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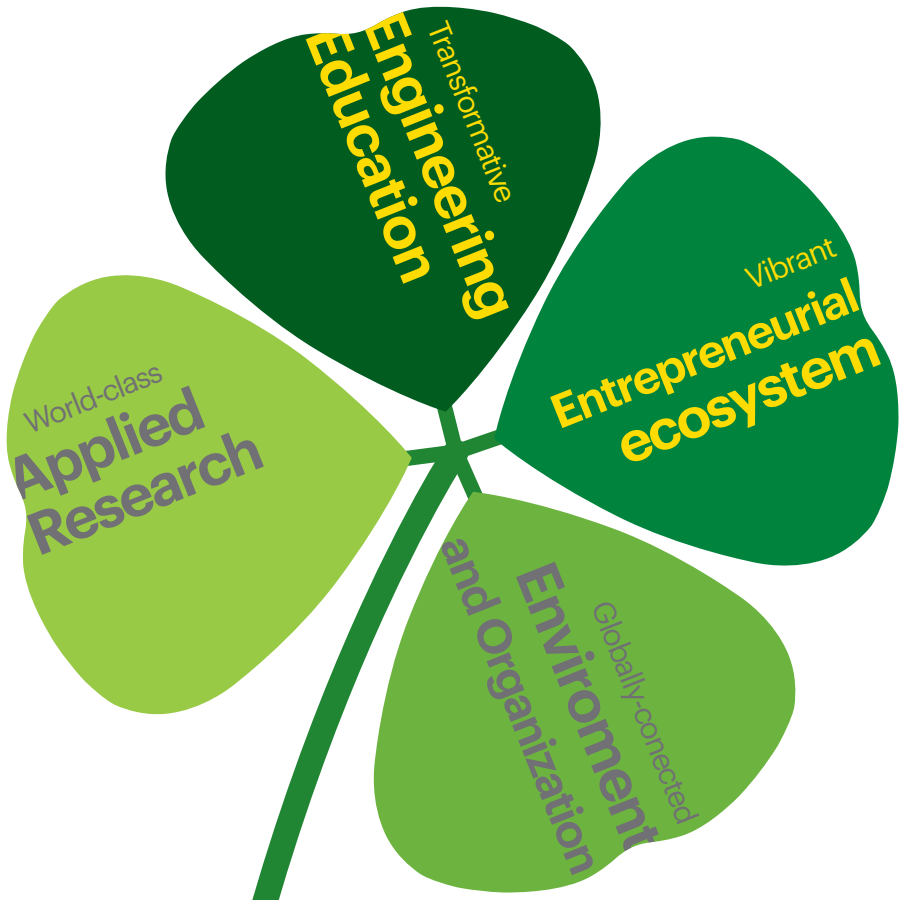

THE CLOVER
ENGINEERING 2030

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A NEW GENERATION OF TECHNOLOGY INNOVATORS TO POWER
CHILE´S ECONOMIC AND SOCIAL DEVELOPMENT

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THE CONTEXT FOR CHANGE

Chile is at a crossroads. Historically, the national economy has been highly dependent on natural resources, particularly copper, and for two decades high commodity prices underpinned a strong and growing economy. **This economic strength in turn brought societal improvements for Chile's population, in health, education and quality of life.** The past five years, however, have seen substantial falls in the price of copper and other commodities, which has led to a sharp economic slowdown across the country. Chile now faces a stark choice: to continue its dependence on natural resources and face an economically uncertain future, or to diversify its economic base and build prosperity in new areas. The Chilean Government has proposed a bold vision for change, one in which the country's economic and social development is built upon technology innovation.

Enormous potential exists for Chile to make such a transition. The unique geography and climate of the country offer a 'natural laboratory' for technology innovation in fields as diverse as seismology, climate change, energy and astronomy. Indeed, within the next five years, Chile will be home to over 70% of the world's astronomy infrastructure, representing an investment of over $**6billion**. The past two decades have also brought a four-fold increase in higher education participation across the country and a strengthening scientific research base. In addition, high-profile interventions such as Start-Up Chile have had a marked impact on the entrepreneurial intentions and opportunities of the Chilean working-age population.

These are important building blocks. However, Chile's transition to an innovation-based economy faces challenges. The establishment and growth of the world's leading technology innovation ecosystems have been underpinned by some notable common features. These include international connectivity and mobility of talent, cutting-edge applied research in science and technology, the availability of venture funding, a highly-skilled and entrepreneurial graduate population and a vibrant community of support and trust across academia, industry and the regional entrepreneurial population. Many of these features are still only embryonic in Chile. To achieve its ambitions in technology innovation, the country must urgently address a number of challenges, including:

- **low levels of national investment in research and development (R&D) and a small population of researchers;**
- **limited social mobility and gender diversity amongst the professional graduate population, significantly reducing the talent pool for driving future enterprise;**
- **a restricted national research base in science and technology, with little consideration given to the commercial potential of research or its capacity to drive economic or societal progress;**
- **an engrained academic culture of isolationism, with little national and global connectivity across academia, government and industry;**
- **a limited culture of entrepreneurship and innovation within higher education and industry, with few opportunities to nurture new entrepreneurial talent or support the commercialization of high-potential ideas;**
- **traditional university operating models – organizational structures, physical spaces and curricula – that do not facilitate collaborative, inter-disciplinary hands-on learning and discovery amongst staff and students.**

The transformation to an innovation-based economy will require ambitious collaborative intent by Chilean government, academia, industry and civil society. One group, however, will undoubtedly lie at the heart of this transformation: the nation's engineering schools. Engineering schools are the incubator in which the new generation of technology innovators will be nurtured, and hold the key to driving forward Chile's industrial base and pioneering new routes for economic and societal development. Engineering schools are also the engine driving the country's technology research-base, and are pivotal to transforming the national R&D culture towards an entrepreneurial paradigm with deep connectivity to the world's foremost technology-innovation ecosystems. The Chilean Government recognizes the crucial role that engineering schools must play in the country's economic and societal transformation. In 2012, the government's National Agency for Innovation and Development (CORFO) committed a $**60million** investment in *Engineering 2030*, a program to enable radical and far-reaching reform to the nation's engineering schools.

Clover 2030 seeks to **place USM and UC Engineering at the heart of this transformation**. It has set out a radical program of far-reaching change that will enable a fundamental shift in academic culture and establish a new relationship between universities and Chilean society.

The reform builds on strong foundations. The two universities in the Clover 2030 consortium – the Faculty of Engineering at the Pontifical Catholic University of Chile (UC Engineering) and the Federico Santa Maria Technical University (USM) – each bring a formidable reputation, both in the scientific rigor of their educational and research activities and in the academic quality of their staff and students. Together, USM and UC Engineering were ranked as the two top Chilean universities in the 2017 Times Higher Education World University Rankings. The past decade has also brought a step-change in the ambitions, impact and reputation of both institutions. At UC Engineering, such changes are evident in the increased size and caliber of the school's faculty population, as well as its research output: between 2010 and 2012 alone, faculty numbers have grown by 20% and annual peer-reviewed ISI publications have increased by 63%. Over the same period, USM has driven a significant improvement to the volume and quality of its research output: in the past six years, the number of scholarly papers published has increased by 170% and the normalized impact of these publications has almost doubled to 2.06.

