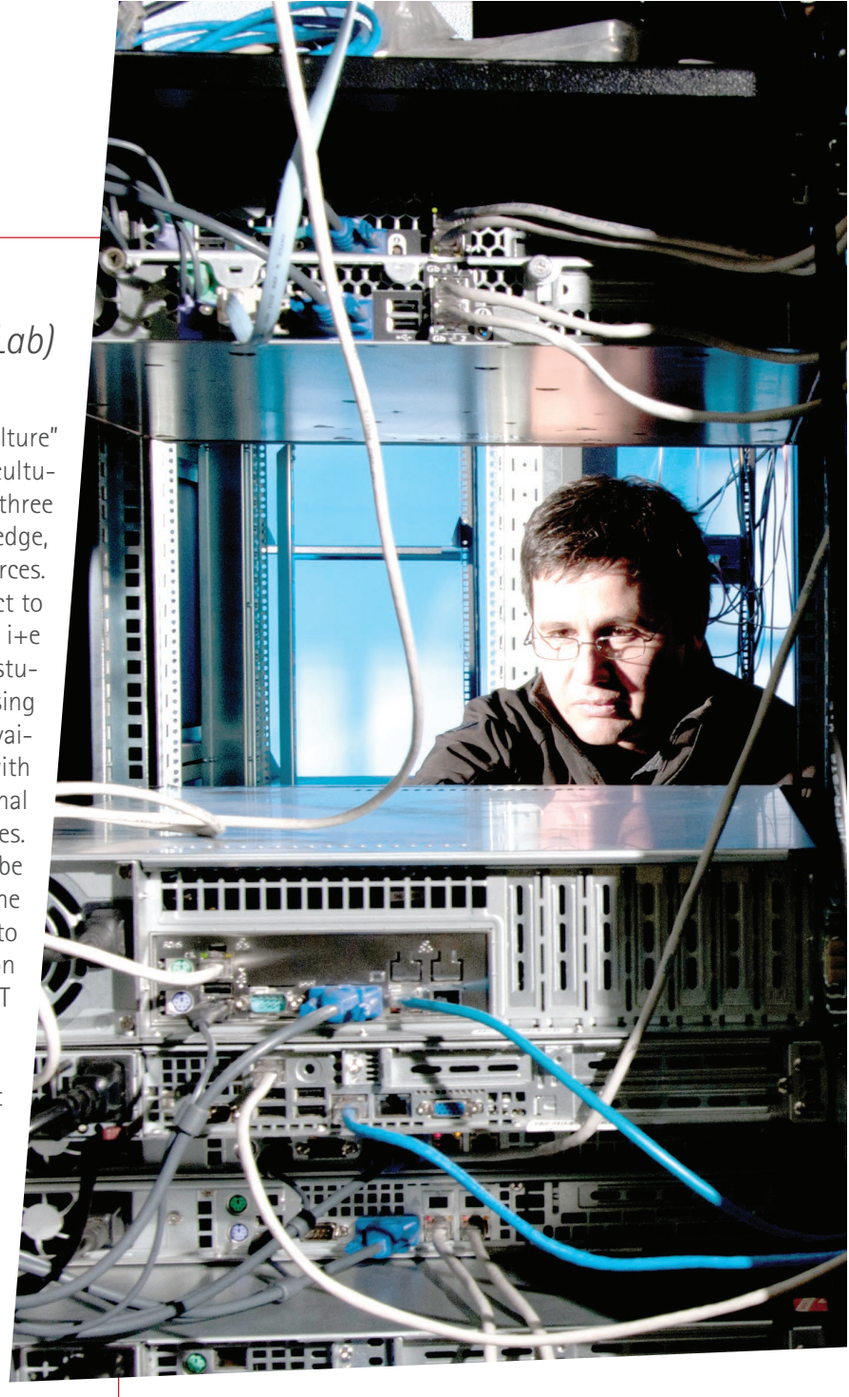
The *Associate Dean for External Affairs* will be in charge of promoting, recommending, standardizing and monitoring the external (national and international) interaction of FCFM. In particular, *External Affairs* will address the increase to the number and quality of national and international relations of FCFM related to undergraduate student mobility (e.g. exchange programs, international internships, etc.). External affairs will be a key office for the sustainability of the strategic plan since this office will coordinate the outreach of the results and the search for partners and investors. In addition, *External Affairs* will support international conferences held in the FCFM campus.

Innovation and Entrepreneurship based on Science and Technology Laboratory (i+e ST Lab)

The *Associate Dean for iTT* will be responsible for proposing and executing the i+e ST and TT strategy, training and hands-on activities. A key element of the new i+e ST structure will be the Lab that will be created. This Lab will generate, foster, assess and communicate all about the educational processes related to i+e ST. Its main function will be to identify the right people that are able to push i+e ST initiatives, and coordinate efforts of both the Undergraduate and Graduate Schools. It will also provide i+e ST support for faculty and staff. The main objective of the Lab and all the i+e ST structure (iTT Office and eAccelerator) is to provide hands-on experience on i+e ST and an easy interaction of the staff and students of FCFM with the community. In that sense, this new structure has an educational value and auto-sustainability will be avoided. Thus, in the long term the i+e ST Lab, the iTT office and the eAccelerator should have fundamental institutional support with a yearly allocated budget, which will be calculated for the desired operation and not only on the profit of the activities related to them, being evaluated every 3 years.

The Lab will work on the cultural change of FCFM and will hold activities to promote the participation in i+e ST training processes within our community (students, alumni and staff) the participation in i+e ST training processes. In particular, the i+e ST Lab will have the task of improving the "i+e ST culture" at the FCFM. The "i+e ST culture", as we refer to it, has three dimensions: i+e ST knowledge, valorization and resources. Through the Lab we expect to improve the knowledge in i+e ST at all levels, among students and staff, advertising and organizing the available in coordination with the entire organizational structure and other offices. In addition, the Lab will be in charge of managing the i+e ST resources in order to improve the coordination and visibility of the i+e ST experiences within FCFM.

The name "Lab" is not used casually and therefore requires explanation. Sometimes the word "center", at least in our community, might imply economic auto-sustainability. On the other hand, the word "Lab" refers to a place where hands-on experience is gained. In that sense the i+e ST Lab will be a space where the FCFM community will have access to resources, exchange experiences with national and international i+e ST communities, transfer multidisciplinary research knowledge and find financial support. The Lab is devoted to educating in i+e ST while identifying motivated and skillful students, in turn, avoiding the notion that the Lab is devoted to only finding marketable prototypes.



Entrepreneurship Accelerator Program (eAccelerator)

The program will set out to create a virtuous circle where an area of entrepreneurship is developed among students who wish to continue in that vocation, serving as a third route in addition to the academic option or the employee career track. The main goal is to allow for financing, managing and improving the likelihood of success of those ventures that originate in the labs.

Specific Objectives:

- Promote and select the best ideas in terms of the likelihood of being entrepreneurially successful.
- Strengthen the chosen ideas to increase the success feasibility as an industrial venture.
- Foster a virtuous mechanism of development for innovation and entrepreneurship.
- Get efficient return of investment so that the system may grow autonomously.

Possible Models:

Model 1. The University maintains total control of the evolution over time of the developed product/service, of both factory and R&D. On a one-time basis, the University sells the know-how to different vendors and also licensing upgrades that ensures vendors a regularly updated and improved product. This is basically a permanently applied R&D consultation.

Model 2. The University maintains partial control of the evolution over time of the developed product/service, usually related to the corresponding R&D oriented knowledge. On a one-time basis, the University sells the know-how to a spin-off created by the inventors. This spin-off company sells the final product to different retailers. Likewise, the spin-off receives contract license upgrades for the factory to ensure a regularly updated and improved product. This is basically a permanently applied R&D consultation.

Model 3. A model where the developed product/service generates a spin-off of both factory and R&D, and the University sells this development on a one time basis. The University removes itself from the said product and its evolution.

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Table 3.3. Possible Business Models

	Model 1 Development Units	Model 2 Development Units + Spin-off	Model 3 Full Spin-off
Characterization	Factory sells know-how and R&D product development stays in-house	Product is sold, factory is a spin-off of inventors, know-how and product development remain in-house	Product is sold, factory is a spin-off of inventors, know-how and product development remain with spin-off
Main advantage	Finances applied research and internal synergy of the university	Funds applied research, generates inventor benefits and commitments	Funds finance risk-free venture
Main disadvantage	Contractual risk taken, lose control of product quality	Contractual risk taken, lose strength of internal commitment	Lose contact with product and its evolution

Important considerations

This mechanism is a third way within the School and requires consideration that there will be friction when utilizing traditional channels. Working models need to be efficient, low cost and of high productivity. Therefore, we work with part-time undergraduate students, honorary avatars, experienced part-time teachers or qualified academics with industry experience. This requires a connection with the company and a business vision. The development unit or spin-off cannot pay high salaries, nor accept a lack of rigor in terms of dedication and achievement of goals. The development plan must be strict and demonstrate a clear business purpose. The product has a time period, a target price and a market. These concepts could face the burden of providing scientific proof in terms of considering a thesis and verifying it with experiments. Here, results must be voluntarily acquired or created. This also involves trading market behavior since it is part of successful development. It is not necessary to obtain patents or publications. It is only successful if the product gains commercial success and generates a growing and prosperous company. In short, the success of a project is measured by whether the same commercial results equal the expected results.

At the university level, the Vice President for Research and Development (VID, in Spanish) is in charge of coordinating research, innovation and artistic creation carried out by academic teams at the Universidad de Chile. In particular, this office coordinates between applied research projects, channeled by research directives per academic unit with the petitioners of the services / products developed within the university, whether public or private. With regard to FCFM, the VID supports the development of high impact research projects, with a strong component in innovation, the establishment of criteria for proper legal protection, either through patents, copyrights and industrial ownership, with the ensuing strategy to reach other potential user markets from these project results. The creation of an iTT

Office at FCFM, aims to improve the early detection of market opportunities that could be filled by applied research projects. In this sense, the VID will establish general guidelines for possible cross synergies with other academic units to further improve the value proposal towards markets, reorient the research objectives, set early protection of results and allow for adequate technology transfer.

II. Research Improvement

Based on the benchmarking it seems reasonable that our school adopts the strategy of focusing on specific problems/subjects where Chile and in particular, FCFM may have strategic advantages and, in a multidisciplinary way, solve problems related to highly relevant or globally competitive sectors in the country. Due to some concerns that this idea may have within the school, the approach will be to develop pilot programs in specific areas, where the advantages and disadvantages of prioritizing a subject can be analyzed.

As mentioned above, research is a key element in i+e ST, in particular, to innovation. Although, our research productivity is probably the highest in the country and one of the leaders in the region, we are still far behind the standards of developed countries. We are truly committed to improving our research productivity, elevating numbers and also the quality and pertinence of the research. In the last 15 years we have improved the quality of our faculty body, reaching an average publication rate of 1.6 papers per year by full-time professors, which is good in the Chilean context. This average is common for an individual researcher working more or less independently; the saturation number for quality publications is probably around 2. In that sense we are close to that saturation point. In order to improve our number of publications as well as their quality beyond the saturation point, four main measures will be taken based on our benchmarking process: (1) Promoting and supporting multidisciplinary research within FCFM, the country and abroad; (2) Strengthening our PhD program, in number of students (6 PhD students to 1 faculty seems ideal, though still a far off number) and also for standards of quality, attracting the best students of the region, (3) Concentrating research on problems where we have competitive advantages and with high impact on our society, (4) Attracting larger postdoctoral fellows support.

The Associate Dean for External Affairs (ADEA) will be responsible for attracting foreign students from Latin America with the idea that increasing the number and quality of the students will strengthen the PhD program. For example, some international Universities devote personnel to be in contact with scholarship agencies in foreign countries in order to facilitate the recruitment of outstanding students from the region. In addition, the ADEA in coordination with the Associate Dean for Academic and Research (ADAR) will be responsible for the exchange program experience (with our world-class partners) of our PhD students. The Associate Dean for Student Affairs (ADSA) in coordination with the ADAR and the ADEA will be responsible for the quality of life issues related to the PhD students. The PhD program will be supported by this grant to encourage multidisciplinary collaboration between disciplines, with specific activities that will be described in detail in section 1.3.2.

Regarding i+e ST and TT.

As suggested by Boh et al. [2] courses of i+e ST will be offered to PhD students. Boh et al. [2] mention that one of the most effective strategies to generate spin-offs (with a small effort from the faculty[1]) is through a partnership of a faculty and PhD student(s)/postdoc(s). In addition, a partnership between faculty, PhD student(s) and business (MBA) students also shows effectiveness with an efficient effort from the faculty. In coordination with the i+e ST Lab, iTT office and eAccelerator, we will identify the "transferable research", encouraging the faculty and PhD student(s) (in charge of this research) to join the class along with business (MBA: Master in Business Administration) students. Specific attention will be placed on project-oriented courses on technology commercialization. At the beginning and with frequency we will partner with international consultants and institutions in order to offer the TT and i+e ST courses and acceleration of projects (spin-offs, and start-ups). In particular, Prof. Uzi de-Haan from Technion will advise us. Courses and applied research will be also performed in foreign institutions of technology transferring profiles such as the new Cornell NYC Tech campus.

The Cornell NYC Tech is a model under construction for an "interface" campus where industry and university coexist and grow in parallel with one another. In the year 2020, FCFM will be starting the construction of its own "interface" campus where industry-university partnerships will enhance the FCFM research and the competitiveness (worldwide) of Chilean engineering: Laguna Carén. This site encompasses more than 2,000 acres located in the Lo Aguirre valley, east of Santiago, on Route 68 to Valparaíso and next to Santiago's international airport, 20 minutes by car from FCFM's Beauchef campus.

III. Education

Regarding the curriculum, we plan to deepen our development based on CDIO, adding two major components: (1) assessment and (2) innovation and entrepreneurship education, which has been recently included in CDIO. Specialist, Dr. William Lucas, from the Gordon-MIT Engineering Leadership (GEL) program, will assist us in assessment procedures. In particular, we will also work on courses related to i+e ST based on the CDIO curriculum. During our interviews with specialists from the GEL program, it was brought to our attention that Latin American culture is more adverse to risk than US culture. In that sense, in order to develop an entrepreneurial spirit, we should be starting with leadership development and enhancement of the self-efficacy (a better indicator of good performance within the STEM area). The courses together with the assessment can be implemented by using more active (project-based) methodologies. We plan to take advantage of digital platforms as Classroom TV (a partner of the Universidad de Chile) to transmit the content of the courses to the students, then using the class time to work on synthesizing, operating and implementing the knowledge. In order to improve the communication and professional skills of our students, it was suggested that the outputs of the projects become public, also improving our outreach speed.

It was identified within the diagnostic that the major lack of hands-on experience correlates to the 3rd and 4th year of the bachelor degree. After the common core, during the first two years, the interaction of the students of one program/degree is minimal in comparison with students of other programs. We plan to add project courses after the common core, as electives courses, to let students of different programs of UChile such as Engineering, Medicine or Biology, interact with each other. We will have a Minor in Technology Innovation during the 3rd and 4th year. Other multidisciplinary minors will also be explored. We will also have, as optional, a variety of i+e ST courses available for students and staff.

Figure 3.4. Schematic of the FCFM curriculum

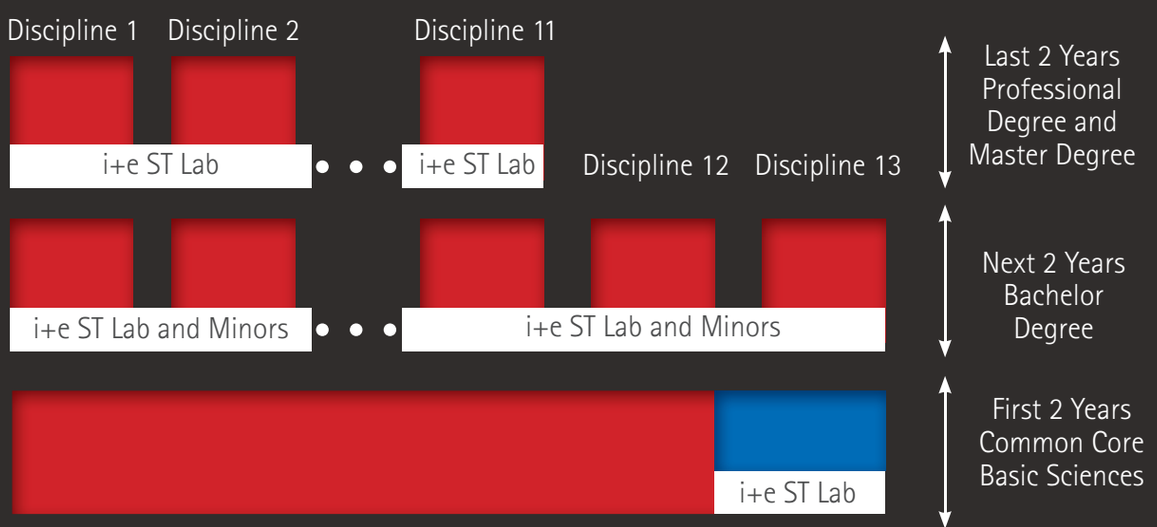


Figure 3.4. Schematic of the FCFM curriculum. The current lecture courses are in blue and the current project oriented courses within the common core are in orange. Red sections show the courses and activities to foster interaction among students from different disciplines. In order to overcome the lack of interaction among students from different programs, we will use the new i+e ST Lab with project-oriented courses and activities, in addition to the i+e ST minor and with improvement of the other minors in order to foster multidisciplinary collaboration.

