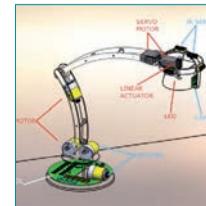
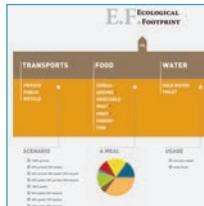




Multidisciplinarity and innovation ASP projects **3**



POLITECNICO DI MILANO
POLITECNICO DI TORINO

**Multidisciplinarity
and innovation
ASP projects 3**

Preface

This marks the third cycle of students that have completed their course of studies at 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 bond between these two cities, both of which are key to the Italian economy and during Expo 2015 will be tightly linked, we are increasingly confident that we made the right decision four years ago, a decision that during this time has come to fruition, evolved and improved.

We believe that, especially in light of the current global economic crisis, universities should do more than issue degrees, rather they should prepare their students to meet the demands of labour markets for new know-how and professions. In this sense, Alta Scuola Politecnica provides an education that goes far beyond the traditional academic approach. ASP students are given the opportunity to continuously gain insight from one another, from the course's two host cities and from 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, the know-how gained from managing projects (as illustrated in this book) and the internship opportunities offered substantially enrich the learning experience. We strengthen polytechnical training through a multi-disciplinary approach and method, yet we do not lose sight that our principal goal is to offer students specific and technical skills and 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

The Investors

ASP is funded by external institutions which support and share our vision of educating talented students and promoting interdisciplinary innovation. The Italian Ministry of University Education and Research provided endorsement and start-up financing for this unique initiative and we are also grateful for the important contribution of the Fondazione Cariplo and Compagnia di San Paolo. Other institutions have joined in by providing financial support as well as a foundation for developing projects and opportunities for the career development of our students. ASP Investors have the opportunity to meet our students while they are in undergoing the educational process and may access their CVs and challenge them with new projects. Their precious support is hereby acknowledged.



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 making grants to organizations for projects and initiatives it judges worthwhile.

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 focuses its efforts on improving the living conditions in its 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 Foundation nurtures a breeding ground for scientific research, technology transfer and the development of applied research findings, by backing synergic actions geared to the creation of networks and partnerships, the participation in international projects, the development of human capital, the production of better knowledge and improved scientific communication, as well as the dissemination and enhancement of applied research findings. Being up to date on all projects and initiatives already put in place by the public administration and professional associations, the Foundation can warrant none of its projects is a duplicate and it fulfils its role as a convener and catalyst, multiplying resources and their effectiveness.

In 2007 Cariplo Foundation awarded 1.174 grants in its various areas of activity, amounting to 196.8 millions euro. 181 grants were awarded in the scientific research and technology transfer area, totaling 48.5 millions euro. Between 2001 and 2006 the scientific research sector of Cariplo Foundation received about 2.000 applications, appraised 1.500 projects, and funded 450 projects.

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 in support of "excellence human capital" must entail a close connection between training and teaching activities, on the one hand, and research and exposure to an advanced international scene, on the other.

These are the motivations underlying Cariplo Foundation decision to support the ASP, an advanced international Faculty able to attract the best young foreign students and able to educate Italian high profile graduates.

www.fondazione cariplo.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 2008 the Compagnia awarded 918 grants in its areas of activity, amounting to 150.8 million euros. Notably, 200 grants were awarded in the Research sector, amounting to 34 million euros, and 58 grants were awarded in the Education sector, amounting to 20.9 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, with two annual grants amounting to € 200.000 each. The grants were aimed at funding ten scholarships for the ASP course beginning in the year, requiring, in the latter case, a special attention to students not based in Piedmont, or with an immigrant origin.

www.compagnia.torino.it



Promoting the economic development of the province of Torino: this is the mission of the Chamber of Commerce, realised through several promotional activities, focused on the local economic development. The Torino Chamber of Commerce offers a wide range of services to nearly 230,000 companies working in the province and listed in the public Register of Enterprises. These activities include the following: 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 organisation of events with a significant impact on the economic growth, access to financing, information and consultancy for companies involved in foreign trade. The Torino Chamber of Commerce supports training activities as well. Particular attention is given to the different levels of education, ranging from professional courses to post-degree Masters. The economic development of a territory, in fact, requires a strong interrelation between the academic world and companies. Therefore, it is necessary to promote the institutional sharing of strategic objectives. Networking culture, partnership with universities, public and private institutions: these are some of the aims the Chamber of Commerce wants to carry out. This is the reason why the Torino Chamber of Commerce, three years ago, decided to collaborate with the ASP, an advanced international Faculty, founded by the Politecnico di Torino and the Politecnico di Milano. This alliance is very important to increase local competitiveness but also to enhance the capacity to emerge in the international markets.

www.to.camcom.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.

www.epo.org



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 186,000 people serving clients in over 120 countries, the company generated net revenues of US\$ 23,39 billion for fiscal year ended Aug. 31, 2008. In Italy all Accenture's group companies employ 9.500 people (Milan, Rome, Turin, and Verona) and generated net revenues of 1,02 billion in the fiscal year ended Aug. 31, 2008. 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. Accenture works for nearly 4000 clients in a full range of industries around the world and include 94 of the Fortune Global 100, and governments in 24 countries. In Italy, Accenture works for 15 of the first 20 financial national groups, for the first 4 insurance 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.