Reform has not been confined to the research domain, however, and the educational models at both USM and UC Engineering have seen fundamental change in recent years. For example, at USM, over 100 faculty have participated in dedicated educational training to support the curricular transition toward student-centered learning in an entrepreneurial environment. These developments have been supported by the university's growing research strength in engineering education, leading them to become the country's largest engine for research in university teaching and learning. At UC Engineering, the school implemented a root-and-branch reform to its curricular model in 2013, establishing a student-centered educational approach and embedding increased student mobility and choice. Indeed, since 2015, UC Engineering has been the only Chilean institution of its kind to be accredited by ABET, the US engineering program accreditation board.

Both USM and UC Engineering also share a deep-rooted commitment to inclusion and social mobility, which has been reflected in the growing number of outreach activities to improve engagement and access. At USM, where 40% of students are from low-income backgrounds, the university has been offering programs of teacher support and training for Chilean high schools in disadvantaged areas. At UC Engineering, the *Talent and Inclusion* program offers a dedicated admission route for highly-talented students from disadvantaged socio-economic backgrounds and enabled an increase in the proportion of female engineering students from 18% to 25%.

These and other reforms paved the way for the Clover 2030 transformation, establishing an ambitious and inclusive culture of collaboration and excellence. Building on these foundations, Clover 2030 will bring UC Engineering and USM to the world stage in research, education and innovation, providing a vehicle for economic and social change across Chile.

OUR VISION

Our vision is for the Clover 2030 consortium to play a pivotal role in driving Chile's future economic and societal development. **Through Clover 2030, we seek to nurture the entrepreneurial culture, capacity, ideas and talent necessary to advance a new economic base for the country in technology innovation.** Building on the commitment to excellence at both USM and UC Engineering, change will also be underpinned by the values of social inclusion, equality and diversity.

The vision for change is built upon five strategic goals:

- **transforming lives:** to use technology innovation and discovery to advance Chile's societal development, driving forward opportunities to improve health, education, the environment and quality of life across the country;
- **supporting industry:** to build Chile's strength in scientific and technological discovery, both through advancing the country's existing national industry base and through pioneering new avenues for growth and development;
- **connecting globally:** to establish global presence and connectivity, providing a bridge to the best talent, research, ideas and communities of support from across the world;
- **changing cultures:** to build a vibrant and collaborative culture of innovation, creativity and discovery in science and technology that infuses Chilean academia, industry and civil society and inspires the next generation;
- **establishing leadership:** to position both UC Engineering and USM on the world stage and establish the institutions as Latin American centers for excellence in engineering education, applied research and technology innovation.

OUR STRATEGY

To achieve our vision, Clover 2030 is built around four pillars of reform:

PILLAR 1. Transformative **engineering education** that will nurture a new generation of technology innovators and leaders

PILLAR 2. World-class **applied research** that will transform lives

PILLAR 3. A vibrant **entrepreneurial ecosystem** that will foster pioneering co-innovation and partnership across Chile

PILLAR 4. A **globally-connected environment and organization** that will advance world-class innovation and enable talent to flourish

THE CLOVER

The lucky **four-leaf clover** was chosen to represent this ambitious transformation program. The four leaves of the clover represent the four pillars of change: **education, applied research, entrepreneurship and an enabling environment.** The stem reflects the connectivity to society, which feeds and nurtures each of the leaves. The stem provides stability, support and nourishment to the clover, without which it would wither and die. It ensures that the transformation is deeply rooted in the challenges and opportunities facing Chilean society and will allow the effects of change to infuse across all sectors of the economy.

PILLAR 1.

TRANSFORMATIVE **ENGINEERING EDUCATION** THAT WILL NURTURE A NEW GENERATION OF TECHNOLOGY INNOVATORS AND LEADERS

The Clover 2030 consortium is committed to providing the country with a new generation of engineering graduates that has the talent, ideas and entrepreneurial ambition to drive societal and economic progress. We will nurture and support this new generation throughout their educational lifecycle, starting in high-school and extending long into their professional careers. To achieve these goals, we aim to establish a world-class student-centered education that:

1. is built upon a **scholarly approach** to engineering teaching and learning;
2. infuses **technology-driven entrepreneurship and innovatio**n within and beyond the engineering curriculum;
3. offers students a **global outlook** with opportunities for national and international mobility;
4. **attracts and retains the best talent**, regardless of gender, culture and socio-economic background.

1. IS BUILT UPON A SCHOLARLY APPROACH TO ENGINEERING TEACHING AND LEARNING

Stage 1.1: To ensure that the Clover 2030 curricular transformations will be underpinned by a deep understanding of engineering teaching and learning within the Chilean context, both USM and UC Engineering have established dedicated centers in engineering education research and innovation: the *Division of Teaching and Learning* and the *Division of Engineering Education* respectively. The centers will engage in three primary activities:

1. driving the development and implementation of new programs and teaching techniques. Activities include a suite of new Massive Open Online Courses (MOOCs), delivered in partnership with Coursera at UC Engineering and a new faculty diploma in engineering teaching and learning at USM to support the integration of pedagogies such as flipped classrooms.
2. evaluating the quality and impact of the Clover 2030 educational reforms. Major studies already launched include an impact analysis of the USM curricular reform on the employability of the university's graduates and an evaluation of the impact of the new 2030 curriculum on UC Engineering students' entrepreneurial capabilities and aspirations.
3. working in collaboration with national and global partners to establish the Clover 2030 consortium as a hub for support and leadership in engineering education research across Latin America. Activities range from a visitors' program for the national and global higher education community to learn from and take courses at USM, to an annual engineering education conference at UC Engineering that will bring together and advance the regional engineering education research community.

2. INFUSES TECHNOLOGY-DRIVEN ENTREPRENEURSHIP AND INNOVATION WITHIN AND BEYOND THE ENGINEERING CURRICULUM

Stage 1.2: Fundamental to the Clover 2030 transformation is the drive to establish a culture of entrepreneurship and innovation (E&I) at the heart of Chilean engineering. UC Engineering and USM are developing a wide range of experiences and opportunities, both within and outside the formal curriculum, to nurture the entrepreneurial attitudes and talents of their engineering student population. Taking a hands-on project-based approach, many of these experiences challenge students to create working solutions to authentic engineering problems, drawing on both campus-based prototyping workshops and mentorship from regional entrepreneurs. They also build upon the dual strengths of the two universities in engineering design and engineering science, combining creativity and divergent thinking with a deep understanding of the engineering fundamentals. Examples include a new hands-on Introduction to Engineering course at USM, where all first-year students are tasked to build a robot capable of investigating the aftermath of a nuclear disaster, and the 'visible and invisible curriculum', which offers UC Engineering students a suite of courses, activities and experiences, both within and outside the curriculum, to progressively build their capabilities and aspirations in technology-driven entrepreneurship.

3. OFFERS STUDENTS A GLOBAL OUTLOOK WITH OPPORTUNITIES FOR NATIONAL AND INTERNATIONAL MOBILITY

Stage 1.3: The national and international partnerships established through Clover 2030 will offer students a global view of engineering with unprecedented opportunity for mobility across and beyond Chile. These opportunities include:

- new scholar exchange programs, allowing USM and UC Engineering students the opportunity to study at world-class partner universities from across the world, such as MIT, Texas A&M, TU Munich, the University of Melbourne and the University of Edinburgh;
- an extension to the Undergraduate Research Opportunities Program (UROP) at UC Engineering, to offer students the opportunity to conduct research in universities across the world;
- an increasing number of courses taught in English at both USM and UC Engineering.