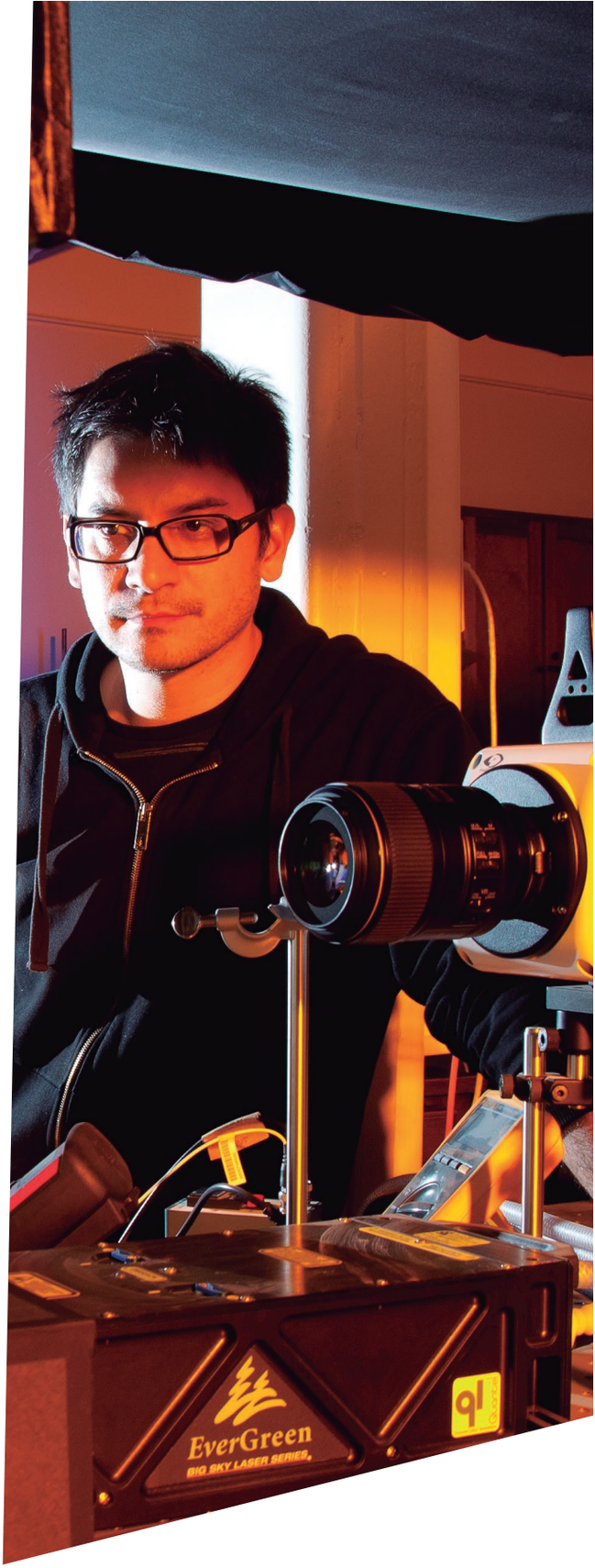
Besides the courses, special attention will be paid to the national and international internships. During the benchmarking process, there was an observed lack of commitment, resulting in it being highlighted as a problem area. Successful universities in TT and i+e ST have a strong commitment to the internships of their students. The Capstone program will be also analyzed to evaluate its feasibility within our school.

In addition to the curricular activities, we will have multiple extra-curricular activities, such as thematic clubs, i+e ST and TT contests (local, regional and international), common spaces for innovation and experimentation as the FabLab (http://fablab.uchile.cl/en) Through the I+E ST Lab, we will support students and staff for application and implementation of TT projects. The Lab will also support the acceleration process of some ideas with assistance from the Global Founders' Skills Accelerator (GFSA) program from MIT- Martin Trust Center.

IV. External Engaging and Outreach

In particular, outreach activities will be used to tackle three weaknesses: (1) the understanding of the current engineering challenges, (2) the transferring speed of the knowledge to the community outside our school, and (3) the communicational and professional skill of our graduates. We plan to publish and advertise over a University platform all projects developed within the courses. In this manner the students will improve the level of their output as their work will be read and utilized by people other than professor(s) of the course. Ethics related to plagiarism can be also treated in context, as student work will one day be public, making the practice of copying and pasting a more dangerous and detectable practice. We will implement clubs and pilot programs based on the Terrascope initiative (from MIT), which brings challenging geophysical problems to freshman students. The output of the projects is made public in different formats, as reports, presentations and radio news. By using this material created by the students we may accelerate the knowledge transfer to the community and include them in the activities under development by students and FCFM researches.

The i+e ST Lab will host a national and international conference to report our advances and errors made on the subject of promoting innovation and entrepreneurship within engineering schools. This conference will aid in the distribution/exchange experiences with others, and also help us systematize the annually developed work.



Metrics and Control procedure

It has been suggested in the literature (Graham R. , January, 2013.) as well as observed during our benchmarking, that the natural i+e ST output variables should be complemented by input and process variables. The numbers of output variables such as spin-offs, start-ups, patents, licenses and royalties, usually say nothing about the extent of i+e ST activity within the institution. For instance, a relatively small number of "blockbusters", after a significant government subsidy, could produce those numbers. For this reason it is recommended to measure input variables such as the number of resources, courses (mandatory and optional) and training (extra-curricular) on i+e ST available for students and staff while processing variable accounts for the interest of the community on that information and those resources. Some process variables are: the number of students and staff: attending i+e ST classes, participating in the extra-curricular activities (clubs), participating in i+e ST contests, applying to participate in international i+e ST classes or contests, attending conferences and seminars.

All the Administration (organizational Directions (Associate Deans) will keep track of the data relevant to their work. In particular, the *Associate Dean for Innovation and Technology Transfer* will keep track of the information regarding i+e ST and TT. In a coordinated effort, all the *Associate Deans* will turn in two semi-annual reports to the Dean, the FCFM Counsel and the Advisory Committee. Committees outside FCFM will review the contests on Science-Technology innovation and entrepreneurship.

These results will provide relevant information about the quality of the ideas and proposals; offering the opportunity to evaluate how relevant the i+e ST courses and activities are for the students competing in the contest by comparing the performance between students attending the courses and activities with those who are not.

Action will be taken based on the numbers of inputs, process and output variables. However, it is clear that fast results can be achieved much easier on input and process variables (adding courses or activities, and improving advertisement or incentives to attend them). The results of the i+e ST contest and feedback from students and staff will be also included to suggest improvement to the curriculum and extra-curricular activities.

Participation of the Community

Participation will be mainly through the Counsel (formed by department chairs, elected counselors and students) meetings. In addition, an annual workshop will report the advances and failures of the process. The performance reports will be made public, however, the Counsel and Advisory Committee feedback will lead the activities to guarantee the rigorousness and accuracy of the evaluation.

Long Term Plan and Sustainability

In the second year of this project we plan to apply to the MIT Regional Entrepreneurship Accelerator Program (REAP), which brings together 5 regional stakeholders (Entrepreneur, University, Risk capital, Government and Corporate) to articulate a diagnosis and further policies and actions to foster innovation-driven entrepreneurship. This will be the first stage to make Santiago, and eventually Chile, a scientific-technologic hub within the Latin American Region. In the long term we plan for an integrated campus with national and international industry to foster applied research and i+e ST in Laguna Carén. This technology hub will be formed with the assistance and guidance of a Cornell-Tech initiative, allowing the financing of our plan after the sixth year of the specific grant.

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[1] R. Graham, "Technology Innovation Ecosystem Benchmarking Study: Key findings from Phase 1," January, 2013.

[2] W. F. Boh, U. De-Haan and R. Strom, "University technology transfer through entrepreneurship: faculty and students in spinoffs," 2012.

[3] E. F. Crawley, "The CDIO Syllabus: A statement of goals for undergraduate engineering education.," Massachusetts Institute of Technology, 2001.

[4] Facultad de Ciencias Fisicas y Matematicas, Universidad de Chile, «"FCFM Hoy",» Santiago, 2013.

[5] R. Graham, "Royal Academy of Engineering and MIT report on how to achieve long-term change in engineering education.," March 2012.

[6] D. H. Soderholm and E. Huttner, "The Gordon-MIT Engineering Leadership Program: Relationship to CDIO Syllabus v2," in Proceedings of the 9th International CDIO Conference, 2013.

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b) Main goals and expected results.

Based on our diagnosis, benchmarking processes, and in the framework of the present project, the main goal of FCFM will be to become a world-class institution recognized by its leadership in science, technology, and innovation, driven by a multidisciplinary cutting-edge research facing the global challenges that society needs and providing an outstanding and broad educational experience, with social impact and responsibility within the country and Latin American region.

To carry out our main task, we state the following specific goals:

1) By means of an active participation of our community and by a steady diffusion of our activities, to develop the actions defined in our strategic plan and to adapt the FCFM institutional structure to foster, monitor and assess Science and Technology innovation and entrepreneurship.

2) To promote multidisciplinary research and education, increasing the impact of our activities and the pertinence of our education, generating enhanced innovation capabilities.

3) Curriculum: to continue to deepen and improve the CDIO methodology by adding two major components: (1) assessment and (2) innovation and entrepreneurship teaching, to improve the quality of life and experience of our students by means of a new Student Affairs Direction.

4) Research: To improve the impact of our research on the national and global society by fostering multidisciplinary activities and strengthening graduate programs by number and focus.

5) i+e ST and TT: to push for a profound cultural and organizational change, fostering innovation and entrepreneurship in science and technology (at all levels) by means of an Associate Dean for Technology Transfer and i+e ST and a Scientific-Technology Innovation and Entrepreneurship Laboratory.

6) To improve our internationalization by means of an Associate Dean office for External Affairs.

7) To improve and accelerate our engagement and outreach processes.

Project Outcomes:

The success in the performance of the aforementioned goals will have several outcomes:

Project term:

1) A new hierarchical structure inside FCFM with new Associate Deans, offices and laboratories.

2) A teaching methodology based on projects, multidisciplinary work, and the CDIO approach, allowing the formation of world class students with improved skills in innovation and tools for entrepreneurship.

3) An increase in the number of graduate students and in the impact of their research supporting the innovation and entrepreneurship.

4) New courses, graduate programs and infrastructure fostering innovation and entrepreneurship in our students.

5) A new Scientific-Technology Innovation and Entrepreneurship La-

boratory to formalize the hands-on experiences of i+e activities.

6) Agreements with world leader institutions and universities for supporting our transformation; in particular, new alliances with University of Manchester (UK), Cornell NYC Tech (USA), Technion (Israel), and MIT (USA).

Long term:

1) A relevant improvement in our position of different rankings; in particular, to be among the best 100 engineering schools in the world and top 3 in Latin America.

2) A profound cultural change in our faculty by increasing the available knowledge, valorization and support of innovation and entrepreneurship of all its members with a strong component of science and technology. Based on this cultural change, an improvement in the ecosystem and strong collaboration with local and international industries is expected.

3) A new scientific-technological valley, Laguna Carén, to allow the interaction and organic development of applied research in conjunction with national and international industry, becoming a new framework within the region to develop innovation and entrepreneurship based on science and technology.

c) Analysis of gaps and how to address them.

IDENTIFIED GAP/SHORTCOMING: Lack of a specialized administrative structure to foster innovation and entrepreneurship and Technology Transfer

DESCRIPTION: The most important universities have a technology transfer (TT) office. In fact, the top ten engineering schools (according to the QS ranking) have one. FCFM, however, does not have a central unit to foster and coordinate the requirements of researchers in that matter, which makes knowledge transfer to the industry cumbersome.

PROPOSED SOLUTION/ACTION: Create an Associate Dean for Innovation and Technology Transfer (ADiTT) whose main purpose is to propose and develop strategies to enhance the impact of our research in the industry and society through technology transfer. This Associate Dean will have two offices in charge: the iTT office and the eAccelerator office, which will support the TT process of FCFM. In addition, an Advisory Board will provide advice and guidance for the ADiTT. The TT office will help with the process of matching the FCFM research with industry/society needs. On the other hand, the Accelerator office will help with the acceleration process of FCFM spin-off and start-ups. This process will be done with the collaboration of our partners at the MIT Martin Trust Center and Cornell-Tech.

TIME FRAME: Three years.

MAIN GOAL: Before the end of year 1, the new structure should be operating, with an Associate Dean and staff (a secretary and one or two engineers). The mission of the Associate Dean and offices in the following two years (years 2 and 3) is to define a clear policy and procedure to foster and support technology transfer at all levels and all forms in FCFM.

OTHER COMMENTS: Although we do not have a formal structure/office, the issues related to TT are handled with the joint efforts of the Academic & Research Direction and the Accountable Project office. The former being in charge of the strategic scope, and the latter being in charge of the accounting support. Having a specialized i+e and TT structure would help us coordinate our research with national and international needs, in turn, improving its impact.

IDENTIFIED GAP/SHORTCOMING: There is no mature "culture" for scientific-technological innovation and entrepreneurship (i+e ST).

DESCRIPTION: Through the diagnosis process we discovered that students and staff in the community are really interested in the idea of creating their own companies. On the other hand, from the benchmark process, we found that the main universities of the world pay attention to i+e ST because it is closely related to the relevance and pertinence of research. At FCFM, we understand that by paying attention to i+e ST "culture" our level of research will improve as will the pertinence of our education. i+e ST "culture" can be defined by three dimensions: knowledge, valorization and support of i+e ST. The knowledge will be covered by curricular (regular and project-oriented courses) and extra-curricular activities (clubs and contests). The valorization will be covered by publicizing the activities under development in FCFM while congratulating and supporting the best of them. Management assistance and partial financial sponsorship for accelerating innovative ideas will cover support.

PROPOSED SOLUTION/ACTION: We will implement the following
1) Create courses, tutorships and specialized counseling for undergraduate, graduate students and Staff (postdocs, researchers and faculty).
2) Improve internal and external diffusion of successful cases, recognize best efforts (through awards), and develop a common vision of assessing the results and find a way of obtaining them.
3) A Scientific-Technology Innovation and Entrepreneurship Laboratory (I+E ST Lab) will be created to coordinate and manage internal knowledge and resources.

TIME FRAME: Six years

MAIN GOAL: Installing the "culture" for scientific-technological innovation and entrepreneurship through the creation of a laboratory, specialized courses, an international conference and i+e ST contests.

OTHER COMMENTS: We currently have a number of successful cases of scientific-technological innovations at FCFM; however, we have space to improve the innovative culture of our students and faculties.
The courses mentioned above will be created as a minor at the undergraduate level. In addition, a master in i+e ST program will be created at the graduate level.
The courses and training will be optional for students in order to facilitate assessment. The metric will be measured based on the number of available courses in the topic, the students attending those courses and the comparison between the level of proposed projects/plans to contest of the students that attended the courses/ training activities with students who did not.

IDENTIFIED GAP/SHORTCOMING: Currently, there is no internal policy to promote coordinated, focused, multidisciplinary research.

DESCRIPTION: During the benchmarking process, the importance of a multidisciplinary approach to improve research outcomes was stressed. In FCFM and other Faculty units of the UChile, such as Medicine and Sciences, there is great potential for multidisciplinary research; however, since there is not a clear internal policy to promote coordinated, focused and multidisciplinary research, all the efforts made in this direction correspond to those promoted by external grants. This is also important when one examines how efficiently the researchers use the available laboratories and instruments. When interaction is not promoted, it is common to find duplicated facilities (laboratories, instruments), and inefficient use of the resources.

PROPOSED SOLUTION/ACTION: Coordinate the efforts of the Associate Dean for Academic and Research, and the newly proposed Associate Dean for Innovation and Technology Transfer to promote participation in multidisciplinary research and development projects. The Associate Dean will generate an internal catalogue with all the available capabilities (equipment, knowledge and experience) of the FCFM laboratories, and coordinate these capacities with the society/industry necessities and opportunities.

TIME FRAME: Three years

MAIN GOAL: Having an important percentage of the research done at FCFM that is multidisciplinary research. That number, by the end of the third year of the project, should be 10-20%, and increase to at least 35% by the end of the sixth year.

OTHER COMMENTS: Having an important percentage of multidisciplinary research requires a cultural change among faculty members. Thus far, there is no formal internal recognition for multidisciplinary research. However, the real societal challenges require research and experts from different disciplines. The cultural change requires knowledge of high priority challenges and the tools to tackle them, for example, internal recognition (even for promotion), as well as financial and infrastructure support.

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IDENTIFIED GAP/SHORTCOMING: Still weak (compared to world class institutions) the PhD program, evaluated in number of PhD students per full-time professor and its quality.

DESCRIPTION: The number of PhD students at FCFM is currently 197, which corresponds to an average of less than one PhD student per full-time professor. In the benchmarking we saw that successful Universities i+e ST and TT are characterized by a strong PhD program. For instance, UCLA has 5.8 PhD students per full-time professor. The impact of the PhD student research in terms of publication and its application is weaker than the research of world-class institutions. Internationalization of our program is also low.

PROPOSED SOLUTION/ACTION: Our challenge is to double the number of PhD students, improving the level of the accepted students, and also attracting excellent international and non-Universidad de Chile students in the time frame of the project. We will encourage enrollment through visits, offering double degrees, and post-graduation placement opportunities. In addition, we plan to enhance quality of life and provide allocation facilities for foreign students or students coming from other parts of the country.

TIME FRAME: Six years

MAIN GOAL: Triple the number of PhD students per full-time professor, increase percentage of international students to 35% and improve placement after graduation of our PhD students.

OTHER COMMENTS: Current scholarships are not that attractive for the best students in the region (Latin America), and the PhD Programs are not always well known in the region. Both are aspects to be addressed in order to accomplish the main goal.

IDENTIFIED GAP/SHORTCOMING: There is a need to incorporate active learning techniques and training of professional skills at the undergraduate level.

DESCRIPTION: In contemporary undergraduate engineering education, there is a trade-off between the ever-increasing amount of technical knowledge and the needed professional skills (English/Spanish communication, leadership and ethic) that engineers have to master to actually conceive, design, implement and operate products and systems in engineering teams.
By active education (more than just listening) it is possible to simultaneously accelerate the internalization of knowledge and the development of professional skills. However, assessment procedures have to be updated to better reflect and evaluate the knowledge and desired skills.

PROPOSED SOLUTION/ACTION: We plan to keep widening our development of active learning based on Conceive, Design, Implement and Operate, by adding two major components: (1) assessment and (2) leadership, innovation and entrepreneurship teaching.

TIME FRAME: Three years

MAIN GOAL: Increase the percentage of active learning activities in the classroom. It is expected that by the end of year three, 1/3 of the courses have incorporated active learning activities. To have standardized assessment procedure to evaluate the new methodologies.

OTHER COMMENTS: FCFM has implemented several activities of active learning, however, the percentage of active learning in the classroom is still low. By the end of year three, a seminar will be organized to expose the results of active learning approach to national and international academic community.

IDENTIFIED GAP/SHORTCOMING: Shortage of good, coordinated internships and coordinated multidisciplinary projects with participation of national/international industry

DESCRIPTION: In the benchmarking we saw that posing complex problems to a group of students from different disciplines gives them the ability to integrate knowledge and develop professional skills. These complex problems may be of interest of the national/international industry, and the students could complement the participation in multidisciplinary projects at the University, with coordinated internships at the industry.

PROPOSED SOLUTION/ACTION:
1) Create courses of multidisciplinary projects for our engineering students.
2) Promote internships in technological industry both in Chile and abroad.

TIME FRAME: Three/Six years

MAIN GOAL: To graduate engineers with a multidisciplinary orientation and aware of the current problems that the industry and the society in general are facing. By the end of year three, the multidisciplinary courses should be created, and by the end of year six the first generation of engineers with multidisciplinary orientation should be finishing their studies.

OTHER COMMENTS: The generation of courses of multidisciplinary projects does not imply a restructuration of the engineering program. Since we do have project-based courses, it is only a matter of redefining those courses to solve complex problems that require students of more than one discipline.

