Alta Scuola Politecnica (ASP) is a school for exceptionally talented young students (selected within the top 5% of their BSc classes) who wish to develop their interdisciplinary capabilities for leading and promoting innovation in a multi-disciplinary environment. Founded by the Politecnico di Milano and the Politecnico di Torino in 2004, ASP may only be attended by students enrolling in one of the Masters of Science - MSc (Laurea Magistrale) - programs in Engineering, Architecture or Design at the two Universities.

Each year, ASP selects 150 promising students and gives them the opportunity to participate in an additional advanced programme where ASP students may complement the knowledge achieved in their specific disciplinary MSc courses with a multifaceted and enriched understanding of innovation processes and contexts. ASP is characterised by a multidisciplinary and multicultural community of students and faculty, as well as by projects developed in strict cooperation with business enterprises and governmental institutions.

This book discusses the results of the multidisciplinary projects developed during the fourth ASP cycle. It illustrates the projects developed by teams of students coming from very different disciplinary backgrounds, in collaboration with professors and external institutions. It is a snapshot which illustrates the variety and creativity of ASP contributions, while at the same time attempting to offer an inside view of the work and life of this unique community. The presentation of project results is preceded by a short presentation of the ASP Program by the ASP Board.

For further information on ASP:
Web   www.asp-polito.it
E-mail info@asp-polito.it
Preface

This book marks the fourth cycle of students that have completed their course of studies in the Alta Scuola Politecnica. Created in 2005, the Alta Scuola Politecnica programme draws on the experience of the Politecnico di Milano and the Politecnico di Torino, two universities with different histories, conditions and methods, but that share the desire to offer their students a highly-innovative course of studies.

From the outset, this ambitious project aimed to create an axis of learning between Turin and Milan. Today, as we witness the growing economic and social bonds between these two cities – both of which are key to the Italian economy – we are increasingly confident that we made the right decision five years ago, a decision that during this time has come to fruition and has evolved and improved.

We believe that, particularly in light of the current global economic crisis, universities should do more than simply issue degrees but should also prepare their students to meet the demands of labour markets with respect to new know-how and professions. In this sense, the Alta Scuola Politecnica provides an added value with respect to the traditional academic approach. ASP students are given the opportunity to continuously gain insight from one another as well as from courses offered by both universities and from projects proposed by companies, thereby developing the managerial skills and the comprehensive training that employers are increasingly seeking even from graduates in technical disciplines. The chance to work in teams, as well as the know-how gained from managing projects (as illustrated in this book) and the internship opportunities, substantially enrich the learning experience. We strengthen polytechnical training through a multi-disciplinary approach and method, yet we do not lose sight that our primary goal is to provide students with specific and technical skills in addition to knowledge. It is not by chance that 90% of ASP graduates find employment within one month of earning their degree.

This is therefore an important achievement that confirms that the path we chose to follow in 2005 is the best one for the future and one that encourages us to continue pursuing this project with the same enthusiasm shown by our ASP students.

Prof. Giulio Ballio, Rector, Politecnico di Milano
Prof. Francesco Profumo, Rector, Politecnico di Torino
ASP is partially financially supported by external institutions which share our vision of educating talented students and promoting interdisciplinary innovation. Following a three-year initial financial support from the Italian Ministry of University Education and Research, the main supporters of ASP are currently Compagnia di San Paolo and Fondazione Cariplo. Other institutions, both private and public, have joined in by providing financial support as well as a relation aimed at developing projects and opportunities for the career development of our students. The logo of each of our sponsors for the year 2010 is presented below and their valuable support is hereby gratefully acknowledged.

Along with an ever diversely assorted graduate education offer with 13,000 new degrees or diplomas granted every year, an excellent post graduate training system makes Piedmont and the province of Torino a centre of attraction for young talents. Moreover, thanks to the presence of more than 200 research centers, today Piemonte ranks 12.5% of Italy’s investments in R&D and it is the second Italian region for private R&D investment. The region invests 1.8% of its GDP in innovation, and the private sector investment in R&D constitutes almost 80% of the total R&D expenditure. Partnership with public and private institutions, network between territories, support to innovation and research are main objectives for the Torino Chamber of Commerce which promotes the economic development and the local businesses growth.

The Chamber offers a wide range of services to nearly 238,000 companies working in the province and listed in the Public Register of Enterprises: training, technological innovation, collection and distribution of information, fostering of business relations at home and abroad, creation of services and financing of projects designed to assist new businesses, promotion and organization of events, access to financing, information and consultancy for companies involved in foreign trade. A particular attention is dedicated to the different levels of education, from professional courses to post-university Masters, with a special focus on high education systems and international training, which represent a significant tool for the attractiveness and worldwide relations, together with the solidity of the industrial fabric, the pro-business mood of the public administration, the quality of life in a creative, cultural and artistic context.

This is the reason why the Torino Chamber of commerce, three years ago, decided to cooperate with the ASP, the advanced international Faculty, founded by Politecnico di Torino and Politecnico di Milano, to enhance links between the two cities. Italian Chambers of commerce work to build local area networks between research centers and enterprises, individual enterprises, institutions, territories and cities, as well as technological networks. Torino, Milan and Genoa Chambers of Commerce support the development of North-western macroeconomic region by means of projects. Figures are significant: north-western Italy (Piemonte, Lombardia, Liguria) is one of the European biggest areas, with a population of almost 15 million people and more than 1.270.000 enterprises. It is an integrated territory that can proudly compete with the other European polycentric regions. The North-western region needs economical and infrastructural actions, as the new railway connection between Torino and Milan, but also stronger cultural relations, focusing in particular on art, with a special attention to the contemporary art, education and organization of international events, as Torino Celebrations of 150 years’ unity of Italy and Milano Expo 2015. Torino Chamber of Commerce: working with businesses to build the future.

www.to.camcom.it
The Compagnia di San Paolo, founded in 1563 as a charitable brotherhood, is today one of the largest private-law foundations in Europe.

It pursues aims of public interest and social use, in order to foster the civil, cultural and economic development of the community in which it operates. The Compagnia is active in the sectors of scientific, economic and juridical research, education, art, preservation and valorization of cultural heritage and activities and of environmental assets, health, assistance to the socially deprived categories.

In 2009 the Compagnia awarded 682 grants in its areas of activity, amounting to 121.4 million euros. Notably, 118 grants were awarded in the Research sector, amounting to 30 million euros, and 45 grants were awarded in the Education sector, amounting to 13.8 million euros. The Compagnia pays particular attention to advanced research and to the development of scientific and technological centres of excellence, seen both as catalysts and multipliers of research and higher education initiatives. It supports the reinforcement of Torino's university system, especially through the promotion of excellence at Politecnico di Torino and the University.

The commitment of the Compagnia in the field of Education is focused on university and post-graduate education, starting from the growth of human capital, internationalisation and the provision of infrastructures, with special attention to the conditions that assure equal access. In this context, the ASP’s focus on excellence and innovation – besides characterising it as a valuable initiative per se – gives this programme the capacity to enhance the global attractiveness of the Universities involved and foster, within the leaders of the future, a specific attention to the interdisciplinary and international dimension of nowadays society. The programme also represents an interesting synergy among educational institutions located in the north-western region of Italy.

The Compagnia has supported ASP since 2007: the grants are aimed at funding scholarships for the ASP course beginning in the year, requiring a special attention to students not based in Piedmont, or with an immigrant origin.

Cariplo Foundation, established in 1991 as a nonprofit organization with the purpose of furthering the common interest and the public good in various fields, is today – thanks to the sheer size of its assets (over 7 billions euro) – one of the world’s leading philanthropic entities annually funding grants to organizations for the fulfillment of selected projects and initiatives. The Foundation’s assets, which are the fruit of the labour of generations of men and women, though considerable, are not sufficient to solve the many problems afflicting the civil society in Lombardy, Italy and the entire world. Therefore, Fondazione Cariplo efforts focus on the improvement of the living conditions in the local community. To Fondazione Cariplo this means improving the living standards of individuals as well as their social, cultural and economic environment. Fondazione Cariplo nurtures those conditions which enable individuals to achieve their potential, express their personality, freely pursue their inclination and fulfill themselves. Fondazione Cariplo gives priority to financing specific projects rather than providing general aid to organizations. This is, in fact, the only way to precisely assess whether a program is innovative and responds to the needs of the community.

The Cariplo Foundation pays particular attention to the support and promotion of human capital development, particularly by focusing on a limited number of projects whose purpose is to start activities capable of achieving excellence in university and post-university studies. Furthermore the Foundation is also firmly convinced that actions supporting “excellence human capital” must entail a close connection between training and teaching activities, on one hand, and research and exposure to an advanced international scene, on the other. These are the reasons underlying Cariplo Foundation decision to support the ASP, an advanced international Faculty able to attract the best young foreign students and capable of Italian high profile graduates education.

www.cariplo.it

fondazione.cariplo.it
The European Patent Academy is proud to be one of the main sponsors of the Alta Scuola Politecnica Summer School - Management of Innovation. An understanding of the role that Intellectual Property plays in today's economy – and the vital importance to any enterprise in fostering innovation and seeking to protect it – is needed by every university student. By encouraging IP teaching beyond law faculties in scientific, engineering and business faculties, the European Patent Academy also aims to facilitate the transfer of technology and innovation from universities to industry and contribute to a better understanding of the European patent system. The interdisciplinary nature of IP is reflected both by the programme of this Summer School and its participants. The diversity of topics, ranging from law and economics to business and management, offers a broad perspective with participants gaining a first-hand insight from highly qualified lecturers, all with their own area of expertise. The Summer School will provide the participants with a first class experience, invaluable for their future careers.

The European Patent Academy is responsible for all external training activities of the European Patent Office and is constantly working to encourage and support Intellectual Property training at universities across Europe.

Accenture is a global management consulting, technology services and outsourcing company. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. With more than 181,000 people serving clients in over 120 countries, the company generated net revenues of US$ 21.58 billion for fiscal year ended Aug. 31, 2009. In Italy all Accenture's group companies employ 9,200 people (Milan, Rome, Turin and Verona) and generated net revenues of 1.01 billion in the fiscal year ended Aug. 31, 2009. Accenture stands out for the ability to combine the skills and experience of its professionals in various industries - Communications & High Tech, Financial Services, Public Service, Products, Resources - with functional capabilities in Managing Consulting, Information Technology and Outsourcing. We have extensive relationships with the world's leading companies and governments and work with organizations of all sizes - including 96 of the Fortune Global 500 and more than three quarters of the Fortune Global 1000. In Italy, Accenture works for 15 of the first 20 financial national groups, for the first 4 insurances companies and for 11 of the first 15 industrial groups. Accenture supports ASP because believes in high potentials: “Talents make the difference”. The greatest challenge is to build up a mosaic of different skills in order to face market request of specialization.

The Boston Consulting Group is a global management consulting firm and the world’s leading advisor on business strategy. Founded in 1963, BCG has 69 offices in 40 countries. We partner with clients in all sectors and regions to identify their highest-value opportunities, address their most critical challenges, and transform their businesses. Our customized approach combines deep insight into the dynamics of companies and markets with close collaboration at all levels of the client organization. This ensures that our clients achieve sustainable competitive advantage, build more capable organizations, and secure lasting results. In our client work, we aspire to make a difference, and we succeed because we are different. We help our clients change the rules of the game, not just play better. The BCG difference lies in the power of individuals: challenged by mentors, supported in teams, motivated by results. We look for outstanding talents and people who have the curiosity and drive to find innovative solutions. Our consultants work with clients to define the problem and determine the best approach. BCG offers to all its employees to grow further challenging their mind, partnering with leaders, making a difference and ultimately charting a career that fits them.

Our goal is therefore to help ASP students better understand the challenges and opportunities of a consulting career. We are highly committed to develop initiatives to meet, interact and support ASP students in their growth. BCG: Grow Further! Shaping Your Future. Together.

Three billion times a day, P&G brands touch the lives of people around the world. And P&G people work to make sure those brands live up to their promise to make everyday life just a little bit better, now and for generations to come. Innovation is P&G’s lifeblood. Innovation is at the heart of P&G’s business model. It is the primary way we delight consumers, create value with our retail partners, and create new business models to deliver consistent, sustainable growth. By connecting what consumers want with what technology can deliver, we have been creating brands inspired by the needs and aspirations of consumers around the world for over 170 years. The diversity of P&G’s brand portfolio gives us the opportunity to innovate in more aspects of consumers’ lives than nearly any other company. We use our diverse mix of sciences and technologies to make innovation connections. P&G’s global scale allows us to quickly flow innovation across countries. We invest more than $2 billion a year in R&D, competing at the top of our field. In Western Europe, we employ almost 3,000 scientists who have deep expertise in many different technologies. We multiply the power of our internal innovation capability by connecting it to a vast external network of scientists from some of the best institutes and companies around the world: an approach we call “Connect and Develop”. Today, more than half of all P&G innovation includes an external partner.

It is in this context that we have chosen to be an investor ASP. We strongly believe the multi-disciplinary training and the international exposure will prepare the ASP talents to innovate the way we innovate.

www.epo.org
www.accenture.com
www.pge.com
www.bcg.com
Training to innovation in the “Alta Scuola Politecnica”


The contemporary world is increasingly characterized by highly complex problems, which can not be faced through disciplinary approaches: the most significant innovations typically stem from the cross-fertilization of disciplines and are supported by collaborative processes among experts from different fields. Starting from this perspective, ASP’s main challenge is exploring the field of multidisciplinary innovation, innovation certainly requires the strong expertise and solid foundations that ASP students can only obtain by taking advantage of their MSc studies; but often crucial innovation comes from the combination of different deep competences. The focus of ASP programs is the design process, a process by which complex problems are addressed and treated in order to find solutions. But what do we mean by complex problems?

In many cases, the technology to use is not very clear or it is partially unknown. Examples include designing, and multi-disciplinary expertise. The ASP program offers a series of six full-immersion, one week courses (dedicated to: innovation management and its impact upon society and environment; decision making, modeling; creativity) as well as multidisciplinary projects carried on within groups, led by professors of the two universities and with external commitment from the private and public sector (10-15 projects per cycle). This program is hereby presented in terms of its didactic principles and objectives, its organization and management, its early results and future challenges.

1. “Alta Scuola Politecnica”: history, mission, organization

The “Alta Scuola Politecnica” (ASP) is a school of excellence rooted within the two major Italian Universities of Engineering, Architecture, and Design, named the Politecnico di Milano (PolMi) and Politecnico di Torino (PolTo). The ASP program was jointly proposed by the Rectors of the two institutions to the Italian Ministry of Education in 2004, and was one of the three schools of excellence which were selected and launched upon society and environment; decision making, modeling; creativity as well as multidisciplinary projects carried on within groups, led by professors of the two universities and with external commitment from the private and public sector (10-15 projects per cycle). This program is hereby presented in terms of its didactic principles and objectives, its organization and management, its early results and future challenges.

In other cases, the technology is clear but the design goals are not agreed upon. This happens, for example, when the introduction of new technological products brings about social, technological or environmental controversies; a world-famous example is the Mose system for water level control in the Venice lagoon. In such cases, designers should alternate between problem setting activity and problem solving activity for a long time before finding a solution which is “good enough”, by taking into account its deployment within the surrounding environment.

Complex design is therefore an activity which deals with complex and dynamic environments, and requires considerable cognitive capacities, talent for interpersonal relations, capacity to manage organizational and communicative processes, awareness of the interests and the interactions that take place within the specific contexts, and flexibility in adapting to the cognitive processes upon which the design process is based.

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selected among BSc population of the two Politecnici, about 40% of students are selected from different schools, and specifically 25% are foreign students from about 20 different countries; more than 1/3 of them are women. All ASP activities take place in the first four cycles of MSc students, whereas the 5th and 6th cycles are currently enrolled, and the procedures for selecting the students of the 7th cycle have started. ASP is managed by an Executive Board (EB) or by project professors (the co-authors of the present paper), 4 from each university, who broadly represent the various disciplines which are present in PoliMi and PoliTo.

The mission of ASP is to provide society with high-profile graduates combining in-depth (vertical) disciplinary knowledge from their MSc programs with interdisciplinary (horizonates from ASP have founded the ASP Alumni Association as a significant contribution towards the development of a future class of innovation-aware top-quality professionals in Italy.

2. Focus and challenges in the ASP cultural project

ASP’s main focus and challenge is the field of multidisciplinary innovation. The vast majority of graduate education today focuses on specific disciplinary fields. Innovation certainly requires the strong expertise and solid foundations that ASP students can only obtain by taking advantage of their MSc studies, but it is commonly noticed that crucial innovation comes from the combination of differing and in-depth competencies. Every academic tutor, research professor, or external consultant is aware of the fact that the chances of creating innovation strongly depend on the capability of fostering cooperation between different experts. The most significant innovations come from the openness to new perspectives, from the availability to change standpoints, and the ability to combine a plurality of expertises. As a result, the ASP cultural project, first of all, aims to complement the MSc education (120 credits) with 30 additional credits, equally divided between courses and projects, so as to expose its students to a multidisciplinary method for managing complex problems by fostering the capacity of ASP students to address multidisciplinary problems and tackle them in an innovative way. While the MSc studies give them extensive, deep, high-quality skills in focusing on a specific discipline, ASP allows the best students of our universities to broaden their competence by developing their ability to manage complexity and promote innovation. Complex problems are difficult to address but are at the same time the best opportunity for innovation and change. But what do we mean by complex problems? What are the most adequate capacity and skills to address these problems?

The focus of ASP cultural project is the design process, a process by which problems are addressed and treated in order to find a technical solution; this emphasis on the design process is probably the most qualifying aspect in the mission of the two universities. The term “process” designates a tension field, where the designer usually needs to move back and forth from problems to solutions many times. Designers begin by understanding the problem, which often includes gathering and analyzing “requirements” from customers or users. Once they have specified the problem and have analyzed its requirements, they are ready to formulate a solution, and eventually implement that solution. Many standard design problems, albeit in many cases technically very difficult, are well understood and well covered; they typically fall within one technical discipline. These technical problems have a solution that can be identified by using standard and well-tested methodologies and a linear approach. For example, the logic followed in this process can be represented as a chess game. In the chess game the problem is clearly given: how to checkmate the king of the opponent in the smallest number of moves and before your opponent checkmates your own king. All the actors share the same goal: winning the game. Even technical requirements (the rules of the game) are clear and both the opponents have to follow them. In standard design problems, the best designer is the one who finds out the solution first. Clearly framed problems are mostly addressed by students in their MSc studies, where learning specific technical abilities allow them not only to find good technical solutions to problems, but also to program and optimize the solving process. This strong competence is the solid background that is essential in order to approach technical problems, and it is the main asset upon which students build up their careers, once they enter into the labour market. But what do we mean by complex problems? What are the most adequate capacity and skills to address these problems?
conflict situations. In such cases, designers should fluctuate alternate problem setting activity and problem solving activity for a long time before finding the "right solution", or a solution which is "good enough" by taking into account its deployment within the surrounding environment.

Complex design is therefore an activity which copes with complex and dynamic environments, and requires considerable cognitive capacities (aptitude for learning), talent in interpersonal relations (human and social interaction), the capacity to manage organizational and communicative processes, awareness of the interests and the interactions that take place within the specific contexts, and flexibility in adapting to the cognitive processes upon which the design process is based. The ASP courses seek to sustain and to enhance these fundamental skills, all of which are increasingly crucial in the development of innovation.

The issue of interdisciplinary studies in technical domains is of innovation. Skills, project and innovation management capabilities, skills and demands stemming from the external environment in a state of profound change, characterized by the progressive internationalization of innovation, production, and distribution processes. Designers are increasingly involved in projects with ever-widening ranges, and need to be aware of the socio-technical and environmental context in which innovation occurs and develops. The first ASP course is focused on the contribution of social sciences to the understanding of innovation processes. Designers are increasingly involved in projects that is "good enough" by taking into account its deployment within the surrounding environment. The latter is focused upon the management of decision-making processes, conflict resolution, and the ability to involve external actors in essential strategic decisions. Besides good innovative and design abilities, therefore, lies the capacity to recognize and to appreciate all the various actors and decisions involved in the design process as a whole. The third track is focused upon paradigmatic methods to manage complex problems. Complex problems require not only the ability to represent them appropriately (in a manner that is not excessively simplistic), but also specific tools to solve them. The most difficult challenge in ASP is providing an intuition about the vast diversity of the methods that can be used for approaching complex problems. Two main paths which were historically developed within our universities in order to respond to these highly challenging situations: on the one hand, a top-down approach, typical of engineering, based on the technical development of logic models allowing the representation and management of specific problems, and on the other hand, a bottom-up approach to the development of design skills, typical of architecture and design, based on creativity and the promotion of new visions. The two final ASP courses, focused on these two different and complementary approaches, seek to provide participants with the skills not only to understand and appreciate these approaches, but also to grasp and then possibly re-utilize the underlying cognitive frameworks.

The table below indicates the six courses that were offered during the academic year 2008-09, ordered according to the module-ularization which was described above. The main academic tutors of the 6 courses are professors from PoliMi and Polite, with one exception (Prof. Bucchi from University of Trento).

**ASP Projects**

Multidisciplinary projects are the educational context where students have the possibility to apply transversal (horizontal) skills – learned through ASP courses – to complex problems stemming from real-life contexts. Multidisciplinary projects are the most original and challenging ASP endeavour, as their structure and organization is significantly different from the classical projects offered during master studies; they offer students stimuli to concrete experimentation of how to deal with complexity in real realistic settings – and students respond to such stimuli in a very diversified way, in some cases generating extremely good results (measured through results such as patents and publications, or the appreciation of project’s stakeholders), and generally going through a very productive learning experience. Multidisciplinary projects are proposed either by professors of the two universities (in response to a public call issued by...
the EB or by sponsor companies (i.e., companies paying to ASP fees for given services; one of them is the possibility to propose a project), they are selected by the EB by highly ranking complex multidisciplinary design problems, which can give to ASP students an ideal project setting. Projects cover the entire lifecycle of students in ASP, from “day one” (at the opening of ASP courses), when students express their preferences on the project they like to join, until the “final exam”, where project results are discussed and evaluated. In building what’s become of ASP courses), when students express their preferences on the

■ Problems

Selecting the “right” problems and the “right” teams.

During a project presentation day). Students are matched to short presentation (all projects are described to all students of the student on the project, as perceived after attending a within the project description, and the individual interest to address the requirements of a number of stakeholders, ity to address the belief that project results, though not immediately applicable, can be starting points for further investigation within each organization.

■ Selecting a team of academic tutors with multidisciplinary competencies. The success of a project is clearly associated with the tutors’ capability to provide students with diversified intellectual stimuli and multidisciplinary guidance. We have set as a requirement that academic tutors, similarly to students, should represent a variety of disciplines, and should belong to both institutions. This procedure has generated cooperation between the students to the tutors). The final objective of delivering solutions (e.g., prototypes of lamps, drug diffusion schemes based on innovative chemical substances, nanotechnology-inspired designs of gloves and home textiles, designs of intermodal exchange stations in given locations, and so on). Adoption of project guidelines provides the project teams with a methodology that is useful in avoiding the risk of “skimming the surface”, without going beyond a preliminary analysis. A team’s work is monitored at various phases (an “initial interview”, semester-based project reports, a mid-term project presentation allow the EI to rapidly de- tect cases where the work-plan deviates from expectations and team work appears to be misfocused, possibly leading to a clarifying discussion with the tutors). The final objective of delivering, documenting, and motivating a design solution teaches to students that designing is the underlying com- petency that – despite of the obvious differences in domain knowledge – is common to all professionals in the fields of engineering, architecture, and design.

least at the stage of a conceptual design and feasibility study. Many teams then go much beyond such a minimal stage, and deploy working solutions (e.g., prototypes of lamps, drug diffusion schemes based on innovative chemical substances, nanotechnology-inspired designs of gloves and home textiles, designs of intermodal exchange stations in given locations, and so on). Adoption of project guidelines provides the project teams with a methodology that is useful in avoiding the risk of “skimming the surface”, without going beyond a preliminary analysis. A team’s work is monitored at various phases (an “initial interview”, semester-based project reports, a mid-term project presentation allow the EI to rapidly de- tect cases where the work-plan deviates from expectations and team work appears to be misfocused, possibly leading to a clarifying discussion with the tutors). The final objective of delivering, documenting, and motivating a design solution teaches to students that designing is the underlying com- petency that – despite of the obvious differences in domain knowledge – is common to all professionals in the fields of engineering, architecture, and design.