4. ATTRACTS AND RETAINS THE BEST TALENT, REGARDLESS OF GENDER, CULTURE AND SOCIO-ECONOMIC BACKGROUND

Stage 1.4: UC Engineering and USM have each taken pioneering approaches to tackling inequalities in access to higher education in Chile. Clover 2030 aims to build on these achievements to provide further support, encouragement and opportunities for young people across the country to access engineering higher education, regardless of gender, culture and socio-economic background. Activities are focused in three key areas:

1. strengthening STEM engagement amongst Chilean schoolchildren. The consortium is working with schools and regional Chilean communities to establish a suite of interventions to encourage children to consider following a career in engineering. Examples include an annual robotics competition at UC Engineering and a schools outreach program at USM involving over 3000 high-school students.
2. offering a dedicated admissions route for underrepresented groups. Through the *Talent and Inclusion* and *TACE* programs at UC Engineering and USM respectively, the Clover 2030 consortium are reshaping their admission systems to allow them to identify talent and potential amongst prospective students, regardless of socio-economic background.
3. supporting and retaining student talent. The Clover 2030 consortium is establishing a wide array of activities to build student engagement, nurture a student-led community of support and ensure the retention of talent, across and beyond the engineering degree pipeline. Activities at both USM and UC Engineering include dedicated mentoring and support offered to underrepresented student groups and the establishment of high-profile events to showcase and celebrate the best of female Chilean engineering talent.

EXAMPLES OF PILLAR 1 ACTIVITIES

UC Engineering Case study: Research, Innovation and Entrepreneurship course

In 2015, UC Engineering launched *Research, Innovation and Entrepreneurship* (RI&E), a hands-on entrepreneurship and innovation course for all 500 engineering students in the third year of undergraduate study. Delivered in partnership with the *Center for Entrepreneurship and Technology* at the University of California, Berkeley, the course challenges cross-disciplinary student teams to develop technology-based solutions to key problems facing Chile. The challenge posed changes each year; in 2016, the theme was 'smart cities'.

The course takes a structured and hands-on approach to guiding teams through the user-based design and entrepreneurship process. Chilean entrepreneurs play a critical role in the delivery of the course, sharing their experiences of starting a business, supporting the activities and mentoring the teams. Undergraduate teaching assistants – many of whom were previous RI&E participants – also provide support and guidance. For example, mid-way through the course, the undergraduate teaching assistants deliver two weeks of workshops focused on practical design and prototyping skills to support teams as they progress their ideas. By the end of the 12–week course, student teams will have developed an innovative technology-based solution to the design challenge and a physical prototype; these are then presented to a panel of entrepreneurs, professors and industry experts.

Amanda Céspedes was amongst the first cohort of students to participate in RI&E. A biotechnology student by training, she was initially reluctant to take part: *"all my life, I wanted to be a scientist, someone who works in the laboratory. I didn't want to do any innovation and entrepreneurship. I didn't want to do that with my life."* Her experience on the course, however, transformed her attitudes and aspirations. She pointed, in particular, to the experience of working with the entrepreneurial mentors and professors: *"the entrepreneurs told us a real story, it was so motivating. There is no one better to teach about that than a real entrepreneur."* Amanda described her experience on RI&E as challenging, with students asked to confront and address their attitudes to failure and rejection as part of the entrepreneurial process. She also explained that the course put the user at the center of solutions: "*we had to do ten interviews every week, with anyone – experts, users – that really helped us to develop a product for a real problem."*

After the close of the course, Amanda's team decided to further progress and commercialize their innovation, a device to measure cholesterol levels using saliva. As she explains, *"since the class, we have been working for almost eight months on the prototype. It's really hard, but we are so motivated with this idea, we haven't had vacation since the project started! I can't believe we are only 20 years old and we are able to do this. Now I have a different focus for my life. I not only want to create knowledge, but also create products to help people."*

Consortium Case study: Gender diversity and inclusion

The Clover 2030 program is established on the principle that students should be selected on the basis of talent and potential, independent of socio-economic background, culture or gender. A number of activities have been developed at both USM and UC Engineering to support this ground-breaking goal and to ensure that engineering talent from underrepresented groups is engaged, supported, retained and celebrated. One example is the consortium's focus on inspiring and supporting women in engineering, before, during and after their undergraduate degree:

- ***Before studies:*** activities include new outreach programs with Chilean high schools, organized by both UC Engineering and USM, providing mentorship and inspiration to girls and providing teachers with practical advice and support for the development of new in-school engineering experiences;
- ***During studies:*** activities include a new student-led society of women engineers at USM, whose participation has grown rapidly since its establishment last year, and a boot camp at UC Engineering for female engineering students to develop leadership and self-awareness;
- ***After studies:*** activities include an annual event to showcase and celebrate outstanding women engineers at UC Engineering (attended by engineering professionals, students and high school students) and a weekly radio show with a national audience of two million, to showcase, support and celebrate Chilean women in engineering and entrepreneurship.

USM Case study: *Multidisciplinary thesis*

Launched in 2015, *Multidisciplinary Thesis* tasks inter-disciplinary teams of final-year USM students to tackle challenges facing Chilean industry. Lasting eight months, this hands-on, immersive experience constitutes more than two-thirds of the participants' final-year credits. Marcos Zúñiga, the academic lead on the initiative, described the aims underpinning the course: firstly, to *"form students not just to have technical skills, but to be leaders and innovators, able to solve problems in teams and…create a new technology industry in Chile"*; secondly, to *"create systematic links between the university and society and industry… so that society can perceive universities as a potential source of solutions to their problems."*

The course begins with industry partners identifying and describing key problems affecting their business; on the basis of each student's interest and expertise, one multi-disciplinary team is assigned to each challenge. The industry partner provides ongoing mentorship to the team, complemented by academic supervision by USM. The students' development is also guided by modules running across the two semesters, focusing on topics such as *Innovation, Design Thinking, Leadership and Entrepreneurship*. At the end of the course, teams provide a proof-of-concept and working prototype to their industry sponsor. One of the 30 companies that has collaborated with *Multidisciplinary Thesis* is Microsoft. Hans Nemarich, Principal Technical Evangelist at Microsoft, explained some of the company's motivations for the partnership: *"it's the opportunity to find a fresh and outsider perspective into an 'improvement area' and at the same time, to be able to demonstrate the usage of our technology pushing the boundaries of what's possible in a real life scenario."*

The roll-out of the *Multidisciplinary Thesis* to USM's Santiago campus later in 2017 will increase student participation, from 46 in 2016 to an estimated 120 in 2017. The development team also has plans to establish broader collaborations with other Chilean universities, establishing *Multidisciplinary Thesis* as a national model to nurture innovation-ready graduates and broker enduring partnerships between higher education and industry.

PILLAR 2.

WORLD-CLASS **APPLIED RESEARCH** THAT WILL TRANSFORM LIVES

The Clover 2030 consortium aims to establish a program of world-class applied research with the potential for sustained societal and economic impact both nationally and globally.