IDENTIFIED GAP/SHORTCOMING: Challenging Ecosystem for innovation and entrepreneurship in science and technology (i+e ST)

DESCRIPTION: In the benchmarking we saw that most of the successful institutions in i+e ST are currently placed in fertile, innovative and entrepreneurial ecosystems. However, there are some cases of successful institutions placed in challenging environments (e.g. Technion in Israel). In addition, some of the institutions appear as the drivers of the regional change. In that sense the FCFM expects to be a driver for ecosystem change within Santiago, Chile and the Latin American region.

PROPOSED SOLUTION/ACTION:
1) Application to the MIT Regional Entrepreneurship Accelerator Program (REAP) and to Technion regional programs in conjunction with other relevant stakeholders.
2) The development of a Technology Village at the Laguna Carén site near Santiago's Airport.

TIME FRAME: Three/Six years

MAIN GOAL: To collaborate in the development of a rich, innovative, and entrepreneurial ecosystem

OTHER COMMENTS: It is relevant to connect the engineering schools with other stakeholders (entrepreneurs, venture capitalists, large corporations, government, etc.) in order to produce an effective and sustainable change after this particular subsidy

d) International recognition

The strategy plan considers three central objectives to significantly increase our international recognition: 1) Improve our internationalization, 2) Climb up in the international rankings and 3) Become known as world-leaders in specific areas.

1 *Internationalization*

We will generate an active and effective internationalization scheme through different activities, which we will institutionalize via creation of an External Affairs office. The specific list of activities and performance indicators are the following:

A. Associate Dean for External Affairs

We will create an Associate Dean for External Affairs that will push forward a fruitful and enduring internationalization of FCFM and will act as a way to professionalize and institutionalize the actions below.

B. Evaluate the structure of the programs

The overall objective of the activity is to restructure our engineering programs to make them comparable with internationally accepted academic degrees. This implies making a link between academic and professional degrees and changing the programs in terms of duration (Bachelor of Science = 4 years; MSc = 2 years - in conjunction with the Professional Degree, and PhD in 3-4 years after MSc), as well as teaching methodologies.

Recognition mechanism: Number of dual-degree programs and students exchange agreements with leading international institutions.

C. Student Exchange to partner institutions and international internships

This item includes the generation of periodic scholarships for undergraduate, graduate and foreign students to spend some time abroad for short/long term studies or internships in an international company. Also, we will be actively attracting foreign students from Latin America, Europe, North America and Asia to our Faculty for short or long term studies within FCFM.

Recognition mechanism: Number of national students from each cohort spending time abroad, Number of foreign students from each cohort spending time in FCFM, Number of FCFM students doing international internships.

D. Organization of international conferences and seminars at FCFM

We seek to increase the number of international events organized at FCFM. For this purpose the international affairs office will have a specific unit devoted to provide assistance in the organization of international events. In addition, every two years we will organize an international conference in Scientific-Technological Innovation and Entrepreneurship.

Recognition mechanism: Number of international events organized at FCFM, Number of international attendees to the events.

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2 *International rankings*

Recognition mechanism: Position in the engineering and technology-QS ranking, number of engineering subjects in the top 100 of the QS ranking.

The Universidad de Chile is among the top universities in Latin America. In the QS ranking, the FCFM ranks above the 200th position in five engineering subjects although four of these are rather close to the 200th position. In the Engineering and Technology raking the FCFM ranks in the 225th position. The QS scores institutions in four categories; the following table summarizes them and presents the mean, minimum and maximum values for the top 100 institutions.

	Score	Academic reputation (40%)	Employer reputation (30%)	Citations per paper (15%)	H-index citations (15%)
Mean	74.4	77.4	83.8	78.7	74.4
Minimum	60.8	60.8	72.8	53.6	60.8
Maximum	100.0	100.0	100.0	100.0	100.0

The scores for FCFM are Academic reputation: 60, Employer reputation: 69.4, Citations: 72.1, H-index: 54.8.

It is the FCFM's ambition to hold a top 100 QS ranking in engineering and technology by the year 2030. The only factor in which we are close to the average for the top 100 is in citations per paper, though we need to improve in academic reputation, employer reputation and H-index. This will be a result of a new culture of innovation and entrepreneurship based on science, technology and engineering. The internationalization activities described in the previous section will help improve our academic reputation. To improve our research (H-index) and climb up in the international ranking the following specific activities are proposed:

Multidisciplinary research

Multidisciplinary research is a key element in achieving excellence. As clearly shown, FCFM currently has a unique situation to foster multidisciplinary research, given the number of fields that we successfully pursue. Yet, institutional barriers (essentially departmental frontiers), inertia in research agendas and some funding policies preclude that multidisciplinary research takes place with the intensity that is required. We propose the creation of chairs and projects funded for specific areas to help overcome these difficulties.

Recognition mechanism: Number of projects with an impact beyond academia, impact of research measured by number of articles in top ten journals, percentage of articles in Q1 journals, number of citations per article, number of patents, number of applied research projects that improve the efficiency of the industry and public sector.

A. International Specialization program for faculty

This item includes the generation of a specialization program for the academic faculty of FCFM. The objective of the program is to create mobility for the academic staff for a period of six months to two years in a top-50 (ARWU) research institution.

Recognition mechanism: Number of FCFM academics actively researching in top institutions, number of courses given by the FCFM academic in foreign universities, number of articles generated in collaboration with international recognized researchers/groups.

B. Placement and Post-doc Excellence program

This item includes the creation of a post-doctoral program to place FCFM postgraduate into post-doctoral positions in the best institutions of the world, starting with our partner institutions.

Recognition mechanism: Number of FCFM post-graduates in outstanding positions around the globe.

3 *World-leaders in specific areas*

By the year 2030 FCFM aspires to have more than 70% of its research output at an international standard of excellence and also to have at least three world-leading research groups.

The first step will be to detect areas where FCFM had competitive advantages over others universities. These areas will be defined in conjunction with an External Advisory Committee (EAC). The EAC will active ely assist and advise FCFM in terms of education and research by providing valuable input concerning current and future trends in industry, the nation and the world. EAC members should be recognized as Ambassadors of FCFM both in Chile and internationally.

After the previous analysis, some key areas will be selected from which different research groups will be formed. These groups will bring together academics from different disciplines to solve the grand challenges. These academics will work in partnership with international research leaders and exploit their capabilities to form new and groundbreaking multidisciplinary research topics.

Recognition mechanism: Number of world-leading research groups, number of agreements with international leading institutions.

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e) Relationship with the environment

The relationship between FCFM and the national and international environment, namely industry, public and private sectors, and other universities, is of utmost importance. Indeed, in order to have both a deep impact upon Chilean development and international recognition, our engineering school needs to pursue many different paths. Some of these include: (i) preparing our engineers for a globalized world with the skills that are needed in industry, public sectors, and for the given profile we have chosen (namely, strong Science and Technology know-how) (ii) being able to raise funds to improve education and research (iii) identifying industry trends and Chile's more acute problems in order to establish meaningful research agendas.

The strategy set up in this project to significantly improve FCFM's relationship with the environment starts with the creation of two important pieces in a proposed new institutional arrangement. First, as described in 3.4, we will establish an External Advisory Committee (EAC) for FCFM. EAC members will be carefully chosen from both national and international industry leaders, successful innovators and entrepreneurs, top researchers from universities, and people with public sector experience. The EAC will be the primary FCFM connection to the environment, actively assisting and advising FCFM in terms of education and research by providing valuable input concerning current and future trends in industry, resources for research and development, industry interfaces and exchanges, recruitment opportunities for our graduates and guidance for entrepreneurs. Our vision is that EAC members should be recognized as FCFM Ambassadors both in Chile and abroad.

EAC Primary Objectives are:

- Be an FCFM primary resource to foster and facilitate connections and interaction with the environment, both locally and internationally.
- Promote teaching excellence (both undergraduate and graduate).
- Advise FCFM and the undergraduate and graduate schools of the professional skills expected of Engineers, Masters and PhD graduates from our university, and that are hired in industry, business, and government.
- Promote excellence and relevance in research, fostering Innovation and entrepreneurship.
- Facilitate and help Science and Technology transfer based on our research.
- Assist FCFM in fund-raising and promotional activities.

EAC is an advising body; thus, in order to implement the strategies, actions and tasks that FCFM governing bodies and EAC define, and to propose further action, a specific leadership is required. We will therefore establish an Associate Dean for External affairs (ADEA). This official will be the principal point of contact for all relations between FCFM and the environment. Among other things, the ADEA will be in charge – at times

on its own, and sometimes in collaboration with other FCFM officials – of all Internationalization activities in FCFM at all levels (students and staff), promoting and enabling international strategic alliances. Some of these project-related activities are:

- To look for and establish the international relations of FCFM related to undergraduate student mobility (e.g., exchange programs, international internships, etc.)

- Help strengthen the PhD program, in focus and number, by attracting outstanding foreign students from Latin America. For this, the ADEA will devote personnel to be in contact with scholarship agencies in foreign countries in order to facilitate the recruitment of these students from the region.

- In coordination with the Associate Deans of Academic Research and Graduate School, create and maintain a solid exchange program experience (with our world class partners) for our PhD students.

- Sign, make and maintain agreements in the most productive manner possible with world leading institutions and universities that we are negotiating with in the context of this project: NYC Cornell-Tech (USA), Technion (Israel), and MIT (Gordon Leadership Group, MIT Terrascope initiative, MIT Skoltech,).

- Support international conferences held in the FCFM campus.

The ADEA is also, the main contact point with the national environment. It will be in charge, for example, of the interface between FCFM and Industry in Chile, modeled after Cornell NYC Tech. It will help the TTE and the I+E ST approach industry, and to agree upon strategic alliances. It will also be in charge of all outreach activities where the chores of FCFM are shown to the nation.

Given the breadth and depth of actions we are proposing, we commit to ADEA being a highly demanding and relevant position, and probably the subject of a high amount of exposure. The person in charge has to be someone that simultaneously knows about and understands well, industry, governments and FCFM research and teaching; thus, hiring the adequate profile is step one for a successful operation and that will be our task in the first year of the project. The ADEA will have a team of professionals to help him/her; profiles and number of these professionals are to be decided within the project.

The project includes a number of collaborative activities. The ones that FCFM already has are described in Section 1.1.B. The activities that require collaboration or improved connections are:

Evaluation of impact of our curriculum change of 2007 and the ensuing update. Improve and strengthen the CDIO approach to teaching.

The curricular evaluation and changes will have the collaboration and supervision of international collaborators, namely MIT Gordon Leader-

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ship Group, MIT Terrascope initiative, MIT Skoltech and Cornell-Tech, among others. We plan to deepen our curricular development based on the CDIO approach by adding two major components: (1) assessment and (2) leadership, innovation and entrepreneurship teaching. CDIO specialist Dr. William Lucas, from the Gordon-MIT Engineering Leadership (GEL) program, will assist us in assessment procedures. And we will maintain close contact with our international consultants, Doris Brodeur (MIT) and Lynn Stein (Olin).

Creation of a Minor in Scientific-Technological Innovation and Entrepreneurship and creation of a Master of Science in Innovation and Technological Entrepreneurship.

For both courses and programs we will partner with international consultants- In particular, Prof. Uzi deHaan from Technion will advise us. The plan also considers students taking courses and conducting applied research in institutions of high technology-transferring profiles such as the new Cornell-Tech campus in NYC.

Creation of an international Accelerator for international business.

The eAccelerator will support technology-based projects with strong commercial potential, where the core team members are students and staff at FCFM. It will provide support in coaching, office space, contacts and network, knowledge transfer, packaging, business model definition, economic appraisal, and fundraising. Cornell-Tech, whose excellence is internationally recognized, will be our partner for this activity.

Enhance internship programs in Chile and abroad.

This item includes the generation of periodic scholarships for undergraduate, graduate and foreign students to spend some time abroad for one or two semesters.

Scholarships for PhD students

IIn order to attract the best students from Chile and other Latin American countries to FCFM, we plan to significantly increase the number of scholarships for PhD students. Some of these will be funded by this project but in addition, the idea is to obtain external non-government funded scholarships. The ADEA, with the help of EAC, will be in charge of convincing industry and other potential partners that funding PhD scholarships with an institution such as FCFM is a win-win situation. To date, we do not yet have agreements of the sort.

3.2. Management and control mechanisms

To ensure effective implementation and a follow-up plan during this project, and the whole period of the strategic plan, we have committed the direct participation of at least 10% of our full-time academics, representing different departments or areas at FCFM. Most of these academics are young researchers with recognized levels in research and teaching, and will fulfill the function of supporting the faculty authorities and those responsible for the development of the project, detailed implementation plans, accountability, sustainability, corrective actions, and reaction to change. This team will also support the participation of the rest of our faculty in the main activities of the strategic plan.

The activities are grouped according to the responsible authority. The existing units in charge of project activities are:

- Associate Dean for Academics & Research
- Associate Dean for the Undergraduate School
- Associate Dean for the Graduate School
- Chief Financial Officer

The strategic plan includes the creation of the following new units:

- Associate Dean for Innovation and Technology Transfer.
- Associate Dean for External Affairs.
- Associate Dean for Student Affairs.

These directive units will meet weekly with the Dean and Deputy Dean at the Faculty Operating Committee -- a regular committee already present at FCFM. In these committee meetings the Head of the Project will report on the implementation progress of the project. All the directive units will report on the status of the project activities under their supervision to the Dean and to the Head of the Project. To this end, the staff of each existing unit will be increased in order to support administration and management of the planned tasks.

Each task will also be associated with one or more academics belonging to the Academic Committee. This committee is composed of the academics that participated in the strategic planning stage, as well as six other academic faculty incorporated for the implementation stage. One of the members of the academic committee will be named academic coordinator of the project and will be responsible for coordinating the committee. They will meet weekly to assign specific tasks such as personnel hiring, preparation and review of documents, resolution of problems and corrective action proposals. The Academic Committee as well as the Head of the Project will also report each semester to the FCFM council and the community about the development of the strategic plan.

3.2.1. Work team and control units (responsibilities and competencies)

The Operations and Control unit of the Project will consist of a chief administrator, an operational coordinator and one management controller. This unit will coordinate with the Deputy Head, the academic committee and the professionals unit to:

- Centralize all the necessary information to prepare the reports for monitoring and accountability.

- Provide administrative and operational support for the implementation and progress of the project and the units to be created.

The strengths of this configuration are upheld by the support and supervision of the Academic Committee who offer their experience, specifically in the areas of teaching and research.

The Senior Professional unit, composed of two part-time professors, supports the project via its expertise in innovation, entrepreneurship, technology transfer, management and relationships with the private and public sectors.

The Deputy Head has the function of maintaining a direct and straightforward relationship with CORFO, therefore requiring extensive experience with the characteristics and instruments of that agency.

The Academic Committee will be in charge of preparing periodic benchmarking, support monitoring and evaluation of contracts associated with the strategic plan, as well as organizing the annual conference where the results of the implementation of the strategic plan will be presented.

a) Existing managing personnel

Every directive unit will be responsible for implementing the assigned tasks of its unit. All faculty authorities will meet weekly in the Faculty Operating Committee, where issues related to the implementation of the strategic plan will be addressed. Table 3.4 presents the existing authorities and their function within the present project.

The President of the Universidad de Chile, the highest authority, will head the Project Advisory Committee. The Faculty Operating Committee includes those shown Table 3.4 under the Dean's supervision.

The Head of the Project is a position assigned to an academic scholar with at least five years of FCFM management experience.

Table 3.4. Existing authorities and their function within the project

Name of the directive	Affiliation	Position/Duty	Dedication (monthly hours)	Function within the project
Víctor Pérez	Full Professor	President	2	Chairs Advisory Committee
Francisco Brieva	Full Professor	Dean	16	Chairs Academic & Operating Committees; Advisory Committee member
Felipe Álvarez	Associate Professor	Deputy Dean	44	Head of the Project
Carlos Palacios	Full Professor	Associate Dean, Academic & Research	24	Academic research activities
Diana Comte	Full Professor	Associate Dean, Graduate School	24	Postgraduate activities
Patricio Poblete	Full Professor	Associate Dean, Undergraduate School	24	Undergraduate activities
Helmuth Thiemer	Associate Professor	Chief Financial Officer	24	Financial administrative activities

The Head of the project chairs the Project Operating Committee, which further includes the Deputy Head, one academic coordinator of the academic committee and one member of the professional unit. The Deputy Head has an academic background and extensive experience with Innova-CORFO, taking responsibility for the communications with this government agency.

Table 3.5. Project faculty and senior consultant teams

Name of Professor	Affiliation	Position in the Project	Dedication (monthly hours)	Function within the project
Felipe Álvarez	Associate Professor	Head	44	Project Leader
Juan Velásquez	Associate Professor	Deputy Head	24	CORFO liaison
Leonardo Basso	Associate Professor	Academic Committee	16	Supports and supervises some activities
Viviana Meruane	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Claudio Falcón	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Humberto Palza	Associate Professor	Academic Committee	16	Supports and supervises some activities
Willy Kracht	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Bárbara Poblete	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Jorge Pérez	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Martín Reich	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Juan Cristóbal Zagal	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Fabián Rojas	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Francisco Ortega	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Marcos Díaz	Assistant Professor	Academic Committee	16	Supports and supervises some activities
Jaime Alée	Part-time Lecturer	Senior Consulting Engineer	12	Innovation and technology transfer
Teodoro Wigodski	Part-time Lecturer	Senior Consulting Manager	12	Change Management

Table 3.6. Project Advisory Committee

Name	Affiliation	Position/Duty	Expertise
Víctor Pérez	Universidad de Chile	President	Information Technologies; Public Policies on Education
Claudio Muñoz	Telefónica Chile	President	Innovation; Business and Administration
Diego Hernández	Antofagasta Minerals Group	Executive President	Mining
Ricardo Baeza	Yahoo! Research	VP for Europe and Latin America	Algorithms; data structures; data retrieval
Sally Bendersky	Business Success Coach Network	Senior Associate Coach	Public Policies on Higher Education; Innovation; Incubation
Eduardo Abeliuk	Classroom.tv TeselaGen Biotechnology	Founder	Innovator & Entrepreneur
Claudio Hetz	Neuroscience Biomedical Institute, Universidad de Chile	Full Professor & Deputy Director	Research

b) Profile of personnel to be hired

All the personnel to be hired must have the following skills and abilities:

- Strong written and verbal communication skills in Spanish and English
- Strong interpersonal skills with both faculty and students
- Superior organizational and problem resolution skills
- Strong computer and analytical skills
- Work effectively as either a leader or a team member
- Ability to prioritize work and perform well under pressure
- Ability to manage multiple tasks and meet deadlines

The specific requisites for the associate deans in the new directives are:

• Associate Dean for Innovation and Technology Transfer

Must have a proven record of leadership; exceptional skills in creating networks and establishing alliances; a commercial vision; experience in technology management and start-up/spin-off/

spin-in development; knowledge of national laws and regulation; knowledge of the national innovation system and of the local and regional industry. Also, the director must have at least five years of experience in a relevant field.