■ Having an outer organization acting as a “client” of each project. The role of external organizations is not only providing guidance and access to data and information, but most of all anchoring students to deal with real-life issues and to decision-making problems that are undertaken in reality. In most cases external organizations perform this task very well and are driven by the belief that project results, though not immediately applicable, can be starting points for further investigation within each organization.

■ Defining a coherent work-plan for approaching projects. Work follows a given structure, starting from a study of the current state of the art, then moving to an in-depth analysis of the requirements existing in a complex situation (“problem setting”), and finally designing a solution (“problem solving”), at

■ Having two-three teams working on each project. After an initial period of research and analysis, gen- erally performed together, each team must define and pursue a different direction in tackling the problem. This requirement narrows the scope of each team’s ef- fort, thus limiting the risk of performing a very broad (but possibly inconclusive) work. At the same time, teams have the perception that the direc- tion they take is not the only way to face the problem, but simply one of the possible alternatives; in some cases, comparison between the works of different teams deepens students’ overall understanding of the problem.

■ Asking students to manage projects “professionally”, including financial resources. Teams are asked to deliver a series of interim reports and perform a mid-term review presenta- tion. Deadlines and milestones provide participants with a structured and disciplined approach that helps in delivering results, especially since the problems at hand are very “open ended”. Moreover, each student has a budget for covering ex- penses related to the project (e.g. for buying books, for tech- nical visits or for attending conferences, for buying materials to be used for building prototypes, etc.). Though the amount of money is small (and sometimes remains under-spent), stu- dents must take management decisions; they understand that a lack of resources (within reasonable limits) can not be used as an excuse for not completing the work assigned to them. Besides this, students gain a hands-on understanding of the role of financial resources in performing project work.

In the five ASP cycles so far, a total of 56 projects have been launched; we are therefore in the position of attempting an ini-
Multidisciplinarity and Innovation: ASP Projects 4

5. Preliminary indicators of ASP performance

A preliminary indicator of the performance of the ASP students during their first cycle in completing their studies and of their current employment was performed in 2008. A similar study is being conducted now for the 2nd cycle. As a first indication of success in their studies, 88% of the students completed the MSc with 110/110 or more (59% cum laude). The questionnaire was submitted online during the spring in 2008; 64 replies were collected, i.e., 50% of the total 1st cycle ASP graduates. All of the percentages below refer to the subset of students who replied, unless otherwise noted. Most of the students (73%) found a job in less than one month after graduation, nobody needed more than 2 months, and 17% of them had already started to work before graduation. Half of them work for a private firm, while 28% entered a PhD program, in a professional studio and 3% work for a Public Administration; 22% of them are now working or studying in a foreign country. Among ASP students who have chosen private companies and professional studios, 33% work in the field of business services, 13% are in the automotive field, while the others are in 10 different fields (including biomedical, finance, and ICT). Among the PhD students, 22% have been admitted to universities abroad. In the companies, ASP graduates are employed mainly in R&D (19%), design (19%) and IT (13%), which are typical activities for graduates from the Politecnico di Milano and the Politecnico di Torino, but only some of them (34%) are also employed in non-traditional "typical roles", such as human resources, administration, finances, and retail. The present survey highlights the capacity of the ASP graduates to find good and stable jobs, mainly in R&D or design sectors. The close contact of ASP with enterprises helps ASP students to relate to them, and the first reports on how ASP students are appreciated by companies and universities seem to be equally positive.

6. Conclusions: the challenges ahead of us

In conclusion, the ASP cultural project faces challenges in several areas: Can students who simultaneously attend different disciplinary programs find the time to work together in ASP? Can ASP work be being scattered in two regions? Will ASP provide interdisciplinary skills through courses and at the same time put students at work on multidisciplinary problems without losing focus? Six years after the beginning of ASP operations, we believe that these questions are positively answered, especially by looking at the enthusiasm of the ASP Alumni association which was created to maintain the ASP community and its values beyond the end of ASP studies. More information about ASP and their Alumni Association is available on the Web site (www.asp-poli.it).

The initial funding, covering the start-up period (2005-2008), was provided by the "Ministero dell’Università e della Ricerca" and has made this project possible through a significant investment. Such initial funding has now been largely used, and ASP needs renewed support. We are therefore interacting with public and private institutions – primarily the Bank Foundations of Milan and Turin (Cariplo and Sanpaolo), which recently awarded ASP substantial funding for the forthcoming three years – as well as the two Chambers of Commerce, and the so-called ASP "Sponsors", i.e. private and public companies supporting ASP through a program which was set up together with the co-operation of the career services of both universities. ASP would simply not exist without the precious financial contribution of all these institutions, and our major challenge ahead is to generate continuous and sufficient support for ASP in future years.

References
SUSTAINABLE PLANNING OF HOSPITALS IN URBAN AREA
The project of the new Health City that will bring together three of the most important Health and Research Institutes of the city of Milan

Project Description

The challenge Regional Council of Lombardia approved the hypothesis of an "agreement plan" in order to realize a new health centre near Milan. It will be named the "Health City" and will be built in the area of Sacco Hospital as well as the neurological institute Besta and the national tumour institute. New compound will arise in an area of about 250,000 square metres and will have a capacity of 1,405 sleeping accommodation. The agreement plan already defines sleeping accommodation separations between the three original hospitals and the surface area percentage dedicated to research & treatment and accessories functions.

"Health city" is new function where pathology treatment is combined with scientific research, keeping singular institute peculiarity and improving research and didactics role.

The team In order to have excellent result, the architectural project must answer to many requirements structured in different levels. The focus was on welfare activities and, where relevant, the indications defined by "Metaprogetto Piano – Vero-ness" (12/12/2000); these were integrated and applied into the generally analyzed scenario. According to this point of view, the activities of ASP students involved in "Sustainable planning of hospitals in urban area" included the creation of a Masterplan of "Health City" project area. Subsequently students have to integrate new structures with Sacco Hospital, so they decide where localize new structure and they have to study green area placement, road networks and traffic flows.

In parallel to these activities students have to study advanced themes related with transport flow and internal layout. The last one was analyzed from a functional and organizational point of view.

The results Starting with different backgrounds, ASP students develop a consistent project from an architectural and organizational point of view.

The "Health City" area will be subject to big development during the next few years. In the northern area of Milan, where the project is located, human resource recruitment of 25,000 people is forecasted. From an accessibility point of view, it is a good area because it's highly connected with northern part of Lombardia and it’s nearby Malpensa.

According to the Lombardia President, "Health City" will be finished in 2015. It will offer services for a huge part of the population and it’s already possible to think about an expansion of its area. The decision for the place was made in light of a potential future expansion.
MULTIDISCIPLINARITY AND INNOVATION

ASPI PROJECTS

Alberto Barbesta worked in analyzing modularity benefits and a case study of private public partnership in Italian health sector. He studied the benefits and disadvantages of each solution applied to hospital service model.

Gloria Forini analyzed the urban environment of Milan and the project area. She studied the integration of health care buildings with research and teaching as well as environmental, social and economical aspects. According to the “Piano-Veronesi Model,” she created a functional layout.

Chiara Giverso, a biomedical engineer with mathematical modeling skills, developed a Matlab script to manage the position of different units inside the hospital. She then focused on the possible development of research studies and treatment of different units inside the hospital.

Stefano Predebon worked in analyzing which solutions for sustainability were embedded in modern hospitals by means of a case study method and developed an analysis about the queuing system in the hospital service model.

Viola Hyvonen and Nyree Grifeo, a biomedical engineer with mathematical modeling skills, blended with a passion for architectural design, who developed a Matlab script to manage the position of different units inside the hospital. She then focused on the possible development of research studies and treatment of different units inside the hospital.

The concept for this new centre is based on the final goal for increasing customer satisfaction. The principal users of this new centre will be patients and doctors, but it will also involve researchers and students. This is due to the fact that it will be one of the most important research centres of Italy and it will include a building with educational activities.

In this last case, we also developed a concept of hospital layout.

For this reason, it is essential to plan fast routes of access. In addition to that – and from an architectural point of view – it must “fit” in the existing and future landscape while trying to save as many green areas as possible.

Economical sustainability – Historically, a hospital is built to ensure a comfortable environment for patient.

The increasing costs of machinery and maintenance, for example, along with an accurate management of the hospital’s organization. Cost saving technology were developed to minimize energy consumption or even for energy co-generation. Similarly to an industrial sector, customer satisfaction is known to bring several advantages, just as in a hospital for patient satisfaction.

Social sustainability – A hospital also plays an important social role, such as in a hospital for patient satisfaction.
A significant amount of surgical operations are performed in order to visit some of the most outstanding healthcare districts. Several case studies in order to know more about new trends in hospital planning process by using sustainability as a target goal. Starting from the concrete example we have – the plan to merge the hospitals in Bovisa area, Milan – we analyzed how to improve the hospital planning process by using sustainability as a target goal.

Exploring the Opportunities
First of all, we considered the development of the hospital concept over the years, focusing on the last decades. We analyzed several case studies in order to know more about new trends in hospital planning. Members of our group traveled to the US in order to visit some of the most outstanding healthcare districts and structures of the world. What was immediately clear to us is that nowadays hospitals are mostly research oriented; as a result, a significant amount of surgical operations are performed on daily basis by allowing the patient to go back home without staying overnight. This is a key concept for three reasons. Firstly, it means there is the need to manage intense inflows and outflows of people from the hospital and who are attending day-hospital services on a daily basis. Secondly, when planning the inner structure of the building one should focus on the research area foreseeing future expansions and needs. Thirdly, since the patients in the stay-in area are the ones with severe disease, the rooms and the stay-in area in general should be planned in order to complete themselves, two hospitals must be tightly connected.

A flow analysis of the patients in order to improve the performance of the healing service for the non-medical part of the process. In the next paragraph we will describe our contribution to these themes in detail.

Generating a Solution
The solution we identified for the hospital as a sustainable building involves very different input. We started from our specific case about Bovisa district while studying the surrounding urban area and which is expanding quite rapidly due to the proximity of the EXPO 2015 site. We planned the site in order to have very good connections with the main street and public transport, that reduces depression and patients stress perception; just examples of what we intend with “hospital experience”.

A model of the new hospital rooms. Every room offers sleeping accommodations for one individual.

A detailed urban and architectural planning for the new hospital in Bovisa area, Milan.

A study about connection and mobility between the hospital and the city.

A function analysis to optimize the location of the departments inside the building.

A flow analysis of the patients in order to improve the performance of the healing service for the non-medical part of the process.

A detailed urban and architectural planning for the new hospital in Bovisa area, Milan.

A description of “Health City”: This plan represents the application of different concepts explained in previous pictures. Focus was on building orientation, project area (functional division, the flush line for true orientation and main building modularity).

A description of “Health City”.

A model of the new hospital rooms. Every room offers sleeping accommodations for one individual.

A flow analysis of the patients in order to improve the performance of the healing service for the non-medical part of the process.

The urban study of the area to the location of the rooms and the department inside the building. The shape of the hospital gave us the chance to introduce a very innovative feature: a modular building pattern. This means considering a “fixed shape block” as the unit for the building construction. This allow one to easily and flexibly add new departments or areas, as required by the development of the medical science. Inside the building we decided to optimize the flow of the medical personnel by studying the interaction among departments. We solved this optimization problem by using the software Matlab and by taking into account the legislative, functional and resource-based constraints of the departments.

A model of the new hospital rooms. Every room offers sleeping accommodations for one individual.
PROJECT 2

WAVES AS A VALUABLE ENERGY SOURCE
The aim of the Project involves the design of systems capable of converting sea wave energy into electric energy.
Abstract

The continuous growth in the global trade of goods in the last years has increased substantially traffic intensity on land and sea tracks. The demand for safety and security is increasing together with requests for peoples’ wellness and life quality. To satisfy all these requirements, a new solution seems to be the development of a new set of sea routes with high monitoring capabilities that will allow the displacement of a large part of heavy traffic from ground routes to sea routes. New set of sea routes is commonly called the “sea motorways system.”

To develop this new transportation system, it’s essential to develop the entire information-telecommunication system used for the continuous monitoring of the sea-ways system. This can be based on a network of active buoys used to outline the route as well as to acquire traffic data, transmit it to the central control system and signal the presence of obstacles under the sea surface. All these devices need a continuous power supply and a ground electrical network which is much too expensive, nor does it provide a flexible and environmentally sustainable solution. For these reasons it is necessary to develop an autonomous system capable of generating energy without expensive fixed foundations.

Our project focused on the development of a self-sustaining buoy, creating the most flexible device capable of generating energy and which can be used around the world while respecting all environmental and legislative issues.

The aim of our studies is to prove the feasibility of a stand-alone device capable of floating in the sea and auto-generating the energy it needs from waves. The stakeholders of the project are the Gaeta commune and Selex. Contacts with the latter have underlined two main purposes: the creation of a basis for a sea-high way management infrastructure (Selex) and the need for lighting systems used to signal obstacles (Gaeta).

The main requirements of the project can be summarized as follows:

- Economical requirements: low costs of installation and maintenance must be guaranteed in order to create a competitive solution;
- Technical requirements: the design must be flexible given that the device can be used at different locations, it can be exposed to different wave climates and the power request can vary between 40 to 1000 Watts depending on the functionality. The possibility to connect sensors, electronic devices and GPS system should be considered and the buoy dimensions must be limited; the materials are supposed to be resistant to the marine environment while heavy and fixed foundations should be avoided.

Tasks & Skills

Michele Anti focused on the technology used to convert the motion in electricity and kept contacts with stakeholders.

Maria Giulia De Donno worked on data collecting, feasibility, analysed marine forces and anchoring in addition to maintaining contacts with stakeholders.

Enrico Delogu studied the mechanical system and the device design.

Andrea Ferranti focused on the environmental impact and the legislation useful for the buoy installation.

Michele Rampanelli studied the mechanical system and the marine forces, and evaluated the economical impact.

Exploring the Opportunities

State of the Art: The major research activity on wave energy converters has been done in Norway, Scotland and Portugal. All current technologies are created for an ocean wave environment in this part of the world the power flow is equal to 70 kW/m and the medium wave amplitude is equal to 10 meters or more. The current technology must be changed in order to create an energy conversion system which can work within the Mediterranean wave environment.

The device proposed in this poster uses some features of wave buoys already existing in literature, in particular the permanent linear generator buoy that is a starting point the permanent linear generator buoy designed by University of Oregon.
The feasibility: The first challenge involved the analysis of data obtained from the station of wave measurements of Ponza, an island in front of the Gaeta Gulf. On the basis of the analysis, project waves-amplitudes and periods were determined and it has been concluded that a medium power flow of 4.2 KW/m can be obtained from the sea. This source can be enough for the power requirement of the buoy. The morphologic features of the seabed are ideal for our project (it is characterized by sediment and sand) and the water depth is not excessive (max 120 m). Finally, a survey with the qualified authorities has been done. Their approval gave us the possibility to conclude the feasibility study and to choose some possible installation sites.

Different solutions: Three different solutions were initially investigated: one of them used the swinging movement of a preserver over the waves by integrating a pendulum inside the buoy, the second device foresaw a spring-mass system with three generators and the last solution was the vertical movement of waves by integrating a pendulum inside the buoy (vertical movement of the buoy). The decision: A mixture of the second and the third device has been chosen as the definitive solution because of its simplicity, high efficiency and small dimensions. Some of its initial features have been changed in order to optimize the power conversion efficiency and to minimize the cost of installation and maintenance as well as the risk of floating away and the environmental impact.

The technical solution: The final design of the buoy has the form of a linear generator. It converts the vertical movement of waves to electricity. The biggest point of innovation in respect to state of art technologies is the insertion of an elastic component between the magnet and the spires. Its rigidity has been optimized in order to increase the amplitude of oscillation due to dynamic effects. A battery to store the energy has been implemented in the design in order to allow the system to also work in calm sea conditions. Standards current and voltages specifications have been guaranteed. Some innovative features have also been introduced in the anchoring technology: it consists of a rigid body linked with the seabed with three pre-stressed cables and opportune anchors (the shape of the anchors has been designed in order to support also vertical forces, indeed commercial anchors resist generally only to horizontal forces). The rigid body is submerged and it has a medium density lower than the one of water: due to this feature, the cables are always tense and the rigid body remains fixed with respect to the seabed. This body serves as a guide for the movement of the buoy and no restrictions are given to vertical motion: only some chains are used for security reason in the case of catastrophic events. This geometry has been studied in order to emphasize the movement of the buoy due to the sea waves.

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Legislative and environmental issues: Legal procedures are the same of ordinary floating devices since there is a lack of “Ad Hoc” legislation. Some influences come from different types of renewable energy generators. The device proposed has some good features from an environmental point of view: wave energy is one of the greenest technologies since CO2 emissions are relevant only in the building of the buoy and do not represent a considerable quantity with respect to the power produced during its life; the anchor technology chosen is not very invasive and can be moved very easily. The life-cost analysis shows that a lot of material and sources are saved if a self powered device is used and finally the landscape impact is very limited. Moreover the presence of these buoys can avoid disasters such ship collisions with hidden obstacles.

The social and economic impact: As seen in the abstract, the creation of a continuous monitoring and signaling sea-ways system is essential for the future development of commerce. The proposed technology is nowadays quite expensive (0.60€/KWh) but it shows great future potential and the costs will gradually decrease. However the proposed device has certain clear environmental and technological advantages that can justify the initial investment.

Conclusions: Our solution presents a lot of characteristics that can make it a success: the system is environmentally friendly, its shape is compact and regular, it is completely self-powered, it can be integrated directly in the existing buoys and connected with different electronic devices. The power production is in compliance with user requirements and the reliability of the system is really high. Moreover, the interest showed by politicians, professionals and common people during meetings we participated in confirmed that this project could be very well accepted by the public with great expectations.

Main bibliographical references

Design of the anchor
Design of the self-powered floating device
Life cycle assessment of a wave energy converter
Life cycle emissions of different energy sources
Energy flux [KW over m] of waves on European coasts
A conceptual wave energy generation park and generator schematic (the permanent linear generator buoy) designed by Oregon University

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ABSTRACT
Marine energy production is at its very early stages. At the moment no technology seems to be the winner. The aim of the project was that of designing a device for marine energy generation which transforms the power from waves (not that from tides or currents) into electric power. The device the team was requested to design was supposed to generate electric energy for the island of Pantelleria (maximum peak 10 MW at summer) in order to contribute to the energy self-sufficiency of the island which, at the moment, obtains energy from diesel engines, an expensive and polluting (but reliable and easy to handle) technology. The proposed marine technology does not mean to substitute the whole traditional power generation system since marine energy is characterized by a certain variability which traditional systems are able to handle. Until now, lots of different Oceanic systems have been proposed. The case of the Mediterranean is of course a big challenge given the much lower power density and peculiarity of the sea waves (characterized by a small amplitude and a high frequency).

The proposed device, which seems to be a good solution for generating electric energy in Mediterranean conditions, is a pendulum driving a shaft inside an 8m diameter aluminium buoy which rotates into an alternator generating electricity; the latter will then go through an onshore static frequency converter in order to respond to the parameters of the grid in terms of frequency and voltage. Each device (named PoliPante) is designed to generate a nominal power of around 270 kW for 1,850 equivalent hours. The pendulum solution is able to produce a nominal power of 16kW/m. Since waves are of modest amplitude, we focused on other exploitable characteristics, such as frequency. Data from the hydrological station of Mazara del Vallo, which operates around 16kW/m. Since waves are of modest amplitude, we focused on other exploitable characteristics, such as frequency. Data from the hydrological station of Mazara del Vallo, which operates around 16kW/m. Since waves are of modest amplitude, we focused on other exploitable characteristics, such as frequency.

EXPLORING THE OPPORTUNITIES
Like all forms of renewable sources, wave energy is unevenly distributed over the globe. The power in a wave is proportional to the square of the amplitude and to the period of the motion. While the best wave environments have an annual average power density between 20-70kW/m², the sea nearby Pantelleria offers around 16kW/m². Since waves are of modest amplitude, we focused on other exploitable characteristics, such as frequency. Data from the hydrological station of Mazara del Vallo, which operates around 16kW/m. Since waves are of modest amplitude, we focused on other exploitable characteristics, such as frequency.

The pendulum solution is able to produce a nominal power of 266 kW for an 8m diameter sphere shaped buoy, for 1,850 equivalent hours. The system belongs to the family of point absorbers. In general, these are floating structures which exploit energy coming from all directions through their movements on the wave surface.

PROJECT TEAM
PoliPante, responsible for data collection and analysis; Andrea Gulisano, involved in the mechanical analysis and followed the construction of the prototype; Emanuele De Cartis, involved in the mechanical and electrical conversion system analysis; Nicole De Togni, considered the environmental and social impact of the device, focusing on its interaction with the sea and on the process for its public acceptance; Paolo Longoni, focused on the economic aspects connected with the development of the device, exploiting its future market through a business plan of the idea; Davide Pigoli, responsible for data collection and analysis; support in the design phase; Claudio Salerno, evaluated power outputs and the conversion system.
Such a system is suitable for the integration in a power generation infrastructure or for stand-alone applications. To validate the studies we decided to build a prototype to be tested in the wave channel of the Politecnico di Torino (Dep. of Hydraulic Eng.), in order to verify the dynamics of the system and to study the real feasibility of the latter. Despite the environmental benefits of renewable energies, a low level of public acceptance is seriously slowing down the development of these systems. On the island, solar and wind power plants are thwarted mainly because of their encumbrance and visual impact. Since conflicts mainly arise as a result of a public lack of knowledge, we considered relations and communication with the public to be a fundamental aspect of dealing in every phase of the process in order to provide all necessary information. Participation was promoted from the very early stages, and since the environment itself will have an impact on the device, the proposed solution differs from other wave energy devices because it deals with Mediterranean waves, thereby entering an innovative segment of the market with very few internal competitors given that, at the moment, there are only demonstration prototypes to be installed in completely different sea conditions. Internal competition should instead be carefully evaluated given that there is a wide range of substitute products, such as wind, solar or hydro energy, already at an advanced stage of testing, diffusion and acceptance, even if with a reduced possibility of improvement compared with wave power.