To achieve this aim, we will:

1. **build cross-disciplinary research capacity** in areas of critical national and global importance;
2. advance the development of our research capacity through **deep-rooted collaborations** with some of the world's leading engineering schools;
3. nurture and support a **new generation of innovative and ambitious research leaders**;
4. promote a **supportive and inclusive faculty culture** that recognizes, supports and rewards innovation and excellence in applied research.

1. BUILD CROSS-DISCIPLINARY RESEARCH CAPACITY IN AREAS OF CRITICAL NATIONAL AND GLOBAL IMPORTANCE

Stage 2.1: Both USM and UC Engineering are establishing new high-impact, cross-disciplinary research centers, focused on critical areas of national and global concern. Collaborative and interdisciplinary by nature, these new research centers will build upon the two universities' growing strengths in applied research and drive state-of-the-art technology innovation that cuts across the traditional engineering disciplinary boundaries.

At UC Engineering, four inter-disciplinary centers are under development, each focused on a theme of critical national and global relevance: *Health, Sustainability, Information* and *Engineering in Science*. To advance this inter-disciplinary research capacity, UC Engineering will establish new faculty positions that are shared between departments and create new doctoral and post-doctoral posts attached to these centers. Dedicated managers will also be appointed at each center, to build research capacity in the field and foster collaboration across and beyond UC Engineering.

At USM, two inter-disciplinary centers are under development – CCTVAL, which is designing equipment for the *Large Hadron Collider* in Switzerland as well as for the mineral processing industry, and AC3E, which brings together researchers from seven universities across Chile. The centers will focus on the development of new products and services in five research areas of particular relevance to national and global industry: electronics; clean energy; robotics and automation; industry processes; and the internet of things. USM's cross-disciplinary research capacity will be strengthened by a new center for testing mineral processes and equipment and the DAL Bio Center, a new on-campus biotechnology applied research facility.

2. ADVANCE THE DEVELOPMENT OF OUR RESEARCH CAPACITY THROUGH DEEP-ROOTED COLLABORATIONS WITH SOME OF THE WORLD'S LEADING ENGINEERING SCHOOLS

Stage 2.2: UC Engineering and USM will advance their applied research capacity and impact through 'standing on the shoulders of giants,' fostering substantive partnerships with academic leaders from across the world. In turn, the Clover 2030 consortium will offer its global partners a gateway to the emerging economies of Latin America, and research expertise that is rooted in the unique 'natural laboratory' of the Chilean environment, in fields such as energy, natural resources, sustainability and natural disasters.

A number of activities will advance and support these partnerships. For example, UC Engineering has established the *Seed Fund Program*, to cultivate global research collaborations to tackle challenges specific to the Chilean environment, and has developed a range of double and dual doctoral programs with institutions such as King's College London and the University of Edinburgh. Examples from USM include dual masters and PhD programs with global partners such as TU Berlin, Aalborg University and the University of Nottingham, and a range of international collaborations such as a clinical research project in partnership with Harvard Medical School to improve the prevention, diagnosis and treatment of Vocal Hyperfunction, a condition related to laryngeal muscle tension.

3. NURTURE AND SUPPORT A NEW GENERATION OF INNOVATIVE AND AMBITIOUS RESEARCH LEADERS

Stage 2.3: The Clover 2030 consortium will nurture a new generation of research leaders equipped to tackle the complex interdisciplinary challenges facing Chile and drive forward the country's applied research base in science and technology. To achieve this ambitious goal, both USM and UC Engineering will significantly increase the size of their graduate student populations, targeting the best talent and encouraging a research focus on the critical challenges facing Chilean industry, government and society.

A number of different strategies will be employed to build the capabilities and aspirations of this group of future leaders, as well as ensure that their research interests align with the most pressing needs facing industry and society. For example, UC Engineering will establish a program of one-to-one mentoring for its early career academics. Mentorship will be offered both with experienced senior faculty members, to support their navigation through the academic world, and with members of the entrepreneurial community, to develop an awareness of the opportunities available to support and progress entrepreneurial ideas. In a second example, in 2017, **USM** will roll-out a new PhD program in *Applied Engineering* that focuses on key business-critical challenges identified by Chilean industry partners. The doctoral students will be co-supervised and guided by industry. USM has also developed a new Masters program in *Innovation and Technological Entrepreneurship*, designed to train the next generation of inventive and entrepreneurial leaders and facilitate innovation as applied to both the start-up and corporate domains.

4. PROMOTE A SUPPORTIVE AND INCLUSIVE FACULTY CULTURE THAT RECOGNIZES, SUPPORTS AND REWARDS INNOVATION AND EXCELLENCE IN APPLIED RESEARCH

Stage 2.4: Establishing a faculty culture of interdisciplinary collaborative research innovation is critical to achieving the Clover 2030 vision. To advance this culture change, both UC Engineering and USM will enable a fundamental reform to their faculty promotion systems, such that contributions to innovation, applied research and technology commercialization are explicitly recognized and rewarded. One of the major challenges to improving university recognition for such 'third mission' activities is the lack of accepted metrics by which to evaluate faculty contributions in this domain. Both institutions have therefore engaged in activities to help faculty demonstrate their achievements in applied research, innovation and entrepreneurship. For example, USM has ensured that the intellectual property contributions of researchers and faculty are explicitly documented within MOUs with commercial partners, such that this evidence can be used to support their career advancement at the university. UC Engineering is developing additional packages to ensure that the best faculty talent is retained, including sabbatical entitlements, funding for international travel and consultancy opportunities. New adjunct faculty positions are also being created to provide UC Engineering with additional specialist expertise in both the teaching and research domains.

EXAMPLES OF PILLAR 2 ACTIVITIES

Consortium Case study: Integrated Tsunami Prediction and Alert System

Chile is an acutely seismic country that is spread along a 4300 km coastline; tsunamis therefore pose a major threat both to the safety of Chile's population and to the national economy. In 2010, an earthquake occurred off the Maule cost, in central Chile, that triggered the country's worst tsunami in 50 years. In the wake of this devastating event, the Hydrographic and Oceanographic Service (SHOA) – the Chilean Navy division responsible for the country's tsunami warning and response protocols – convened an expert committee to explore how the country might improve its response to such natural disasters. The committee included a group of research experts from both USM and UC Engineering and the two universities quickly reached agreement on the key national priority for change: to develop a state-of-the-art tsunami warning system that provides a rapid and reliable prediction of its hazard level and geographical focus.

By 2012, SHOA, USM and UC Engineering had launched a major program of joint research to deliver this new system. Early work focused on evaluating the progress and impact of previous tsunami events in Chile as well as benchmarking best practice approaches from the *Japanese Meteorological Agency*, within the framework of a cooperative research project between Chile and Japan. The team then set to work to develop a new technology-enabled platform for predicting the course and impact of tsunamis in Chile. The research project brought together expertise in information technology and informatics at USM with expertise in hydraulics and environmental science at UC Engineering. The system developed was underpinned by a database of thousands of simulations of different tsunami event scenarios along the Chilean coastline. When compared to its predecessor, which largely relied on human judgement for national tsunami prediction, this new system offered two critical benefits. Firstly, an accurate and rapid assessment could be made of the hazard level of the tsunami, offering more time to evacuate affected populations and prepare response teams. Secondly, the model was able to predict tsunami hazard by geographical region, allowing warnings to be focused on areas of acute risk and avoiding unnecessary evacuations of unaffected regions.