• Associate Dean for External Affairs

Must have proven record of leadership; excellent ability to create networks and establish alliances; a development vision of institutional relations; research and teaching experience; knowledge of national laws and regulations, and knowledge of the national and international university systems. In addition, the director must have a minimum of five years experience in a relevant field.

• Associate Dean for Student Affairs

A Master degree in Counseling, Student Personnel Administration or other related field is required. Five years related experience, demonstrating responsibility in student affairs preferably in a non-profit university. Knowledge of current practices and theories in higher education student affairs. Prior experience in developing departmental budgets either through span of control or as a contributor.

The requisites for the personnel of the Operations and Control unit are:

• Operations Coordinator

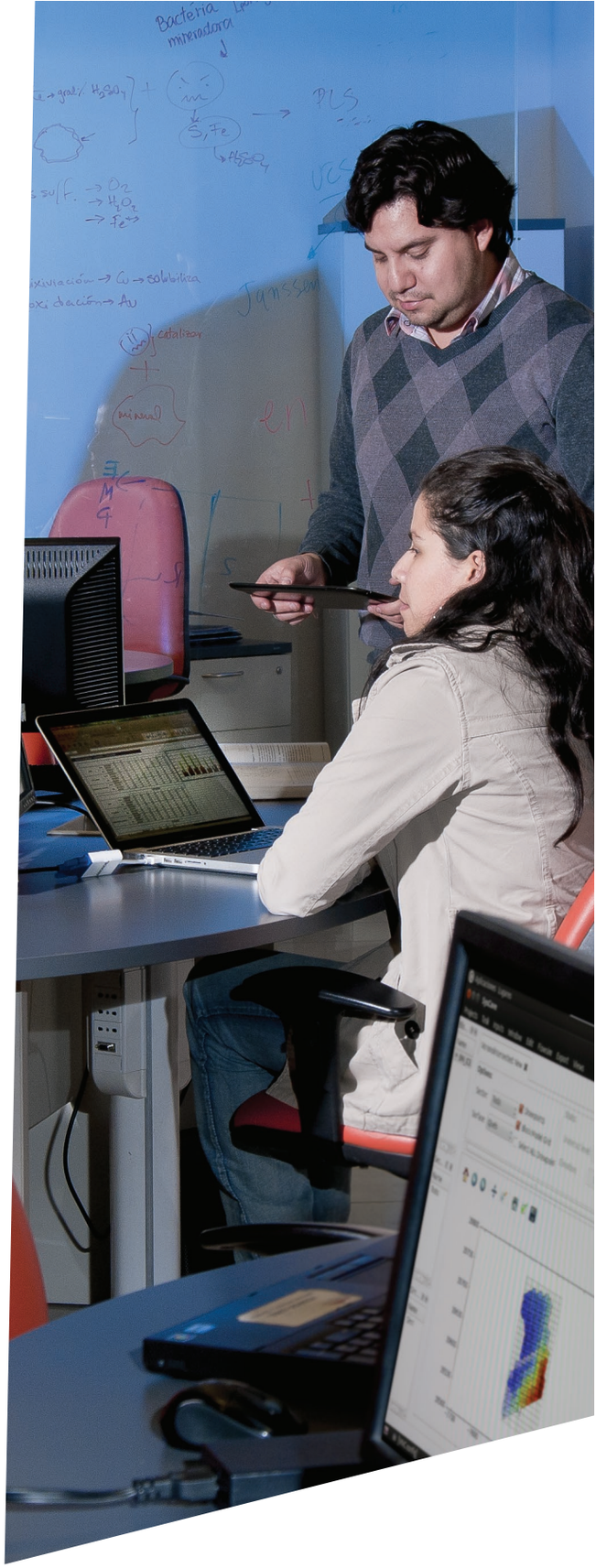
Titled Engineer, it is desirable to have at least 3 years experience in university business administration.

• Management Controller

Titled Engineer, it is desirable to have at least 3 years experience in university business administration.

• Chief Administrator

Titled Accountant or engineer, it is desirable to have at least 3 years experience in university business administration.

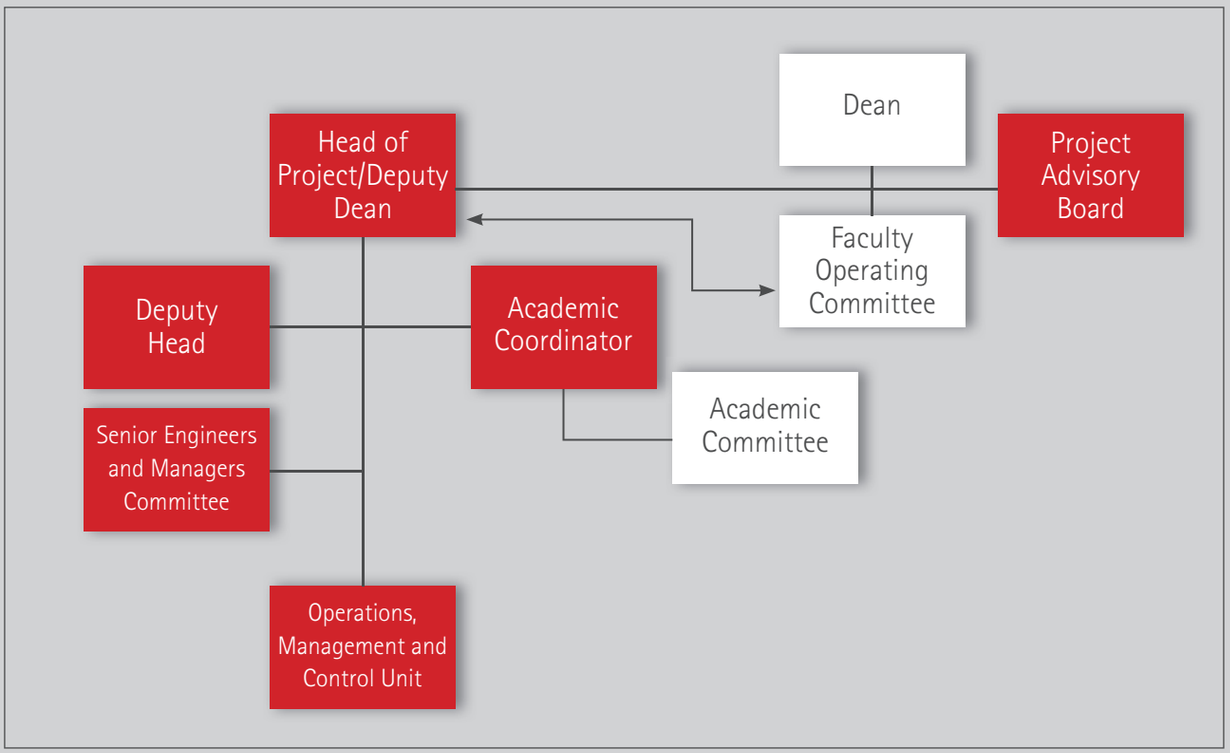


c) Organization chart

Figure 1 presents the organization chart for the present project. Existing FCFM units have been omitted. It has been established that an FCFM authority will ideally occupy the Head of the Project. If not possible, this position will be filled by an academic with experience in management positions in universities. This position has overall responsibility for, and answers to, the project and therefore must yield accountability and coordinate efforts at the highest institutional level. The Faculty Operating Committee led by the Dean represents existing faculty authorities.

The project will have an advisory committee comprised of individuals with extensive experience in private companies, the public sector, universities and / or be featured in the cultural or scientific field. The Deputy Head has a principal function of establishing communications with CORFO. The academic coordinator represents the Academic Committee in the Project Operations Committee led by the Head of the Project.

Figure 3.5. Project organization chart



3.2.2. Tracking and monitoring procedures

The Head of the Project will be responsible for coordination of the different tracking and monitoring procedures as well as the implementation of various strategic plans. However, the Head of the Project will distribute these activities among each responsible unit (each activity has a responsible unit with human resources and assigned materials). The Head of the Project will also take care of the Operations and Control unit of the project consisting of two engineers and a chief administrator that are in charge of consolidating the information with the support and supervision of the Academic Committee. In this way, the tracking and monitoring procedures are the responsibility of each unit and its corresponding staff, while the Head of the Project will just coordinate the different activities.

The Dean and Deputy Dean, by means of the Faculty Operation Committee, will also be involved in these procedures as the Head of the Project will report weekly to this committee on the activities. Moreover, the directive units will also meet with the Faculty Operating Committee on a regular basis.

The performance measures indicated and detailed throughout the plan will be calculated and reported annually. The Dean, Associate Deans, and Heads of academic units will provide annual progress reports that highlight that year's strategic achievements and challenges and identify the areas of the plan yet to be implemented. These reports will also include new strategies to capitalize on opportunities or deal with challenges not identified at the beginning of the plan period.

As important as these published updates are, the process that leads to their development is what is truly essential. Each year, each unit will dedicate time to analyze the performance indicators, discuss the plan's implementation to date with various stakeholders and consider new opportunities and challenges. The Project team will also hold an annual retreat to bring together and consider the richness of information resulting from each unit's update process and to make decisions accordingly.

The impact and result indicators are summarized in table 3. The three main variables that report the principal aspects of the FCFM transformation are: 1. Increasing multidisciplinary research, 2. Strengthening of the Ph.D. programs, and 3. Developing a culture of innovation and entrepreneurship. The last two indicators of impact are the improvement of our academic and employer reputation according to QS University Rankings by Faculty (engineering).

Table 3.7. Impact and Result indicators

Variable	Description	Goal	Unit	Period of time	Responsible Unit
% Multidisciplinary papers	% multidisciplinary publications - ISI	35% multi-disciplinary	%	6 years	Assoc. Dean for Academic & Research
Number Full time professors	Number Full time professors	Increase by 10%, from 206 to 226	%	3 Years	Assoc. Dean for Academic & Research
Number PhD Students	Number of PhD students	400	Students	6 years	Assoc. Dean for Graduate School
% Undergrad Students with R&D activities	% of students had a R&D or multidisciplinary experiences as voluntary	20	%	6 years	Assoc. Dean for Undergraduate School
Employer Reputation	ER QS Ranking by Engineering	Top five in Latin America	QS	6 years	Assoc. Dean for Innovation and Technology Transfer
Academic Reputation	AR QS Ranking by Faculty Engineering	Top five in Latin America	QS	6 years	Assoc. Dean for External Affairs.

Our proposal for implementation of the strategic plan consists of 3 stages:

- Stage 1: Design and Contracting of the human resources needed for the different new units or for the improvements of the existing ones. Months 1 to 12.

- Stage 2: Consolidation of the new organizational structure and academic programs. Months 12 to 36.

- Stage 3: Development and Outcome. Months 37 to 72.

The critical milestones at the end of each stage are:

- Stage 1. All proposed units operating with less than 30% of the staff engaged in permanent operation.

- Stage 2. Design proposal of all academic programs submitted for evaluating by university.

- Stage 2. Achieve 95% compliance with budget execution.

- Stage 2. All committed tasks and activities initiated and evaluated.

- Stage 3. Sixth international conference with general balance sheet assessment of the strategic plan implementation.

The main process indicators are the displayed in the following table.

Table 3.8. Project process indicators

Variable	Description	Goal	Unit	Period of time	Responsible Unit
% of people hired	% hired non-academic personnel	30% of total engaged in permanent operation	%	First year	Project Operations Committee
% Academic programs designed	% Academic programs submitted for approval	100% Programs committed	%	3 Years	Assoc. Dean of Graduate School and Undergraduate School
% Compliance with budget execution	% Total expenditures accounted for by total expenditure committed to at year 3	95	%	3 years	Head of the Project
% of activities initiated and evaluated	% Total activity evaluated by the total committed activities	100	%	3 years	Project Operations Committee
Quantity of international conferences carried out	International conferences accountability and dissemination of results	6	Conferences	6 years	Deputy Head

3.3. Budget and Co-financing (subject to changes)

FINANCING ENTITY	STAGE 1 BUDGET (CLP)	STAGE 2 BUDGET (CLP)	Total (CLP)
INNOVACHILE CORFO	6.000.000.000	4.500.000.000	10.500.000.000
FCFM - UCHILE	2.869.000.000	4.789.000.000	7.658.000.000
PROJECT TOTAL ($)	8.869.000.000	9.289.000.000	18.158.000.000

3.4. Work plan

3.4.1. Stages of the Project

N°: 1

NAME OF THE STAGE:
Setup of the Transformation Plan

Description:
During this stage, five tasks will be carried out:

1) Enhancement and improvement of key activities currently being pursued by FCFM
- Enhancement of Human Resources office ($36 million pesos).
- Enhancement of Projects Support office ($36 million pesos).
- Activities of the graduate School as stays of our doctoral students in foreign universities ($153 million pesos).
- Activities of the academic & Research as support for multidisciplinary teams ($111 million pesos).

2) Creation of new units for the proposed new organization of FCFM
- Associate Deans offices will be created (TT and i+e ST, Student Affairs, External Affairs
- A Technology Transfer office will be created
- An accelerator for startups and spin-offs will be created
- An External Advisory Committee (EAC) will be created.

3) Investment in necessary infrastructure and human resources.
- Investment expenses for $215 million pesos to create Innovation and Entrepreneurship Lab ($175 million pesos) and improve other installations ($40 million pesos).
- Lab Equipment for FabLab ($43 million pesos).
- Lab Equipment to improve teaching laboratories ($128 million pesos).
- Improvement of Mining Engineering building ($212 million pesos).
- New Equipment for the Technology Transfer office ($85 million pesos).
- $75 million pesos to launch a satellite to be built in a multidisciplinary student project.
- Hiring of 16 professors ($452 million pesos)
- Recruitment of Associate Deans, technical staff and administrative personnel ($443 million pesos).
- Hiring project administrative staff ($78 million pesos).
- Hiring project administrative chief ($22 million pesos).

4) Planning for the next two stages:
- Planning Strategies for development of the technological valley at Laguna Carén ($27 million pesos).
- Travel of undergraduate school officials to consult and plan the new programs.

5) Changes in curricula, programs, teaching and student experience
- On line-courses (MOOCS) will be created
- i+e ST and leadership courses will be created
- Minor in i+e ST will be created
- Clubs for i+e ST will be created

Duration: 12 months.

N°: 2

NAME OF THE STAGE:
Implementation of the Transformation Plan

Description:
During this stage, some of the units created in the previous stage should be in actively carrying out activities. This is the case of the technology transfer, external affairs and student affairs areas, as well as the External Advisory Committee. Students clubs, the minor and the new courses will be operational. Funding for student and academic activities will be assigned. Mechanisms for faculty and student participation and feedback, and for management of resistance to change will be in place Work with partner universities should be running smoothly.

Duration: 24 months.

N°: 3

NAME OF THE STAGE:
Maintenance, Measurement, Improvement and Sustainability of the Transformation Plan

Description:
During this stage, evaluation and measurement of the activities undertaken in the first two stages will be carried out. This will accelerate those functioning well, while taking corrective actions for those that work less well. A report with metrics and milestones will be compiled and the results communicated broadly. Will be launched (FCFM i+e ST challenge, application to REAP program, Scientific-Technological Innovation and Entrepreneurship Conferences, Chairs for multidisciplinary research)

Duration: 36 months.