The device will have to deal with other existing uses of the sea. Restrictions due to natural reserves, prohibition of mooring and intersections with ship routes were identified in the preliminary planning phase, conditioning the selection of the project site. Unavoidable interactions with fishing and recreational activities can be compensated, from a socio-economic point of view, by the creation of new jobs associated with the new power plant, thereby bringing economic benefits to a local community which mainly depends on tourism. Although the Italian law about wave energy is not fully clarified yet, the device will have to satisfy the environmental impact assessment as any other power plant. Some impacts could be expected, but effects on the natural habitat and on wild flora and fauna have been minimized by paying attention to both the seabed and the coast, with acceptable noise, visual impact and effects on the hydrography. Since the environment itself will have an impact on the device, we considered sea currents, corrosion, marine fouling and material intrusions or deposits during the design phase in order to avoid a reduction in the efficiency and failures. A visit to the CNR in Genova helped us with the collection of interesting data about suitable materials. The potential market in the Mediterranean area is constituted by more than 180 islands where the production of electrical energy is mostly conferred to diesel generators, with costs ranging between 0.30 and 0.44 €/kWh, up to 0.67 €/kWh depending on the accessibility of the site and the size of generators. Given that the wave energy devices will be complementary to the existing systems and, excluding any potential government incentives, the estimated cost will approximately total 0.4 €/kWh, including O&M. The proposed solution differs from other wave energy devices because it deals with Mediterranean waves, thereby entering an innovative segment of the market with very few internal competitors given that, at the moment, there are only demonstration prototypes to be installed in completely different sea conditions. External competition should instead be carefully evaluated given that there is a wide range of substitute products, such as wind, solar or hydro energy, already at an advanced stage of testing, diffusion and acceptance, even if with a reduced possibility of improvement compared with wave power. In an organizational phase, a company conceived as a spin-off of the Politecnico would outsource the production of the devices to specialized companies. R&D as well as the promotion and sale of the devices, provision of ancillary services prior to installation, monitoring, testing and post sales consultancy would be kept within the company. The evolution of requirements for the company would imply two different phases: a first phase lasting two years in which the device will be produced in its real dimension, development activities will be provided and the business structure will be initialized, and a second phase including the commercial launch and the starting of the production.
AN INTEGRATED PROGNOSTICS AND LOGISTIC SUPPORT SYSTEM FOR THE ENGINES OF AN AIRCRAFT FLEET
IPROS
An integrated prognostics and logistic support system for the engines of an aircraft fleet

The research addresses a knowledge based system capable of assessing the health of an aircraft engine, in addition to activating the logistic chain and minimizing the life cycle cost.

PROJECT DESCRIPTION
The IPROS project addresses an issue of growing importance: that of maximizing time equipment while minimizing maintenance and operating costs. The area of intelligent maintenance and prognostic-enabled condition-based maintenance of machinery is a vital one for today's complex systems in industry, aerospace vehicles, ships, automotive industry, and elsewhere. As manpower levels are reduced and equipment becomes more complex, intelligent maintenance schemes must replace the old pre-scheduled and labor intensive planned maintenance systems in order to ensure that equipment continues to function. While fault detection effectiveness with very low false-alarm rates continues to improve, prognosis requirements are more ambitious and present very significant challenges to system design teams. Prognostics has the potential to be very beneficial in terms of both reduced operational and support cost and life-cycle total ownership cost of many types of machinery and systems. The evolution of diagnostic and monitoring systems for aircraft and other complex systems has led to the recognition that predictive prognosis is both desirable and technically possible. The objective of the IPROS project was to perform a feasibility study of an engine health monitoring and support system integrating engine prognostics directly into the logistics pipeline. Although different critical engine parts were analyzed, the effort was primarily focused on the engine gearbox since valuable data for this engine component were made available by the industrial sponsor. A knowledge-based system was defined as one capable of generating and integrating multiple information in order to efficiently assess the health of an engine, activate the logistic support chain and minimize the life cycle cost. All issues of an engine prognostics and logistic support system were addressed to assess its viability in managing just-in-time logistic support chain and minimize the life cycle cost. The research defined the system, assessed its merits recognized. The IPROS project addressed an aircraft engine, but its synergistic approach to health monitoring technologies, integrated reasoning capabilities, interpretation of fault-detect outputs, reliability assessment, maintenance and product support practices can serve as a paradigm for similar initiatives in other systems: from industrial machineries to food processing plants, from railways to marine applications. The research project was presented at the first international conference of the PHM society where it was well accepted and its merits recognized. The IPROS project addressed an aircraft engine, but its synergistic approach to health monitoring technologies, integrated reasoning capabilities, interpretation of fault-detect outputs, reliability assessment, maintenance and product support practices can serve as a paradigm for similar initiatives in other systems: from industrial machineries to food processing plants, from railways to marine applications.

TEAM A
Matia Gabriele Vismara
[Team controller] Industrial Engineering and Management
Daniele Cavaglieri
Mechanical Engineering
Francesca Licandro
Industrial Engineering and Management
Bojan Markovic
Electronic Engineering
Giuseppe Randazzo
Automotive Engineering

TEAM B
Matteo Gabrielle Vismara
[Team controller] Automotive Engineering
Djan Markovic
[Team controller] Telecommunications Engineering
Stefano Alneri
Automotive Engineering
Giulio Canone
[Project Communication Coordinator] Industrial Engineering and Management
Marco Maurizio Dondi
Management, Economics and Industrial Engineering
Lucrece Urielle Mekogue Dongue
Electronic Engineering

EXTERNAL INSTITUTION
AVIO

EXTERNAL Tutor
Franco Tortarolo
Avio

ACADEMIC TUTORS
Giovanni Jaccino
Mechanics, Politecnico di Torino
Stefano Borella
Mechanics, Politecnico di Milano
Lorenzo Borello
Aerospace Engineering, Politecnico di Torino
Fiorenzo Franceschini
Production Systems and Business Economics, Politecnico di Torino
Stefano Pastorelli
Mechanics, Politecnico di Torino
Paolo Rocco
Electronics and Information, Politecnico di Milano
Matteo Rossi
Electronics and Information, Politecnico di Milano
Massimo Sorli
Mechanics, Politecnico di Torino

PRINCIPAL ACADEMIC TUTOR
Giovanni Jaccino
Mechanics, Politecnico di Torino

The IPROS project addressed an issue of growing importance: that of maximizing time equipment while minimizing maintenance and operating costs. The area of intelligent maintenance and prognostic-enabled condition-based maintenance of machinery is a vital one for today’s complex systems in industry, aerospace vehicles, ships, automotive industry, and elsewhere. As manpower levels are reduced and equipment becomes more complex, intelligent maintenance schemes must replace the old pre-scheduled and labor intensive planned maintenance systems in order to ensure that equipment continues to function. While fault detection effectiveness with very low false-alarm rates continues to improve, prognosis requirements are more ambitious and present very significant challenges to system design teams. Prognostics has the potential to be very beneficial in terms of both reduced operational and support cost and life-cycle total ownership cost of many types of machinery and systems. The evolution of diagnostic and monitoring systems for aircraft and other complex systems has led to the recognition that predictive prognosis is both desirable and technically possible. The objective of the IPROS project was to perform a feasibility study of an engine health monitoring and support system integrating engine prognostics directly into the logistics pipeline. Although different critical engine parts were analyzed, the effort was primarily focused on the engine gearbox since valuable data for this engine component were made available by the industrial sponsor. A knowledge-based system was defined as one capable of generating and integrating multiple information in order to efficiently assess the health of an engine, activate the logistic support chain and minimize the life cycle cost. All issues of an engine prognostics and logistic support system were addressed to assess its viability in managing just-in-time maintenance of the engines of an aircraft fleet and its economic benefits. The research defined the system, assessed its merits and evaluated its effectiveness when applied to actual engines. The two teams working on the project addressed different issues of the project in a highly coordinated approach. Team A initially identified the most critical components of an aircraft engine, leading to the development of a prognostic algorithm for the fuel pump because of its high criticality in terms of reliability. Both teams then focused on developing prognostic algorithms for the gearbox by using different approaches and performed an economic analysis in order to understand the merits of the prognostic system. Finally, team B developed an algorithm for the logistic and maintenance support system in order to understand how an innovative approach can improve its economic convenience. All activities were performed for the operational scenarios of a commercial and of a military aircraft. The research project was presented at the first international conference of the PHM society where it was well accepted and its merits recognized. The IPROS project addressed an aircraft engine, but its synergistic approach to health monitoring technologies, integrated reasoning capabilities, interpretation of fault-detect outputs, reliability assessment, maintenance and product support practices can serve as a paradigm for similar initiatives in other systems: from industrial machineries to food processing plants, from railways to marine applications.
An integrated prognostics and logistic support system for engines of a civil aircraft fleet

An integrated Prognostics and Logistic Support System for the engines of an aircraft fleet

ABSTRACT
The area of Prognostic and Health Management is a complex engineering field undergoing rapid growth and with growing interest among academic and industrial communities. PHM combines many different aspects, technical and economic, usually examined separately. However, very little is known about the economical benefits. The objective of our research is to perform a feasibility study of an engine health monitoring and support system that integrates engine prognostics with economic aspects by focusing on civil aircraft characterized by a scenario of use much different from the military one. The first implemented activity was an overview of the failure modes of an aircraft engine in order to identify the most critical components in terms of reliability. The results of this analysis led to a focus on two components: the fuel pump for its highly critical state and the gearbox, in response to the investor’s request. The behavior of the fuel pump was analyzed through an analytical model because experimental data wasn’t available; the decrease of the fuel flow rate to the engine is taken into account with the simulation of linear and quadratic losses. Data generated in this way are the inputs of the prognostic algorithm which exploits the minimum square method in order to reconstruct the fuel flow rate and determine the remaining useful life. On the contrary, an analysis of gearbox failures was performed through experimental data provided by the industrial partner. In order to build a reliable diagnostic algorithm, different feature extraction and classification methods were evaluated. In order to validate the convenience of the prognostic system, an economic analysis was implemented by comparing the Life Cycle Cost with and without the prognostic unit, completed by the Discounted Cash Flow Analyses. Sensitivity analyses of costs that may allow for the offering of a more competitive service. Sensitivity analyses of costs that may allow for the offering of a more competitive service. Sensitivity analyses of costs that may allow for the offering of a more competitive service.

Understand the problem
Customers are increasingly expecting both reduced costs on flights and improved service performances. PHM allows one to effectively respond to these interconnected needs. A typical PHM architecture consists of: remote monitoring, data pre-processing, feature extraction, anomaly detection, diagnostics and prognostics followed by logistic decisions. Remote monitoring is implemented by placing different sensors in strategic locations on the engine; data pre-processing consists of all operations on raw sensor data prior to feature extraction; feature extraction is one of the most critical steps as it aims at extracting features that prove to be good enough for the following diagnostics and prognostic steps; anomaly detection consists in determining if the system operates normally observing the features; if abnormal operation is detected diagnostic step determines the type of fault that has occurred; prognostics consist in determining in time to failure (TTF) i.e. remaining useful life (RUL); by knowing the RUL, logistic decisions can be made (e.g. optimal maintenance and inventory management).

Explore the opportunities
The failure mode analysis of a civil aircraft engine revealed that the fuel system (fig. 1) has a high probability of failure; this result is due to the fact that, when fuel filters are out, they are bypassed in order to allow the transit of fuel toward the engine. Hence the fuel system after the filters receives impurities. Thus its behavior was investigated through an analytical model (fig. 2), linear and quadratic fuel losses were reproduced (fig. 3), including sudden performance falls. This model aims at simulating the supply and monitoring of the fuel with high accuracy and with a good estimator of the health of the pump. In real applications, the FFR can be detected by monitoring the differential pressure across a restrictor positioned after the pump. Moreover the industrial partner provided a dataset for gearbox fault analysis. This data consisted of six raw data values: four accelerometers, torque and pickup, all acquired during both healthy and faulty engine work. In order to acquire the vibration data, several types of accelerometers - piezoelectric, piezoelectric with internal electronics, piezoresistive and variable-capacitance, differing in performance, power requirements, uses and signal-conditioning characteristics - were considered. Accelerometers sense motion and produce an electrical output proportional to the magnitude, frequency and amplitude of the input. After the processing of electrical-based data, the first step was to extract features that are capable of capturing the differences between healthy and faulty system conditions and which can therefore be used for the
classification. Two different types of feature extractions were con-
considered: mean value and variance and Spectral analysis. The mean value, variance and spectral analysis were calculated in different time intervals and then combined with two different classification methods: Artificial Neural Networks and Fuzzy Logic. The differ-
ent combinations of features and classification methods have been compared in order to choose the one with the best performance.

To assess the economic evaluation, different models can be devel-
oped. The same LCC model is heavily dependant on the assump-
tions done on the failure rates. The model that can be applied to
Arvo data is based on constant failure rates. Nevertheless, this
assumption may reveal some critical issues; an approach consid-
ering failure rates following a Weibull distribution may be more
realistic. Moreover a LCC disregarding the change on the Main-
tenance cost present between 2 and 5 hours; class 4: failure present
5 and 11 hours. While more experimental data would be neces-
sary to improve the training process and to more accurately vali-
date its performance, the resulting diagnostic algorithm showed
high classification accuracy on the available data set.

The model developed to evaluate the economic convenience of
the prognostic system is a generic LCC that can be modified ac-
cording to the nature of the data available. After developing the
generic model, a specific application for data provided by Arvo
was developed. The model can be divided into two parts: situation As-Is and situ-
atation To-Be. The first part consists in identifying the failure rates
and accordingly the most suitable probability distribution. After
that it is possible to calculate the average number of failures dur-
ing the life cycle; this allows one to evaluate the total costs of fail-
ures and maintenance during the life cycle. The same reasoning
holds for the second part where the prognostic unit is introduced.

GENERATING A SOLUTION
On one hand, the differential pressure transducer (fig.6) selected
to monitor pressure includes an all-welded stainless steel enclo-
sure in order to avoid corrosion and harsh environmental con-
tamination as well as external material damage and warranties
high Mean Time Between Failure rate. On the other hand, the
data created by the analytical model of the fuel pump was used
as input in a simple prognostic algorithm for the computation of
the remaining useful life of the pump. This algorithm determines
how many flight hours remain before the substitution of the com-
ponent, reconstructing the FFR trend with the minimum square
method (fig. 4). Moreover the computation starts after the FFR
decreases under a tolerance value.

Extreme heat environments of gas-turbine engines have increased
tamination as well as external material damage and warranties
a high Mean Time Between Failure rate. On the other hand, the
data created by the analytical model of the fuel pump was used
as input in a simple prognostic algorithm for the computation of
the remaining useful life of the pump. This algorithm determines
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ures and maintenance during the life cycle. The same reasoning
holds for the second part where the prognostic unit is introduced.

classes of gearbox health status: class 1: no failure, engine gearbox
is healthy; class 2: failure present for less than 2 hours; class 3: fail-
ure present between 2 and 5 hours, class 4: failure present,
5 and 11 hours. While more experimental data would be neces-
sary to improve the training process and to more accurately vali-
date its performance, the resulting diagnostic algorithm showed
high classification accuracy on the available data set.

The model developed to evaluate the economic convenience of
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ing the life cycle; this allows one to evaluate the total costs of fail-
ures and maintenance during the life cycle. The same reasoning
holds for the second part where the prognostic unit is introduced.

This unit modifies the model through the addition of costs re-
lated to the unit itself but also because it decreases costs by con-
verting serious failures into less expensive ones due to the ability
to intervene in advance.

Finally – and in order to fully evaluate the profitability of the in-
vestment – the Net Present Value was calculated. Results obtained
are heavily dependent on assumptions made on failure rates and
costs, hence sensitivity analyses were completed in order to un-
derstand to which extent the prognostic unit has to improve its
performance to be more confident on its convenience (fig 7). Fi-
nally, to investigate the economic impact of the prognostic unit
in more depth for the case of an entire aircraft fleet, a dedicated
software (fig 8) – capable of evaluating not only the average Life
cycle cost but also its distribution – was developed (fig 9).
An Integrated Prognostic and Logistic Support System for the Engines of a Military Aircraft Fleet

**ABSTRACT**

The main purpose of JIPROS project is to assess the feasibility of an information system that is capable of producing, gathering and elaborating plentiful information in order to lead military MRO (maintenance, repair and overhaul) activities and to obtain substantial savings in operations, logistics and overall LCC (life cycle cost). To achieve this goal, several methods were analyzed in order to determine the optimal approach to assess the RUL (remaining useful life) of an aircraft engine while focusing, more specifically, on engine gearbox components whose experimental data were provided by Avio. The project seeks to appraise whether the implementation of a gearbox prognostic system - developed by Avio and based on vibration analysis and in-line oil debris monitoring - will lead to a reduction of the engine life-cycle cost and thus worthy or not to be implemented. To claim the feasibility of such a prognostic approach, an economical assessment is needed by developing an LCC model connected to the entire logistics support system. Specifically, the present study includes an analysis of the impact of the RUL estimation was the first goal assigned to the team. Consequently, the overall results show how costs related to MRO can decrease from the introduction of PHM. In order to have a benchmark, a LCC model had to be developed with the aim of estimating costs associated with the faults and maintenance of a military aircraft gearbox in addition to evaluating the economical impact deriving conditions of a gearbox by using data collected by a specific oil debris monitoring system. Several detailed studies were conducted in order to evaluate, first of all, the influence of the oil system and based on vibration analysis and in-line oil debris monitoring...
tion of a prognostic unit on LCC has been analysed by assessing which available cost data were to be taken into account as implications and potential cost avoidance linked to PHM use. Another issue to be discussed was the role of uncertainty.

As mentioned, maintenance contributes significantly to the re-
duction of total costs; an appropriate maintenance concept must be tackled on a holistic standpoint that includes mutual relationships among all involved variables. Hence, the most challenging objective of the project was the definition of a fully integrated approach that could consider technical, economical and operational issues concerning the implementation of a predictive maintenance policy. In order to accomplish this task, an extensive preliminary literature review has been performed. As for technical issues, the review focused on understanding the typical failure modes of mechanical components and their related degradation patterns. Thereafter, the research objective shifted to the analysis and selection of the most suitable predictive algorithms which are commonly applied on the degradation patterns reviewed in the previous step. What is found from the literature review is that only a few attempts have been done in order to integrate all the issues mentioned previously. Furthermore, those studies which focused only a few attempts have been done in order to integrate all the aspects discussed until this point. In particular, a diagnostic algorithm based on the use of features thresholds and capable of detecting failure conditions was developed. In addition, a polynomial weighted equation which allows the merging of the data coming from the different features was used. The choice of developing this type of algorithm was due to its capacity to generate significant diagnostic results by using meager experimental failure data unlike what occurs with neural network-based and statistic-based algorithms. However, the algorithm thresholds and weights can be updated as more failure data become available; hence its performance can be compared with that of statistical based algorithms. This algorithm is easily adaptable to analyze other types of fault and can also distinguish between different system anomalies. As a consequence, its ability to detect failure conditions — several hours before catastrophic bearing failures - was demonstrated, thereby leading to potential reductions of its maintenance costs. The previously described prognostic algorithm is an example of a common source of data for a LCC model since it provides information such as the remaining life of the component. The project proposes a LCC framework, which is a statistical model based on the merging of the data coming from the different features was used. The choice of developing this type of algorithm was due to its capacity to generate significant diagnostic results by using meager experimental failure data unlike what occurs with neural network-based and statistic-based algorithms. However, the algorithm thresholds and weights can be updated as more failure data become available; hence its performance can be compared with that of statistical based algorithms. This algorithm is easily adaptable to analyze other types of fault and can also distinguish between different system anomalies. As a consequence, its ability to detect failure conditions — several hours before catastrophic bearing failures - was demonstrated, thereby leading to potential reductions of its maintenance costs. The previously described prognostic algorithm is an example of a common source of data for a LCC model since it provides information such as the remaining life of the component. The project proposes a LCC framework, which is a statistical model based on reparable systems’ reliability theory. The resulting LCC gearbox

**Generating a Solution**

The IPROS project for military applications came out with an overall solution involving all the aspects discussed until this point. In particular, a diagnostic algorithm based on the use of features thresholds and capable of detecting failure conditions was developed. In addition, a polynomial weighted equation which allows the merging of the data coming from the different features was used. The choice of developing this type of algorithm was due to its capacity to generate significant diagnostic results by using meager experimental failure data unlike what occurs with neural network-based and statistic-based algorithms. However, the algorithm thresholds and weights can be updated as more failure data become available; hence its performance can be compared with that of statistical based algorithms. This algorithm is easily adaptable to analyze other types of fault and can also distinguish between different system anomalies. As a consequence, its ability to detect failure conditions — several hours before catastrophic bearing failures - was demonstrated, thereby leading to potential reductions of its maintenance costs. The previously described prognostic algorithm is an example of a common source of data for a LCC model since it provides information such as the remaining life of the component. The project proposes a LCC framework, which is a statistical model based on reparable systems’ reliability theory. The resulting LCC gearbox

has been refined through a DCF analysis which provides indications about the economical convenience of the PHM investment by means of a largely used index as NPV. Within this scenario, the role of uncertainty has been dealt with by performing sensitivity analyses on the most relevant parameters and assumptions used in the model and by developing a software solution which uses Monte Carlo methods. Finally, the LCC model has been applied to the Avio gearbox in order to compare the present LCC with the one deriving from the introduction of PHM. Although the developed LCC model is application-specific and not exhaustive, it provides a first conservative estimate of the economic impact of PHM and has a good degree of flexibility, making it easy to adapt to different business cases.

Finally, a broad solution capable of taking into account all the most important factors occurring in the MRO system was proposed. It is based on the physically and experimentally proved assumption that in every mechanical component subject to failure we can find a feature or an health index with a degradation pattern which evolves exponentially. Therefore, we created a set of exponential-shaped patterns with variable coefficients. This set was then used to determine a priori RUL probability function that is updated through a Bayesian algorithm which re-estimates the RUL probability density function as the exponential pattern evolves in time. An RUL prediction was completed in order to find optimal conditions for scheduling and performing prognostic-based maintenance tasks through a cost function minimization. To assess the related potential benefits in case of a military aircraft operational scenario, we set up a discrete event simulation based on a Monte Carlo analysis. In realizing the simulation, a degradation pattern was associated with each aircraft and the Bayesian algorithm described above was iteratively run to simulate health sensor monitoring and real-time RUL estimation for optimal maintenance scheduling. Through the results of the simulation we obtained the LCC, availability, maintenance and fleet performance distributions in both scenarios.

**Main Bibliographic References**

PROJECT 4

ORTHOROB

ORTHOPAEDIC SURGERY AND ROBOTICS
The project, in conjunction with Galeazzi hospital, aims developing a robotic system for cutting mask alignment during total knee replacement surgery

The challenge
In total knee arthroplasty (TKA) procedures, the surgeon is required to correctly orient the cutting guides to ensure the surgical operation outcome. Navigation systems and medical robotic systems are becoming part of surgical practice, but they are still not easily accepted in clinics due to their disadvantageous cost benefit ratio; they offer solutions which are too high-tech for the surgical requirements without meeting the safety and economic constraints.

The Orthorob project is aimed at providing the surgeon with a robotic assistant which holds surgical tools in the correct position while surgical cuts are being performed. The idea is to totally reconfigure present robotic assistants in order to design a newly conceived system which could be smoothly integrated in the operating room and easily accepted by surgeons.

As a result, the system has to be modular, flexible and adaptable to surgeons demands, not cumbersome but safe and reliable and, above all, should permit mini-invasive access to the surgical field.

The teams
The project is divided in two sub-projects: A and B: project A is dealing with aspects related to the patient-robot relationship, while project B is dealing with the robot-surgeon interaction. In this framework, the know-how of the people involved in both the teams guaranteed that all the aspects related to: requirements and specifications collection (biomedical engineers); design and implementation (electronics, design and automotive); results dissemination (all); market analysis and products exploitation (all) can be accomplished in both the sub-projects (A and B) during the project duration.

The results
The team working for project A designed an integrated system for patient limb immobilization during the surgery and for attaching the robotic arms bases. The arms, newly conceived lightweight components, hold the surgical instrument and the optical cameras for objects localization. In order to increase patient safety (in the patient-robot relationship field), the team also worked on a robust robot – optical system calibration routine and implemented a contact sensor that prevents the robot movement in case of impact with the patient. The sensor was tested in the laboratory and proved to be robust under minimum contact (estimated delay was accepted).