Following extensive testing by the USM/UC Engineering research team and SHOA, the *Integrated Tsunami Prediction and Alert System* (SIPAT) became operational in May 2016. Even in the short time since its installation, the impact of the SIPAT system on the Chilean population and economy has been profound. As Patricio Catalan, the research team lead from USM, explained, its effects are most simply demonstrated by comparing the national responses to the tsunamis affecting the country immediately before and immediately after the installation of the SIPAT system: *"in the 2015 Illapel Earthquake and Tsunami, nearly one million people were [evacuated] and factories had to be shut down all along the coast of Chile, from Arica in the northern part to Punta Arenas in the southern part. In contrast, during the last event of Christmas day in 2016, only fifteen thousand people were [evacuated] following an earthquake in the southern part of the country, near Melinka. Residents in areas in northern Chile and far south did not get an evacuation notice and were able to continue with their daily activities. By that sole measure, the project has had a significant impact."*

USM Case study: PhD in Applied Engineering

USM has recently launched the *PhD in Applied Engineering*, a new world-class doctoral program focused on solving the key challenges faced by Chilean industry. The design and focus of this program was guided by both a benchmarking study of high-performing university-based technology innovation ecosystems from across the world, and market research with prospective graduate students and Chilean businesses. The strength of the university/industry partnership was identified as a crucial factor in the success of similar initiatives worldwide. Feedback from Chilean industry echoed this finding: they consistently called for a doctoral program that was co-designed and co-delivered by industry, with shared responsibility for selection, training and mentoring of the students.

The industry/university partnership is therefore placed at the heart of the *PhD in Applied Engineering*. Industry partners include ENAP, the copper mining industry, the Air Force and the Ministry of Transport and Telecommunications. Overall, two key features distinguish it from a traditional doctoral program:

1. the thesis topic is provided by the Chilean industry partner and the research outputs are multi-disciplinary and applied in their nature:
2. each doctoral student benefits from three supervisors, one from USM, one from the industry partner and one from a top-ranked European university;

The first cohort of four students commenced doctoral study on the program in March 2017, in topics ranging from the environmental impact of biofuels to the opportunities for improving energy efficiency in highways.

UC Engineering Case study: *Seed Fund* program

Launched in 2015, the *Seed Fund* program aims to scale up the impact of applied research at UC Engineering through strategic partnerships with world-class universities. The *Seed Fund* supports collaborative research by UC Engineering and global university partners, such as MIT, the University of Edinburgh and Texas A&M, with each one-year project within the program jointly developed, funded and delivered by UC Engineering and the external university partner. Student engagement is a key feature of the *Seed Fund* program, which is designed as a stepping stone towards deeper strategic research collaborations with global leaders in the field. It also provides a platform from which UC Engineering is able to access state-of-the-art infrastructure and technology, explore global networks, build its international research reputation and access international sources of research funding.

Each project is led by two faculty members, one from UC Engineering and one from the partner university. In addition to the joint research, the fund supports exchange visits by both the faculty leads and the undergraduate and postgraduate students engaged in the study. Quality outputs are expected from the collaborating team, including joint high-impact publications and a collaborative proposal for broader external funding.

Three rounds of seed funding, in consecutive years from 2014–2017, will be distributed as part of the Clover 2030 program, with around 25 new *Seed Fund* projects supported each year. The majority of the funds will support collaborative research projects with one of UC Engineering's five strategic partner institutions – Columbia University, UT Austin, Texas A&M, the University of Notre Dame and the University of Edinburgh. An additional 'open' category of seed funding is also available, for research collaborations with top-ranked research universities that have been fostered independently by UC Engineering faculty. In 2016, *'Open' Seed Funds* were awarded to support research collaborations with a range of leading global universities, including ETH Zurich, Stanford University, Monterrey Tech and Aalto University.

Dr Karim Pichara was one of the 60 UC Engineering faculty who applied for the *Seed Fund* program in 2016. He secured an *'Open' Seed Funds* award for collaborative research with Harvard University in the field of astronomy and data science. As Dr Pichara explained, his research responds to the rapid growth in Chile's astronomical infrastructure and the opportunities this offers to the country's knowledge base and economy: *"we have new telescopes coming in Chile that will be producing 30 terabytes of data a night... What we can do with this data is amazing – identify asteroids that could impact the earth, detect new objects in the sky – but we need to prepare for the new data sets that are coming."* Dr Pichara's research collaboration with Harvard University is focused on developing a platform to process, analyze and catalogue the data produced by Chile's new telescopes, as well as developing tools to visualize the results.

The *Seed Fund* program has been instrumental in supporting and driving forward this research, providing Dr Pichara with access to leading experts in the field as well as high-performance computer systems and state-of-the-art software at Harvard University. The fund has also enabled Dr Pichara and four members of his research team to undertake research visits to Harvard. Dr Pichara noted that this experience has had a transformative impact on the postdoc and masters students in his team: *"it has had a huge impact on their motivations, on their commitments for the research and for the results. They have been able to contribute so much more. They have made new networks... and when they return to Chile they can still use the Harvard cluster to continue their data analysis."*

PILLAR 3.

A VIBRANT **ENTREPRENEURIAL ECOSYSTEM** THAT WILL FOSTER PIONEERING CO-INNOVATION AND PARTNERSHIP ACROSS CHILE

Clover 2030 will drive culture, capacity and opportunities in technology-driven entrepreneurship within and beyond USM and UC Engineering, laying the foundations for a vibrant, globally-connected and ambitious innovation ecosystem across Chile.

To achieve this, we will:

1. provide support and development opportunities to **build entrepreneurial culture and capacity** amongst USM and UC Engineering students, faculty and the wider regional community;
2. provide professional training, support and development **opportunities to Chile's industrial and public sectors**;
3. ensure the maximum **societal and economic benefit** is derived from the school's applied research output.

1. PROVIDE SUPPORT AND DEVELOPMENT OPPORTUNITIES TO BUILD ENTREPRENEURIAL CAPACITY AMONGST UC ENGINEERING STUDENTS, FACULTY AND THE WIDER REGIONAL COMMUNITY

Stage 3.1: Clover 2030 will coordinate and establish a range of open-access interventions to build both entrepreneurial capacity and commercialization opportunities across the UC Engineering/USM consortium and Chile's science and technology community. These interventions will build upon a growing entrepreneurial infrastructure at the two universities and will include:

- at **UC Engineering**: an incubation fund for early stage venture creation, a business accelerator to advance prototype ideas, and programs to support intellectual property protection and technology transfer. Many of these activities will be hosted within the university's *Innovation Center*, alongside co-working space and specialist prototyping workshops that can be accessed by innovators, researchers and businesses from across Chile.
- at **USM**: a new office to advance business creation and co-innovation with industry, activities to nurture entrepreneurship capacity amongst students, academics and the wider public, and a program to facilitate the 'soft-landing' of USM technology-based startups in countries such as Spain, Taiwan, Brazil, Colombia and Canada. Many of these activities are coordinated through USM's business incubator, 3IE.