3.4.2. Activities of the stage

Stage N° 1	Setup of the Transformation Plan			
Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Enhancement of the undergraduate school	The goal of this activity is to restructure several aspects of the Undergraduate School and align them with the context of the current project with a special focus on technological innovation.	• Hiring of an expert to act as a consultant • Definition of detailed features of the new undergraduate school	01-03-2014	28-02-2015
Create an Innovation and Entrepreneurship Lab	The i+e lab encourages entrepreneurship and innovation across FCFM, bringing together many cross-curricular interests, fostering team-based and entrepreneurial activities among FCFM students, faculty, industry, and alumni. The main purpose of the innovation and entrepreneurship laboratory is to exploit our research findings, and to empower young talents on their pathway to innovation and entrepreneurship. The Innovation and Entrepreneurship Lab will act as a bridge between research and industry, promoting an ecosystem where innovation happens.	• Definition of the Director's profile • Definition of the work schedule • Definition of the personnel profile • Set-up infrastructure	01-03-2014	28-02-2015
Clubs for innovation and entrepreneurship in Science and Technology (i+e ST)	The goal of this activity is to create a dedicated space with all the necessary tools for groups of students to develop innovative and entrepreneurial projects with a strong scientific and technological focus. The projects will be student-initiated. The expectation is to have students of different levels and specialties working on the same project.	• Set-up infrastructure	01-03-2014	28-02-2015
Strengthen the Teaching Quality Office to deepen the CDIO curriculum	This activity will improve and strengthen current implementation of the CDIO curriculum in FCFM. In particular, we will evaluate the current curriculum, integrate innovation-entrepreneurship education and develop, with the assistance of professionals related to CDIO, MIT Gordon Leadership Group and Skoltech, assessment strategies for the new curriculum.	• Strengthen teaching support office • Define metrics to evaluate the implementation of the CDIO curriculum • Search and selection of human resources • Improve teaching infrastructure • Define metrics to evaluate the implementation of the CDIO curriculum (assessment)	01-03-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Minor in Scientific-Technological Innovation and Entrepreneurship	The minor structure will serve to promote the interaction among interested (on i+e) students of different programs, developing a minor oriented to scientific-technological innovation and entrepreneurship	• Definition of the learning outcomes and regulations • Definition of the lectures and their programs	01-03-2014	28-02-2015
Foster multidisciplinary minors	Improve and develop minors in multidisciplinary fields by adapting and consolidating courses from several departments to face challenging multidisciplinary problems.	• Diagnostic of the current minors • Defining goals of multidisciplinary minors • Create profile and programs of minors • Diagnostic of current minors • Defining goals of multidisciplinary minors	01-03-2014	28-02-2015
Foster current efforts to improve teaching capacities	This activity has the goal of improving the teaching skills and methods of the Professors. Professors will be trained through LASPAU program and CDIO in order to include more active methodologies within the classroom.	• 5 trained professors per year, with international partners, within new teaching methodologies • 2 workshops per year, with the trained professors, about the new methodologies and the experience of implementing them in our classrooms.	01-03-2014	28-02-2015
Improvement and creation of new optional courses on leadership and i+e ST	In collaboration with international institutions (Cornell-Tech, Technion, MIT Gordon Leadership Group, MIT Martin Trust Entrepreneurship Center) we will evaluate our current courses and develop courses related to leadership and i+e ST	• Evaluation of current i+e courses • Improvement of the current i+e courses	01-03-2014	28-02-2015
Foster the inclusion of FCFM teaching material in online platforms (MOOCS)	This activity will provide unlimited participation and open access through the web of FCFM material. The main focus will be to support faculty in generating content and adapt teaching material to be uploaded to online platforms.	• Gather the different tools that are available • Develop prototype experiences for specific courses • Workshop to show the potential benefits of these tools • New teaching material for 4 new courses.	01-03-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Strengthen early science and engineering courses and the communication of the outcomes of the courses	Strengthen the early project-oriented courses and the skills developed in them. In collaboration with the TERRASCOPE initiative from MIT, we plan to explore early exposure of the students to current challenges of science and technology. In addition, we plan to explore the impact in communicational skill with the TERRASCOPE approach where the students' products are reports, audio files, videos and short presentations that are open to experts around the world and to the general community. We plan to produce a platform to upload the students' work, to accelerate outreach and information transfer to the community, in particular to take advantage of the students' work to improve their communication skills and science education.	• Evaluation of the "Introduction to Engineering" (one year course, in the first year) and "Project Workshop" (3rd semester course) courses. • Creation of the Pilot with the TERRASCOPE (related to Geosciences) approach • Creation of other pilots related to other subjects. • Evaluation of the pilots • Creation of a website platform to upload the students outcomes of the pilots and eventually of any student project	01-03-2014	28-02-2015
Update graduate profile	We will evaluate our program to check coherency with declared graduate profiles. We will also evaluate the pertinence of our declared graduate profiles.	• Evaluation of the actual engineering profile we produce, matching it to the current curriculum	01-03-2014	28-02-2015
Multidisciplinary undergraduate projects	The main goal of this activity is to systematize multidisciplinary initiatives: (the airplane, the solar car, Robocup, the CubeSat projects) developed by undergraduate students with the support of FCFM	• Have an increase of at least one of these types of projects every two years.	01-03-2014	28-02-2015
FABLAB enhancement	Strengthen the implementation path of CDIO curriculum through the enhancement of our FABLAB facilities.	• Launch the new FABLAB facilities	01-03-2014	28-02-2015
Associate Dean of Graduate School				
Enhancement of the Graduate School	The goal of this activity is to rethink and redesign the Graduate School of FCFM, from its current small influence/operation to a strong and influent Graduate School, where information and management is centralized. Expected results are increased enrollment from top Chilean and foreigner students, a boost in S&T research and transfer, and a more efficient use of resources.	• Definition of detailed features of the new Graduate School • Appointment of the associate dean of Graduate Studies • Hiring personnel	01-03-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Graduate School				
Master of Science in Technological Entrepreneurship and Innovation	The goal of the Master of Science in Technological Entrepreneurship and Innovation is to provide engineers and scientists with the skills and knowledge required to drive innovation and technological entrepreneurship. The program will prepare students to understand the processes of innovation with a solid technological background and gain insight to practical business development with a particular focus on interdisciplinary projects. This program will be developed in agreement with key international partners.	• Definition and creation of the program and regulations joint with FCFM professors. • Visiting expert professors on chosen topics to improve local capabilities • Marketing	01-03-2014	28-02-2015
Support of PhD theses related with national/ international industry	We plan to support PhD theses related to the industry. We expect to collaborate via the PhD programs with local industry and with international industry through international collaborators, such as Cornell-Tech.	• Support of 3 PhD theses per year	01-03-2014	28-02-2015
International internships for PhD students	The goal of this activity is to enhance and foster international cooperation with leading research and innovation institutions.	• Call to apply and select applicants	01-03-2014	28-02-2015
Contact with and support to PhD graduates	We will develop a system to keep abreast of the opportunities around the world for our PhD graduates and to be able to promptly communicate those opportunities to them. We will maintain contact with our PhD graduates to improve the FCFM network and help them connect with other alumni.	• Hire a professional to follow up and contact our alumni. • Develop the necessary software infrastructure to assist in the process.	01-03-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Academics and Research				
Starting Fund	FCFM will provide resources for new faculty as seed funds to start a research project while preparing the application for external grants.	• Provide funds	01-03-2014	28-02-2015
Support for long term stays of FCFM faculty	This item includes the generation of a support program for long term stays of FCFM faculty at international institutions. The objective is to create strong links with top research groups and to improve the impact of our research.	• Call to apply and select applicants	01-03-2014	28-02-2015
Multidisciplinary scientific and technological projects development	FCFM will foster and support the development of multidisciplinary scientific and technological projects, involving the whole FCFM community (faculty, under and graduate student, postdoc, industry and alumni). It is expected that these projects have a strong impact on the undergraduate students by their active participation. Examples of such projects are the next generation of the satellite, solar car, ultra-light airplane among others.	• To gather information regarding the projects that are being developed in FCFM. • To foster the development of new projects. • Formalize and centralize the management of the projects.	01-03-2014	28-02-2015
Hiring new faculty	Hiring 41 new faculty members according to our strategy plan, with a focus on innovation, technology transfer and multidisciplinary research.	• Definition of Areas of priority development • Call for applications • Hiring the first group of faculty	01-03-2014	28-02-2015
Chairs for multidisciplinary research	The chairs for multidisciplinary research (CMR) are aimed at providing funding for permanent positions of faculty who will lead multidisciplinary research on topics relevant to the country and national industry. CMRs will be defined in pairs, so that two faculty, of different departments, ensure both symmetry and that the research and cross-fertilization process takes place.	• Definition of Areas of priority development • Call for applications • Hiring	01-03-2014	28-02-2015
Induction of new faculty	This activity aims to gather all the information a faculty member needs to know, and write it in an official document. This information includes teaching; research and technology transfer activities, and others metrics required for faculty member in the context of this strategy plan.	• "FCFM faculty guide" textbook	01-05-2014	28-02-2015

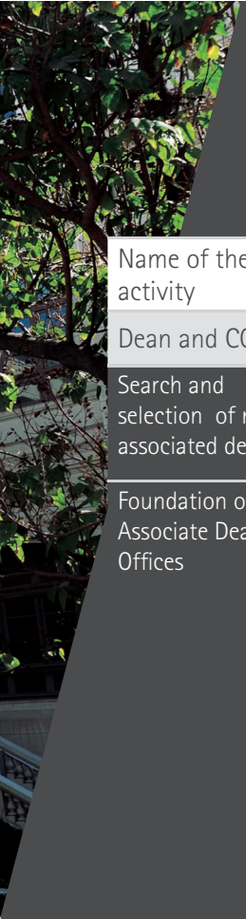
Name of the activity	Description	Milestones	Beginning Date	Ending Date
Chief Financial Officer				
Enhancement of human resources office	The goal of this activity to hire new HR members to assist and train the administrative and support staff in the management of the activities generated by the implementation of the strategic plan. The enhancement office will also improve the management and efficiency in order to achieve sustainability of the project.	• Definition of the required profile • Call for applications • Hiring	01-03-2014	28-02-2015
Enhancement of projects support office	The goal of this activity to hire the necessary staff to manage the accountability of the ING2030 project.	• Definition of the required profile • Call for applications • Hiring	01-03-2014	28-02-2015
Formalize administrative processes and generate the necessary processes documentation	Formalize administrative processes and generate the necessary documentation for the administrative processes of the ING2030 project, including the on-line publication of these documents.	• Formalize processes, and generate and publish the documentation	01-03-2014	28-02-2015
Improving the skills of the administrative staff	Improving the skills of the administrative staff to manage i+e and TT projects	• Interdepartmental workshop for administrative staff	01-03-2014	28-02-2015
Deputy Dean				
Improvement of teaching laboratories	Improvement of current and new technological teaching laboratories to align them with the strategic plan of ING2030 project. The focus will be the "operation" part of the CDIO curriculum.	• Internal call for laboratory-improvement proposals • Layout • Select and purchase new equipment	01-03-2014	28-02-2015
Creation of an external advisory committee for FCFM	The External Advisory Committee (EAC) will actively assist and advise FCFM in terms of education and research by providing valuable input concerning current and future trends in industry and the country, resources for research and development, industry interfaces and exchanges, recruitment opportunities for our graduates and guidance for entrepreneurs. EAC Primary Objectives are: • To promote teaching excellence (both undergraduate and graduate). • To promote excellence and relevance in research, fostering Innovation and entrepreneurship • To facilitate and help S&T transfer based on our research. • To advise FCFM and the undergraduate and graduate schools of the professional skills expected of Engineers, Masters and PhD graduates from our university, and that are hired in industry, business, and government. • To assist FCFM on fund-raising and promotional activities.	• Conceptual Definition of Tasks and profile of External Advisory Committee members • Search and Appointment of External Advisory Committee members	01-03-2014	28-02-2015
Enhancement of Mining Engineering	Multidisciplinary infrastructure of the Department of Mining Engineering is updated.	• Design detailed engineering	01-03-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Direction of Students Affairs				
Student Exchange with partner institutions	This item includes the generation of periodic scholarships for undergraduate, graduate and foreign students to spend time abroad (either short terms of 15-30 days, up to long terms such as a semester). Also, we will be actively attracting foreign students to our program for short or long terms studies within FCFM. We will be in charge of supporting the stays and the educational experience of international students	• Scholarships for the students • Managing protocol of the students exchange experiences with partner institutions	01-03-2014	28-02-2015
Enhance international internship programs	Currently the international internships are limited in number and programs. We will increase the number of students partaking in internships abroad as well as the number and level of companies offering them. The Student Affairs office in coordination with the External Affairs office will coordinate and support all national and international internship related issues	• Pilots of standardized industry internships • Policies and procedures for industry internships • Contact with companies willing to offer structured internships	01-03-2014	28-02-2015
Associate Dean of Technology Transfer (TT) and i+e ST				
Creation of an accelerator for Startups and Spinoffs	The accelerator will support technology-based projects with strong commercial potential and where the core team members are students, staff and alumni at and from FCFM. It will provide support in: • Coaching - ongoing coaching from national-international mentors and grants application support • Office space – dedicated premises with office workspace, kitchen, rooms, teleconference, etc. • Contacts and network – access to potential investors, partners and clients • Financial support –project with potential global impact will have financial support for international acceleration.	• Definition of goals, mission, vision and metrics of the Accelerator • Definition management/ control procedures • Conditioning of the facilities • Hiring personnel	01-09-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Technology Transfer (TT) and i+e ST				
Creation of the Technology Transfer Office	The TT Office will support with the search of opportunities related to TT. It will maintain updated information on conducted research and the potentialities of that research, helping with the connections with potential external partners. In particular, the TT office will support: • The standardization and improvement of the internship programs in Chile • The search for TT opportunities of applied and multidisciplinary research • The legal advisory of Intellectual Property and TT strategy. • The search in coordination with External Affairs for possible investors for applied research at FCFM • The search for investors for the Carén Technology Hub This office will actively work towards the sustainability of the Strategic Plan	• Standards and policies for the Internships • Creation of a Research Database and mechanism for searching multidisciplinary research with industry applications • Policies and mechanism for the Legal support • Definition of the attraction mechanism (short and long terms) of external non-governmental investments • Plan and evaluation procedure for increase of joint project with industry for the first 3 years • Plan and evaluation procedure for an increase of patents and licenses for the first 3 years • Plan and evaluation procedure for an increase of startups and spinoffs for the first 3 years	01-09-2014	28-02-2015

Scientific-Technological Innovation and Entrepreneurship Conference	The Scientific-Technological Innovation and Entrepreneurship Conference is an annual opportunity for experts and world leaders in these fields to meet, share best practices, network and learn from each other. This conference is also an opportunity for students of FCFM to present their developments and find out what is being done internationally.	• Contact international and national specialists for first conference in year 2.	01-09-2014	28-02-2015
MIT Regional Entrepreneurship Accelerator Program (REAP)	We will apply to The Regional Entrepreneurship Acceleration Program from MIT together with different national actors in order to accelerate the ecosystem of Santiago and Chile. With this activity we expect to contribute to the i+e ecosystem of the country.	• Prospection of possible partners for the REAP program. • Application to the REAP program in 2014 • Implementation of the possible conclusions form the REAP program (actions will depend on the program)	01-09-2014	28-02-2015
Training of faculty in Leadership and i+e ST	Professors from FCFM will be trained in Leadership and i+e ST in world class institutions: Gordon Leadership Group and Martin Trust Center from MIT and JTCII from Cornell-Tech.	• Identification of the priorities of the training • Definition of the training goals • Definition of Mechanism for transferring the knowledge to the rest of the community. • Execution of the training.	01-09-2014	28-02-2015
FCFM i+e ST Challenge	As with the same logic of the BizTech Entrepreneurship Challenge from the Bronica Entrepreneurship Center at Technion, we will host an entrepreneurship center where the process (the best projects will be awarded with emblematic incentives) will be supported for acceleration of the projects (acceleration might be performed abroad with partner institutions such as Cornell-Tech)	• Design of the challenge • Search for sponsors and mentors • Implementation of annual Challenge	01-09-2014	28-02-2015
Enhancement of Laboratories of IDIEM for TT	We will develop a mechanism to transfer high-tech services or incipient commercial technologies through IDIEM. IDIEM is already a TT transfer office, specifically for services in structure. The plan is to enhance the TT through this office. We will enhance the Laboratories of IDIEM to expand the TT possibilities of this office. IDIEM is an extremely important spin-in of FCFM and enhancing this unit to support more sophisticated services stemming from our research will be key to the sustainability of the strategic plan.	• Design of policies and mechanisms for TT through IDIEM • Improvement of the Laboratories of IDIEM to enhance the spectrum of TT that IDIEM could offer.	01-03-2014	28-02-2015

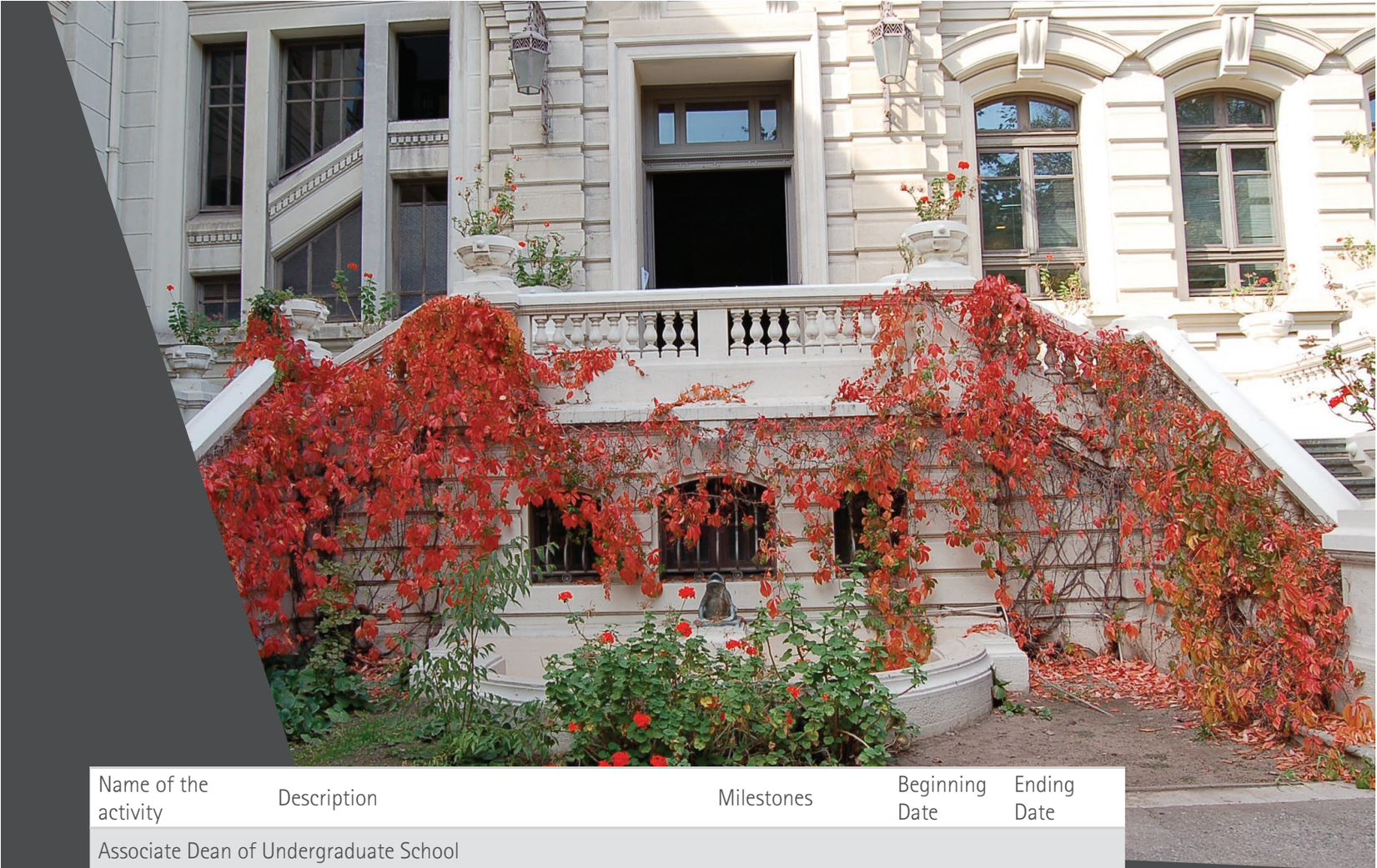
Name of the activity	Description	Milestones	Beginning Date	Ending Date
Direction of External Affairs				
Enhancement of the networks with national and international institutions	This office will organize the current agreements of FCFM with external institutions in order to operatize the agreement. The office will help match the implementation parties with: (offices, research groups, professor, students and staff). This office also will be seeking and supporting new agreements for: • Internships given the standard produced by the TT office • International PhD students with scholarships from their countries • Student exchange • Faculty Exchange • Research collaborations with leading institutions and companies • Collocation of our PhD students in Postdoc positions at leading institutions and world class companies In addition this office will be working toward the Sustainability of the project.	• Protocols for establishing the agreements • Data base with the agreements, executors and expected results • Methodology and policies for seeking external opportunities • Procedure for the implementation of the agreements.	01-06-2014	28-02-2015
Outreach of the agreements and results	Communication of the agreements and their results to the FCFM community and to the external environment is essential for attracting opportunities. The communication will be handled in coordination with the communication office.	**Communication policies and protocol.**	01-06-2014	28-02-2015