The team working for project B worked on a system which aimed to increase surgeon acceptance of the robotic device in the operating room. In order to do that, they developed an augmented reality environment where all Orthorob devices are simulated and can be used in a virtual room with a virtual patient. The surgeon is interactively taught how to perform robotic assisted interventions. Further developments could be directed towards the application of the innovations proposed for other surgical fields in order to increase the exploitation of engineering technologies in clinical training and in therapies.
**Abstract**

Medical technologies and surgical improvements have developed so much during the last decades that a lot of treatments can be undergone easily; nowadays some highly risky operations have become routine owing to modernization and innovation in medical facilities. Computer Assisted Orthopedic Surgery (CAOS) is a type of surgical procedure where computer technology, wireless or optical tracking and robotics are applied pre-, intra- and post-operatively to achieve the best possible outcome for the operation.

Our main aim was to focus on the relationship between the robot and patients: improving a robot’s characteristics means that we would like to guarantee - at the same level - more safety for patients, a faster recovery and a more comfortable operation. The introduction of our innovative model can only be justified by obtaining a balance between costs (economical for the hospital, physical for patients) and real benefits achieved, in terms of space saving, easier work for the surgeon and a patient’s condition which is really improved.

The team developed an innovative concept for an orthopaedic robot integrated into the basement of an operating table. Its name, ROBERTO, has been chosen in reference to our external tutor’s name and it means “ROBtics with Enhanced and Renewed Technology for Orthosurgery”. ROBERTO is the medium between the surgeon and patients so it can not fail. Patient’s safety is such an important aspect in our vision that the entire project focused on the relationship between the robot and the patient.

First of all, we analyzed the possibility to improve some already existing models. Starting from literature analysis, we understood that in the surgical room there is a problem of lack of space. We have to consider that at least the surgeon, the anesthetist, and two or three assistants are required beyond, of course, the patient. The new robot should not be a hindrance for the surgeon; it should be easy to sterilize and, above all, easy to use. Surgeons are in fact quite lazy in understanding and applying new technologies unless it represents a real and equal advantage both for their work and for the patient’s health.

On the other hand, we must consider that there are a lot of costs associated with introduction of the new robot: first of all, the initial investment on the new technology. Secondly, costs for training both the surgeon and his medical equipment. Finally, maintenance costs for the new robot (sterilization, disposable).

For this reason, a balance between costs and benefits must be attained in order to obtain the best result.

**Exploring the opportunities**

First of all, we analyzed the possibility to improve some already existing models. Starting from literature analysis, we understood that we had to guarantee more safety for patients while reducing at the same time both robot dimensions and the risks associated with its introduction.

We initially focused on a robot suitable for industrial applications, available in our laboratory, to have an idea about how it really works. Our main difficulty was to think of something new and to apply it to a model that is not directly suitable for a surgical operation. However, it was a good starting point, letting us become more familiar with the problem: we were able to perform some tests in terms of calibration as well as design and test a contact sensor in order to get an idea of the materials used while becoming conscious about how much space is required not only for the robot, but also for its relative control instruments (for example, the tracking system).

It was at this point that we understood something completely new was required: according to us, it was not useful, or at least quite trivial, to modify something already in existence. We would like to make a real innovation in terms of robot design, new operating table conception and space saving while making the surgeon’s work easier but above all improving patients’ conditions.

A new idea is in fact a successful idea when it can be applied, guaranteeing benefits that overcome costs. With this in mind, we tried to design a new model of surgical robot by making it not only smart in terms of its design, but above all functional in terms of safety for patients.

**Generating a solution**

By analyzing both the problems associated with the use of an industrial robot in an operating room and the requirements demanded by investors and stakeholders, we proposed an innovative solution in which the robot is fully integrated into the operating table.
The name of this system was chosen as “ROBERTO”, meaning Robotics with Enhanced and Renewed Technology for Orthopaedic surgery, with the purpose of highlighting the most important concepts in our solution. The specific requirement of having a system of immobilization to allow for registration during total knee replacement surgery demands a system for fixturing the entire leg. Hence, a design of a system for fixing the hip, the knee and the ankle was performed in an innovative solution, integrated into the surgical table. The different parts constituting the surgical table were also planned: the main element inside the entire structure because it is the seat of the arm that is the most critical one, is performed by inserting a leg section in the surgical table, thereby supplying the possibility of large-scale production. It would represent the best solution to allow for registration during total knee replacement surgery, with the purpose of highlighting the most important concepts in our solution.

In order to perform a total knee operation some specific tools need to be used and stood by the four arms:
- the mask for the cuts
- forceps or an aspirator
- a saw
- a stereo camera
- forceps or an aspirator

All these instruments could be used at the same time, according to what the surgeon requires. They should be conceived in terms of better fitting and adapting to the new arms. Of course, more instruments suggested by the surgeon may be added in the future.

The most important requirement of the robot was the safety during the robot – patient interaction in an operating room. When designing the robot arms, the possibility of a polyvalent solution was taken into account. To attain this objective, the possibility of inserting different surgical tools on the different arms of the robot was evaluated, thereby enlarging its market. One of these specific arms was conceived to be the seat of a force sensor capable of detecting collisions between the robot and surgeon. We have chosen, for the robotic arm, a mechanical approach that is called ‘tendon actuation approach’. This technology was used for the construction of the light-weight robot. The concept has four arms that come out from the base following precise movements during an operation of total knee replacement. The different parts constituting the surgical table were also planned: the table-top and the support column. The latter becomes the most critical element inside the entire structure because it is the seat for the arms of robots performing the surgical operation. With regards to the robot, we improved an existing industrial robot in order to enable it to perform a total knee replacement. The most important requirement of the robot was the safety during the operation of the arms of the robot was evaluated, thereby enlarging its market. One of these specific arms was conceived to be the seat of a force sensor capable of detecting collisions between the robot and surgeon.

The main elements that compose our ROBERTO are briefly described here.
**ABSTRACT**

The primary objective of Team B has been to analyze the cooperation between the surgeon and the robot during a Total Knee Arthroplasty (TKA) surgical operation. The students of team B tried to detect some of the key issues of the human-machine interaction for this application as well as develop innovative solutions for these challenging problems.

In the context of the literature review, our team discovered that only a small percentage of orthopaedic surgeons all over the world use robotic systems to perform TKA while others simply choose to perform the classical manual operation. The principal reason for the lack of popularity of robotic systems in TKA surgery is trust: surgeons are more confident with traditional manual techniques. The robot is often only considered a machine, an advanced technological tool that does not fit in an operating room.

The solution proposed by team B concerns a virtual environment to perform simulated TKA with the aid of robotic systems. The simulated environment is independent from the robot used, making it possible to perform simulations and comparisons by using different systems. This solution is based on a newly developed technology named augmented reality.

The basic concept behind augmented reality is straightforward: by equipping a surgeon with a webcam, it is possible to reconstruct the scene captured by it and to transfer this information to a PC. In particular, great attention is given on the training of surgeons practice the robotic operation, without forgetting the importance of knowing how to perform manual operations; the robotic precision should be demonstrated to be higher than a classical manual operation.

**EXPLORING THE OPPORTUNITIES**

The team had the possibility to visit the operating theatre and to interview the surgeon Roberto D’Anchise. Some crucial points emerged from these meetings:

- The robotic operation should last at most 15 minutes more than the traditional one.
- The use of CAT (Computed Axial Tomography) should be avoided because of time limits, radiations, the need for reservations and budget constraints.
- Robotic precision should be demonstrated to be higher than a classical manual operation.
- The robot should only place the cutting mask correctly; no other tasks should be performed: in particular the robot is not allowed to perform any surgical operation.
- The choice of a robotic manipulator is preferable.

In particular, our team focused on the interactions between the surgeon and the robot by focusing on the surgeon and design a service that fits his needs. In this view we investigate the possibility of the use of virtual reality in the surgical field. On the basis of the interviews we have learned that:

- it would be interesting to use virtual reality to learn how to perform the robotic operation;
- it could be a good idea to use virtual reality to help novice surgeons practice the robotic operation, without forgetting the importance of knowing how to perform manual operations;

**UNDERSTANDING THE PROBLEM**

Research about Computer Aided Orthopaedic Surgery (CAOS) systems has experienced a huge expansion during the last ten years. From a merely technical point of view, a current standard robotic system can easily assure a level of accuracy and reliability which is fully compatible with the specific needs of orthopaedic surgery.

Orthorob Team B (in collaboration with team A) focused its research on the state of the art of Total Knee Replacement surgery with the aid of a robotic system. In the context of the literature review, our team discovered that only a small percentage of orthopaedic surgeons all over the world use robotic systems to perform TKR while others simply choose to perform the classical manual operation. The principal reason for the lack of popularity of robotic systems in TKR surgery is trust: surgeons are more confident with traditional manual techniques. In addition, the great majority of surgeons report that the use of a robotic system is a loss of time because it extends the duration of the operation without providing any advantage. In fact, results in the manual re-alignment of the mechanical axis of the leg are considered satisfactory. There is no clear evidence of improvements achievable through the use of robotic systems because of a lack of data due to the need to monitor the patient for a long period of time after the operation. Moreover, the use of a robotic system implies an additional loss of time because the system must compute a calibration step to fix the reference frames between the real world, the robot and the leg of the patient. The robot is often only considered a machine, an advanced technological tool that does not fit in an operating room.
it would be useful to train other members of the staff in the operational theatre as well.

Generating a Solution
From these observations derives the solution proposed by team B, which concerns a virtual environment to perform simulated TKA with robotic systems.

The simulated environment is independent of the utilized robot used, making it possible to perform simulations and comparisons by using different systems.

This solution is based on a newly developed technology named augmented reality. The basic concept behind augmented reality is straightforward: by equipping a surgeon with a webcam, it is possible to reconstruct the scene captured by it and to transfer this information to a PC. Moreover, by wearing head-mounted display, the surgeon can see the real scene with some virtual objects added by the PC.

Intra-operative use of augmented reality has been already reported in literature. Splechtna et al. (2002) developed a system which is capable of displaying CT images on the body of the patient with the aim of accurately locating pathological tissue before performing incisions. By applying this technology, Orthorob Team B proposes the novel use of the simulation environment with coexistence of real and virtual objects.

Gloves can be used to improve the simulation by giving tactile feedback to the surgeon and by expanding his perception beyond the visual sphere. The technology of gloves for virtual reality is well established, and gloves suitable for this application can be easily found on the market.

Great attention is given to the training of novice surgeons. For this application a simulated environment should provide different levels of abstraction, allowing a learning-by-doing process: Theoretical presentation of CAOS systems in order to explain how a robot can improve the results of the surgical operation.

The aim of this phase is to make the surgeon aware that he can improve his technique and performance by using the robot:

- First levels of simulation: in these phases the entire patient, robot and tracking system is virtual. In this way, the surgeon, by performing the operation in a controlled environment, can not be accidentally injured by the robot, and he begins to learn the practical fundamentals of TKA (Total Knee Arthroplasty);
- Last levels of simulation: in these phases, the surgeon experiences a situation in which the patient is virtual, but all the other objects are real, even the robot.

This approach ensures a soft learning curve, introducing all the complex issues of performing a surgery with a CAOS system in a step-by-step manner. Orthorob Team B strongly believes that a generation of surgeons trained with this kind of tools will be much more confident with the CAOS system and will be aware that robots represent an opportunity for improving their professional performances. This would be a great improvement in the surgeon-robot relationship and represents the primary objective of Orthorob Team B.

Main Bibliographic References
PROJECT 5

CREATING A PLANNED AND PARTICIPATORY FORM OF CULTURAL HERITAGE MANAGEMENT
Sharitage
Creating a planned and participatory form of cultural heritage management

A conceptual proposal for a participated preservation of architectural heritage. Parties involved: Comune di Milano and Soprintendenza per i beni architettonici

PrINCIPAl ACADEMIc tutoR
Pedro Porto Barque de Gusmao

TEAM A
Andrea Balestreri [Project Communication Coordinator]
Architecture
Alice Jasmine Crippa [Team controller]
Communication design
Pedro Porto Barque de Gusmao
Telecommunication Engineering
Automotive Engineering

TEAM B
Chiarara Baracchinì
Soprintendenza per i Beni Architettonici e il Paesaggio e il Patrimonio Storico, Artistico ed Etnoantropologico di Lucca e Massa Carrara
Do.co.mo.mo
Italia Nostra

EXTERNAL tutoRS
Chiara Baracchinì
Soprintendenza per i Beni Architettonici, Paesaggistici, Storici, Artistici ed Etnoantropologi per le province di Pisa e Livorno

EXtERNAl INStItUTIONS
Soprintendenza per i Beni Architettonici, Paesaggistici, Storici, Artistici ed Etnoantropologi per le province di Pisa e Livorno

PROJECT dESCRIPtION
The challenge. In a new perspective of the value of the past, the preservation domain is being enlarged by a strong increase in the types of artifacts being considered worthy of protection and conservation: in addition to monumental high-style architecture (traditionally the preservation concern) many new categories of sites are now recognized as equally meritorious: cultural and natural landscapes, historic towns and villages, vernacular and industrial structures, etc. The urban and landscape preservation specificity is not only a matter of scale, but also methodological approach: we must study our territory as a continuum of diffused cultural sites and not as a simple container of single buildings of historical interest isolated from their environmental context.

The purpose of this research is focused on conservation and management of architectural heritage also when not protected by national laws for preservation (as historic town centers, modern districts, industrial architectures, rural buildings and landscapes, farms, factories, trails, gardens, etc.) with the goal to survey historic sites and features, read cultural and architectural values and analyze planning tools and conservation treatments in order to reach a proper approach to preserve, rehabilitate and manage the historic heritage defining specific plans.

In this view the communication empowerment between the actors become a key challenge, facilitating knowledge and decisional flows, also increasing the awareness about cultural items. Also the involvement of common people become relevant in this perspective because their point of view results important to fully evaluate and manage preservation processes.

The team. The work group has used its skill in the field of Cultural Heritage and in computing and management and has consulted the following stakeholders:

- Conservation and preservation bodies (Soprintendenze, Commissions provinciali BAAA, Commissioni edilizie)
- Professional associations (Ordine Architetti)
- Owner/investors
- Private Associations (Italia Nostra, Do.co.mo.mo, etc.)
- Studied tools: Open GIS (Grass, quantum GIS, ArcGis)
- Open Maps (Openstreetmaps, ESRI maps)
- 3D integration with Sketch-Up models
- Photoshyn technology
- Deep analysis of case study.
- SAFE METHOD Danmark
- GEOSYSTEM Benevento
- ARTPAST: ARISTOS, SICAR
- Social communication methods

The results. The team has done the program planned and prepared a summary report outlining the theoretical and methodological issues addressed and defining the possible lines of research development. These could concern the improvement of the ministerial standard GIS tool SICAR with new features focused on programmed refurbishment as a way to put in practice theoretical principles faced during analysis. The team proposed solutions for present problems overcoming lacks of communication and lacks of important automations that could make the preservation process more effective and well-timed.

In addition to these specific improvements the team studied a broader perspective of development suggesting more complex lines of research for long-time innovations.

To improve participation and awareness about cultural items the team suggested also new services, specific social actions and communication campaigns addressed to people and possible investors.

The framework provided is intended both for Soprintendence and architects (providing a more efficient tool to work) and also for the great part of stakeholders involved (municipalities, provinces, regions, owners and common people).
The present lack of communication between actors involved in the process, could be ameliorated introducing internet based tools admitting to share a large quantity of information. In order to reach this goal, Sharitage had been harmonized to an ambitious project of Italian Ministry of Culture called Risk Map that stresses an innovative conception of preservation that doesn’t focus only on an artwork itself, but conceives it as a complex object constantly related to its environment. After a large browsing of opportunities was chosen SICAR, an innovative tool developed in Pisa and Lucca superintendance, as the most suitable system on which base an innovation plan. The development program concentrates on a well defined mat- ter: the programmed refurbishment practices. It consists in the possibility of planning a well-timed mainte- nance calendar of steps, that could prevent not reversible deter- ioration, reduce costs amount and increase their predictability instead of thinking about urgent and isolated refurbishment ac- tivities.

The project focused on a new service for SICAR that, perform- ing simple compilations makes the system able to notify the needed activities to the item supervisor and also to self-update a database of craftsmen and maintenance products.

Second focus concerned the conception of “call for funds” cam- paigns designed for a more participative management of the cul- tural heritage. This researching phase bring us to reflect about the invitation, as technology provider and collaborators, one of the best discov- ered GIS implementers. The American ESRI, producers of the well known arcGIS, or GOOGLE, as producers of EARTH well understood the Problem

The project in understanding the scenario concerning Sharit- age project followed two lines of research. The first one investigates the position that Sharitage had to take regarding MIBAC (Ministero dei beni artistici e culturali) fragmented asset. Due to the problematic context, our task was implemented by harmonizing it to the most ambitious project intending to reorder the way of working of this institution.

This project, nowadays held by ICR (Istituto Centrale del Re- stauro, “Central Restoration Institute”), is called Risk Map and stresses an innovative conception of preservation; it doesn’t fo- cus on an artwork itself, but conceives it as a complex object that is constantly related to its environment as a continuum. Cultural Heritage Bureaus and Regions are thought of as adminis- trative and scientific supporters charged to safeguard and enhance cultural heritage (as disposed by D.L.42/2004) and are aided by innovative tools working in GIS environment. The second research line investigates the definition of Cultural Item. Until recently, it was the task of some MIBAC specialized peo- ple, holding the necessary cultural and political authority, to decide that something was a cultural Item or not in reason of a uniform culture of the nation. After the actual melting pot producing cosmopolitan and multi- cultural nations, the meaning shift in the national cultural item concept couldn’t be underestimated. What is interesting in a growing multicultural society is the way of working of this institution. The theorists of the Risk Map implemented their innovative idea in a GIS highlighting restoration needs but with tools today considered outdated because they are not internet based. The research field in GIS Internet based technology grows quickly in this direction till today arriving to provide excellent open source products and open source cartographies, optimal in ministerial research because they are compulsory in the use of open source software.

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entific committee of SICAR was fruitful because it allows new ideas to take rapidly shape and grow upon an already implemented architecture. Sharitage research lines proposed to build new categories to be added to SICAR standard interface. These innovations deal particularly with communication problems that are at the base of many project rejections as well as a significant amount of time lost for architects, many halted investors initiatives and lost occasions.

Empowering communication was central in Sharitage goals but not only between Cultural Heritage Bureaus, Architects and Investors, but rather by also giving importance to communications with the population.

Its role in the bound process proposition or in “call for information” campaign permit to change the normal perception that historians or books gave to a Cultural Item.

Programmed refurbishment was a concrete solution: instead of thinking about isolated refurbishment activities, carried on when an emergency occurs, it’s possible to plan well-timed maintenance steps that could prevent uncontrolled rather than reversible deterioration.

Programmed refurbishment has also practical benefits regarding costs: routine activities are cheaper than major restoration processes and their costs are also predictable and well known. So it’s possible to estimate a clear budget and plan activities during the most convenient period of the year.

The idea was to build a new dedicated service for SICAR that could be “generative” in the sense that an user - performing usual operations through SICAR and adding a few simple checks and time decay indications – would make the system itself capable of reporting the needed activities in advance to the responsible party. With the same method the user also supports the constant updating of a craftsmen and maintenance products database through the compulsory fields required by the system. This is a concrete way to put in practice the “Manuale della manutenzione” (Maintenance Manual), but also adding the recommendations included in the “Libretto di utilizzo” (Usage Manual), often skipped or forgotten by restorators.

Nevertheless there are some disadvantages. First of all Italy is a country highly sensitive to emergencies but not well adapted to a preventive attitude. In addition, the distribution of new standards is slow and greatly linked to legal provisions. SICAR is the ministerial standard but it is only “recommended” for now. This system also requires well trained people and the greatest benefits increase proportionally with the number of people that use it. These disadvantages could be faced thinking that the Cultural Heritage Bureau has the duty to manage cultural items and has a strong need for a new internet based tool to improve present practices. The Cultural Heritage Bureau evaluated this proposal as a good one also to promote the use of SICAR itself.

But there is another big benefit that also has to be pointed out. For predictable costs it is possible to look for funds in advance, public or private. This point gave the idea to involve the general public and new private investors through a “call for funds” communication campaign, the second focus developed by this project.

Non-profit and public campaigns, in other countries, are some of the most effective examples of communication, also in light of fundraising issues. In Italy only Pubblicità Progresso takes care of those themes but with low creativity and quality. So the Cultural Heritage Bureau and MIBAC, with low budget solutions, can start to take advantage of communications that are facilitated to perform their role.

In addition to a “call for funds” campaign, two others have been developed in order to facilitate a more participatory manner of conceiving cultural heritage management. The first regards the possibility of collecting old useful documents and memories from the general public both to build item memories, if they were get lost, and also to research new values. The second invites people to suggest new cultural items, keeping this concept itself really up to date. For all of these conceptual proposals, a low street budget campaign, linked to dedicated websites or to preexistent tools (social networks, photosharing tools etc), is intended to raise interest among items at a high level by making their preservation simpler and promoting it to the public.

REFERENCES

SPACE HOTEL DESIGN
The Space Hotel Design project performs a feasibility study for a space system targeted on bringing in common people for fun and relax.
Orbiting Space Hotel

ABSTRACT
In the last decade eight, people flew to space to spend an unusual holiday and experience the unique adventure of living in a microgravity environment while looking at the Earth from a different point of view. Space tourism is indeed a new reality that deserves being analyzed for the strong impact it is going to have on our society. The main objective of the “Space Hotel Design” project is to provide future space tourists with a global experience that encompasses the means and the "to-dos" of this outstanding holiday. In order to attain this goal, the project focuses on an Earth-orbiting space hotel and presents a feasibility study under several perspectives, such as the market, health-related issues and the development of habitat concepts, technologies and services suited for sustaining human life in microgravity conditions.

Initially, people’s expectations are analyzed in order to understand future market developments. Future generation’s trends and attitudes are examined, with a focus on the luxury market and its generational-dependent trends. Secondly, existing or short-term planned concepts are examined and compared with each other so as to come up with innovative solutions from a structural and technical point of view. An assessment of these is implemented in order to choose the most suitable, i.e. the one which meets the users’ requirements and satisfies the constraints imposed by the context. Consequently, the final solution is conceived as a four-module structure with a scientific laboratory where a permanent two-member crew manage the six guests’ journey. Tourists will undergo a two-week long training on Earth and will be allowed to spend one week in space. Each area in the hotel is designed for specific purposes and entertainment plays a key role. Ethical implications are taken into account in such a way that space tourism no longer means a waste of money if research is constantly passed the means and the “to-dos” of this outstanding holiday. In order to attain this goal, the project focuses on an Earth-orbiting space hotel and presents a feasibility study under several perspectives, such as the market, health-related issues and the development of habitat concepts, technologies and services suited for sustaining human life in microgravity conditions.

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TASKS & SKILLS
Alfonso Aragona. Studied the technologies for power production, investigated the effects of the space environment on the human body and focused on health risks for future space tourists.
Giuseppe Cataldo. Studied the influences of the external orbital environment on the space hotel, implemented a preliminary study to design its subsystems and main technical features and calculated the final mass budget.
Robert Maffei. Studied the architecture for microgravity as well as pneumatic and inflatable technology for space, the hotel architectural layout and habitability in space.
Alessandro Grenc. Studied a business plan for the space hotel focusing on the demand and main markets as well as the price-demand relationship, safety and risk standards accepted and the evaluation of the best time-to-market.
Andrea Paraboschi. Studied the space hotel guest profiling, developed the hotel 3D-model and studied both the entertainment technology on board and space hotel advertising.

UNDERSTANDING THE PROBLEM
The main customers interested in this project provided us - directly or indirectly - with their targets, needs and requirements. In particular, we dealt with Thales Alenia Space Italy (TAS), our main stakeholder, and received direct feedback by or gathered information from:
• National and international space institutions (such as ASI, ESA and NASA) that might become potential partners of the project and, as governmental institutions, are aware of the current space policies
• Private investors or companies that would potentially invest in the project
• Future space hotel guests

During several meetings, TAS managers asked both teams to think of a possible space hotel model and to assess different feasibility options. Additionally, they invited us to focus on the entire experience rather than the technical complexity of the different subsystems and to leave a further in-depth technological analysis for future research studies. These requests were also confirmed during the mid-term review by the ASP Board, which strongly encouraged us to describe the whole “Space Hotel Tourism” experience. According to these suggestions, our attention gradually moved to the demand side of the equation, following a bottom up approach.