2. PROVIDE PROFESSIONAL TRAINING, SUPPORT AND DEVELOPMENT OPPORTUNITIES TO CHILE'S INDUSTRIAL AND PUBLIC SECTORS

Stage 3.2: Professional educational and development programs will be coordinated and delivered from the *Department of Consulting and Technology Transfer* at USM and from the dedicated *School of Executive Education* at UC Engineering. In addition to providing cutting-edge training and development, the professional education programs will also be used to support and grow the Clover 2030 consortium's cross-sector community in science and technology innovation. Acknowledging the diversity of training needs, the units will offer a range of different mechanisms by which industry and public sector professionals can engage with the two universities. For example, *Unit for Continuing Professional Development* at USM offers a range of industry-oriented courses, open to both students and the external community, including a Masters in Energy Economics, postgraduate courses in Informatics that focus on the development of leadership and problem-solving skills and a new MBA program that focuses on business, entrepreneurship and management. The UC Engineering School of Executive Education will offer a professional masters' program (to develop in-depth research expertise within a specialist domain), diploma courses (focusing on broader domain knowledge within specific topics such as energy or health) and in-company programs (tailored to the specific needs of each business). Considerable flexibility will also be offered in the program delivery, and UC Engineering is developing a suite of online courses and modules to support professionals based outside Santiago. This online capacity also offers the potential to deliver professional education beyond Chile, across Latin America as a whole.

3. ENSURE THE MAXIMUM SOCIETAL AND ECONOMIC BENEFIT IS DERIVED FROM THE SCHOOL'S APPLIED RESEARCH OUTPUT

Stage 3.3: USM and UC Engineering have each established a new *Office of Industrial Liaison* to manage and progress both industry-sponsored contract research and technology commercialization on their respective campuses. The offices will provide a single point of contact for each institution's industrial and commercial partners. Through creating and strengthening their external networks throughout and beyond Chile, each *Office of Industrial Liaison* will seek to broker and manage new avenues for contract research that are driven by the urgent challenges facing industry, government and the third sector. The offices will also work closely with the engineering-specialist technology transfer functions already operating at both USM and UC Engineering to ensure that the commercial potential of applied research emerging from the universities is realized.

EXAMPLES OF PILLAR 3 ACTIVITIES

USM Case study: FENIX House

The FENIX House initiative was established in 2012 as a final-year undergraduate project for USM Architecture and Engineering students to enter into the Solar Decathlon, a global competition for student teams to design and construct solar-powered houses. A key priority for the USM students was to design a house that responded to the particular needs and challenges of the Chilean environment. Knowing that urban fires were a major threat facing residents of Valparaiso, the city of USM's main campus, the students decided to develop a design for low-cost emergency housing aimed at victims of fires.

In April 2014, on the eve of the team's departure to France to showcase their prototype house at the Solar Decathlon, Valparaiso experienced the worst urban fire in living memory, leaving ten thousand people without homes and three thousand houses destroyed. As Nina Hormazábal, the faculty director of FENIX House project, explained, this devastating event was to place the significance of the FENIX House project into sharp relief and led the group to develop a new and more personal goal: *"to create a new home for at least one of the victims of this fire."*

Design on the second-generation FENIX House began almost immediately. A small group of USM faculty from architecture and engineering joined the design team, bringing with them expertise in specialist fields such as energy-efficient technology and post-occupation evaluation. Working in collaboration with families affected by the Valparaiso fire, the team developed a technology-enabled home that offered anti-seismic protection through its distinctive wooden structure while keeping its production costs in line with the government subsidy for social housing. The house is modular in its design. The basic 14m2 unit – termed the *Survival Module* – is supplied in kit form and is designed for rapid construction by non-specialists in the immediate aftermath of a disaster. Once a permanent site for the house is established, the *Survival Module* can be reassembled alongside a *Mechanical Module*, bringing the solar technology for water and power systems, and any number of 14m2 *Living Modules*, depending on the available space and budget.

In October 2015, a family who had lost their home in the 2014 fire moved into a two-story, technology-enabled 92m2 FENIX House in the Las Cañas Hill of Valparaiso. After this critical milestone was achieved, the team set their sights further: on commercializing the approach and offering FENIX Houses to a much wider group of families within and beyond Chile. Already, the team has submitted five patent applications emerging from the FENIX design, in fields as diverse as emergency protocols and functional design. The team are now working with the Chilean Emergency Office to commercialize the house design, and have engaged a local building firm to develop a low-cost production-ready model. The team have also developed an interactive prototype of the FENIX House on the USM campus, designed to build community awareness of domestic energy consumption. As Nina Hormazábal noted, the on-campus prototype is also being used to *"show the housing authority and local people that, in a seismic country, wooden housing is a great solution to offer safe and low cost housing."*

Consortium Case study: *Brain Chile*

Establish in 2015, *Brain Chile* is a program to accelerate technology-driven innovations emerging from Chilean research. It is designed to fill the funding and support gap for emerging startups between developing a proof-of-concept or prototype and securing seed-funding investment. *Brain Chile* was originally designed to support innovations emerging from UC Engineering, but with considerable interest from across Chilean higher education and sponsorship from Santander, the initiative quickly established a national remit. By its second iteration, in 2016, 135 projects representing 325 applicants from across the country, applied to participate in the program. Eighty percent of participants were affiliated to a Chilean university – as an undergraduate, postgraduate or faculty member – with the remaining 20 percent coming from Chilean business or the entrepreneurial sector. As Constance Fleet, the organizer of *Brain Chile* explained, activities focus on building the team's entrepreneurial capabilities and advancing the quality of their prototype: *"most of the applicants are researchers, who are motivated by research but not entrepreneurship. We give them the skills and a lot of support to build a business model. Help them to improve their prototype to bring their idea closer to seed funding or the market."*

Brain Chile is structured in two key phases. Thirty teams participate in the initial stage, a week-long boot camp providing specialist guidance and workshops on a range of topics including intellectual property protection, prototyping techniques and developing an entrepreneurial mindset. Ten teams are then selected to participate in the second stage: the acceleration process, involving specialist workshops and funding to advance their prototype. Throughout this stage, teams are provided with two specialist mentors: one from the industry representing the 'market' for their product, and one that reflects the major perceived weaknesses in their business case. At the close of the program, the ten shortlisted teams also compete in the *Brain Chile* final, where they pitch their business concept to a jury of investors, entrepreneurs and industry experts.

Francisco Palma, a Chemical Engineering PhD student from UC Engineering, participated in the 2015 iteration of *Brain Chile*. Drawing on his research in biopolymers, Francisco had developed a coating of natural and organic compounds to extend the shelf life of fruit. Since his participation in *Brain Chile*, Francisco's company – Shel-Life – has grown steadily. It now employs seven staff and has received investment support from the Chilean Government and a number of entrepreneurship competitions from across the world. He noted the important role played by *Brain Chile* in propelling this business forward: *"here in Chile, there is a very big gap between having your idea and your low-quality prototype and being able to set up a business. [Brain Chile] had a very big impact, helping me bridge that gap to bring the idea to the next level."* The national media coverage generated by the initiative also raised the profile of Francisco's company, connecting him with three key Chilean fruit exporter companies; they have since been working with Shel-Life to validate the technology prior to its commercialization.

Daniel Zuñiga participated in the 2016 *Brain Chile* when he was in his third year of study for a Mechanical Engineering degree at USM. The idea that Daniel brought to the competition was inspired by his father, a physiotherapist, who had recognized the enormous potential for rigorously-collected data that linked the use of different therapeutic approaches to the speed and progress of the patient's recovery from different injuries. Such data would not only help to guide physiotherapists towards treatments with the highest probability of success, but would also provide patients with more accurate information on likely recovery times. The challenge, however, was how to capture and classify data relating to the different manual therapy treatments delivered, accounting for differences in technique between physiotherapists. In response, Daniel developed the concept of a technology-enabled glove with integrated pressure and motion sensors that would be worn by the physiotherapist to capture this data in real time during treatment sessions. Daniel and other members of the startup team entered *Brain Chile* to develop the prototype and business plan for this new concept. In the months since his participation, the fledgling company – Khapto – has successfully secured external investment and is now producing the first products to go to market.