Name of the activity	Description	Milestones	Beginning Date	Ending Date
Dean and CORFO 2030 Team				
Search and selection of new associated deans	Search and selection of the associated deans of Technology Transfer and i+e ST, Students Affairs and International Affairs.	• Appointment of new associated deans	01-03-2014	28-02-2015
Foundation of New Associate Dean Offices	The Associate Dean of TT and i+e ST: will foster TT and i+e ST through a central and hierarchical organizational structure. All the TT activities will be centralized and supported by this specific unit having authority inside the faculty. There is also a plan to improve the search of opportunities and project management related to TT by the creation of a new TT Office. An accelerator office will be also created to support the start up and spin off formation. The Associate Dean of Students Affairs: will monitor the quality of the external experiences of the undergraduate and graduate students, in particular, dealing with the exchange programs, the visiting experiences of our students abroad and the international students at FCFM. This post will also manage the national and international internships, implementing the established designs and agreements made by the Associate Deans of External affairs and TT.) The Associate Dean of External Affairs: will be in charge of looking for and establishing all the external relations of FCFM. In that sense it is the office that will work with external, national and international, institutions in order to enhance education, research, i+e ST and TT. This office will pay close attention to the establishment of national and international internships, to attract international undergraduate and graduate students, to search for and communicate opportunities for our graduate students and to seek investment opportunities outside FCFM. Implementation of the agreements will be handled by other offices, though the link will be established by this office. In addition, this office will support the preparation and execution of conferences at FCFM, and in conjunction with the Associate Dean of TT and i+e ST, it will actively work toward the sustainability of the strategic plan.	• Definition of goals, missions, visions and metrics • Definition of the management and control procedures • Definition of the personnel profile • Hiring personnel • Set-up infrastructure	01-06-2014	28-02-2015
Hiring support professionals for the CORFO 2030 Project	Hiring support professionals (3 engineers + 1 administrative) for the management of the ING2030 project.	• Definition of the required profile • Call for applications • Hiring	01-03-2014	28-02-2015

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Dean and CORFO 2030 Team				
Tracking and improvement of the CORFO 2030 strategic plan	Evaluation of the selected metrics and improvement of the implementation of the strategic plan.	• Define the metrics to evaluate the implementation of the strategic plan and existing associate dean offices	01-03-2014	28-02-2015
Management of the Opposition to Change directed to current and new faculty and staff	We plan to keep informed and involved with the FCFM community through annual workshops and the international i+e ST conference. In addition, we plan to reward the change through: 1. Support (for faculty, staff and students) of the activities described above 2. Awards to faculty and staff (during the international i+e ST conference) 3. Recognition of the efforts within the faculty and staff meetings highlighting the best practices.	• Definition of the detailed strategy to manage the opposition to change • Definition of the i+e ST award • Implementation of annual workshops to keep the FCFM community informed and involved • Inclusion of motivated faculty, staff, students and alumni within the strategic plan	01-03-2014	28-02-2015
Hiring support professionals for the CORFO 2030 Project	Hiring support professionals (3 engineers + 1 administrative) for the management of the ING2030 project.	• Definition of the required profile • Call for applications • Hiring	01-03-2014	28-02-2015

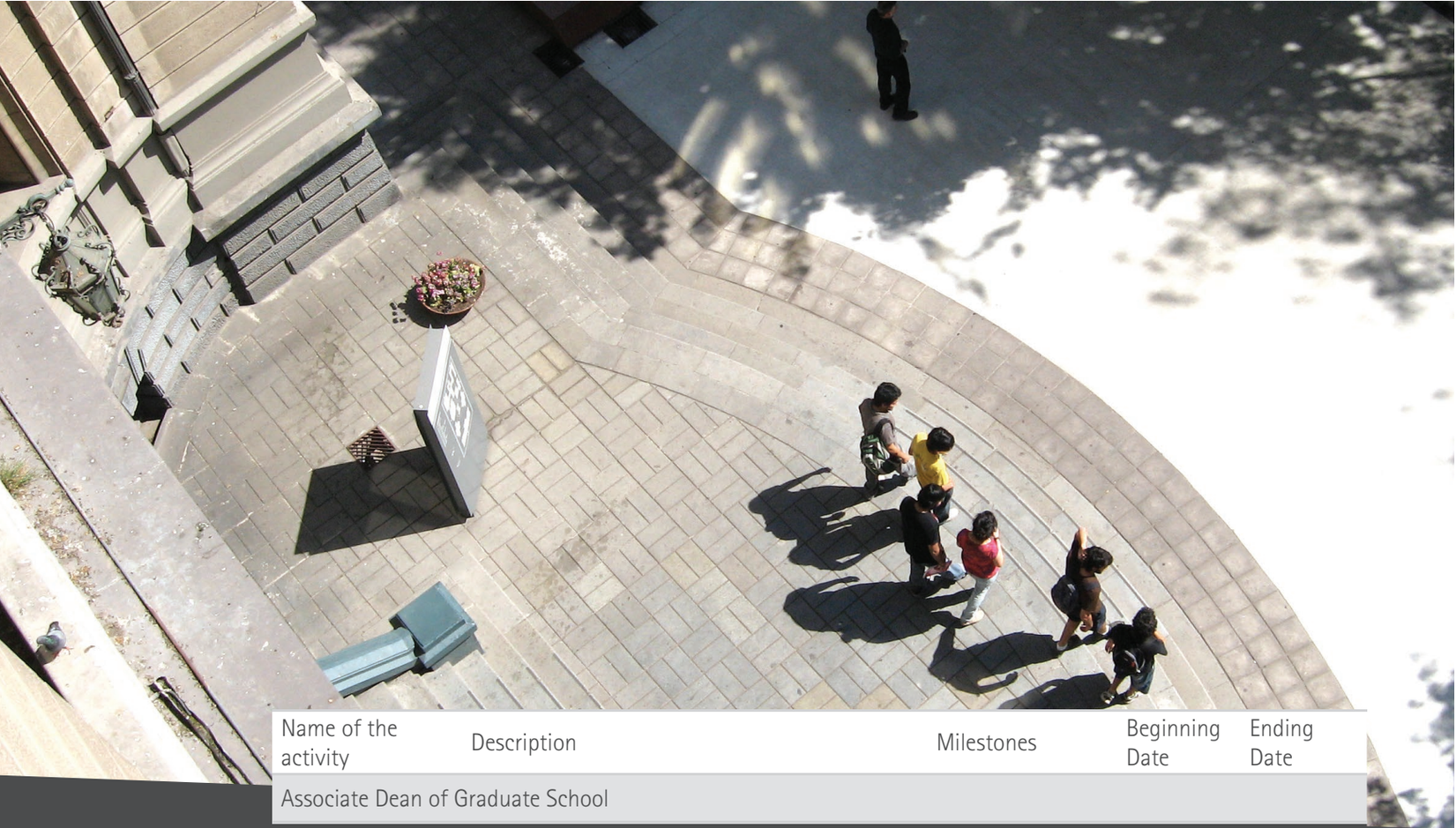
Stage N° 2	Implementation of the Transformation Plan			
Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Innovation and Entrepreneurship Lab	The i+e lab encourages entrepreneurship and innovation across FCFM, bringing together many cross-curricular interests, fostering team-based and entrepreneurial activities among FCFM students, faculty, industry, and alumni. The main purpose of the innovation and entrepreneurship laboratory is to exploit our research findings, and empower young talents on their pathway to innovation and entrepreneurship. The Innovation and Entrepreneurship Lab will act as a bridge between research and industry, promoting an ecosystem where innovation happens.	• Hiring personnel	01-03-2015	28-02-2017



Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Clubs for innovation and entrepreneurship in Science and Technology (i+e ST)	The goal of this activity is to create a dedicated space with all the necessary tools for groups of students to develop innovative and entrepreneur's projects with a strong scientific and technological focus. The projects will be student-initiated. Students of different levels and specialties are expected to work on the same project.	• 2 clubs in operation	01-03-2015	28-02-2017
Strength the Teaching Quality Office to deepen the CDIO curriculum	This activity will improve and strengthen current implementation of the CDIO curriculum in FCFM. In particular, we will evaluate the current curriculum, integrate innovation-entrepreneurship education and develop, with the assistance of professionals related to CDIO, MIT Gordon Leadership Group and Skoltech, assessment strategies for the new curriculum.	• Improvement of teaching infrastructure • implementation	01-03-2015	28-02-2017
Minor in Scientific-Technological Innovation and Entrepreneurship	The minor structure will serve to promote the interaction among interested (on i+e) students of different programs, developing a minor oriented to scientific-technological innovation and entrepreneurship	• Courses available	01-03-2015	28-02-2017
Foster multidisciplinary minors	Improve and develop minors in multidisciplinary fields by adapting and consolidating courses from several departments to face challenging multidisciplinary problems.	• New content for courses	01-03-2015	28-02-2017

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Foster current efforts to improve teaching capacities	This activity has the goal of improving teaching skills and methods of the professors. Professors will be trained through LASPAU program and CDIO in order to include more active methodologies within the classroom.	• 5 trained professors per year, with international partners, within new teaching methodologies • 2 workshops per year, with the trained professors, about the new methodologies and the experience of implementing them in our classrooms.	01-03-2015	28-02-2017
Improvement and creation of new optional courses on leadership and i+e ST	In collaboration with international institutions (Cornell-Tech, Technion, MIT Gordon Leadership Group, MIT Martin Trust Entrepreneurship Center) we will evaluate our current courses and develop courses related to leadership and i+e ST	• Creation of new leadership courses • Creation of new i+e courses	01-03-2015	28-02-2017
Foster the inclusion of FCFM teaching material in online platforms (MOOCS)	This activity will provide unlimited participation and open access through the web of FCFM material. The main focus will be to support faculty to generate content and adapt teaching material to be uploaded to online platforms.	• Gather the different tools that are available • Develop prototype experiences for specific courses • Workshop to show the potential benefits of these tools • New teaching material for 4 new courses.	01-03-2015	28-02-2017

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Undergraduate School				
Strengthen early science and engineering courses and the communication of the outcomes of the courses	Strengthen the early project-oriented courses and the skills developed within them. In collaboration with the TERRASCOPE initiative from MIT, we plan to explore early exposure of the students to current challenges of science and technology. In addition, we plan to explore the impact of communicational skills with the TERRASCOPE approach where the students products come in the form of reports, audio files, videos and short presentations that are open to experts around the world and to the general community. We plan to produce a platform to upload the student work, to accelerate outreach and information transfer to the community, in particular to take advantage of the student work to improve their communication skills and science education.	• Evaluation of the "Introduction to Engineering" (one year course, in the first year) and "Project Workshop" (3rd semester course) courses. • Creation of the Pilot with the TERRASCOPE (related to Geosciences) approach • Creation of other pilots related to other subjects. • Evaluation of the pilots • Creation of a website platform to upload the student outcomes of the pilots and eventually of any student project	01-03-2015	28-02-2017
Update graduate profile	We will evaluate our program to check for coherency between declared graduate profiles. We will also evaluate the pertinence of our declared graduate profiles.	• Updating of the graduate profiles • Updating of the curriculum and the assessment procedures to achieve the desired profile.	01-03-2015	28-02-2017
Multidisciplinary undergraduate projects	The main goal of this activity is to systematize multidisciplinary initiatives, such as: the airplane, the solar car, Robocup, the CubeSat projects), all developed by undergraduate students with the support of FCFM	• Have an increase of at least one of these types of projects every two years.	01-03-2015	28-02-2017

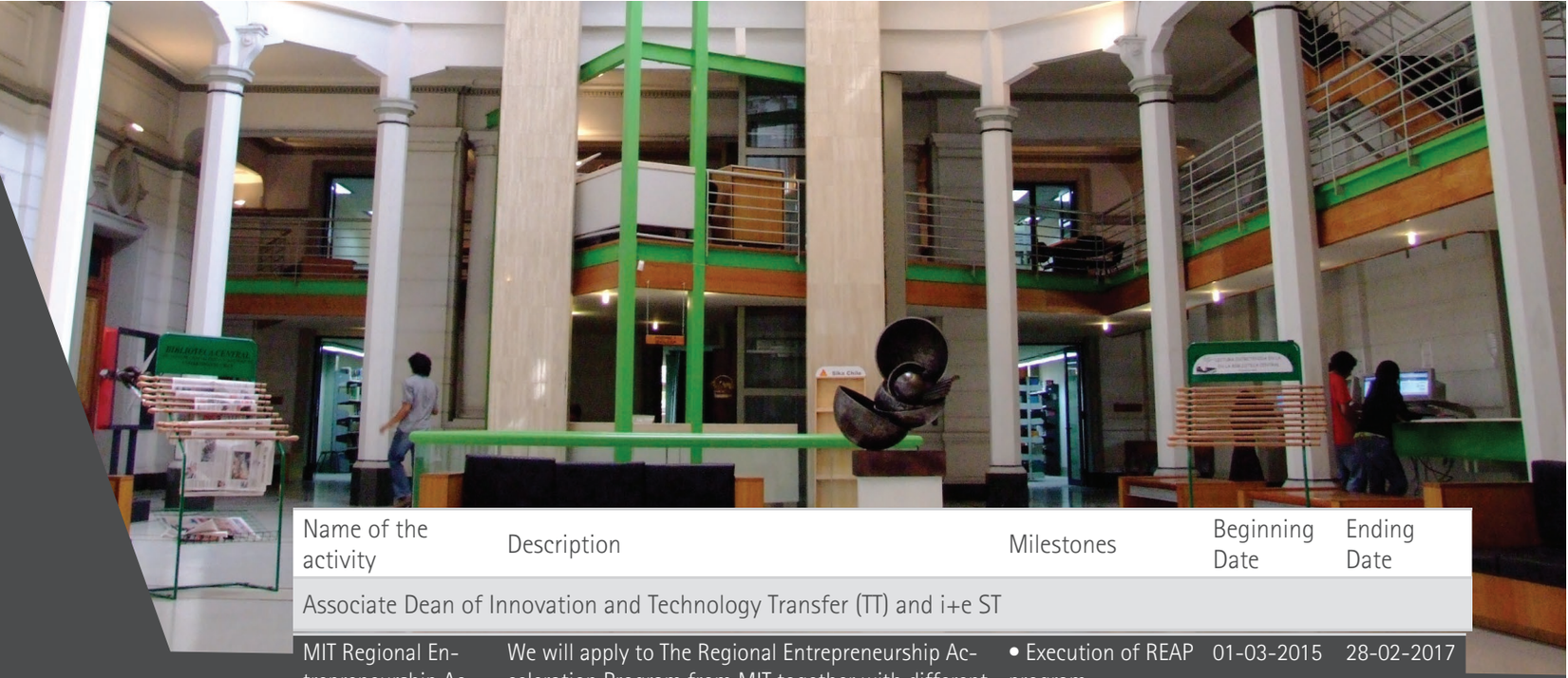


Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Graduate School				
Master of Science in Technological Entrepreneurship and Innovation	The goal of the Master of Science in Technological Entrepreneurship and Innovation is to provide engineers and scientists with the skills and knowledge required to drive innovation and technological entrepreneurship. The program will prepare students to understand the processes of innovation with a solid technological background and to gain insight to the practical business development with a particular focus on interdisciplinary projects. This program will be developed in agreement with key international partners.	• Execution of the courses.	01-03-2015	28-02-2017
Support of PhD theses related with national/ international industry	We plan to support PhD theses related with the industry. We expect to collaborate via the PhD programs with local industry and with international industry through international collaborators, such as Cornell-Tech.	• Support of 3 PhD theses per year	01-03-2015	28-02-2017
International internships for PhD students	The goal of this activity is to enhance and foster international cooperation with leading research and innovation institutions.	• Call to apply and select applicants	01-03-2015	28-02-2017
Contact-with and support-to PhD graduates	We will develop a system to keep abreast of the opportunities around the world for our PhD graduates and promptly communicate those opportunities to them. We will maintain contact with our PhD graduates to improve the FCFM network and to help them connect with other alumni.	• Hire a professional to follow up and contact our alumni.	01-03-2015	28-02-2017

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Academics and Research				
Starting Fund	FCFM will provide resources for new faculty as seed funds to start a research project while preparing the application for external grants.	• Provide funds	01-03-2015	28-02-2017
Support for long term stays of FCFM faculty	This item includes the generation of a support program for long term stays of FCFM faculty at international institutions. The objective is to create strong links with top research groups and to improve the impact of our research.	• Call to apply and select applicants	01-03-2015	28-02-2017
Multidisciplinary scientific and technological projects development	FCFM will foster and support the development of multidisciplinary scientific and technological projects, involving the whole FCFM community (faculty, under and graduate student, postdoc, industry and alumni). These projects are expected to have a strong impact on the undergraduate students through their active participation. Examples of such projects are the next generation of the satellite, solar car, ultra-light airplane, among others.	• To gather information regarding the projects that are being developed in FCFM. • To foster the development of new projects.	01-03-2015	28-02-2017
Hiring new faculty	Hiring 40 new faculty members according to our strategy plan, with a focus on innovation, technology transfer and multidisciplinary research.	• Definition of Relevant Areas • Call for applications • Hiring the first group of faculty	01-03-2015	28-02-2017
Chairs for multidisciplinary research	The chairs for multidisciplinary research (CMR) are aimed at providing funding for permanent positions of faculty who will lead multidisciplinary research on topics relevant to the country and national industry. CMRs will be defined in pairs so that two faculty, of different departments, ensure both symmetry and that the research and cross-fertilization process takes place.	• Definition of Relevant Areas • Call for applications • Hiring	01-03-2015	8-02-2017
Induction of new faculty	This activity aims to gather all the information a faculty member needs to know, and record it in an official document. This information includes teaching; research and technology transfer activities, and others metrics required for a faculty member in the context of this strategy plan.	• "FCFM faculty guide" textbook	01-03-2015	8-02-2017

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Chief Financial Officer				
Improving the skills of the administrative staff	Improving the skills of the administrative staff to manage i+e and TT projects	• Interdepartmental workshop for administrative staff	01-03-2015	28-02-2017
Deputy Dean				
Improvement of teaching laboratories	Improvement of current and new technological teaching laboratories to align them with the strategic plan of ING2030 project. The focus will be the "operation" part of the CDIO curriculum.	• Purchases of new equipment	01-03-2015	28-02-2017
External advisory committee for FCFM	The External Advisory Committee (EAC) will actively assist and advise FCFM in terms of education and research by providing valuable input concerning current and future trends in industry and the country, resources for research and development, industry interfaces and exchanges, recruitment opportunities for our graduates and guidance for entrepreneurs. EAC Primary Objectives are: • To promote teaching excellence (both undergraduate and graduate). • To promote excellence and relevance in research, fostering Innovation and entrepreneurship • To facilitate and help S&T transfer based on our research. • To advise FCFM and the undergraduate and graduate schools on the professional skills expected of Engineers, Masters and PhD graduates from here, and that are hired in industry, business, and government. • To assist FCFM on fund-raising and promotional activities.	• One meeting per year	01-03-2015	28-02-2017
Enhancement of Mining Engineering	Multidisciplinary infrastructure of the Department of Mining Engineering is updated.	• Implementation of improvements.	01-03-2015	8-02-2017
Direction of Students Affairs				
Student Exchange with partner institutions	This item includes the generation of periodic scholarships for undergraduate, graduate and foreign students to spend some time abroad (either short terms of 15-30 days, up to long terms such as a semester). We will also be actively attracting foreign students to our program for short or long term studies within FCFM while managing and supporting the stays and educational experience of the international students	• Scholarships for the students • Managing protocol of the students exchange experiences with partner institutions	01-03-2015	8-02-2017