We started to analyze what people actually expect from space travel in order to understand how this market can evolve. In addition, we looked over future generations’ trends and attitudes, with a focus on the luxury market and its generational-dependent evolutions. Meanwhile, a global structural design was developed, starting from studying some competitors’ solutions, in order to determine strengths and weaknesses of the existing or short-term planned concepts and to propose a possible solution by using pneumatic modules. Furthermore, since safety plays a key role in any space project, our attention was concentrated on the space environment and all the factors that influence life in space. The training - being an important phase in this process - was defined to be half of the whole experience.

In conclusion, all user requirements can be summed up in these four categories:
• Experiential (demand-side needs): satisfying future guests’ expectations, legitimating their expense
• Economic: feasibility, costs and revenue mechanisms
• Technical (structural design): materials and solutions
• Safety: guaranteeing the highest safety standards for both the guests and crew
In addition to these four main requirements, we dealt with some ethical implications which are strictly connected to each of them and ultimately to the success of the entire project. Actually, building an orbiting space hotel means spending a lot of money and time in research in order to satisfy the wishes of only a few and initially extremely rich people. In order to transform this elite activity into a useful activity for those people that will only see the orbiting hotel as a little spot in the sky, we agreed to transform this activity into a useful activity for those people that will ultimately become the main protagonists of space tourism.

The space environment influences on both humans and structures

The microgravity effects on human body

The state of the art led us to analyze the International Space Station’s features, for it is the most complex space station orbiting the Earth and hosting a crew of up to six astronauts. It is made of different subsystems capable of keeping the crew alive and allowing them to accomplish their mission. ISS’s operation requires great effort in relation to the transportation of the astronauts, equipment, goods and data from and to Earth. The logistics and operational subsystems are relevant for determining ISS’s orbit, its design and all of its peripheral systems, as well as integration and ground support. Most of the subsystems are linked or partially merged so that, in addition to the required subsystem functions, even higher objectives are achieved. As a matter of fact, various objectives result from implementing synergism in space system design.

The European Columbus laboratory’s characteristics have been considered in order to have an initial idea of what the Space Hotel may be looking like, especially in terms of dimensions and masses.

The space environment influences the condition and properties of used materials, as well as the onboard crew, the experiments and their operation. Therefore, health becomes a problem for two main reasons:

- The microgravity effects on human body
- The space environment influences on both humans and structures

As for the first issue, adequate training is required before flying to space in order to adapt to the new conditions and minimize negative effects. As for the second, space structures are currently designed so that they can resist the impact of this harsh environment and guarantee safety for the whole crew.

As far as guest profiling is concerned, nowadays tycoons and very rich people are the main protagonists of space tourism: up to now, seven of them flew to space and the ISS.

All individuals born between 1980 and 2000, the so-called “Generation Y”, are expected to be the next future space tourists. They are thought to be luxury explorers, for they prefer the uniqueness of the experience rather than the luxury itself.

Generating a solution

After a careful comparison of all possibilities, a modular approach similar to the one used for the International Space Station was decided as the best design solution. As a matter of fact, it allows a clear definition of habitable spaces on the basis of their function and a simple construction of the hotel.

The final concept consists of three modules: one core module and two peripheral modules for the connection of all the modules. Moreover, the possibility to increase the habitable volume by adding three further modules has also been taken into account and the employment of an innovative solution based on inflatable structures has been preferred.

The construction of the hotel will require four launches, if the Space Shuttle or a launch vehicle with a similar capacity is employed. It will orbit in Low Earth Orbit at an average distance of four hundred kilometres from the surface of our planet. A traditional solution based on six photovoltaic arrays has been considered as the best option for the power production system, while innovative solutions have been proposed for the economic exploitation of the hotel.

The typical experience has been thought to be three weeks in length for a group of six tourists: two weeks would be required for training and preparatory activities on Earth, while about one week would be devoted to the real space experience, from the launch to the return on Earth. In orbit, tourists will be assisted by two professional astronauts and will be encouraged to live as such for the entire duration of their journey.

Main bibliographic references

MOOREA Moon Resort Architecture

Task & Skills
Mural Kinran. Worked on guest accommodations. Study of the interior design of facilities. Responsible for product design. Collaborator on the interior design scheme.

Umberto Melia. Worked on psychological issues. Analyst of the physical implications of a low-gravity habitat on human beings. Study of the training phase.

Luca Milani. Responsible for logistical issues and the economic feasibility study. Mission costs and extravehicular activities analyst.

Andrea Minelli. Worked on subsystems design and sizing, requirements and constraints analysis. Responsible for environment analysis (site selection, radiation shielding). The hostile characteristics are linked with the development of shielding and protection systems and with in-situ resources utilization.

A mission cost analysis with the payload fairing volume constraint precedes the identification of the best modules layout in terms of number, size, shape and materials. Module configuration, site location and logistics are all studied together in order to find the best feasible compromise of each of them. A hybrid rigid-inflatable configuration was presented with its modular scheme.

A logistical plan in order to transport all modules and freights is presented. An idea for a surface rover and a lunar lander (both permanent on the Moon) is also developed. Psychological and physical aspects increase their importance and affect the entire project. This is due to the presence of "untrained" people from the general public. A small and closed community will be studied in order to define the main aspects of this micro society. To avoid or minimize psychological problems, countermeasures involve guest's selection, training, and in-flight support.

Entertainment is studied in order to highlight future guidelines and design drivers.

Understanding the Problem
When dealing with space missions, the most important aspects to be considered are: technology, safety, and costs. As an addiction to these ones, a hotel project can increase the relevance of other aspects such as ergonomics, psychological and physical problems and all the aspects related to human wellbeing in a hostile environment. These have to be analyzed starting from psychosocial or interpersonal stressors, associated with long-duration spaceflight, revealed by precedent long flight experiences.

Lunar environment is characterized by vacuum, extreme temperatures, low gravity, radiations and meteorites. The settlement location is strictly related to the environmental analysis. Power sources, ISU/ architecture, day and night transitions, Earth visibility depend on the lunar region selected. A first, important trade off to be managed involves the mobile habitats versus a permanent settlement. The first solution seems temporary that implies less comfort and safety for the crew. A fixed ground base can satisfy the constraints in terms of safety (environmental protection), comfort, and optimal in situ resources utilization. The resources utilization is one of the main aspects in the operation phases. The fixed base solution does not imply constraints on the choices between a closed or a open cycle architecture, so both of the alternatives are considered, as well as a combination of them.

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The logistic study has led to a plan which consists in three initial launches from the Earth to the Moon surface to transport all the facilities needed to install the Hotel. Then, several re-supply launches will be performed from the Earth to a hub/warehouse orbiting around the Moon, because it represents a less difficult solution. From there, the lunar lander is in charge to shuttle from the hub and the landing pad on lunar surface and v.v.
Physiological aspects regard the protection from radiation, the absence of natural time parameters, the adaptation of the body systems to microgravity/low-gravity, the sensory/perceptual deprivation of various natural spaces, Space Adaptation Sickness (SAS).

It is evident that in a very small and closed "community", it is fundamentally important to know and to try to avoid the "negative" interpersonal relations, as well as to pursue the "positive" ones. "Negative" interpersonal relations, if not promptly reduced, act as very powerful stressors as they are underhand. Interpersonal tensions linked to schemes, rules and group dynamics, have to be taken into account, making relation with psychological internal stressor, that includes the individual psychological factors.

Geting A Solution

Concept

The concept for the Moon Space Hotel has begun with basic requirements: first and foremost, the habitat needs to be transportable to the lunar surface. It is developed a modular system that combines ease of transportability and convenience of expansion. We assume that the scenario of 2030 on which we focus requires the hotel to have the capability to expand in a further future. So in case of any redesign process, new modules can easily be inserted for additional activities, that can change in a further future. The hotel is designed with the scenario of 2030 on which we focus that combines ease of transportability and convenience of expansion.

The fitness & training module is made of an interior flexible spaceframe is inserted; the spaceframe's individual membranes whose shape can actively be adjusted by the astronauts. The Fitness & Training module is a space created to make people move and have fun.

The Fitness & Training module is made of an interior flexible membrane whose shape can actively be adjusted by the astronauts and tourists. Between inner and outer skin, a high resolution spaceframe is inserted; the spaceframe's individual members are pneumatic bars. The active data driven structure works like a bundle of muscles. The interior skin is immersed with innumerable led and LCD panels that work together to form a large overall image or text. In this way, thank to these virtual windows, tourists would be able to experience the feeling of being on the lunar surface without having physical windows.

The first module to arrive on the lunar surface is the Maintenance Module that is equipped to perform the functions of dust control/removal, maintenance, storage and hygiene. After the Maintenance Module, comes Logistics and Accommodation Module. In consequence, the hotel is composed by 10 rigid/inflatable modules which have been transported by 5 Ares V launches. Furthermore, an inflatable reception module is successive.

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1. Form finding process

2. Hotel layout scheme

In the Accommodation module 4 rooms are placed. This solution offers the tourists and the crew a private, modern, comfortable space. The rooms are designed as 2 floors. The bathroom and communication space are in the first floor while the bed room is underground in the inflatable area. The sleeping unit is shaped according the inflated part's contour and is composed by a bed and a partially illuminated commode. The bathroom is one of the indispensable spaces of Moonia. It is equipped by a shower cabin, a washbasin, a toilet, mirror and circular shelves. The shower cabin has a special system, where its telescopic walls spread successively concentrated steam with shampoo and pure steam to the toilet. The toilet is designed with handles for comfort of tourists who are not used to the low gravity. The shelves are halves spheres embedded inside the wall.

The hotel contains also other functional modules related to the different entertainment activities. Restaurant Module has all the features required to have dinner and relax. It contains a big circular window at the centre of ceiling illuminated around. Under the window takes place circular table divided in to let enter the crew member in charge inside and serve to tourists. The dining area is surrounded by relaxing area where are installed suspended armchairs that can move up and down thanks to a telescopic bar. On the other hand, Cinema Module allows tourist to spend amusing time watching movies or just looking outside thanks to a huge window. Fitness & Training Module is a space created to make people move and have fun.

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PROJECT 7

THE RETAIL BANK IN THE FUTURE: EMERGING BUSINESS MODELS AND NEW CUSTOMER RELATIONSHIP MANAGEMENT STRATEGIES
The project aims to develop emerging concepts for retail bank branches and for electronic payments. Istituto Boella collaborates to the project

RBOF, THE RETAIL BANK IN THE FUTURE: EMERGING BUSINESS MODELS AND NEW CUSTOMER RELATIONSHIP MANAGEMENT STRATEGIES

Project Description

The challenge: Significant changes are affecting the retail banking industry in the last few years. The risk of disintermediation coming from the rise of new models such as Financial Social Networks or direct banking players, changes in the regulatory framework about payments (i.e. SEPA) and the deployment of new Information and Communication Technologies are generating a profound transformation in retail bank business and operational models. Beyond this, the recent financial turmoil has increased the pressure on retail banks’ goal of improving both their reputation and their operational efficiency. In this environment, banks are redesigning their front-office organizations to achieve full integration of three key channels: the Internet, the telephone and the physical branch. More specifically, banks are designing their internet banking platforms in order to allow customers to not only perform all transactional services (i.e. managing an account, transferring money, trading securities, controlling returns on investments), but even more complicated services (i.e. underwriting a mortgage or a credit card). Branches will not disappear, but their role will change significantly: the physical branch will be still the last line of contact for customers and the location to organize the sale of more complicated (and profitable) products. In the same way, customers’ trust will mainly be built inside the branch. In a similar way, banks will try to discourage the use of cash (whose logistics is complex and expensive) and will foster the use of electronic payments. This will have considerable implications for back-office operations and the availability of data about customers that banks can use to understand their customers’ financial habits.

The teams: The project has been developed by two students’ team. Team A was involved in designing a concept for a new branch. Team B worked on the development of a concept for mobile payments. Both teams worked in collaboration with the “Istituto Superiore Mario Boella”.

The results: Team A developed a branch concept based on more customer self-service and automation for transactional services, improved customer flow, improved comfort, ergonomics and privacy for customers. Changes in lay-out, office furniture, covering, technology and organization of work were studied in order to maintain branches’ operating costs and productivity at similar levels to the ones of current branches. The proposed concept represents a creative act in which the need for improving customer satisfaction on retail banking services, and the goal of banks to improve their operational efficiency and the efficacy of their sales activities, are combined. As such, it raised great interest at the Istituto Boella. Team B developed a concept based on the use of Near-Field-Communications technology. Students analyzed the critical factors that caused the failure of mobile payment services that were launched in the last few years (lack of investments in complementary assets such as POS networks, low usability of the device, low security in the transaction). Based on these results, and in order to foster the diffusion and the advantages of this technology, the team decided to combine the core mobile payment service with the typical recommendations functionalities that e-commerce players and social networks currently use. Evaluation of the potential diffusion of NFC-based mobile phones and payments performed through this type of device was also analyzed.
The Branch of the Future Is Here Today

**ABSTRACT**

The disintermediation process enabled by the Internet as well as new social and economic phenomena (such as the micro-credit diffusion, off-shoring trends for information-based services) and new Information and Communication Technologies (ICT) will produce a profound transformation in retail bank business models and in their customer relationship management approaches. The aim of the study is to express a vision for the trends which retail banks will face over the next 10 years. In particular, the work has the objective of understanding, in depth, the role of the physical bank branch and its evolution (or revolution) in relation to current trends. We propose both a new organization for physical layouts and of the work organization in the branch, particularly in reference to the lending of mortgage process. The project is aimed at defining the development retail banks must undertake in order to adapt to emerging trends in the technological and socio-economic context. So the principal objectives are:

- Develop a new concept for the role of the branch
- Hypothesise a possible evolution of the business model

In particular, we intend to define the concept of the branch in 2020. We observed that current branches are unsuitable or are becoming less and less useful for addressing the needs of some particular customer segments. Our idea is to propose an innovative concept by not only re-organizing existing bank networks but by giving the branch a new strategic role so that the branch needs to be both virtual and real in addition to having flexible working hours and a specific location. We will also study the connections that the branch will have in the future (and it is currently having) with the Internet Banking and the telephone channels. We have decided to approach the project with a longer term view in order to be more free in developing innovative ideas and avoid being constrained by actual concept trends and hypotheses that characterize the main players in the retail banking industry.
At the same time, we attended an EFMA conference in Istanbul on this topic in which different banks proposed their solution for a “branch of the future”, we organized a focus group with ten industry experts from European banks in this primary research and the experts gave us practical suggestions and ideas to answer their needs. The next step was to make use of a Quality Function Deployment to formulate the specifications needed to address the customers’ and retail banks needs (emerged through the results of the two focus groups) in terms of the branch of the future. Technical requirements were obtained by comparing some solutions which were adopted and illustrated by the banks present at the conference in Istanbul. The trans-disciplinary approach of the team let us transform the needs of banks and customers into some tangible values and to think about what must be done to the product design in order to fulfill the necessary requirements. At the end of the process, we obtained a priority ranking for each product requirement; in this way we were able to understand where to intervene first.

Our solution
The physical branch responds to the questions and the necessities we found by trying to include all of our decisions into an interior design environment and connecting it to the new asset of the customers’ roles. The project is a prototype of a medium largeness branch; it is designed in 2d in order to understand spaces and the human relations into them; we also propose a 3d model where the materials and the interior perception are shown to obtain a pleasant and interactive branch (interactions being between the customers, employees and the physical space). The interior space we propose is composed of different areas visually separated by opaque and transparent glasses and the use of materials; at the same time all of the areas are in the same environment, in the way to create a unique space where the customer could understand the function of the zone he is acting in. To create a more familiar environment, we eliminated the barriers between the exterior and the interior, and a “meeter and greeter” welcomes the customer at the entrance. There is also an area provided with kiosks, open 24 hours a day for 7 days, where customers can perform every transactional service at an “advanced ATM”. The waiting time due to queues is not passive, because customers can be informed about bank products in many ways, with a pull approach; in fact we provide three different solutions: 1. a relaxation area, in the centre of the branch, with magazines, newspapers and a LCD screen which provide information about bank services. 2. a tablet PC area, where the customer can be trained by bank’s employees on how to use the internet services of the bank, read about promotional products and download informative materials on his mobile phone. 3. a retail area, where information about products promoted by the bank are provided. 4. with regards to branch services, the project plans three offices to perform counter services, one office for the financial promoter and one for the director; moreover there is an area devoted to small businesses. The number of employees is equal to 6, plus a promoter in the retail area, who may not be a bank’s employee.
Smart Money

ABSTRACT

The goal of the project is to aid retail banks in facing the threats and the opportunities offered by recent changes in technologies and regulations. The introduction of new regulations (i.e. the Single European Payment Area) could affect the traditional role of the bank by facilitating the creation of new payment instruments. Retail banks thus need to propose and foster innovative payment services in order to retain old customers and attract new ones. In Italy, cash is currently the most widespread form of payment: this situation does not bring any benefit to the bank because cash is not related to the customer's identity and does not provide any revenue. Furthermore, cash is highly expensive due to complex logistics and security reasons. In our project, we focused on possibilities provided by mobile technologies in order to develop new payment services that are capable of gaining customer acceptance thus reducing the usage of cash. The project is developed from a technical, economic and social point of view. The starting point was the analysis of the different payment methodologies alternative to cash. Then we decided to exploit the mobile Near Field Communication (NFC) technology for its all advantages in speed, security, usability. The usage of the mobile phone as a payment device allows for the development of services with a real strong value proposition for both banks, customers and merchants. Smart Money is the service concept resulting from this initial study. It not only provides an innovative payment method but offers a deep value proposition to the customer and the shopping environment.

UNDERSTANDING THE PROBLEM

Banks are facing some challenges due to the new SEPA and PSD regulations and due to the risk of being dis-intermediated by the entrance of new players in the payment market. The main issue of the project is to help retail banks in assessing the threats and opportunities offered by these recent changes. Furthermore, banks need to reduce cash, which is very expensive to manage (in Europe, in 2002, the total cost of cash was about 0.5% of total transactions). Currently, 85% of total transactions in Italy are made using cash, and 80% of cash transactions are of small amount (0-25E). Non-cash transactions in Italy now are made mainly by cards, direct debits and credit transfers, and are expected to grow in coming years (while cheques are expected to disappear after 2013): the number of non-cash transactions per inhabitant is expected to double in the next four years. So, after analyzing future payment trends, the focus of the project was on the development of electronic based payment services. This project started by identifying bank needs and fears and by exploring the current payment scenarios and how the opportunities offered by new regulations and technologies could be exploited.

The mobile phone has been identified as the key device over which to build an innovative payment method; it could provide an enriched shopping experience to the customer, particularly for small amounts of money. This solution can help banks in retaining their image by offering an innovative service that can stimulate loyalty, attract new customers and moreover reduce the amount of cash transactions.

EXPLORING THE OPPORTUNITIES

The current scenario on payments systems has been analyzed in depth in the first phase of the RBOF project. A state of the art analysis clearly revealed that cash represents the main cost for banks; this is mainly due to opportunity costs as well as security and logistics reasons. So we have considered the reduction of cash usage as the main objective to be pursued in this project. In recent years, the use of credit/debit cards has grown significantly all over the world. However, especially in Italy, card payments still represent a tiny percentage of the total payments value, approximately 2%. Nevertheless the usage of non-cash payment instruments is increasing and cards are slowly replacing cash, even for low-value payments. We focused our analysis on identifying possible solutions that could make electronic payment systems more appealing. The challenge in identifying a reasonable solution was to provide enough advantages to all stakeholders involved in the payment process. In particular, we are analyzing the situation of clients, merchants and banks. Each of these stakeholders requires the new payment system to offer an added value with respect to cash, in order to be willing to switch from the old to the new payment method. The most interesting solution that we have identified consists in promoting the use of the mobile phone as a new payment instrument. Nowadays about half of the global population has a mobile phone and in Europe the number of mobiles per person is even greater than one. We therefore considered exploiting the widespread distribution of mobile systems and also using them for payments using NFC as the enabling technology. We decided to promote the use of mobile systems as payment instruments through the implementation of a social network which is able to connect groups of customers. In this way customers are able to see the recommendations of friends in their network and to see comments and ratings about the products which they may be interested in. Moreover, they are able to release feedbacks on the products they have bought, thereby providing useful information to other customers. In addition, for every payment done through mobile systems customers receive bonuses which can be used to have access to promotions and discounts and which in turn have been conceived as an additional way of incentivizing the use of this new payment instrument. Respectively, in case of cash, merchants can collect information about their clients and, by processing it, are able to offer targeted promotions to their clients. With regards to banks, the expected result is to significantly reduce the usage of cash with a strong and positive impact on the bank's operational costs. Furthermore, by proposing the intro-
and banks. Payments does not simply mean changing the payment instrument but offering great added value to customers, merchants and banks.

GENERATING A SOLUTION

Smart Money is an enriched payment service that integrates the payment functionality into mobile phones, thus allowing for deeper interaction in the customer and the shopping environment. The concept focuses on multimedia/books/music/movies stores (e.g. FNAC, Mediaworld...) and aims at implementing interactive and attractive service for each book/disc/dvd it is possible to download, directly from the shelves, additional information, as well as other customers' feedbacks and reviews; 3. these stores are divided into specific thematic areas: this allows to place different interactive advertisement devices which display promotions related to the thematic area; 4. event ticketing is often offered by these stores: downloading an e-ticket through the mobile phone can be a very attractive alternative with respect to the traditional paper ticketing.

The concept stakeholders are customers, retail banks, merchants and mobile phone operators. The idea is developed by primarily focusing on the need of retail banks to retain customers, attract new ones and, moreover, reduce the expensive usage of cash payments. For these reasons the aim of Smart Money concept is to propose an attractive application that can incentivize the distribution of magnetic cards in the case of micro-payments. The project evaluates some realistic perspectives about the evolution of this payment method.

NFC mobile phones are considered the core device on which the concept is built. This technology is selected since it can provide a secure, fast and channel without physical contacts through which the payment information can be exchanged. Furthermore, it is assumed that customer's mobile phones have a flat-rate connection to the Internet in order to interact and access the online contents offered by the service.

The concept is based on the strong assumption that NFC will gain massive distribution in the next years. This assumption reflects the common opinion of key retail banking experts: NFC has the potential to be a complementary technology of magnetic cards in the case of micro-payments. The project evolves some realistic perspectives about the evolution of this payment method, during the period from 2009 to 2030, by applying the Bass diffusion model and by creating some scenarios that combine different significant variables (i.e. transaction volumes, learning curves, diffusion of contactless POS and NFC phones).

Smart Money service is developed by a retail bank in partnership with the multimedia retail company. The bank must implement an electronic wallet mechanism which can be accessed and used from the NFC mobile phone and can be recharged through the customer's bank account or through a credit card payment from the customer's personal page on the website.

1. The web page we designed to communicate the service
2. An example of the retail network interface
3. A scheme of the main benefits the stakeholders will have using the service
4. targeted offers and promotions that can be downloaded from LCD/RFID panels to the mobile;

From the technological point of view, four main device are considered:

1. Customer’s NFC mobile phone.
2. Merchant’s NFC POS (which can be a NFC mobile too).
3. LCD panels with RFID tags in order to show interactive advertisements to customers in the shop.
4. Web portal that allows the user to manage his account, check his expenses, write feedbacks and reviews on purchased items and read feedbacks and reviews produced by other users (friends + integration with major social networks).