UC Engineering Case study: *Bridge* program

The Bridge Program offers high-potential UC Engineering students the opportunity to spend four weeks operating within one of the world's two leading entrepreneurial ecosystems: Boston and Silicon Valley. The experience is explicitly designed to be student-led and student-directed. The onus is placed upon the participants to seek their own opportunities: to enter Silicon Valley or Boston as a confident and ambitious young entrepreneur who can broker new relationships that will endure beyond the four-week experience and lead to new opportunities on their return to Chile. As Pedro Bouchon, Director of Research, Entrepreneurship and Postgraduate Study at UC Engineering, explained, *"by being independent, the student is able to understand on their own some of the critical clues about how Silicon Valley works, how open it is to develop a venture and how to be taken seriously."*

This student-directed approach does not mean, however, that the four-week program is not carefully supported and managed. The experience is scaffolded by mentorship, training, placements in existing startups and professional development, both before and throughout their four-week stay. For example, Bridge participants visiting Silicon Valley are able to access activities and courses at the *Sutardja Center for Entrepreneurship & Technology* at the University of California, Berkeley and are able to use the *Campus PUC*, established in the heart of the University of California, Berkeley campus, as a base during their stay from which to connect with other Chilean businesses, entrepreneurs and researchers operating within this thriving entrepreneurial ecosystem.

Camila Amengual was one of the 13 UC Engineering students selected to participate in the 2016/17 *Bridge Program*. She travelled to Boston in early 2017 with one other member from her startup team that is working on new techniques to detect and prevent sleep apnea episodes. Speaking from Boston, she described the profound impact that the Bridge experience has already had on her, both professionally and personally. For example, she noted the transformative improvements to her team's startup concept in the few short weeks she has been in Boston: *"I came to realize that what we were doing could be done so much better (thanks to Boston and what I've been able to have access to here) and more efficiently that we could've imagined."* The experience has also seeded in Camila the desire to translate the mutually-supportive entrepreneurial culture that he has experienced in Boston back to Chile: *"while in Boston, we've gone from meet ups to Venture Cafés, to meetings with doctors, people at MIT who are willing to help, etc…. Something that has surprised me is that, unlike in Chile, Boston has a well-developed cooperative culture where you can ask for help, engage in a sharing relationship, and no one is going to look at you as if you're taking advantage of them… People will gift you 15 minutes of their time just to see if they can help. That, for me, is priceless – and personally, something I want to bring back to Chile."*

PILLAR 4.

A **GLOBALLY-CONNECTED ENVIRONMENT AND ORGANIZATION** THAT WILL ADVANCE WORLD-CLASS INNOVATION AND ENABLE TALENT TO FLOURISH

World-class engineering institutions must be supported by world-class infrastructure, organization and management. To achieve the Clover 2030 vision with respect to education, applied research and innovation, UC Engineering and USM must each establish a globally-connected environment and organization that advances world-class innovation and enables talent to flourish.

To achieve this, we will:

1. **establish state-of-the-art infrastructure** that supports collaborative, interdisciplinary learning, innovation and discovery in both the research and education domains;
2. **maximize the benefits of the consortium's global university partnerships** through taking a professional and coordinated approach to their management;
3. create an organizational structure that **facilitates cross-disciplinary collaboration and discovery**;
4. **establish robust and adaptable systems** for monitoring the institution's performance that can be benchmarked against peer institutions from across the world;
5. establish a robust plan for the school's **financial stability and growth**.

1. ESTABLISH STATE-OF-THE-ART INFRASTRUCTURE THAT SUPPORTS COLLABORATIVE, INTERDISCIPLINARY LEARNING, INNOVATION AND DISCOVERY IN BOTH THE RESEARCH AND EDUCATION DOMAINS

Stage 4.1: Through Clover 2030, USM and UC Engineering will undertake a program of major investment in their physical infrastructure, establishing new buildings, laboratories, 'maker spaces' and classrooms. These new spaces are designed to facilitate and advance an environment of cross-disciplinary collaboration, hands-on discovery, global connectivity and cutting-edge research innovation. At USM, the new infrastructure includes the establishment of the *IF Valparaiso 3IE* collaborative entrepreneurial space, as well as major modifications to on-campus learning spaces to allow them to support large-scale hands-on student projects and active learning. At UC Engineering, the new infrastructure will include the *Arnaldo Hax Interdisciplinary Building*, dedicated to collaborative interdisciplinary research and innovation, and the *Science & Technology Building*, supporting hands-on engineering learning and discovery.

2. MAXIMIZE THE BENEFITS OF THE SCHOOL'S GLOBAL UNIVERSITY PARTNERSHIPS THROUGH TAKING A PROFESSIONAL AND COORDINATED APPROACH TO THEIR MANAGEMENT

Stage 4.2: A major component of Clover 2030 is to advance the progress, impact and profile of both UC Engineering and USM through strategic national and global partnerships. These partnerships will infuse all aspects of the transformation, across the universities' education, research and innovation domains, and will include:

- academic partnership agreements with global universities to advance international research collaborations, student exchange programs and joint doctoral programs;
- opportunities for staff and students to gain hands-on experience working in the world's leading entrepreneurial ecosystems;
- community outreach activities that promote engineering, entrepreneurship and innovation across the country.

Both UC Engineering and USM are creating new internal structures to support these activities. UC Engineering is establishing a *Division of International Liaison* to broker, coordinate and manage its external relationships, offering partners and potential partners a single point of access to the school. USM is creating a new structure, managed by the university Academic Vice Rector, to build its graduate programs and their international connectivity.

3. CREATE AN ORGANIZATIONAL STRUCTURE THAT FACILITATES CROSS-DICIPLINARY COLLABORATION AND DISCOVERY

Stage 4.3: Focused primarily on UC Engineering, this program of work supports a transition away from a school structure that was divided by mono-disciplinary 'siloes' towards a more collaborative, cross-disciplinary environment for learning and innovation. Three new schools will be established, for undergraduate education, graduate education and executive education respectively. The new **Undergraduate School** will immerse students in a broad multi-disciplinary learning environment, from which they can select specialist majors in later years according to their interests and talents. The **Graduate School** will develop a centralized structure for the provision of graduate training and will establish new world-class PhD programs in targeted areas of excellence at UC Engineering, such as Civil Engineering, Biological Engineering and Seismology. Many of these new PhD programs will be delivered with international university partners, such as King's College London. The **Executive Education School** will bring the training and development of industry professionals into the heart of UC Engineering, ensuring that they are taught by researchers and innovators at the cutting-edge of engineering science and technology.

4. ESTABLISH ROBUST AND ADAPTABLE SYSTEMS FOR MONITORING THE INSTITUTION'S PERFORMANCE THAT CAN BE BENCHMARKED AGAINST PEER INSTITUTIONS FROM ACROSS THE WORLD

Stage 4.4: Both UC Engineering and USM are establishing new monitoring systems to collect and track real-time data relating to the operation, performance and impact of their operations.