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Direction of Students Affairs				
Enhance international internship programs	Currently the international internships are limited in number and programs. We will increase the number of students partaking in internships abroad as well as the number of companies offering them. This office will coordinate and support the students with the process of internships. With the information from External Affairs, this office will operate the internships. It will pay special attention to the international internships.	• Contact with companies willing to offer structured internships	01-03-2015	28-02-2017
Associate Dean of Innovation and Technology Transfer (TT) and i+e ST				
Accelerator for Startups and Spinoffs	The accelerator will support technology-based projects with strong commercial potential and where the core team members are students, staff and alumni from FCFM. It will provide support in: • Coaching - ongoing coaching from national-international mentors and grants application support • Office space – dedicated premises with office workspace, kitchen, rooms, teleconference, etc. • Contacts and network – access to potential investors, partners and clients • Financial support –project with potential global impact will have financial support for international acceleration.	• 1 startup each year	01-03-2015	28-02-2017
Technology Transfer Office	The TT Office will support with the search for opportunities related to TT. It will maintain updated information on conducted research and the potentialities of that research, helping with the connections with potential external partners. In particular, the TT office will support: • The standardization and improvement of the internship programs in Chile • The search for TT opportunities of applied and multidisciplinary research • The legal advisory of Intellectual Property and TT strategy. • The search in coordination with External Affairs of possible investors for applied research at FCFM • The search for investors for the Carén Technology Hub This office will actively work towards the sustainability of the Strategic Plan	• The office will determine opportunities for Technology Transfer	01-03-2015	28-02-2017
Scientific-Technological Innovation and Entrepreneurship Conference	The Scientific-Technological Innovation and Entrepreneurship Conference is an annual opportunity for experts and world leaders in these fields to meet, share best practices, network and learn from each other. This conference is also an opportunity for students of FCFM to present their developments and to find out what is being done internationally.	• One conference organization in year 2 • One conference organization in year 3	01-03-2015	8-02-2017



Name of the activity	Description	Milestones	Beginning Date	Ending Date
Associate Dean of Innovation and Technology Transfer (TT) and i+e ST				
MIT Regional Entrepreneurship Accelerator Program (REAP)	We will apply to The Regional Entrepreneurship Acceleration Program from MIT together with different national actors in order to accelerate the ecosystem of Santiago and Chile. With this activity we expect to contribute to the i+e ecosystem of the country.	• Execution of REAP program	01-03-2015	28-02-2017
Training of faculty in Leadership and i+e ST	Professors from FCFM will be trained in Leadership and i+e ST in world class institutions: Gordon Leadership Group and Martin Trust Center from MIT and JTCII from Cornell-Tech.	• Identification of the priorities of the training • Definition of the training goals • Definition of Mechanism for transferring the knowledge to the rest of the community • Execution of the training.	01-03-2015	28-02-2017
FCFM i+e ST Challenge	As with the the BizTech Entrepreneurship Challenge from the Bronica Entrepreneurship Center at Technion, we will host an entrepreneurship center where the process will be supported for acceleration of the projects (acceleration might be performed abroad with partner institutions such as Cornell-Tech)	• Design of the challenge • Search for sponsors and mentors • Implementation of annual Challenge	01-03-2015	28-02-2017
Enhancement of Laboratories of IDIEM for TT	We will develop a mechanism to transfer high-tech services or incipient commercial technologies through IDIEM. IDIEM is already a TT transfer office, specifically for services in structure. The plan is to enhance the TT and the Laboratories of IDIEM to expand the TT possibilities of this office. IDIEM is an extremely important spin-in of FCFM, enhancing this unit to support more sophisticated services coming from our research will be key to the sustainability of the strategic plan.	• Design of policies and mechanisms for TT through IDIEM • Improvement of the Laboratories of IDIEM to enhance the spectrum of TT that IDIEM could offer	01-03-2015	8-02-2017
Preliminary design, concept master and business plan for Carén Technology Park	Preliminary design, concept master and business plan for the Carén Technology Park	• Preliminary architectural concept •Business plan of the project.	01-03-2015	8-02-2016

Name of the activity	Description	Milestones	Beginning Date	Ending Date
Direction of External Affairs				
Enhancement of the networks with national and international institutions	This office will organize the current agreements of FCFM with external institutions in order to operatize the agreement. The office will help match the implementation parties with: (offices, research groups, professor, students and staff). This office also will be seeking and supporting new agreements for: • Internships given the standard produced by the TT office • International PhD students with scholarships from their countries • Student exchange • Faculty Exchange • Research collaborations with leading institutions and companies • Collocation of our PhD students in Postdoc positions at leading institutions and world class companies In addition this office will be working toward the sustainability of the project.	• New agreements	01-03-2015	28-02-2017
Outreach of the agreements and results	Communication of the agreements and their results to the FCFM community and to the external environment is essential for attracting opportunities. The communication will be handled in coordination with the communication office.	• Communication policies and protocol	01-03-2015	28-02-2017
Financial leverage for the execution of Stage Nº 1 of Carén Technology Park.	Financial leverage for the execution of Stage 1 of Carén Technology Park.	• Investment available	01-03-2015	28-02-2017
Dean and CORFO 2030 Team				
Tracking and improvement of the CORFO 2030 strategic plan	Evaluation of the selected metrics and improvement of the implementation of the strategic plan.	• Measurement and implementing improvements	01-03-2015	8-02-2017
Management of the Opposition to Change directed to current and new faculty and staff	We plan to keep informed and involved with the FCFM community through annual workshops and the international i+e ST conference. In addition, we plan to reward the change through: 4. Support (for faculty, staff and students) of the activities described above 5. Awards to faculty and staff (during the international i+e ST conference) 6. Recognition of the efforts within the faculty and staff meetings highlighting the best practices.	• Implementation of annual workshops to keep the FCFM community informed and involved • Inclusion of motivated faculty, staff, students and alumni within the strategic plan	01-03-2015	8-02-2017

Stage N° 3	Maintenance, Measurement, Improvement and Sustainability of the Transformation Plan			
Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Associate Dean of Undergraduate School				
Innovation and Entrepreneurship Lab	The i+e lab encourages entrepreneurship and innovation across FCFM, bringing together many cross-curricular interests, fostering team-based and entrepreneurial activities among FCFM students, faculty, industry, and alumni. The main purpose of the innovation and entrepreneurship laboratory is to exploit our research findings, and to empower young talents on their pathway to innovation and entrepreneurship. The Innovation and Entrepreneurship Lab will act as a bridge between research and industry, promoting an ecosystem where innovation happens.	• Hiring personnel	01-03-2017	28-02-2020
Clubs for innovation and entrepreneurship in Science and Technology (i+e ST)	The goal of this activity is to create a dedicated space with all the necessary tools for groups of students to develop innovative and entrepreneurial projects with a strong scientific and technological focus. The projects will be self-initiatives by the students. Students of different levels and specialties are expected to work on the same projects.	• 2 clubs in operation	01-03-2017	28-02-2020
Strengthen the Teaching Quality Office to deepen the CDIO curriculum	This activity will improve and strengthen current implementation of the CDIO curriculum in FCFM. In particular, we will evaluate the current curriculum, integrate innovation-entrepreneurship education and develop, assessment strategies for the new curriculum, with the assistance of professionals related to CDIO, MIT Gordon Leadership Group and Skoltech,	• Improvement of teaching infrastructure • implementation	01-03-2017	28-02-2020
Minor in Scientific-Technological Innovation and Entrepreneurship	The minor structure will serve to promote the interaction among interested (on i+e) students of different programs, developing a minor oriented to scientific-technological innovation and entrepreneurship	• Courses available	01-03-2017	28-02-2020
Foster multidisciplinary minors	Improve and develop minors in multidisciplinary fields by adapting and consolidating courses from several departments to face challenging multidisciplinary problems.	• New content for courses	01-03-2017	28-02-2020
Foster current efforts to improve teaching capacities	This activity has the goal of improving the teaching skills and methods of the professors. Professors will be trained through LASPAU program and CDIO in order to include more active methodologies within the classroom.	• 5 trained professors per year, with international partners, within new teaching methodologies • 2 workshops per year, with the trained professors, on new methodologies and the experience of implementing them in our classrooms.	01-03-2017	28-02-2020

Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Associate Dean of Undergraduate School				
Improvement and creation of new optional courses on leadership and i+e ST	In collaboration with international institutions (Cornell-Tech, Technion, MIT Gordon Leadership Group, MIT Martin Trust Entrepreneurship Center) we will evaluate our current courses and develop courses related to leadership and i+e ST	• Creation of new leadership courses • Creation of new i+e courses	01-03-2017	28-02-2020
Foster the inclusion of FCFM teaching material in online platforms (MOOCS)	This activity will provide unlimited participation and open access through the web of FCFM material. The main focus will be to support faculty in generating content and adapting teaching material to be uploaded to online platforms.	• Gather the different tools that are available • Develop prototype experiences for specific courses • Workshop to show the potential benefits of these tools • New teaching material for 4 new courses.	01-03-2017	28-02-2020
Strengthen early science and engineering courses and the communication of the outcomes of the courses	Strengthen the early project-oriented courses and the skills developed within them. In collaboration with the TERRASCOPE initiative from MIT, we plan to explore early exposure of the students to current challenges of science and technology. In addition, we plan to explore the impact in communicational skill with the TERRASCOPE approach where the students products are reports, audio files, videos and short presentations that are open to experts around the world and to the general community. We plan to produce a platform to upload the student work, to accelerate outreach and information transfer to the community, in particular to take advantage of the student work to improve their communication skills and science education.	• Evaluation of the "Introduction to Engineering" (one year course, in the first year) and "Project Workshop" (3rd semester course) courses. • Creation of the Pilot with the TERRASCOPE (related to Geosciences) approach • Creation of other pilots related to other subjects. • Evaluation of the pilots • Creation of a website platform to upload the students outcomes of the pilots and eventually of any student project	01-03-2017	28-02-2020
Multidisciplinary undergraduate projects	The main goal of this activity is to systematize multidisciplinary initiatives, such as the airplane, the solar car, Robocup, the CubeSat projects), all developed by undergraduate students with the support of FCFM	• An increase of at least one of these types of projects every two years.	01-03-2017	8-02-2020

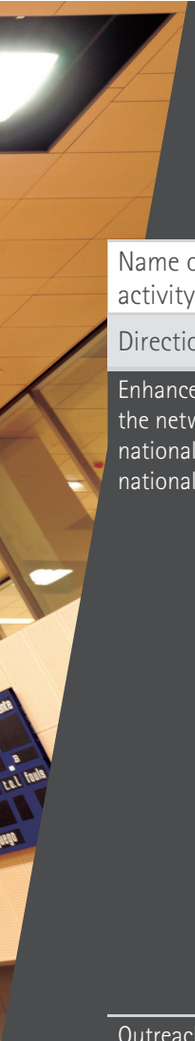
Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Associate Dean of Graduate School				
Master of Science in Technological Entrepreneurship and Innovation	The goal of the Master of Science in Technological Entrepreneurship and Innovation is to provide engineers and scientists with the skills and knowledge required to drive innovation and technological entrepreneurship. The program will prepare students to understand the processes of innovation with a solid technological background and to gain insight in the practical business development with a particular focus on interdisciplinary projects. This program will be developed in agreement with key international partners.	• Execution of the courses.	01-03-2017	28-02-2020
Support of PhD theses related with national / international industry	We plan to support PhD theses related to the industry. We expect to collaborate via the PhD programs with local industry and with international industry through international collaborators, such as Cornell-Tech.	• Support of 3 PhD theses per year	01-03-2017	28-02-2020
International internships for PhD students	The goal of this activity is to enhance and foster international cooperation with leading research and innovation institutions.	• Call to apply and select applicants	01-03-2017	28-02-2020
Contact with and support to PhD graduates	We will develop a system to keep abreast of the opportunities around the world for our PhD graduates and promptly communicate those opportunities to them. We will maintain contact with our PhD graduates to improve the FCFM network and help them connect with other alumni.	• Hire a professional to follow up and contact our alumni.	01-03-2017	8-02-2020

Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Associate Dean of Academics and Research				
Starting Fund	FCFM will provide resources for new faculty as seed funds to start a research project while preparing the application for external grants.	• Provide funds	01-03-2017	28-02-2020
Support for long term stays of FCFM faculty	This item includes the generation of a support program for long term stays of FCFM faculty at international institutions. The objective is to create strong links with top research groups and to improve the impact of our research.	• Call to apply and select applicants	01-03-2017	28-02-2020
Multidisciplinary scientific and technological projects development	FCFM will foster and support the development of multidisciplinary scientific and technological projects, involving the whole FCFM community (faculty, under and graduate student, postdoc, industry and alumni). It is expected that these projects have a strong impact on the undergraduate students by their active participation. Examples of such projects are the next generation of the satellite, solar car, ultra-light airplane among others.	• To gather information regarding the projects that are being developed in FCFM. • To foster the development of new projects.	01-03-2017	28-02-2020
Hiring new faculty	Hiring 40 new faculty members according to our strategy, with a focus on innovation, technology transfer and multidisciplinary research.	• Definition of Relevant Areas • Call for applications • Hiring the first group of faculty	01-03-2017	8-02-2020
Chairs for multidisciplinary research	The chairs for multidisciplinary research (CMR) are aimed at providing funding for permanent positions of faculty who will lead multidisciplinary research on topics relevant to the country and national industry. CMRs will be defined in pairs, so that two faculty, of different departments, ensure both symmetry and that the research and cross-fertilization process takes place.	• **Definition of Relevant Areas** • **Call for applications** • **Hiring**	01-03-2017	8-02-2020
Induction of new faculty	This activity aims to gather all the information a faculty member needs to know, and write it in an official document. This information includes teaching; research and technology transfer activities, and others metrics required for faculty member in the context of this strategy plan.	• "FCFM faculty guide" textbook	01-03-2017	8-02-2020

Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Chief Financial Officer				
Improving the skills of the administrative staff	Improving the skills of the administrative staff to manage i+e and TT projects	• Interdepartmental workshop for administrative staff	01-03-2017	28-02-2020
Deputy Dean				
External advisory committee for FCFM	The External Advisory Committee (EAC) will actively assist and advise FCFM in terms of education and research by providing valuable input concerning current and future trends in industry and the country, resources for research and development, industry interfaces and exchanges, recruitment opportunities for our graduates and guidance for entrepreneurs. EAC Primary Objectives are: • To promote teaching excellence (both undergraduate and graduate). • To promote excellence and relevance in research, fostering Innovation and entrepreneurship • To facilitate and help S&T transfer based on our research. • To advise FCFM and the undergraduate and graduate schools of the professional skills expected of Engineers, Masters and PhD graduates from here, and that are hired in industry, business, and government. • To assist FCFM in fund-raising and promotional activities.	• To gather information regarding the projects that are being developed in FCFM. • To foster the development of new projects.	01-03-2017	28-02-2020
Direction of Students Affairs				
Student Exchange with partner institutions	This item includes the generation of periodic scholarships for undergraduate, graduate and foreign students to spend some time abroad (either short terms of 15-30 days, up to long terms such as a semester). We will be actively attracting foreign students to our program for short or long terms studies within FCFM. We will actively manage and support the stays and the educational experience of the international students	• Scholarships for the students • Managing protocol of the students exchange experiences with partner institutions	01-03-2017	8-02-2020
Enhance international internship programs	Currently the international internships are limited in number and programs. We will increase the number of students partaking in internships abroad, and the number of companies offering them. This office will coordinate and support the students with the process of internships. With the information from the External Affairs, this office will operate the internships and pay special attention to the international internships.	• Contact with companies willing to offer structured internships	01-03-2017	8-02-2020

Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Associate Dean of Technology Transfer (TT) and i+e ST				
Accelerator for Startups and Spinoffs	The accelerator will support technology-based projects with strong commercial potential and where the core team members are students, staff and alumni at and from FCFM. It will provide support in: • Coaching - ongoing coaching from national-international mentors and grants application support • Office space – dedicated premises with office workspace, kitchen, rooms, teleconference, etc. • Contacts and network – access to potential investors, partners and clients • Financial support –project with potential global impact will have financial support for international acceleration.	• 1 startup each year	01-03-2017	28-02-2020
Technology Transfer Office	The TT Office will support with the search for opportunities related to TT. It will maintain updated information on conducted research and the potentialities of that research, helping with the connections with potential external partners. In particular, the TT office will support: • The standardization and improvement of the internship programs in Chile • The search for TT opportunities of applied and multidisciplinary research • The legal advisory of Intellectual Property and TT strategy. • The search in coordination with External Affairs of possible investors for applied research at FCFM • The search for investors for the Carén Technology Hub This office will actively work towards the sustainability of the Strategic Plan	• The office will determine opportunities for Technology Transfer	01-03-2017	28-02-2020
Scientific-Technological Innovation and Entrepreneurship Conference	The Scientific-Technological Innovation and Entrepreneurship Conference is an annual opportunity for experts and world leaders in these fields to meet, share best practices, network and learn from each other. This conference is also an opportunity for students of FCFM to present their developments and to know what is being done internationally.	• One conference organization in year 4 • One conference organization in year 5 • One conference organization in year 6	01-03-2017	28-02-2020

Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Associate Dean of Technology Transfer (TT) and i+e ST				
MIT Regional Entrepreneurship Accelerator Program (REAP)	We will apply to The Regional Entrepreneurship Acceleration Program from MIT together with different national actors in order to accelerate the ecosystem of Santiago and Chile. With this activity we expect to contribute to the i+e ecosystem of the country.	• Execution of REAP program	01-03-2017	28-02-2020
Training of faculty in Leadership and i+e ST	Professors from FCFM will be trained in Leadership and i+e ST in world class institutions: Gordon Leadership Group and Martin Trust Center from MIT and JTCII from Cornell-Tech.	• Identification of the priorities of the training • Definition of the training goals • Definition of Mechanism for transferring the knowledge to the rest of the community • Execution of the training.	01-03-2017	28-02-2020
FCFM i+e ST Challenge	As with the BizTech Entrepreneurship Challenge from the Bronica Entrepreneurship Center at Technion, we will host an entrepreneurship center where the process will be supported for acceleration of the projects (acceleration might be performed abroad with partner institutions such as Cornell-Tech)	• Design of the challenge • Search for Sponsors and mentors • Implementation of annual Challenge	01-03-2017	28-02-2020
Construction stage Nº 1 of the Carén Technology Park project	Construction stage 1 of the Carén Technology Park project.	• Infrastructure Available	01-03-2017	8-02-2020