The data coming from the merchant about customers purchases and interests can be used by the bank and by the merchant in order to profile customers and offer attractive targeted promotions through the customer’s personal page as well as through messages on the user’s mobile phone.

MAIN BIBLIOGRAPHIC REFERENCES

NEW SOLAR
A new generation of solar cells

Project Description

The challenge
• To create a world free of carbon emissions, where power is plentiful, safe and truly green and where even the most remote village has Internet access and with light in every home, including aesthetic solutions for buildings.
• To mimic the energy production in plant leaves, creating artificial photosynthesis in a new kind of solar cells – dye sensitized solar cells (DSSC) – which are not yet in the market but which could represent a cost-effective alternative to silicon and thin film-based systems.
• To explore solutions aimed at improving competitiveness by implementing new production processes and by suggesting potential applications and new business opportunities, thereby creating the highest level of design flexibility without compromising between aesthetics and functionality.

The teams
• Two teams, one focused on solar energy conversion in buildings, roofs and facades; the other studying flexible cells for portable electronic devices.

The results
• Analysis of the predictable performances of the dye sensitized solar cells, and comparison with those of current solar photovoltaic technologies.
• Identification of possible compromises between best performances and cost; proposal of process implementations to improve DSSC technology in order to take advantage of a faster entrance in the market.
• Design of DSSC-based objects and structures, related to the idea of being “green”, generating electricity even indoors and in low light conditions, without a tradeoff between aesthetics and functionality.
Building Integrated Photovoltaics

Abstract

Energy plays a role of primary importance in our society, but the constraint of fossil fuels reserves along with issues related to pollution are resulting in an effort to enhance the efficiency of energy processes in addition to reducing their losses and promoting renewable energy sources. One of the most interesting renewable energy forms is Photovoltaics. Solar radiation, widely available all over the world, free and inexhaustible, is used to produce electricity. However, despite its relatively high power density, the related cost of energy production is significantly higher compared to traditional energy sources. As a result, research is focused on the development of cheaper PV cells, such as DSSCs - very promising electrochemical devices where the process of conversion of solar energy into electricity is promoted by dye molecules linked to a nanocrystalline TiO2 layer. DSSC are characterized by a low cost of raw materials and production, moderate efficiency, partial transparency, and related aesthetic qualities, light weight, flexibility, in addition to being capable of working in the absence of direct light. Although the principle of functioning is not completely clear yet, DSSC might represent a very competitive technology. The objective of the present work is to investigate the strengths and weaknesses of DSSC in order to find out innovative and competitive applications linked to the integration of solar modules in buildings. A scientific study on the principles of functioning of these cells and an in-depth analysis on materials and processes are carried out as a basis for the definition of their properties.

After that, the general trends and needs of potential customers have been investigated in order to suggest innovative architectural applications; two were selected among these, and analysed in detail: the first one is feasible in the short term, while the second one is more futuristic and creative, yet not completely feasible at the current state of development.

Understanding the Problem

Technological development of society has resulted in increasing energy demands. However, progressive depletion of fossil energy reserves, on the one hand, along with the environmental consequences of their combustion, on the other hand, have been matter of concern lately. As a result, increasing interest has focused on renewable energy sources, solar energy representing their primary form. Nevertheless, photovoltaic energy still has significantly higher costs with respect to other energy sources, and efforts have focused on the development of a new generation of low costs PV cells. Furthermore, some general trends have emerged from society in the last years which could also affect its relationship with energy supply and that should therefore serve as a basis for the identification of appropriate solutions. The tendency of people to travel more and more and to change locations frequently, with the relevant problems of moving their lifestyle items with them, calls for a first key issue: flexibility. A second major trend is the use of energy while in motion, and the related problems of recharging portable electronic devices. Finally, another important issue that is gaining importance in modern society is sustainability and equity, given that energy and food independency in poor regions are key factors in implementing development strategies. Hence the necessity of developing a solution that is capable of coupling low costs for renewable energy production with the required flexibility and mobility and in a sustainable and equitable manner. DSSC technology, if properly implemented, might represent a good solution to such requirements. The purpose of the present work is to identify suitable applications, particularly those related to the architectural integration of such devices.

Exploring the Opportunities

The term "photovoltaics" indicates a wide group of different technologies which have been organised into three categories: first, second and third generation. The 1st generation solar cells are silicon-based. This technology is quite mature and efficiencies have been measured higher than 20%. Its main drawback is the substantial impossibility to reduce production costs. The 2nd generation of solar cells was developed to reduce production costs and is based on the use of a thin film of PV material. Despite efforts to reduce costs, their commercialisation has not yet reached the desired results yet.

Tasks & Skills

Stefania Butura, analyzed the environmental performances of DSSC modules as well as their sustainability and suggested many potential innovative applications in addition to contributing to the analysis of their technical aspects and environmental impacts. She also coordinated the team’s work and contributions to the project.

Paolo Grassi, investigated the properties and the cost of DSSCs, carrying out a systematic comparison with other standard photovoltaic technologies. He also coped with some technical issues of the proposed applications, particularly the electric configurations.

Filippo Marchione, studied the state of the art of DSSCs, their functioning, their processing technologies and critical points.

Elena Scripelliti, strongly contributed towards the identification of building integrated applications of DSSC modules, in particular, she addressed the issue of the indoor and outdoor architectural integration of panels, both from a conceptual and graphical perspective.

Angel Trifonov, carried out the marketability analysis of DSSC technology and thoroughly investigated the needs of all relevant stakeholders and the potential customers. He also gave a fundamental contribution to the brainstorming session by proposing innovative and groundbreaking solutions.
The 3rd generation was developed to achieve a strongly competitive cost/efficiency ratio, either with very high efficiencies but high costs, or with moderate efficiency but cheap devices (η=15-20%). Dye Sensitised Solar Cells, invented by Grätzel and O'Regan in 1991, belong to the latter category. DSSCs have many interesting features; first of all, they are able to produce energy even in absence of direct incident solar radiation. As a consequence, although their efficiency (a value of 8% was assumed from scientific literature) is actually lower than traditional PVs, the overall amount of energy collected is comparable.

On the other hand, the long-term stability of DSSC is quite a debated issue. The cells' degradation mechanisms are not fully understood yet. The cells' degradation mechanisms are not fully understood yet. Furthermore, the costs for materials and processes are low, and the assembling of the modules is relatively easy. Another strength point of these cells is that they are aesthetically enjoyable, partially transparent and can be realised in different colours. Finally, they have a low weight and can be either rigid or flexible, depending on the substrate. All these features make DSSCs rather interesting for building integrated applications, and indoor uses may be considered as well.

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The aim of this work is to analyze organic photovoltaic technologies by focusing, in particular, on dye sensitized solar cells (DSSCs), in addition to studying their potential as an energy supply system for portable devices. A multidisciplinary approach is necessary in order to handle the complexity of the subject (Luzzi for Dyenoel, 2nd International Conference on the Industrialization of DSC, St. Gallen, 13-09-2007), making DSSC perfect for an ASP project. Complexity in DSSC technology arises primarily from the fact that the technology is still not well defined: thousands of materials are referred to in the literature and many of them are not well characterized yet (Schubert for IOLITEC, DSC Industrialization Conference, 2007), moreover, a standard device has still to be settled and procedures for certification are not ready as well (Hinsch for Fraunhofer ISE, 2nd International Conference on the Industrialization of DSC, St. Gallen 11-09-2007). The first part of our work is focused on describing the characteristics of the main photovoltaic technologies. Subsequently, the team performed a more in-depth study of DSSC technology in order to present nowadays state of the art, both in terms of technological principles and characteristics of the cells. In the following chapter, the weaknesses and strengths of DSSC technology are discussed from the perspective of addressing the right field of application; within this analysis, the team has carried out a comparison with other thin-film technologies that represent the most likely competitors on the market. In the last chapters, the team proposes potential solutions on two different levels. From a technical point of view, the suggestions aim at improving DSSC competitiveness by implementing new production processes and by testing and eventually adopting new materials. From a market perspective, the team suggests potential applications and new business opportunities, ranging from the solar umbrella to a solar modular fabric to be sold as a B2B product.
roll-to-roll process. A second promising field for applied research concerns biocompatible electrolytes and biodegradable materials which can substitute plastics. These steps are needed in the future in order to further reduce environmental impact and to create an opportunity for new fields of application, for instance in the medical industry. In addition to this, a roll to roll process can be implemented for the production of integrated devices; integration of different functionalities in a singular device is possible in biosensors, screens, batteries, scanners, electronic newspapers, medical disposables, labels, RFID tags, etc. Integration is nowadays considered the main driver for technology implementation and availability.

Technical aspects only assume a secondary position in this scenario; it doesn’t matter how the device itself works, but the message it communicates. However, the realization of fashionable design items is related to the feasibility of ad-hoc productions that still have to be implemented for continuous processes. Industrial facilities and knowledge become central in defining winners and losers. Finally, new opportunities that are not directly connected to cell production or utilization, like the development of companies specialized in implementing industrial facilities or in designing new integrated systems are made possible by cheap solar cells availability.

**Generating a solution**

**Technical solutions**

Since complexity in dealing with DSSC technology arises from the large amount of different state of the art solutions reported, the introduction of new materials was not the main focus of the work; however, the team has found the introduction of many alternative solutions to be promising, including carbon nanotubes, fluorescent polymers and biocompatible materials. Process implementation was also considered to improve DSSC technology. In particular, available techniques were preferred to futuristic solutions in order to take advantage of a faster entrance in the market.

A roll-to-roll process is proposed for the production of scalable, light, transparent DSSC devices with low environmental cost. PET is suggested as substrate; PL passages for the production of a metal grid, capable of granting scalability, are inserted at the beginning of the process, and followed by ITO deposition in vacuum; afterwards, TiO2 is deposited and an UV irradiation step is considered to grant sintering. Ink-jet printing for dye deposition is then suggested. Finally, electrolyte chosen, were not univocally indicated. Technical solutions, such as the introduction of a metal grid, can push opportunities even further forward.

**Business solutions**

Tackling the problem from a business perspective, the team identified two main opportunities that deserve to be analyzed in more depth.

First, a new firm could try to enter the market as a futuristic cloth supplier. This means producing modular frames that could later be used to manufacture clothes or fashion objects, but which are also able to perform specific solutions: abandoning the idea of modularity improves devices esthethical appearance. DSSC technology for advertisement is the second proposal. The substitution of PV silicon panels in urban integrated systems is already feasible: companies can be interested in committing personalized frames for some billboards made of DSSC, thereby generating public awareness. Market entrance of cheap plastic DSSC or OPV systems, potentially integrated with an OLED display, can push opportunities even further forward.

**Applications and design**

Finally, applications are considered and new design ideas are generated. Due to their versatility in term of flexibility as well as a fashionable aesthetic impact, achievable through the proper modulation of dyes, DSSCs can be generally implemented in many devices and used either in common life or luxury items. This feature could foster a revolutionary change in the conception of energy: from a centralized service to a delocalized and transmitted concept as the drivers for innovation.

With regards to applications, the transparency, lightness and opportunity of colorful frames, obtainable through the utilization of materials related to the idea of being “green”. Indeed, if appearance of colorful frames, obtainable through the utilization of green energy revolution. The Solar Bag can easily integrate DSSC solar cells by stimulating, through fashion, the idea of a green energy revolution. A portable and fashionable energy producer, the Solar Bag is an emblematic solution. Printing on a cloth like a normal plastic film. In the reported example, semi-transparency grants the opportunity for all day sun exposure without reducing too much luminosity of internal spaces. In more depth.
AdMIRE 2
Advanced Mobile Intelligence and Reactive Environments

Paola Franzosi
Engineering, Politecnico di Milano

Pietro Patelli
Architecture

Federica Pecoraro
Engineering for Cinema and Methods of Communications

Antonio Monestrelli
Architecture and Planning, Politecnico di Milano

Alessandro Juan Manuel Repetto
Engineering Computing Systems

Daniele Casulli
Team controller

Mostafa Sharaf

Paola Bertola
Industrial Design, Art, Communication and Fashion, Politecnico di Milano

Franca Garzotto
Electronic and Information, Politecnico di Milano

Luigi Buzzacchi
Bianca Boretti
Giovanni Azzone
Michela Arnaboldi
Marco Ajmone Marsan
Paolo Paolini
Franca Garzotto

Principal Academic Tutors

Paola Di Blassi
Electronic and Information, Politecnico di Milano

Nicoletta di Blas
Electronic and Information, Politecnico di Milano

Barbara Di Santo
Electronic and Information, Politecnico di Milano

Paolo Paolini
Electronic and Information, Politecnico di Milano

Multidisciplinarity and Innovation

Electronics and Information, Politecnico di Torino

Production Systems and Business Economics, Politecnico di Milano

Electronics and Information, Engineering, Politecnico di Milano

Management, Economics and Industrial Electronics, Politecnico di Torino

Politecnico di Milano

Politecnico di Milano

Politecnico di Milano

Politecnico di Milano

Computer Engineering for Cinema and Methods of Communications

Environmental friendly product Design

Modigliani institute

Using and visualizing the physical appear-
ance of the environment, for different places and situations.

Defining the user experience, the environment, the protocols, implement-
ing the necessary software and interfaces, making the necessary economic assessment.

The teams

The specific assignments for TEAM A were:

Defining and implementing an architecture to support the functionalities.

Defining a suitable architecture supporting the functionalities.

TEAM A

TEAM B

Defining mobile interfaces for different functionalities, includ-
ing "down" upload, "upload", "downstreaming".

Developing and implementing an architecture for the project vision.

Developing all the necessary components for the mobile devices.

The specific assignments for TEAM B were:

Defining mobile interfaces for different functionalities, includ-
ing "down" upload, "upload", "downstreaming".

Developing and implementing an architecture for the project vision.

Developing all the necessary components for the mobile devices.

The specific assignments for TEAM A were:

Defining mobile interfaces for different functionalities, including both direct control over individual appliances, or overall control of the global environment.

The challenge

AdMIRE combines the "presence everywhere" of ICT and the mobile devices, thereby becoming the "personal" technology tool.

TEAM A

The specific assignments for TEAM A were:

Defining and prototyping interfaces for the new functionalities of the mobile devices.

Defining a suitable architecture supporting the functionalities.

Layering the solution in different protocols: from user level, to an intermediate generic level, to a (device specific) low level protocol.

TEAM B has achieved a number of interesting results as well:

Developing drivers and low level protocol for real devices.

A conceptualization of a new "user experience" for using the mobile device during the shopping experience.

A new business idea and the planning of a start up company providing applications for Apple iPhone, related to made in Italy's shopping experiences (food, fashion, design).

The complete interface for a new application related to food shopping and services named iEat.

A suitable architecture supporting all the functionalities of the new application.

A functioning prototype of the application, integrated with wireless and data networks of supermarkets.

TEAM A has achieved a number of interesting results as well:

A conceptualization of the "user experience" in providing innovative features, based on mobile devices, in different environments, specifically home and public spaces.

Defining the "concept" for interactive installation.

Defining and prototyping interfaces for the new functional-
ities of the mobile devices.

A conceptualization of the "user experience" in providing innovative features, based on mobile devices, in different environments, specifically home and public spaces.

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Defining and prototyping interfaces for the new functionalities of the mobile devices.
ABSTRACT

ADMIRE research project aims at putting smart mobile devices at the center of a new concept of User Experience by creating a natural and immediate interaction between people and their environment, taking place everywhere and at every time [1]. Namely the main goal of this project is the creation of an immersive experience where control over the physical environment is actualized through the mobile phone and by means of a pervasive computing approach. In our vision the mobile phone is not only a universal remote controller but it also hosts the artificial intelligence capable of controlling the elements of the environment through both a profile-based and real-time approach. The complexity is hidden from the end users and the information processing dissolves in behavior.

The team explored a wide spectrum of domotic functionalities, home automation appliances and services covering environmental, security and safety controls as well as entertainment and communications; then the focus shifted to the design of a multi-sensorial experience in an immersive atmosphere involving a dynamic composition of elements, such as sounds, lights, colors, aromas, water and vapor, that we refer to as the hard, soft and digital realms of space. In order to coordinate these situations and transitions we developed the I-Domo application. The technological approach adopted is based on a service-oriented architecture. This choice provides unlimited flexibility: it allows for the different technological modules on the server side, without any constraints on the client side. 1-Domo’s results involve the building of an intuitive, user-friendly and elegant interface, a flexible rich interior design and a ubiquitous technological paradigm. Research is currently focused on innovative solutions applied to private or semiprivate environments, but the 1-Domo paradigm can be extended also to public spaces, being the customization of a shared environment a major challenge for future developments.

UNDERSTANDING THE PROBLEM

In the last few years ubiquitous computing has grown in popularity. From PDA to mobile phones, from GPS applications to domestic appliances, technology is silently permeating our daily routines [2].

In this scenario, the work site, the home, the avenue are transformed into locations where information is processed and gathered. In particular, all habits of daily life (as the way to manage the electrical appliances, purchase groceries or watch TV) turn into a chance to interact with technological devices in a spontaneous and ordinary manner. Nowadays, buildings have intelligence distributed everywhere (air conditioning, electrical appliances, televisions, home theatre, computers) which – combined with the ever-increasing popularity of wireless technologies – allows for complete control of the domestic environment. The mobile phone is the ideal interface to manage an environment: it is portable, always on, and allows for access to the home’s functionalities regardless of the user’s position (at home or away). This extreme versatility permits the use to easily interact with the house while allowing for flexible use of systems like surveillance, entertainment, energy consumption and so on.

EXPLORING THE OPPORTUNITIES

The I-Domo proposal involves remodelling our lives around a non-invasive paradigm where people would interact with a responsive environment fluently and naturally.

A lot has been written about reactive environments [3] and mobile technology; however, very few previous works exist on the combination of these two concepts. In I-Domo, the iPhone processing becomes a wearable universal control tool which offers the consumers “anywhere-anytime” access to their house while keeping track of the user’s state, needs, preferences and options available at any precise moment. All information becomes accessible from “anywhere-anytime” and delivered in a way which is appropriate for the user’s location and environment.

One of the major challenges faced by the team was putting together existing technological modules. In fact, considering the fact that single intelligent blocks are already available in the house market, the challenge was to eliminate all remote controllers, all user interfaces and different access terminals to easily manage a “domotic house”. Furthermore, the intelligent systems of today are very expensive for the mass market; they are not scalable and not accessible remotely.

1-Domo proposes to build the basic architecture for implementing smart controllers operating in reactive environments. Compared to traditional domestic schemes, intelligence does not reside in a single central computer but on a distributed system. The mobile device becomes the centre of our lives and it is used as a controller of the global environment as well as a “content repository” of the information exchanged with other people or...
devices and as an intelligent system keeping trace of the user's history. In these home control scenarios, interoperability and communication between devices play a fundamental role. Although a single standard would be strongly desirable, the actual coexistence of multiple communication strategies had to be managed, considering that each of them meets specific unique demands. However, I-Domo's approach to a reactive environment goes beyond standard control functionalities: the ideal home should be able to understand the habits of its hosts, foreseeing actions or even hazardous situations while fully exploiting the technological possibilities of the environment.

**Generating a Solution**

The research team attempted to find a still unexplored area of study that could consider a partnership with Teuco company. The choice of working on the concept of a “bathroom of the future” resulted as the most appropriate. We imagined a highly technological, exciting and extremely customizable space where the edges between public and private spaces are blurred. We have faced social and behavioral challenges in our reinterpretation of the bathroom environment from a functional configuration to a housing and living space, used for relax, wellness, body care, but also for content fruition and social interaction, a radical design, both visionary and factual at the same time, makes this vision tangible and becomes a key point for the I-Domo project. In order to accomplish our goals we have defined some strictly interdependent sub-tasks:

- implementation of a pervasive, ubiquitous technology,
- development of a multi-sensorial experience in an immersive atmosphere,
- definition of a hybrid functional program,
- design of the architectural features,
- design of the user interface.

From the technical point of view the solution has three levels and each level defines a protocol: the user level interface, the high level interface and the low level interface. The user level interface mainly refers to human computer interaction (HCI) design; the intermediate level plays the role of middleware, acting as a broker between mobile devices messages (using SOA) and low level messages (using bit-level communication) sent to the domotic devices; the low level protocol defines an electronic communication standard for managing sensors and controllers. The greatest advantage of this model is its ability to easily mix and integrate different services, combined with its scalability properties. This flexibility has allowed us to manage a wide range of domotic devices without changing the proposed architecture. Simple client-server architecture would need extensive adjustments each time a device is added to the environment. Furthermore, the integration between new and old devices would be very complex. With respect to the factual technology, the team selected the Apple iPhone as a smart controller due to its forecasted growth in market-share, as suggested by international research. Moreover, its usability has been considered a good start to develop new experiences; its multi-level touch screen would offer interesting interface opportunities and should enhance our idea of effortless and natural interaction with technology.

The I-Domo experience has two levels of complexity. First, the I-Domo application is used to manage, automatically or remotely, the basic functionalities of the house, such as light controls, the security and intercom system, room temperature, energy savings, the tub temperature and spa with efficient controls and easily handled devices. Then I-Domo allows the user to recreate an immersive environment displaying multimedia content on the off-white surfaces of the bathroom.

**Main Bibliographic References**

Food shopping and technology

As a matter of fact food and technology relationship has become closer and closer in the last years. Looking at already existing solutions and newly arising trends, it was realized that many experiments were carried out in recent years on new ways of interaction using technology directly with customers in order to improve the shopping experience in stores for food and other products. The team focused its attention and researches on such trends in order to provide innovative solutions.

**ABSTRACT**

The project developed by Team B is related to the creation of a start-up, MADit, whose mission is to combine the quality of “made in Italy” with technology, using a single device. The company presents different levels of detail, in order to visualize the user experience. With a simple application the buyer becomes an interactive user of the supermarket: he can get detailed product information, scan the products and pay them directly via mobile, he can leave and read comments on his purchases, in a 2.0 social network view; he can receive suggestions and other contents from the supermarket system in order to discover new products and useful information.

The business team conducted a detailed analysis of the market, considering both supermarket and mobile state of the art, as well as existing points of overlap, moreover, considering the direct and indirect competitors, the device and the strategy to enter the market were chosen after evaluating opportunities and risks. The technology team concretely implemented indications and inputs: iPhone was chosen as a device and the technology to realize the vision was also defined; the product scan is obtained using the iPhone camera and the RedLaser Software Development Kit (SDK). The payment is not concretely developed, but the system is designed to obtain it by using widely spread SIM cards.

The design team initially investigated different potential applications of AdMIRE technology and then focused on the thematic area of food promotions and sales. Scenarios of use were elaborated, with different levels of detail, in order to visualize the user experience enhanced by iEat, and to structure the user interface. All the sub-teams worked in strict cooperation and contribution, with a continuous exchange of inputs and observations. The final result is the prototype of iEat Application, intended as a starting point to show its potential and the main features that integrate the scan phase of a product within the mobile application.

**GENERATING A SOLUTION**

A first concrete application deriving from MADit vision is the “iEat” system based on the Apple iPhone, it changes the way to experience shopping. With a simple application the buyer becomes an interactive user of the supermarket: he can get detailed product information, scan the products and pay them directly via mobile, he can leave and read comments on his purchases, in a 2.0 social network view; he can receive suggestions and other contents from the supermarket system in order to discover new products and useful information.

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**UNDERSTANDING THE PROBLEM**

The AdMIRE Project features interactive, rich contents and mobile technology. They are the means which transform a mobile device into an intelligent access point for the sake of hi-tech services and contents forming the frontier of reactive environments. Based on this concept, the food shop scenario was developed. In addition, the team was inspired by looking at current examples of ad-hoc applications dealing with user experiences, even though they did not satisfy most of the key principles of interactivity, user-friendliness, richness of contents, community and information quality. The research has consequently focused on two parallel paths: AdMIRE’s System architecture and AdMIRE’s mobile application. This involved adapting and integrating the first into the chosen scenario and developing the second on one of the latest mobile technologies as well as on the most successful mobile device, the “iPhone”.