At **UC Engineering**, a new *Academic Intelligence System* (AIS) will be established to collect data ranging from teaching evaluation scores to the licensing revenue from research commercialization, and from the entrepreneurial intentions of undergraduates to the numbers of international faculty. The AIS will provide robust, real-time data that will support performance-monitoring and facilitate rapid and transparent decision-making. It will also allow the school to horizon scan and benchmark its performance and progress against leading engineering schools and universities across the world.

At **USM**, a new office will be developed to collect and benchmark the university's performance in key national and international higher education ranking systems, such as the QS World University Rankings, allowing the institution to identify and direct opportunities for improvement. A second system is also under development to streamline the collection and interpretation of the university's financial and academic data.

5. ESTABLISH A ROBUST PLAN FOR THE SCHOOL'S FINANCIAL STABILITY AND GROWTH

Stage 4.5: UC Engineering and USM have each established new fundraising strategies to support their future financial stability and growth. Unlike the US, Chile does not have an established culture of philanthropic donations or of alumni donating back to their alma mater. The fundraising strategies launched by UC Engineering and USM will therefore be both ambitious and strategic. They will focus on both the traditional channels for university fundraising – alumni networks, industry partners, etc. – and seek out new sources of incomes, such as through executive education programs offered to industry. UC Engineering will also be establishing a new endowment fund.

EXAMPLES OF PILLAR 4 ACTIVITIES

Consortium Case study: Interdisciplinary spaces

The ambitious plans of the Clover 2030 consortium in the education, research and entrepreneurship domains will be supported and advanced by the development of cutting-edge multi-disciplinary spaces at both USM and UC Engineering. Three examples of such new spaces are given below.


IF Valparaiso 3IE

The ***IF Valparaiso 3IE*** (USM) is a new collaborative space, opened in 2016, that brings together entrepreneurs, companies and university researchers – from inside and beyond USM – to foster technology-driven co-innovation. It is designed to develop Valparaiso as a globally connected hub for innovation through nurturing collaboration and synergies across the regional entrepreneurial ecosystem. It blends four major components:

- a co-working space that brings together regional entrepreneurs;
- office spaces, which are available to any innovation-based organization;
- meeting and events space that, in 2016 alone, hosted more than 70 events, with over 4000 visitors from the entrepreneurial, business and higher education communities;
- prototyping spaces, including 3D printing capabilities, electronic laboratories and a video production unit.


Arnoldo Hax Interdisciplinary Building

The ***Science and Technology Building*** (UC Engineering), which will be completed in March 2017, is dedicated to undergraduate learning and discovery. Supported by state-of-the-art laboratories, maker spaces, classrooms, computer labs and open-working spaces, the building is designed to create a world-class, hands-on learning environment that encourages collaboration, creativity and excellence amongst undergraduate engineers and scientists. The architecture of the building is designed to reflect the students' personal and professional development as they progress through their undergraduate study. The lower floors of the building are dedicated to the early years of study and support students' learning in the fundamental engineering sciences. Within the middle floors of the building, a greater focus on applied science is visible, supporting learning in areas such as electronics and fluid mechanics. The highest floors of the building are dedicated to students' final years of undergraduate study, and are designed to support advanced levels of engineering application, in areas such as molecular gastronomy, astrophysics and robotics.


Science and Technology Building

The ***Arnoldo Hax Interdisciplinary Building*** (UC Engineering), is a 12-story structure dedicated to world-class interdisciplinary research collaboration and discovery. Due to be completed in 2019, the building is designed to bring together UC Engineering researchers with innovators and scientists from across campus to undertake state-of-the-art research that is at the interface between disciplines. For example, the building will be home to the Institute of Biological and Medical Engineering, a new organization established through Clover 2030 by the Faculties of Engineering, Medicine and Biological Sciences. With eight international faculty already in post, this new institute will be launching new cutting-edge programs of interdisciplinary research and establishing a new PhD program in BioMedicine taught exclusively in English. In addition to cross-disciplinary research groups, the center will also host the school's professional education programs and host visitors from international partner universities, industry and the regional entrepreneurial community.

USM Case study: PMI InES project

InES – or *Science Based Innovation* – is an institutional improvement program that seeks to radically increase the quality and scale of technology innovation emerging from USM. This step-change in innovation capacity will be enabled through a three-year coordinated program of reform to the university's strategies, policies and structures. Outlined below are examples of the initiatives underway, structured within the three broad areas of focus of the InES reform program.

Strengthening USM's strategic alliances with industry: activities include a new innovation portal, designed to build USM's market-driven innovation portfolio and create a platform for co-innovation with industry. This portal will allow USM to showcase its portfolio of technologies, ideas and expertise to potential collaborators outside the university and, in turn, will allow industry partners to highlight business critical challenges that could be addressed through USM research.

Supporting commercialization of USM technologies: activities include a project to identify and remedy gaps and blockages in USM's innovation process, designed to ensure that USM faculty and students with high-potential ideas are provided with continual support on each step of their journey towards commercialization.

Nurturing an innovation culture across USM: activities include an internal competition, launched in 2016, to validate and advance early-stage innovation concepts. In its first year of operation, USM financed eight project ideas – ranging from a device to monitor the mercury content of soil to the development of new materials to host parasites used in medical applications.

UC Engineering Case study: Establishment of the Office of International Liaison

International partnerships lie at the heart of Clover 2030 and will inform and nurture every element of the School's transformation. These global relationships will be nurtured, coordinated and managed by the Office of International Liaison. The Office will drive forward a wide range of external engagement activities that connect and support the four pillars of Clover 2030. The activities range from supporting the School's global university partnerships to hosting international students and visitors on campus.

One of the School's major university partnerships is with the School of Engineering at the University of Notre Dame. The potential for an institutional relationship between the two universities was first recognized in 2008. However, it has been under Clover 2030 and the establishment of the Office of International Liaison that the partnership has really flourished. It now brings together a wide range of elements, including dual PhD programs in Civil Engineering, an undergraduate research exchange program, joint research projects and faculty sabbaticals. Indeed, over the past two years alone, the two universities have established 17 joint research projects through the *Seed Fund* program, each of which facilitates the regular exchange of faculty, PhD students and undergraduates between the two institutions. Future plans will further broaden and deepen the partnership and the benefits it brings to both institutions. For example, the University of Notre Dame plans to support two floors of the *Arnaldo Hax Interdisciplinary Building* currently under construction at PUC. This space will establish a permanent presence for the University of Notre Dame on the PUC campus – at the heart of its new research and innovation hub – offering collaborative research centers, student laboratories and offices for faculty on sabbatical/exchange.

Describing the partnership with PUC as *"our deepest relationship with a foreign university,"* Peter Kilpatrick, the Dean of Engineering at Notre Dame, noted the importance of both trust and friendship in enabling *"the roots of the relationship to grow deeper and deeper each year"*. He explained that *"for inter-institutional collaboration to be this strong, you need strong support at the top and strong support at the grass-roots level and there needs to be strong communication between the two"*. Peter Kilpatrick also attributes some of the partnership's success to the shared faith-based values of the two institutions: *"there is something about the Catholic mission that is near and dear to our hearts… They don't just base their education on intellectual foundations, they focus on teaching the whole student. We care a lot about this. [PUC] feel the same way, they get it."*

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