Name of the activity	Description	Milestones	Date of Beginning	Date of Ending
Direction of External Affairs				
Enhancement of the networks with national and international institutions	This office will organize the current agreements of FCFM with external institutions in order to operatize the agreement. The office will help to make the match between the implementation parties and (offices, research groups, professor, students and staff). This office also will be seeking and supporting new agreements for: • Internships given the standard produced by the TT office • International PhD students with scholarships from their countries • Student exchange • Faculty Exchange • Research collaborations with leading institutions and companies • Collocation of our PhD students in Postdocs positions at leading institutions and world class companies In addition this office will be working toward the sustainability of the project.	• New agreements	01-03-2017	28-02-2020
Outreach of the agreements and results	Communication of the agreements and their results to FCFM community and to the External environment is relevant to keep attracting opportunities. The communication will be handled in coordination with the communication office.	• Communication policies and protocol	01-03-2017	28-02-2020
Financial leverage for the execution of Stage Nº 2 of Carén Technology Park.	Financial leverage for the execution of Stage Nº 2 of Carén Technology Park.	• Investment availablee	01-03-2017	28-02-2020
Dean and CORFO 2030 Team				
Tracking and improvement of the CORFO 2030 strategic plan	Evaluation of the selected metrics and improvement of the implementation of the strategic plan.	• Measurement and implementing improvements	01-03-2017	28-02-2020
Management of the Opposition to Change directed to current and new faculty and staff	We plan to keep informed and involved to the FCFM community through annual workshops and the international i+e ST conference. In addition, we plan to reward the change through: 7. Support (for faculty, staff and students) of the activities described above 8. Awards to faculty and staff (during the international i+e ST conference) 9. Recognition of the efforts within the faculty and staff meetings highlighting the best practices.	• Implementation of annual workshops to keep the FCFM community informed and involved • Inclusion of motivated faculty, staff, students and alumni within the strategic plan	01-03-2017	28-02-2020

3.4.3 Results of the stage

Stage N° 1	Design methodology of implementation	
Result/product	Description	Expected date of accomplishment
Setup of the facilities Search and appointment of Associate Deans Document with definitions of the policies, goals, working plans, metrics, management, and control procedures	The Dean and the authorities of FCFM together with the Project team will be in charge of calling for applications, evaluating and selecting the new Associate Deans, who will collaborate in the facilities setup and in the definition of the Office.	28-02-2015
Document with the design of the work plan for the first 2 clubs	The Associate Dean of Undergraduate School together with the project team will elaborate a document with the design of the work plan of the first 2 student clubs. The plan should include the mechanisms to keep students motivated and in charge, together with the sustainability of the clubs.	28-02-2015
Document with the evaluation of the currently implemented CDIO curriculum, suggesting improvements and strengthening the curriculum by the inclusion of assessment methodologies and innovation-entrepreneurship education	The Associate Dean of Undergraduate School together with the project team will conduct the evaluation of the curriculum with assistance of our associated experts in CDIO, assessment and innovation-entrepreneurship. The evaluation should lead to improvement recommendations.	28-02-2015
Document with definition of the first multidisciplinary and i+e ST minors	The Associate Dean of Undergraduate School together with the project team will elaborate a document with the definition of the minors together with partner institutions.	28-02-2015
New multimedia learning material for minor	New material for 2 of the courses of the minor	28-02-2015
International teacher training of 3 professors	3 Professors will be trained abroad in new teaching methodologies. The selection of the professors will be done by an extended call where the professors participate after their training in FCFM workshops to share the gained knowledge, not only in the training courses, but also during the implementation process in FCFM	28-02-2015
Syllabus of 6 new courses, in particular, for i+e ST or in multidisciplinary challenges	The Associate Dean of Undergraduate School together with the project team and interested professors will create the syllabus of 6 new courses in i+e ST and multidisciplinary challenges	28-02-2015
4 courses with free online material available	The Associate Dean of Undergraduate School together with the project team and interested professors will create media material of 4 courses to be uploaded to an online platform being available for free to the external community	28-02-2015
Improvement of the digital fabrication Lab (FabLab)	The Deputy Dean, the Associate Dean of Undergraduate School together with the project team will support new facilities setup of the FabLab in order to use it to foster innovation on a larger scale in our community.	28-02-2015

Result/product	Description	Expected date of accomplishment
3 PhD theses will be supported	The Associate Dean of Graduate School together with the project team and interested researchers will coordinate to have at least three PhD researchers with an applied focus and strong interest in the industry. The associated PhD theses will be rewarded with extra financial support.	28-02-2015
International stays of 8 of our PhD students	The Associate Dean of External Affairs, together with the Associate Dean of Graduate School and with the project team, will make a call for applications of international stays for our PhD students. Eight PhD students will be selected for stays abroad.	28-02-2015
Following of PhD alumni and design of the platform for job opportunities of our PhD students	The Associate Dean of the Graduate School together with the project team will work to establish contact with at least 75% of our PhD alumni. The Associate Dean of External Affairs will seek and formalize communication channels with national and international institutions, starting with partner institutions (such as University of Manchester, Technion, and Cornell-Tech).	28-02-2015
Allocation of funds for initiation of 15 new academic research projects	TAllocation of funds for initiation of 15 new academic research projects	28-02-2015
Enhancement of 5 academics for development training at world-renowned universities	Sending 5 academics for development training to world-renowned universities	28-02-2015
Hiring of 16 new faculty members	The Dean and the hiring council will appoint 16 new faculty members. Innovation and Entrepreneurship is a desired requisite for some of them.	28-02-2015

Result/product	Description	Expected date of accomplishment
Procedure and induction material for new academics	The Dean and the Associate Dean of Academic and Research will mandate the analysis and formulation of recommendation for a better insertion of new faculty.	28-02-2015
Standardization of best practices for management and administration	The Chief Financial Officer together with the team of the Project will work to gather the best practices to foster TT and i+e ST. The best practices will be summarized in a document and presented through the workshops and the human resource office to train new administrative staff.	28-02-2015
Design of the improvements to be performed in the Mechanical laboratory of FCFM. This Lab will be modernized to encourage innovation.	The Dean, the Deputy Dean, the Chair of the Mechanical Engineering Department and the project team will elaborate a design to improve the Mechanical Lab of FCFM in order to foster innovation among the students.	28-02-2015
Annual Committee Session carried out	Annual Committee Session carried out with all its members	28-02-2015
2 of the 4 laboratories being fully functional	2 of the 4 laboratories being fully functional	28-02-2015
Detailed redesign of Department of Mining Engineering	Redesign of interdisciplinary workspace within Mining Engineering	28-02-2015
20 students have started their exchange program	The Associate Dean of External Affairs will find and establish opportunities for international stays. The Associate Dean of Undergraduate School, the project team and the host institutions will advertise the opportunities and select the students for the stays	28-02-2015
10 students have started their internship abroad	The Associate Dean of External Affairs will find and establish international internship opportunities in companies relevant to the field. The Associate Dean of Undergraduate School, the project team and the host companies will advertise the opportunities and select the students for the internships	28-02-2015
5 foreign students have started their exchange program in Chile	The Associate Dean of External Affairs will find and establish international agreements to attract international students. The Associate Deans of Undergraduate School and Student affairs, and the project team will be in charge of international students experience.	28-02-2015
Design program and regulations of Master of Science in Technological Entrepreneurship and Innovation	Design program and regulations of Master of Science in Technological Entrepreneurship and Innovation	28-02-2015
Training of 6 professors or professional staff in Technology Transfer polices and procedures.	The Associate Dean of External Affairs will find and establish international opportunities for TT training (in particular with partner institutions). The Associate Dean of TT and i+e ST, the project team and the training institutions will advertise the opportunities and select the staff to be trained.	28-02-2015
Document with the Design of the i+e ST competition	The Associate Dean of TT and i+e ST and the project team will work in the design of the i+e ST competition	28-02-2015
Application to the REAP program	We will apply to The Regional Entrepreneurship Acceleration Program from MIT together with different national actors in order to accelerate the i+e ST ecosystem of Santiago and Chile. With this task we expect to contribute to the i+e ecosystem of the country.	28-02-2015

Stage N° 2	Implementation of the Strategy	
Result/product	Description	Expected date of accomplishment
4 Clubs functioning. Club work plan for Clubs 5 and 6.	4 Clubs functioning. Club work plan for Clubs 5 and 6.	28-02-2017
All minor courses lectured successfully	Minor courses lectured successfully	28-02-2017
International training of 6 academics	Visit and participation of international scholar training program	28-02-2017
Finished courses with 300 students participating. Syllabus for 6 new courses.	Finished courses with 300 students participating. Syllabus design for 6 new courses.	28-02-2017
8 courses with free online material	Design and generation of lecturing material, available free and online through an adequate internet platform	28-02-2017
Specific funding for 6 new PhD theses	Funding for 6 new PhD thesis projects on industry related applied research.	28-02-2017
Dispatch of 20 PhD students to international internships.	Dispatch of 20 PhD students to international internships at prestigious Universities/Research Centers	28-02-2017
Follow-up with graduate students and workplace searches	National and international work position calls Work Placement for 75% of our graduates	28-02-2017
Research Startup funding allocation for 5 new academics and 2 academics of prominent multidisciplinary research	Research Startup funding allocation for 5 new academics and 2 academics of prominent multidisciplinary research	28-02-2017
Training of 15 academics in world class universities	Training of 15 academics in world class universities	28-02-2017
Funding for 4 multidisciplinary research projects	Funding for 4 multidisciplinary research projects	28-02-2017
Hiring of 10 new faculty members	Hiring of 10 new faculty members	28-02-2017
All new academics have passed induction	All new academics have passed induction	28-02-2017
Improvement of 6 labs. Implementation of upgrade at mechanical engineering machine shop.	Improvement of 6 labs to upgrade the teaching facilities. Implementation of upgrade at the Molina machine shop (mechanical engineering lab).	28-02-2017
Annual session of committee performed	Annual session of committee performed	28-02-2017

Result/product	Description	Expected date of accomplishment
4 out of 4 labs completely functional	4 out of 4 labs completely functional	28-02-2017
40 students have started their exchange program	Commencement of student exchange program	28-02-2017
40 students have started their internship abroad	Students have started their internship abroad	28-02-2017
40 foreign students have started their exchange program in Chile	Foreign students have started their exchange program in Chile	28-02-2017
Dispatch of 2 Startup teams to international accelerator	Dispatch of 2 Startup teams to international accelerator	28-02-2017
2 Scientific-Technological Innovation and Entrepreneurship Conference organization	The Scientific-Technological Innovation and Entrepreneurship Conference is an annual opportunity for experts and world leaders in these fields to meet, share best practices, network and learn from each other. This conference is also an opportunity for students of FCFM to present their developments and learn about what is being done internationally.	28-02-2017
Training of 12 academics or Technology transfer staff	Training of 12 academics or Technology transfer staff	28-02-2017
Determination of 3 projects with high potential for the development of funding counterparts	Determination of 3 projects with high potential for the development of funding counterparts	28-02-2017
Determination of 3 annual multidisciplinary research opportunities	Determination of 3 annual multidisciplinary research opportunities	28-02-2017
Procurement of 3 pre-commercial phase projects	Maturation of pre-commercial phase projects, started on previous years	28-02-2017
Preliminary design, concept master and business plan for the Carén Technology Park	Preliminary design, concept master and business plan for Carén Technology Park	28-02-2016
Financial leverage for the execution of Stage N°1 of the Carén Technology Park.	Budget for the construction stage N°1 of the project.	28-02-2017
50 new students enrolled in Master of Science in Technological Entrepreneurship and Innovation	50 new students enrolled in Master of Science in Technological Entrepreneurship and Innovation	28-02-2017

Stage N° 3	Maintenance, measurement, improvement and self-financing of the strategy	
Result/product	Description	Expected date of accomplishment
10 Clubs functioning	10 Clubs functioning	28-02-2020
300 graduates of the Minor in Scientific-Technological Innovation and Entrepreneurship	300 graduates of the Minor in Scientific-Technological Innovation and Entrepreneurship	28-02-2020
International training of 9 academics	Visit and participation of international scholar training program	28-02-2020
12 courses with free online material	Design and generation of lecturing material, available free and online on an adequate internet platform	28-02-2020
Specific funding for 12 new PhD theses	Funding for 6 new PhD theses projects on industry related applied research.	28-02-2020
Dispatch of 20 PhD students to international internships.	Dispatch of 20 PhD students to international internships at prestigious Universities/Research Centers	28-02-2020
Follow-up with graduate students and workplace searches	National and international work position calls Work Placement for 75% of our graduates	28-02-2020
Research Startup funding allocation for 5 new academics and 2 academics of prominent multidisciplinary research	Research Startup funding allocation for 5 new academics and 2 academics of prominent multidisciplinary research	28-02-2020
Training of 24 academics in world class universities	Training of 24 academics in world class universities	28-02-2020
Funding for 9 multidisciplinary research projects	Funding for 9 multidisciplinary research projects	28-02-2020
Hiring of 15 new faculty members	Hiring of 15 new faculty members	28-02-2020
All new academics have passed induction	All new academics have passed induction	28-02-2020

Result/product	Description	Expected date of accomplishment
Annual session of committee performed	Annual session of committee performed	28-02-2020
Improvement of the Mining Engineering Department	The centennial facilities where the Department of Mining Engineering is allocated is in need substantial improvement	28-02-2020
40 students have started their exchange program	Commencement of student exchange program	28-02-2020
100 students have started their internship abroad	Students have started their internship abroad	28-02-2020
60 Foreign students have started their exchange program in Chile	Foreign students have started their exchange program in Chile	28-02-2020
Implementation of a conference each year	Execution of 3 conferences	28-02-2020
Determination of 3 projects with high potential for the development of funding counterparts	Determination of 3 projects with high potential for the development of funding counterparts	28-02-2020
Determination of 3 annual multidisciplinary research opportunities	Determination of 3 annual multidisciplinary research opportunities	28-02-2020
Procurement of 3 pre-commercial phase projects	Maturation of pre-commercial phase projects, started in previous years	28-02-2020
120 new students enrolled in Master of Science in Technological Entrepreneurship and Innovation	120 new students enrolled in Master of Science in Technological Entrepreneurship and Innovation	28-02-2020
Construction stage N° 1 of the Carén Technology Park project	Start construction of the Carén Technology Park	28-02-2020
Financial leverage for the execution of Stage N°2 of Carén Technology Park.	Continuing the process of financial leverage for Carén Technology Park	28-02-2020

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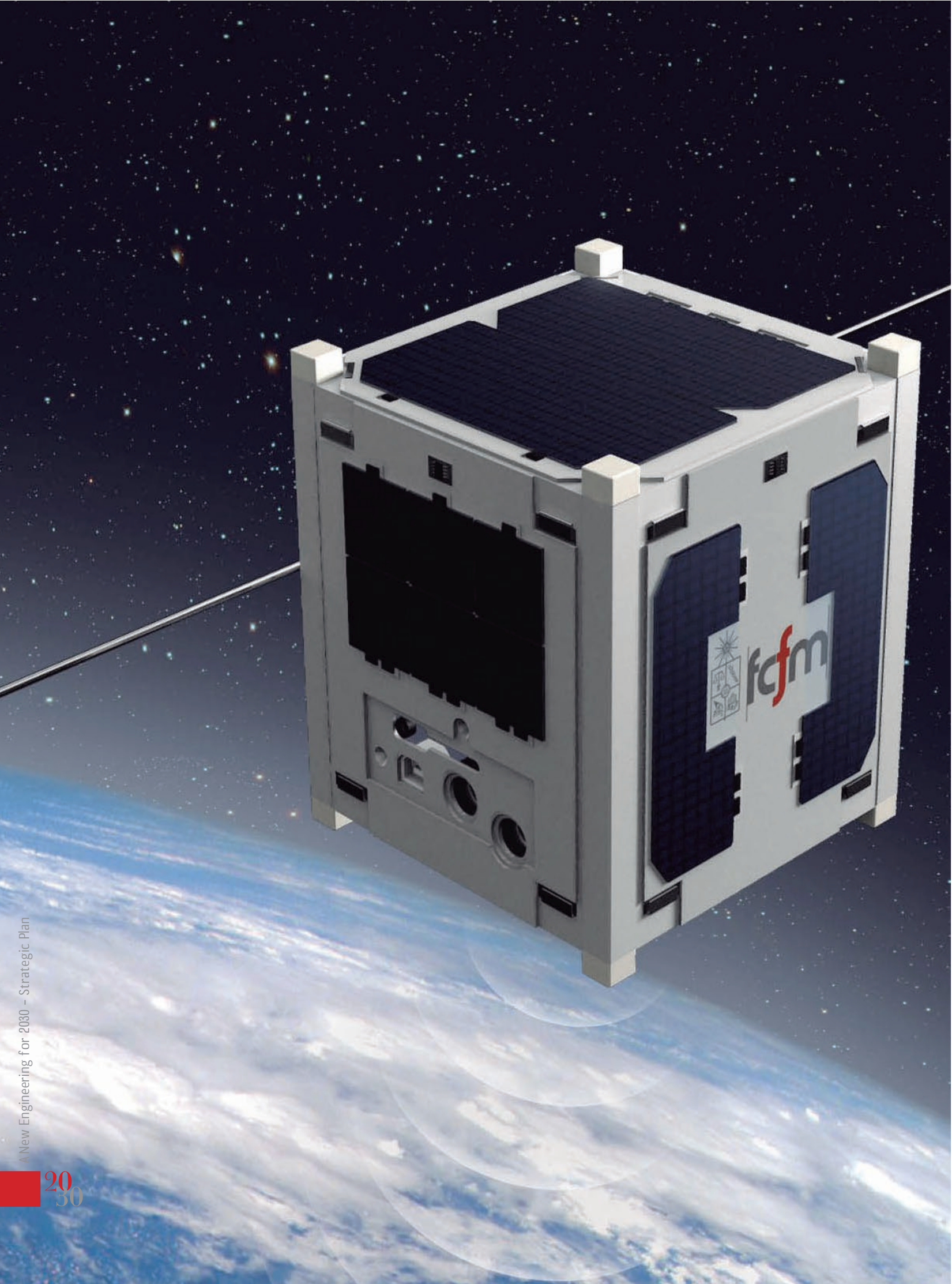
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"Entrepreneurship is a mindset, an outlook that shapes the way you see the world and the possibilities that it holds. It is born of a basic dissatisfaction with the status quo, and it is the courage to say to yourself, 'This could be better.'"

Student of Stanford Technology Ventures Program

Acknowledgements and final words

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The FCFM-UChile is a unique experiment in the Chilean public system for Research and Higher Education in Engineering and Sciences. In the late 1980s, it would have been hard to predict its remarkable development trajectory during the last 25 years. Today, we can see the achievements of this university environment that appreciates diversity, values talent and recognizes excellence. We also see the barriers we should overcome to have a greater scientific, technological, social and economic impact. As before, it is also difficult to predict how far we will go during the next decades. But one thing is for sure: we will work very hard to make of the FCFM a world-class institution by 2030.

We have learned at FCFM that our students and society deserve nothing but the best from us. That is why, as we know that we can do better, we will do better.

Felipe Alvarez
Deputy Dean
Head of "A New Engineering for 2030", FCFM-UChile.

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