**THE TEAM**

**TASKS & SKILLS**

Luca Ricci, Laura Brunet, Elisa Gabriela Emery Gaona. As design team, they investigated virtual and physical food shops, associations for food promotion and culture. The analysis focused on specific trends, like organic and high quality food, and on the customers’ interactions with it. With this background, they came up with the concept for the iEat application and the design of the scenarios of interaction in the daily life of the users. Finally, comprehensive research on iOs led to the design of the user interface and of the look-and-feel of the application.

Stefano Crespi, Mostafa Sharaf. As technology team, they analyzed the current state of the art, exploring existing solutions in the market and options for the system architecture; they also performed the Requirements & Design analysis for the actual iEat Application in strict collaboration with the designers in addition to working on the implementation of iEat Prototype. They concluded with the testing phase in order to assure correctness and satisfactory user experience.

Donato Pietragalla, Elena Pelizza. As business team, they followed the decision making process to choose the appropriate mobile device and technology. Moreover, they completed the business analysis, exploring the appeal and feasibility of the application, in order to create a business plan of iEat and MADit, a start-up to provide mobile applications related to “made in Italy” shopping experiences.

**THE PROTOTYPING PROCESS**

A first concrete application deriving from MADit vision is the “iEat” system based on the Apple iPhone, it changes the way to experience shopping. With a simple application the buyer becomes an interactive user of the supermarket: he can get detailed product information, scan the products and pay them directly via mobile, he can leave and read comments on his purchases, in a 2.0 social network view; he can receive suggestions and other contents from the supermarket system in order to discover new products and useful information.

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As already mentioned the bridging between the two levels is done through wi-fi communication, either with direct access to the internet for services like YouTube videos, general contents or maps, or consuming ad-hoc services developed (e.g. web-services). The implementation has been performed by following Apple directives for iPhone apps development as much as possible in terms of architecture design (MVC and delegation patterns), user experience (simple and friendly interfaces), performance (reactivity, memory management and graphical optimizations), accessibility and general standards.

The user interface combines the user-friendliness of iPhone and touch-screen input with a simple and elegant graphics style made of basic elements that exalt the numerous pictures of food and touch-screen input with a simple and elegant graphics style made of basic elements that exalt the numerous pictures of food to purchase and the results of suggested recipes.

As pointed out, iEat is based on iPhone, and the mission of this application is to allow the user to communicate with a supermarket environment. In fact, after analyzing the two markets, it was noted that supermarkets are more and more interested in mobiles and in the introduction of new ways of payment (“mobile enabled” payment). iEat starts from all these features to build an application which accompanies the user in the whole shopping experience, and together with the new concept of shopping integrated) or because of the traditional experience the costumers have in the supermarkets.

MADit startup
MADit is the start up that has to combine “made in Italy” quality and technology in the real world. It is a company where the business runs around the development of services as a mean to address advertisements and other innovative services based on the typology of the firm: the idea is to be efficient and not invasive in order to create an enjoyable application.

Its core philosophy is that supplied services must change the user experience of everyday life by introducing the paradigm “intelligence” of the mobiles to create new business. MADit is created by a group of young and motivated people who are enthusiastic to enter the market with an innovative start-up. The originality of the team is the variety of backgrounds of the singular person. In fact, the members belong to several technical areas (design, informatics and media). Moreover, the members of the group have an international vocation: the team is composed of people coming from different part of the world and which have worked in several countries (Mexico, U.S.A., Switzerland, Egypt and Japan). This also implies an opportunity to run the company with a global vision.

The 11th Conference on Human-Computer Interaction (HCII), ACM, Bonn, 2009

Main Bibliographic References
**WiFi-4-Energy**

**Project Description**

**The Challenge**
Energy efficiency and green buildings are an important challenge for developed countries in order to achieve the commitments of the Kyoto Protocol. In this field, the WF4E project’s aim was to identify and define solutions for energy retrofitting, environmental monitoring, as well as controls and energy savings in large and complex buildings. Moreover, the goal was to determine strategies by using multidisciplinary techniques and, in particular, by exploiting wireless sensor networks (WSNs).

From this perspective, it is necessary to perform an overall analysis evaluating the energy inflows and outflows of a system in order to identify factors that affect energy consumption and waste. To obtain a simple and effective sensor system, only the most influential among these factors are taken into account and used to determine the most significant variables that need to be monitored. Finally, an effective user interface has to be defined to display the data gathered by the sensors and to highlight anomalies and wastes as well as to solve critical situations and increase energy consciousness in users with the general goal of energy saving in a comfortable environment.

**The Teams**
Team A focused on the analysis and implementation of the wireless sensors network. They carried out a technical feasibility analysis of a monitoring system, defined an appropriate ICT technology, designed a proper topology for the network and chose an effective communication protocol. Economic matters have also been taken into account in order to perform a feasibility analysis with respect to costs and savings associated with the designed system. Team B focused on the analysis of a suitable human-data interface, capable of providing real-time environmental monitoring and controls as well as displaying the real-time situation of a given environment in addition to providing future forecasts. Implementations and feasibility studies have been carried out in order to validate the results. In addition, specific attention has been paid to communication solutions capable of increasing energy awareness in users.

**The Results**
The innovative idea that has driven both teams was based on a different approach concerning energy management. Based on evidence, the comfort of users has always been considered during the design phase of modern buildings. However, it has never been monitored nor controlled during the operative life cycle and the focus in energy management is mainly devoted to energy saving.

The general idea was therefore to develop an ongoing commissioning system composed of a suitable network of sensors capable of detecting the most significant parameters, and a strong and powerful control interface. This system focused on the importance of controlling both energy consumption and the comfort situation of the given environment. The project demonstrated the feasibility of the WSN technology for energy applications.

Moreover, it explored different potential future developments. On the one hand, the introduction of additional features (e.g., integrating monitoring with automatic control of plants, so that anomalies revealed by sensors can be rapidly adjusted) has been considered. On the other hand, the teams conceived particular innovative applications of their commissioning system. With only a few corrections, it could be applied in different scenarios ranging from large and complex buildings (e.g., private residences) to even transportation. In general, all environments where energy saving and comfort represent a twofold objective may be eligible for such applications.
The starting point of this project's work is the awareness of some limits that affect current approaches to the topic of improving energetic performance of complex buildings, an issue that has become essential nowadays given the significant role that the building sector has in energy consumption and CO₂ emissions. Currently available solutions are mainly concerned with the efficiency of plants and materials, in accordance with limitations imposed by laws and standards (whether mandatory or not). These kinds of actions, however, do not ensure that people who live in the building perceive a comfortable environment. Moreover, if no ad hoc measures are taken to check if the energy performance is maintained over time, the building operation will likely result in being far from the energetic/techno-economic optimum.

For this reason, our innovative idea consists in an ongoing commissioning system that — by making use of wireless sensor networks (WSNs) — merges, in the framework of energy saving in buildings, two other fundamental objectives: the maximization of user comfort, and the guarantee of savings over time obtained with appropriately implemented actions.

To reach this objective, we mainly focused on the thermal energy demand of a building since we found that in this sector a sensor/actuator system can offer significant advantages. To obtain a cost-effective solution it is necessary to give precedence to simplicity and identify a limited set of parameters to monitor. Following the approach of the Fanger thermal comfort model, we only selected temperature, humidity and air velocity.

The proposed work represents a novel idea for energy savings, as shown by official statistics it is responsible for approximately 40% of European final energy consumption (source: European Environment Agency). For this reason, energetic performance of buildings is the topic of extensive research nowadays, particularly with reference to the targets established by international commitments and standards.

To deepen our knowledge of this problem we initially carried out an energy analysis in order to understand the system at issue in terms of the inflows that should be considered in an assessment of the energetic performance. Such an analysis brought to a division of the system's energy needs into four classes: thermal energy, light, electric power and venting. Under the supervision of Ingenia s.r.l. - which works on innovative systems in the field of energy, light, electric power and venting. Under the supervision of Ingenia s.r.l. - which works on innovative systems in the field of energy audit, energy certification and continuous commissioning - it has been possible to identify within these classes the main influencing factors that affect energy consumption and waste: efficiency, use and status. The main aim of this procedure was to find guidelines for the development of a system that is capable of reducing energy waste, but costing less than the potential savings. For this purpose, the analysis results were compared with the needs of the Energy Managers of complex buildings. We explored the outcomes of interviews we had with them for the definition of a weight function according to which we evaluated all energy classes and factors. We finally concluded to focus our work on the use of energy in the thermal and venting sectors, which offer the most relevant and cost-effective saving opportunities.

The building sector (tertiary and residential) plays a crucial role in the field of energy savings. As shown by official statistics it is responsible for approximately 40% of European final energy consumption (source: European Environment Agency). For this reason, energetic performance of buildings is the topic of extensive research nowadays, particularly with reference to the targets established by international commitments and standards.

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consumption through calculations of the energy supply and the heating and cooling load. From the sole perspective of energy savings, current approaches are surely effective and well designed to reach their aim. However, they are mainly focused on reducing consumption in accordance with the limitations that come from laws and standards without taking into account the comfort of people who live inside buildings: this is a limit we wanted to overcome with our innovative solution.

A great opportunity that we exploited was represented by Wireless Sensor Networks (WSNs) which we adopted for a non-invasive monitoring of environmental parameters connected to thermohygrometric sector. The main experimental activities of our team are connected to this topic, particularly with reference to topologies, protocols and synchronisation procedures. With more in-depth theoretical understanding of the state of the art followed by some practical tests, we explored available solutions in the perspective of finding the most energy efficient ones amongst them: actually a very demanding issue in WSNs.

Gener AtinG A Solution

■ and

The main factors involved in Fanger's theory of thermal comfort

■ : the number of nodes can vary without any modification in the installation environment. Another important feature we have conceived for these panels is the ability of our idea is that we return to comfort the importance it deserves, considering it explicitly even when talking about energy consumption and waste; in other words, we wanted to guarantee the most energy efficient way to satisfy people comfort needs. In order to obtain a cost-effective solution, it is necessary to privilege simplicity and monitor only a limited set of parameters. To identify them we followed the approach of Fanger thermal comfort model, that is adopted as a reference in standards (ISO 7730:2005), according to which we selected temperature, humidity and air velocity. If compared to the model based on energy balance, our choice surely results simpler because it doesn't require the measurement and estimation of lots of parameters. Here lies the strength of our solution: this system is cost-effective, easy to implement and avoids the risk of making mistakes if some data are not available for the analysis. Moreover the different uses of the environment are implicit in the theory and do not need to be evaluated a priori, but are indirectly assessed through other physical properties. For example, if the number of people in a room increases too much this phenomenon is revealed via an increase in temperature and a change in the index of thermal comfort that moves out of the acceptable range.

Besides the identification of the model we also concentrated on the method to measure the required parameters. After exploring available opportunities and considering aspects like cost, performance, standards and programming ease, we came up with a network based on a multi star topology. This choice is particularly energy-efficient for nodes given that, in this case, they are only in charge of transmitting, so it's possible to minimise the working time of the antenna (the most energy-wasting component). The selected protocol is 802.15.4, mainly for compatibility with other applications.

The main features of the proposed solution are listed below:

■ : the designed solution enables continuous operation, rather than complete failure, when some parts of the system fails;

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■ : the number of nodes can vary without any modification in the installation environment. Another important feature we have conceived for these panels is the ability of our solution to be easily accessed and integrated with a wide range of different applications. In order to demonstrate the technical feasibility of the system and validate our mathematical model, we created a prototype of the network and installed it in different environments in order to acquire data, test the system's reliability and check its lifecycle. We also had the possibility of verifying the installation ease of our system by having it tested by a group of future energy managers. The result was positive, since it showed that the only difficult part is the identification of the best installation areas. A system improvement can be proposed for new buildings: by integrating sensors and sink node in prefabricated modules we will make the solution non-invasive, thereby effectively requiring no modification in the installation environment. Another important feature we have conceived for these panels is the ability to conduct current, if powered on, when they are connected. In this way we drastically increase the system lifecycle, that can be considered unlimited. An interesting future development of this network could be represented by the integration of the three elements that compose a gateway (sink node, PC and LAN router) in a single package: this solution will not only reduce the hardware cost of the system but also the energy budget.

MAin BiBliogrAphy reFerences


**ABSTRACT**

Increasing awareness on the issues of energy savings has helped to consistently improve the environmental quality of the buildings where we live in. The main point of interest of most energy saving projects literally consists in how to save energy and, particularly, in how to improve energy efficiency and the performance of a system, while minimizing costs. On the other hand, the comfort of the people living inside the environments is frequently underestimated and is only considered a side effect.

The main goal of our team was the development of a system aimed at assuring the comfort of those people. While the theoretical basis of our research is well-known and composed of several standardized documents (amongst others, ISO 7730 and ISO 8986), the framework that we have designed is completely new and offers an innovative approach to the problem. By means of a wireless sensor network (WSN) and an intuitive management system, we built a highly flexible ongoing commissioning system: the main difference between our solution and current solutions is the capability of quickly adapting to dynamic situations. In fact, it is possible to monitor the comfort situation of the observed environments in real-time through the management system and take effective measures to face eventual critical events. This is performed by analysing information gathered by sensors networks and by applying a mathematical model in order to understand the current situation. The target of our system therefore includes energy managers and more generally the people involved in the energy management process of a big and complex building.

In order to accomplish a reasonable proposal, we have carefully developed the software and the basic features of the graphical user interface. In addition, they analysed the mathematical model and collaborated in the development of the software.

**TASKS & SKILLS**

Marco Leonarde was the team controller, responsible for keeping the agenda of the project and related submissions and deadlines. Jo Liu developed the software and the basic features of the graphical user interface. In addition, he analysed the framework of current regulations. Matteo Minoa implemented research on innovative solutions and future developments. In addition, he reviewed the internal consistency of the work. Filippo Pizzocchero worked on energy analysis and on the logical path towards the solution. He also developed the mathematical model and collaborated in the development of the software. Diego Tonelli performed the energy analysis in more detail and investigated both the state of art and the possible opportunities. His work also concerned feasibility studies and project implementation.

**Understanding the Problem**

“Wi-Fi 4 Energy” had a tough objective. We had to monitor and correct the energy conditions inside buildings by exploiting wireless technology. Since the best strategy to find solutions to new complex problems is to reduce them to their essentials, we used this “Systems Engineering” approach, which is also one of the strong point of Ingénia (the external institution involved in the project). This approach allows us to increase our knowledge and critique about energy management by understanding deeply the problem as a whole. It is important to stress that this fact does not mean ignoring some factors. It helps, on the other hand, to go deeply into the core of the problem and to only focus attention on the few elements really necessary for its solutions.

The energy analysis we managed with Ingénia was the starting point for developing our own ideas and was driven by both our stakeholders as well as our potential customers. They provided us with useful information about the actual state of the art in relation to their main needs.

We therefore decided to think of an innovative and cheap solution for correct energy management. Firstly, we had to choose the most appropriate approach for our goal and the degree of generality. We defined two parameters for this purpose: the generality and the depth. With generality we mean a scale-to define the level of definition of the analyzed building. A low level of generality corresponds with analyzing a specific kind of building, while minimizing costs. On the other hand, the comfort of the people living inside the environments is frequently underestimated and is only considered a side effect.

We overcame this impasse by exploiting the Systems Engineering approach. In fact, we were able to agglomerate the numerous variables in few important energy factors. Furthermore, we created a weight function with the scope to calculate the importance of each parameter in order to understand the right strategy to follow. Evaluations of the factors inside the weight-function were based on researches and averages of the found values. We also contacted a statistical meaningful number of energy managers from all over Italy in order to listen to their requirements and we included their answers in the weight-function.

At the end of this intellectual process, we found that the most important variables in energy management are heating and ventilation.

**Exploring the Opportunities**

Once the problem was clearly stated and the analysis methodological structure was formalized, we explored the opportunities and choose the main goal we wanted to achieve.

Firstly, we thought of a set of solutions capable of reducing energy consumption from the perspective of pure energy and money savings. There is a large variety of this kind of products available on the market and many big research projects related to the topic has been activated in some of the major enterprises and Universities all around the World. The Politecnico di Milano and Politecnico di Torino are also involved in this kind of research.

The main disadvantages of this approach include high costs of research and implementation and in-depth training of users (non-technical controls and huge number of details). Moreover, the achievable solutions can only be applied to specific environments. We therefore decided to investigate and explore a completely new approach to energy management.

We moved our attention from pure energy savings to better energy quality. As a consequence, we considered the comfort of the users as the core objective of our project and our major issue to face with.

Even if comfort is not easy to define nor measure in a direct way, there are sets of national and international regulations on...
the topic, defining parameters, standards and suggestions in order to assure a better quality of energy demand. These regulations are very often employed during the designing phase of environments. However, after in-depth research on the actual framework, we pointed out that they are not taken into account anymore after that process. Comfort is usually considered as a side effect of energy saving policies, arising from defined control strategies and eventually reported by complaints of users. Afterwards, we had to develop a deep consciousness on the topic as well as collect and exploit results of existing researches in a new context and set the competitive advantages of our solutions. All these activities were aimed at satisfying the needs of stakeholders and customers, thereby minimizing energy consumption and guaranteeing comfort of users in a given environment. We pursued long and careful trade-offs among different alternatives in order to define the main features of what we think being one of the best solutions for future development of energy management tools.

**Generating a Solution**

As we have already said, our solutions aimed to create a situation of comfort with optimal energy consumption. First of all, we needed a formal definition of comfort and we found it in the ISO standard 7730 “Ergonomics of the Thermal Environment” and in the research done by Fanger. The sensation of comfort experienced by a person is assumed as a function of the physiological strain imposed on him/her by the environment. This strain is proportional to the difference between internal heat production and heat losses on the actual environment. Fanger created an equation to calculate this strain on the basis of environmental and personal factors; as a result, he was able to predict the percentage of people satisfied or dissatisfied for certain environmental conditions. We decided to collect information on environmental factors by means of a suitable network of sensors. Wireless sensors were chosen as a reference, since they do not require high costs and are applicable everywhere in a non-invasive way. Furthermore, we developed a mathematical model in order to calculate comfort votes in a complex environment, according to regulations guidelines. This model was therefore implemented in a tool which is responsible for monitoring and controlling real-time situations, thereby also generating future forecasts. The interface that we developed provides a clear visual representation of the comfort situation, a key feature for Energy Managers. The main features of our tool are:  

- **User-friendly interface:** it is simple, clear and comprehensible, and provides information on energy consumption at any level.  
- **Wide applicability:** it is not defined for any particular environment; in fact the model has the possibility to be applied everywhere.  
- **Accessibility:** the way data are gathered and processed exploits availability of different networks as intranet, Internet or wireless connections, leading to faster and more effective decisional processes.  

As a verification, we applied our model to real environments and we obtained very interesting results, with proof of lack of comfort in certain environments as well as explanations and suggestions for possible remedies. To conclude, our tool succeeds in monitoring comfort, revealing situations of unease and, at the same time, allows for the achievement of significant energy savings of up to 10% or even more. We have also had the opportunity of thinking of potential future developments of the project, such as the application of the idea in public transportation. This last aspect is very promising due to the high applicability of our solution as well as the possibility of significantly raising the quality of the public service.
A project on the recovery and reuse of farmhouses owned by the city council which are transformed into cores in a system of spaces dedicated to housing

In Milan there are 58 farmhouses owned by the Municipality. They are located radially at the borders of the municipality, mostly within the major parks of Milan or in agricultural areas near waterways. Some of these farmhouses, initially at the borders of the city, are now surrounded by new development. They are in different conditions, used or partially-used, abandoned and in a state of decay.

Historically, the identity of farmhouses in Milan is linked to agriculture. Today only 14 farm houses are still family-run farms. Some of them combine agricultural production with new services: commercial (direct selling of products), education (educational farms), tourism (restaurants, bed&breakfast) or cultural (concerts, exhibition areas, conferences spaces) services. In the majority of cases just a little part of the spaces and areas belonging to the farmhouse are used for the primal activities.

In recent years, the agricultural vocation of the farms hosted another specific activity, which was developed intertwined with the original one, or replacing it. Many farms were in fact recovered and kept alive by NGO’s and citizens’ associations. The associations have found spaces that are available and flexible in order to accommodate different kind of social and cultural activities like: housing and care areas, community centers, cultural spaces, art, music, teaching and leisure spaces. These farms have become laboratories of integration and citizenship and important social guards of the territory.

Despite the fact that the farmhouses owned by the Municipality of Milan are places of great value, due to their historical, architectural and environmental qualities, there is no specific policy for the their recovery and their development.

The project “Cascine Expo 2015” promotes the recovery and development of Milan-owned farmhouses and the activities hosted by the buildings. The framework considers a sustainable model of open spaces dedicated to agriculture, food, housing. The Expo 2015 theme - “Feeding the Planet, Energy for Life” - could be brought in the very texture of the city due to the farmhouses, thereby helping Milan in becoming a laboratory of sustainability and citizenship.
The network of the farmsteads will act as a filter between the territorial scale and the urban one, linking the countryside (a channel of continuous production) with the city that, by contrast, is characterised by its needs of consumption, making both realities to work in synergy. By enhancing the feeding and agricultural traditions of Milan's farmsteads, the project intends to explore three possible models: the first considers the farmsteads as places of production, the second as places for distribution, while the third one will comprehend a hybrid model.

The project response is the creation of a network model with a complex system of collaboration that provides farmsteads with the possibility to exchange: products, tools, know-how and labour. Using as a reference pole of 21 farmsteads linked to nearby farms, the production system will be associated to a new distribution structure of marketplaces. The farmstead will become a place of social sharing, an educational entity capable of redistributing knowledge about the agrarian traditions of Milan under a model of farmstead community markets, thereby encouraging a multicultural exchange.

The network map of the 21 farmsteads subdivided by production and distribution

The “sustainable city farMIng” project involves a group of Milan's municipally owned and abandoned farmsteads and their surroundings. A significant reflection about the actual time context of the city has facilitated a better comprehension of the issue. Nowadays, the valorisation of the agricultural reality of the farmsteads has become a main issue for Milan due to the Expo 2015. Historically, the most famous Expo’s were the ones that communicated - in their urban structure - the topic of the event. Milano should proudly express its agriculture vocations given by its geographical positioning inside the Po Valley. The recovery of the farmsteads forms part of this program that aims to promote the feeding and agricultural traditions of Milan, thereby endorsing typical Lombardy products manufactured in the city.

The Expo is an important framework for the “sustainable city farMIng” project, as well as the study initiated by multiplicity lab which started working on the topic of farmsteads in the year 2006. At the year 2007 the Alta Scuola Politecnica (ASP) research group of students began to work in the theme. The path followed for the solution comprehends an in-depth research and analysis of the farmsteads in order to understand their conditions. The research gave us the possibility to talk with potential final users, defining all the possible stakeholders, facing their needs and extracting the project requirements. The results of this first common work were shown during an exhibition “Vita Nuda”, held in the Triennale di Milano during the months of May - September 2008. This gave us the chance to show the project for the first time to the public and receive feedback from citizens. The information collected in the exhibition helped us to understand the multiple problems we faced in the project.

The two groups developed different paths for an in-depth analysis of each theme. The topic developed by Team A, “sustainable city farMIng”, followed a feeding and agricultural approach, while Team B’s topic, “Contemporary sheltering for sustainable communities”, looks for a solution to the sheltering problem that (A and B), in fact, resumes the work started by multiplicity lab while paying attention to the cost-benefits analysis of the project.

Matteo Ferranti, focused his attention on the primary technical and economic feasibility of the market model while paying attention to the cost-benefits analysis of the project.

Francesco Franci, analyzed the actual issues that faces Milan focused on the context of the Expo 2015 extrapolating useful data for the project development.

Roberto García & Chiara Geroldi, focused on the development and management of the project based on the prior analysis and realization of a network model for communication exchanges between the farmsteads and the territory. They developed a model for the farmsteads market communication exchanges between the farmsteads and the territories involved in the project.

All the team actively participated to the survey in site (farmsteads, farms, parks, institutions and markets) and to the interviewing of the people involved in the project.
The project “sustainable city farming” presents several innovations with respect to the role of Milan farmsteads. The project classified the 21 farmsteads by dividing them into three categories: activities, starting from their features: production, distribution, and education.

The education factor considers several players in Italy that are involved in the food system: institutional players and final users (sheltering project beneficiaries, citizens, agricultural companies and farmsteads actual residents). The project studied a specific program linked to agricultural and feeding issues for each farmstead. It provided a hypothetical network model involving the farmsteads by identifying in which of incorrect farmstead maintenance policies, our project to—gether with Expo connected activities, looks forward to restore an abandoned architectonical heritage. An in-depth analysis of the agricultural data of Milan reveals that cultivation is mostly concentrated in the Parco Sud area, with a significant share of the land and the gradual reduction of cultivated areas is part of the project’s campaign against environmental issues. Some profitable solutions have been found in their organizations and which could be applied to the project, for instance tasting events (such as “Salone del Gusto” in Turin), education on food quality (pro-moted by Eataly and Slowfood) and the guided tours in the agrarian places of production (Parco Agricolo Sud di Milano, Fattorie Didattiche).

In our model, the biggest challenge is to reconnect the city to its rural roots. Finally, it is important to consider that the farmsteads have diverse features (tools, land, specific know how, and so on) and, as a result, the only viable model to ensure their survival is one based on a mutual collaboration and exchange program. The farmsteads will host open markets and tasting events. The distributed products will follow the guidelines of a km0 production. To differentiate our market from others already existing in Milan, most of the products on sale would be grown organically and locally (fresh or transformed). During the tasting events that will take place on a monthly basis, ethnic restaurants and other institutions will be invited to participate. An important innovation is represented by the chance, for the temporary users of the farmsteads (immigrants, people of low resources and homeless) to be more involved in society. This model looks to develop a place where foreigners can express their culture through food. This process will help to create a multicultural exchange through a “Food Education Program.”

The farmsteads will host open markets and tasting events. The weekly farmstead markets will host spaces dedicated to Expo info points as well as the commercialization of products coming from: countryside farms, agrarian companies and the farm stead itself. The distributed products will follow the guidelines of a km0 production. To differentiate our market from others already existing in Milan, most of the products on sale would be grown organically and locally (fresh or transformed). During the tasting events that will take place on a monthly basis, ethnic restaurants and other institutions will be invited to participate. An important innovation is represented by the chance, for the temporary users of the farmsteads (immigrants, people of low resources and homeless) to be more involved in society. This model looks to develop a place where foreigners can express their culture through food. This process will help to create a multicultural exchange through a “Food Education Program.”

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Multidisciplinarity and Innovation

Abstract

A contemporary metropolis like Milan is oppressed by a constantly increasing demand for social housing solutions and flexible sheltering systems due to continuous internal and external immigration flows. The project is a pilot shelter in a former farm, set in the Western part of Milan (San Siro district). The building nowadays is surrounded by a building environment and it is property of the Municipality of Milan, left in state of total abandon. The refurbishment of the building serves, at the same time, as house for temporary and permanent residents as well as individuals and families in addition to being a service supplier of integration of guests and of those who are in social and economical difficulties or in need of a place to stay. This system avoids the psychological and social implications of the service offered; many of these are run by NGOs and Catholic organizations. Although sheltering and housing problems in Milan are related to the entire region of the city, a partial solution could be provided by exploiting a network of abandoned farms spread out in the rural belt or in a peripheral urban context, an important historical and architectural heritage and property of the city council. The focus on one farm-case study offers the chance to deepen the psychological and social implications of the service offered; many of these are run by NGOs and Catholic organizations.

Tasks & Skills

Tommaso Brambati: collaborated in surveying and studying existing sheltering models in the Milanese region. He contributed to the project by finding technological solutions for its economic feasibility and energetic sustainability while focusing on governmental policies and environmental assessments.

Murilo Gomes Nagato: implemented specific research on external sheltering models applied to the cases of Barcelona, South America and United States (New York). He offered theoretical inputs to draw a model based on the financial strategies and timing schedules for the construction of the project.

Angela Maria Potenza: implemented a comprehensive screening of governmental supports for housing available in the area of Milan. She structured three model distributions with architectural and social devices while specifying financial strategies and timing schedules for the construction of the project.

Understanding the problem

One of the main problems of the contemporary metropolis is the difficulty in meeting a high demand for housing and sheltering solutions from a variegated population that is constantly increasing due to internal and external immigrations and their demographic development. The social policies of the Milanese administration relative to the problems related to individuals in deepest poverty, people suffering from mental or socio-economic problems, and also refugees and the latest arrivals of migration flows, involve temporary solutions which concentrate the masses – without distinction between individuals or families – into large camps (for the Roma community), or shelter them only overnight in public dormitories, or through public policies, which force those without home to minimize and disperse in the folds of invisibility and marginality of the contemporary city. These policies provide inadequate responses to the problem because they have been unable to face such a large number of requirements and different sociological issues. In recent times, the urgency to find a quick solution to this home emergency has provoked the building of lots of individual variations to the established way of sheltering by paying attention to the psychological and social implications of the service offered; many of these are run by NGOs and Catholic organizations.

The project creates housing opportunities for people in need of special rental or environmental conditions and a new centrality with services for the whole neighbourhood. In order to get this goal, we have defined three models, based on three different approaches to homelessness and housing problems: a “Traditional model”, which reflects the traditional way of facing homelessness in Italy, a “Co-housing model”, which is inspired by the American Supportive Housing approach and a “Hybrid model”, which tries to mix different elements from both of the other two projects and which focuses on a more heterogeneous and integrated sheltering system. Each model develops a spatial concept, which describes different kinds of offered housing opportunities and services, and an economic feasibility study, which entails expenses and revenues of the model in order to provide a number of different outcomes and assets for the neighbourhood and the whole city scale.

Tasks & Skills

Raffaele Pe: contributed to the collection of on-site material related to the state of the art of the Milanese sheltering models, paying particular attention to the anthropological principles detected from the American Pathway to Housing model while also managing economic and construction requirements.

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Although sheltering and housing problems in Milan are related to the entire region of the city, a partial solution could be provided by exploiting a network of abandoned farms spread out in the rural belt or in a peripheral urban context, an important historical and architectural heritage and property of the city council. The focus on one farm-case study offers the chance to deepen the problem by providing feasible pilot solutions that can also become re-activation propellers for other Milanese districts or for the whole conurbation.

Cascina Casenuove is an abandoned farm set in the 2nd district of Milan surrounded by a residential area with few different events and urban emergencies such as the Meazza Stadium and the historical social housing development Quartiere Baracca. By exploring the site through surveys, interviews and readings, the main detected critical aspects are related to the low functional variety of the blocks and the presence of a large number of foreigners and refugees, most of them boarded out in the social dwellings of Quartiere Baracca. The number of services for the population is very low and the absence of a cultural and historical centre at the level of the neighbourhood – which can promote the district as a place with a recognizable identity – is evident. Sometimes the international character of the community provokes instability in relationships between different groups. The Cascina Casenuove project wishes to renovate the surroundings introducing in the abandoned farm a new civic centre, with a highly mixed functional proposal: housing opportunities, social and community services and commercial spaces.
The team has developed three functional solutions for a feasible refurbishment of Cascina Casennove. Each solution refers to a different housing and sheltering model inspired by existing models detected in the Milanese area or external models deepenend through research studies and direct interviews. The refurbishment of the farm will then respond to all these principles of housing support in Italy and, in particular, in Milan. The model preserves the old building by placing new functions in the structure for the neighbourhood such as social services and temporary shelters for homeless, thereby transforming the former rural building into a civic centre and a residential development. The model provides an emergency shelter, a flat for 6 people, and two social operators with a kitchen, a bathroom and a talking room. In the central patio of the farm are located a kindergarten and a cultural centre with community gardens and playgrounds. The South wing of the building will be re-used as a house for poor families: 15 flats (max 30 people) with kitchen and services in common. The East wing of the building is a Hostel for tourists and students, while the North wing is a residence for relatives of hospitalised people with 12 beds + living room. The model also presents commercial spaces and association headquarters in which all the operators and administrators of the shelter system are based. Economically the model works on the idea that all the functions should pay back the costs of the shelter system are based. Economically the model works on the idea that all the functions should pay back the costs of the system; in this case, the majority of the incomes should be deducted from the assets of the other two models. The number of co-housing flats and supportive housing is here reduced in order to locate a hostel in the North and East wings. The hostel is one of the most lucrative activities in the community together with the commercial activities. The model preserves an emergency shelter for six people and a housing agency. A bigger space is given to other NGOs with special attention to the economic potential of G.A.S. organizations and organizations that work on sustainability and energy selling and production (Solare Collettivo, Orti urbani etc.). In the two buildings in the south and east part of the square, there is no kindergarten and a cultural centre for the neighbourhood, with a playground for the kids and some private tenant gardens. By comparing the three models, economically, they all should start building their own business in thirty years (time dedicated to pay back the renovation costs). The traditional model offers the largest variety of activities and services that the whole neighbourhood could exploit while the co-housing model – although it stimulates the construction of a sustainable community – risks imploding on itself by attracting a smaller number of external users. The hybrid model blends the positive effects of the first two models including a bigger number of services for the community and for the neighbourhood.

**Main Bibliographic References**

PreMEMB
Prefabricated modules for energy management in buildings

Developed with ENEL Research Center (Catania), this project aims at developing highly energy-efficient building envelope components for Mediterranean countries.

The challenge
In the last decades, it’s becoming more and more clear everyday that the rational use and production of Energy will be a crucial issue for the development of our civilization. Big efforts are being done to find new exploitable energy resources and to improve the performance and efficiency of the existing conversion technologies. To make these efforts useful, it’s easy to understand that a parallel line of action involves decreasing of energy demand. In dealing with this problem, the target of the project is to develop architectural concepts and design prototypes that may lead to scalable, low-energy, cost effective buildings for European and Mediterranean climates. Starting from a case-study building localized near Catania, the students were asked to propose innovative solutions both for the facades and the roof, including active and passive components and exploiting all the possible advantages given by modularity and by prefabrication. A solution that could work with free and clean sources and with sustainable materials, never neglecting the requests of the final users and the aesthetic of the building.

The teams
Considering that the project aims at two different modules for the façade and the roof, it has been natural to split the group in two teams. The characteristics of the work of the two teams are however similar and both teams include architects, civil engineers and industrial engineers in order to allow for a multi-disciplinary approach to the problem.

Team A
Alessandro Scandiffio [Project Communication Coordinator & Team controller]
Building Engineering
Lorenza Bianco
Architecture
Filippo Colzi
Energy Engineering

Team B
Achille Iannazzone [Team controller]
Automotive Engineering
Leandro Candido
Civil Engineering
Stefano Petrucci
Energy Engineering
Erica Pilotto
Architectural restoration and preservation of architectural and environmental heritage
Lilian Tonet Rensi
Chemical Engineering
Antonio Russo
Mechanical Engineering

The results
Both teams, after a first phase of analysis of the problem, the stakeholders and the state of art of the sector, have proposed a solution that involves different innovative technologies and have justified the choices by performing economic and energy simulations. To do these, commercial software and appropriate models written by the students have been used and merged. ENEL, the main stakeholder of the project, has expressed satisfaction about the methodology which was adopted in approaching this complex and multidisciplinary problem, enlightening also the innovative skills of both teams.

The proposed solutions can give an interesting contribution for increasing the energy efficiency of buildings, and this could represent an interesting issue, particularly for Public Administrations that have to deal with a lot of structures for offices, schools, hospitals and other. In a period of economic crisis, this renewal could also be a key point for stimulating, in a sustainable way to reduce energy consumption and as an active way to produce energy. Having different skills inside the team has created a stimulating environment and has permitted to discuss several aspects as energy management, external look and links with other facilities. Heterogeneity has permitted to find different solutions that come from different fields.

Multidisciplinarity and Innovation
ENEL Projects

Prefabricated Modules for Energy Management in Buildings
Smart façade module

Abstract

Energy efficiency in buildings is nowadays one of the most debated topics in the field of architecture and engineering. Yet in the latest 80’s, in Sicily, ENEL, the most important energy firm in Italy, started a project involving the design and testing of “smart” modules for a research center building named Conphoebus. The aim of this work was therefore to imagine and design an innovative solution that could be integrated in external walls of buildings to decrease their energy consumption. When talking about energy as “primary energy”, an effective solution has to consider at the same time different features:

- deal with both thermal and electrical energy
- deal with both energy production and energy saving
- improve the wellness of final users
- exploit cheap, clean and renewable sources
- exploit sustainable technologies

The well known advantages of “big-scale” industrial production and of prefabrication are also non-negligible and extremely interesting features in generating a feasible solution. Working in this direction and after a first phase of analysis of the case-study Conphoebus building and of the state-of-the-art, the team has developed the design of a module that can properly fit the above mentioned requirements. Different technologies have been used, merged and integrated in the same module. A photovoltaic mono axial tracking brise-soleil, an optic fiber collector and a layer of Phase Change Materials inserted in the wall, allow the users gain all the advantages provided by Sun radiation while not being affected by the disadvantages. The use of appropriate layers in the wall, moreover, allows the internal temperature to be within the limits of comfort with low energy consumption. The use of a standard basic structure on which to assemble different components as a function of the desired features, will indeed join together the economic advantages of prefabrication and big-scale production and the advantages of developing an “on-demand” solution.

Understanding the problem

Eleven years after the Kyoto Protocol, in December 2008, the European Council approved another extremely important document which assessed the targets commonly known as 20-20-20. In the year 2020, the electrical energy production should be covered for at least 20% from renewable energies while CO2 emissions should decrease by 20% and the energy efficiency in buildings should rise by 20%. It’s exactly at this last point, considered as important of the two others, that the project wants to intervene. In Italy in 2008 the civil sector has been responsible for almost the 33% of the consumption of primary energy. It has been calculated that an intervention on the energy efficiency of public buildings in Italy could lead to savings from 200 to 600 millions of Euro per year, and from 28,000 to 84,000 tons of CO2. At present, several interventions are possible, but no one has represented a turning point of the situation. A correct energy management in buildings, indeed, is related to the use of technologies and materials with proper characteristics which difficult to obtain and therefore expensive. In the construction phase, when the requirements are often to keep the costs as low as possible, the energy efficiency tends to be neglected. The challenge is so to design a system that could be at the same time efficient, feasible and easy to introduce as well as capable of stimulating the market so to create a virtuous circle.

The constant contact with Enel, main stakeholder of the project, and the analysis and visit of a case-study building, the Conphoebus research center in Catania, have let to a better definition of the problem. In particular, the needs of final users have clearly emerged:

- decrease the direct lightening of offices exposed to south. The direct radiation heats the ambient and creates an uncomfortable environment for the eyes
- decrease the mean temperature of the offices during the summer
- have a glazed part to watch outside.

To these requirements, the more technical ones have to be added:

- introduce an active component for the electrical energy production from a clean and free source.
- decrease the heat flows through the wall.

The efforts of the Team have been focused on giving an answer to all these problems, with the target being to obtain a higher efficiency grade in the Building Energy Label while always trying to maintain economical feasibility.

Exploring the opportunities

The field of energy production and savings presents a huge amount of ideas and proposals, from the most elementary to highly technical ones, ranging from artistic, futuristic and creative ones. Introducing novelties in this context means to try to think in different ways.
ways, what has been done is a contemporary analysis of the state-of-the-art and large-scale brainstorming while being completely unconstrained by physical or chemical laws. By “exploiting” the small experience in this field, the Team has so freely discussed about possible solutions to tackle the proposed problem, enlightening how things that are normally considered dangerous or, at least, useless could be theoretically converted in interesting opportunities. In that sense, proposals have been done, such as to absorb and convert noise, annoying and dangerous, or to exploit the energy connected to the movements of tectonic plates, always present, but considered only when it dramatically appears during earthquakes phenomena. But technical and physical problems obviously exist, and it has been so understood that the real opportunity could have been to integrate and link together different and already existing technologies. Among these, the Italian climate situation fosters the adoption of Photovoltaic modules, nowadays reliable and affordable due to large-scale production (production of standard components) and the ones of on-demand design. The results of the requirements and opportunities analysis have shown the advantage of an innovative and efficient solution in public buildings, and it has been observed that the real opportunity could have been to integrate and link together different and already existing technologies. Among these, the Italian climate situation fosters the adoption of Photovoltaic modules, nowadays reliable and affordable due to public funding. In addition, small wind turbines are now in interesting solutions for energy production, but, after a first phase of study and analysis, it has been evaluated that they don’t fit with a façade device. The performance of the proposed components has been evaluated by means of different models, both commercial and properly written by the team. The economic aspects have not been neglected. The choice and analysis of the proposed components should not live down that the module proposed wants to be flexible; the idea is so that only the basic structure of the module has to be fixed, while it will be a choice of the user as to what kind of components insert. A potential future development of the work could then be the definition of alternative components and a table that could help users choose the right combination as a function of the desired features. In this way, there will be the simultaneous attainment of the advantages of big scale production (production of standard components) and the ones of on-demand design. The performance of the proposed components has been evaluated by means of different models, both commercial and properly written by the team. The economic aspects have not been neglected. The choice and analysis of the proposed components should not live down that the module proposed wants to be flexible; the idea is so that only the basic structure of the module has to be fixed, while it will be a choice of the user as to what kind of components insert. A potential future development of the work could then be the definition of alternative components and a table that could help users choose the right combination as a function of the desired features. In this way, there will be the simultaneous attainment of the advantages of big scale production (production of standard components) and the ones of on-demand design.

generating a solution
The results of the requirements and opportunities analysis have resulted in a solution that integrates different technologies and components in a single prefabricated module. A Photovoltaic mono axial tracking brise-soleil has been designed. Composed of three Silicon modules with a variable tilt, it has been optimized from different points of view, in terms of the choice of the kind of Silicon, the definition of the supports position and the effect of the tracking system on the amount of energy produced. Accurately designed, this component allows at the same time to exploit the advantages of the solar radiation, converted in electrical energy, and to avoid its disadvantages, preventing it from entering in the working environment, heating it and making it uncomfortable. Above the brise-soleil, an optic fiber collector has been positioned. This is capable of transporting natural light inside the building that is free and which, if correctly diffused, is extremely pleasant in a working environment. For the case study building, the optical fiber is an interesting solution in order to enlighten the central corridor, lacking in windows. It is, another time, a way to exploit a positive aspect of the sun radiation. The thermal energy aspect has been considered through an appropriate design of the wall layers. Expanded clay and wood fiber guarantee the required characteristics in terms of structural resistance and thermal insulation, being moreover ecologically harmless. To increase the thermal inertia, a layer of Phase Change Materials has been inserted in the wall, during the day these innovative materials, melting at a temperature quite near to the comfort one, are able to absorb a big amount of thermal energy as latent heat. If properly managed, this behavior can result in a remarkable level of cooling energy savings.

main bibliographic reference
ReNRA
Renewable Energy for Buildings – Roof Applications

ABSTRACT
This work aims at considering all global project guidelines with direct application to the roof. In other words, the work consists of the design of a modular roof with energy saving/production functions which are required to be appropriate both for residential and commercial/industrial applications. In particular, the team studied the application of the final solution on the Conphoebus building, at Enel’s Research Center on Renewable Energy in Catania, Sicily. With the aim of creating an innovative project, the team – from the beginning – chose to work on a solution that would introduce a close interaction between the use of technological devices and the roof. As a result of this intention, the proposed solution is not any type of common device installed on the roof, but is the roof itself. Furthermore, in addition to the main technology, whose goals are energy savings and energy production, the project also takes into consideration two auxiliary technologies, one focused on exploiting the capacity of the roof to collect rain water of the roof, and the other on optimizing the use of sunlight.

ELEONORE RUSSO: focused his work on information gathering, researching products in the market and bibliographic research. He also evaluated the adoption of a trigenerative concept.
ACHILLE IANNAZZONE and Stefano Petrucci: worked on the study of roof energy balances and on its energy performance. They also worked on prices, performances and sustainability of different auxiliary components which are necessary for the solution and contributed to the definition of modular concept.

TASKS & SKILLS
Leandro Candido: focused on the design of the roof structure and the related calculations. He worked on scenario definition and market investigation in the first phase in addition to contributing to the definition of the modular concept.

Antonio Russo, Liliane Tonet Rensi, Erica Pilotto, and Stefano Petrucci contributed to the design of a modular roof with energy saving/production functions.

RESEARCH/STUDY, FOLLOWED BY A COMPARISON OF POTENTIAL SOLUTIONS.
The starting point for choosing technological solutions to adopt consisted in an initial brainstorming, integrated with a phase of research/study, followed by a comparison of potential solutions. As a result of this initial analysis, we found out that all common solutions, such as a green roof and cooled roofs, are only suitable for one climate condition. Generally these devices are placed over the roofing, and this means that they are not well integrated with the roof structure. Furthermore, almost all of these solutions exploit well-known technology, and are anything but innovative.
With this general vision, we concluded that the solution that better fits our targets was the Solar Water Collector. Since this is a brand new technology, there is not enough documentation concerning the modeling of this structure and its real performance. So, at this point, the aim of our project was no longer just centred on the economical analysis of the results in terms of costs and energy savings but also aimed to verify if this solution could be truly applicable or not.

Another important aspect of the chosen technology is that it allows for the application of auxiliary technologies. Since the main technology works with water, we decided to integrate the project with a Rain Water Collector, due to the potentiality of rain water recovery in Catania and the possibility of having such a wide roof area on the Conphoebus building.

Finally, as our solution concerns a roof technology, we decided to study a device that allows the usage of daylight to enlighten the corridor located on the 3rd floor of the Conphoebus building. We decided to draw inspiration from a new alternative solution that is currently being used in the Brasilian favelas for low cost lighting.

This alternative solution consists of a PET bottle full of water that is inserted in the roof through a hole. The bottle in this way works as a concentrator of sunlight and helps supply intermittent low cost lighting.

Gener AtinG A Solution
Solar Water Collector

The core idea of the solution that we present involves a Solar Water Collector. As previously mentioned, this technology is not a device installed on the roof, but is the roof itself. Its structure is divided into:

- A first metallic sheet;
- A first glass layer;
- A second glass layer;
- An air gap for insulation;
- A scrollable curtain.

In a brief description, the possible configurations according to climate conditions are as follows:

**Summer daytime:** the water fills the main chamber in order to provide indoor cooling by free convection, and the scrollled curtain is open in order to protect the roof from solar radiation.

**Summer night time:** the water is sent to the upper glass, in open air. Here it evaporates, and due to thermal radiation emitted to the sky, water should cool the glass for day use.

**Winter daytime:** the water fills the main chamber to collect solar energy and warm up the indoor by radiation. Warm water can be also channelled into the heating system;

**Winter night time:** water is sent to the insulated storage tank in order to maintain the temperature reached during daytime.

As this device is totally innovative, all design methodology was defined by the team members. In particular, we studied possible formulas to determine LGs performances and to estimate how many LGs were required by the case study. Finally, computation of energy savings and comparisons with normal lighting devices were made.

Lightening Globes

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Conclusions

As previously exposed, our solution introduces several innovative elements: first of all, the replacement of the traditional roof structure and a brand new daylight lighting device. Furthermore, it seems to satisfy our initial target in terms of energy savings.

In addition, our project aims at fostering eco-sustainable building technologies. For this reason, we decided to only adopt eco-friendly materials which could be integrally recycled in case of demolition.