www.accenture.com



The Boston Consulting Group is a global management consulting firm and the world's leading advisor on business strategy. Founded in 1963, BCG has 66 offices in 38 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.

www.bcg.com

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Summary

News from Alta Scuola Politecnica 14

ASP Courses: vision and facts 19

Innovation Studies
at Alta Scuola Politecnica 22

EnerCity 26
Sustainability design of micro-scale urban area

MatER 28
Materials and Energy Recombination

Passive House in Cirié 32

The case of Arquata district 36

AMuPreMo 42
Advanced Multisensor Precipitation Monitoring

InfMed 50
*Quantitative methods in cancer treatment:
engineering supports the clinical analysis*

Mathematical modeling, collaboration
and knowledge sharing for cancer
research improvement 52

weHealth 56
A patient-centric scalable framework to
support healthcare decision-making

AdMIRE 62
Advanced Mobile Intelligence Reactive Environments

Home Automation
and Industry Evolution 64

Discovering Content in Urban
Environment 68

MUFFA 74
A multifunctional future for agriculture

Italia 150/Torino 2011 82
*Testing the architectural, urban and territorial effects
of a celebration event*

Planning Great Events: the Ecological
Footprint challenge 84

ViChem 90
*New mathematical molecular descriptors in drug
design and risk assessment*

DWARFe 98
*Environmental nanotechnology: applications, fate and
risks of engineered nanoparticles*

SmartCopter 106
*Sensor-vision-enabled autonomous robotic helicopter
for civil applications in urban environments*

Would you be Mine? 108

R.U.M.S. 112
Modular Shrouded Rotorcraft UAV

4 Rotors 4 Safety: 116
a quadrotor safety package development
for new operation opportunities

SensoBot 122
Sensors and control for societal robots

Helios 124

Aldaron 128

DoMa: 132
Domestic Manipulator

UP4tin 138

The informal settlements 140
Resources and Infrastructural Managing

Planning for change 144

Preserving daily life 148
Risk analysis and Mitigation

Home textile for tomorrow 154

Expo 2015 162
Towards a polycentric Milan

From EXPO to EXPOints 164
A microscale approach

From EXPO to EXPOint(s) 168
A macroscale approach

B²M 174
*The broadcasting revolution: social impacts and
opportunities*

News from Alta Scuola Politecnica

Prof. Roberto Zanino, Director, Alta Scuola Politecnica

Prof. Stefano Ceri, Vice-Director, Alta Scuola Politecnica

This brief article is devoted to summarizing the status and major news from Alta Scuola Politecnica (ASP) in the last year. For a more general introduction to ASP, please refer to [R. Zanino and S. Ceri, “ASP Status and Perspectives”, Multidisciplinarity and Innovation - ASP projects 2, 2008].

We concentrate on the following key items:

- Enrollment
- ASP courses
- ASP multidisciplinary projects
- Networking/Placement/Community
- Scientific Committee
- Reduction of benefits vs. increase of support from investors during the global crisis

With regards to **enrollment**, several new ideas have been introduced.

A *competition* amongst 2nd year BSc students of PoliMi and PoliTo was launched in 2008 and will be repeated this year. Winners are offered to attend the ASP summer school of the first year (Management of innovation). In 2008, ~ 150 applications were received from candidates with average grades above 27/30 by the end of the 3rd semester. 40 candidates were interviewed, and 20 were eventually selected. The candidates were very positively impressed with being offered a reward due to their excellence as students – an attitude apparently not so frequent during the BSc track of PoliTo and PoliMi, which is considered to be just as a transient step towards MSc by good students. It is quite crucial for ASP to strengthen its roots in the BSc. As another little step in that direction, the 100 PC initiative -

which awards a laptop to the top 100 students admitted to the BSc program at PoliTo each year - was connected this year to the award of the best (MSc) graduate student prize offered by the Association of the Cavalieri di Gran Croce, which was received by one of our former ASP students of the III cycle, Mr. Mauro Fassino. Similarly, PoliMi awarded recognition to its 10 best students admitted to the BSc program. As both groups are made of potentially excellent students of the future, they also received a copy of the ASP Multidisciplinary Projects Book as a source of inspiration for their student career.

The second major news, introduced experimentally in 2008 and now permanently confirmed in 2009, was the so called “bollino” procedure. The original criteria for admission to ASP (average mark $\geq 27/30$, BSc degree by October) could be satisfied only by a certain fraction of the students enrolled in the many different BSc programs and the average probability of meeting the admissions criteria¹ was ~ 7.5%; see Table I.

Cycle	PoliMi	PoliTo
I	9.59%	6.20%
II	8.83%	7.36%
III	7.58%	6.65%
IV	7.28%	6.12%

Table I Probability of satisfaction of the cold admission criteria to ASP for BSc students of PoliMi and PoliTo

After detailed studies, we realized however that the distribution of probabilities across the different BSc programs was not uniform, see e.g., Fig. 1, which summarizes the situation for PoliTo IV cycle but is also reasonably representative of all cycles for both PoliTo and PoliMi. Although both the multidisciplinary and a fair distribution of ASP students with respect to

¹ Defined as the ratio between students satisfying the criteria at the time of admission of a given ASP cycle and students enrolled in the given BSc program 3 years before.

their MSc programs had also been guaranteed *a posteriori* in previous years, it is clear that such criteria act as an unfair penalty towards the students of certain BSc programs where, for e.g., the average mark is below 27/30 for most if not all students and/or it is practically impossible to achieve the BSc degree by October.

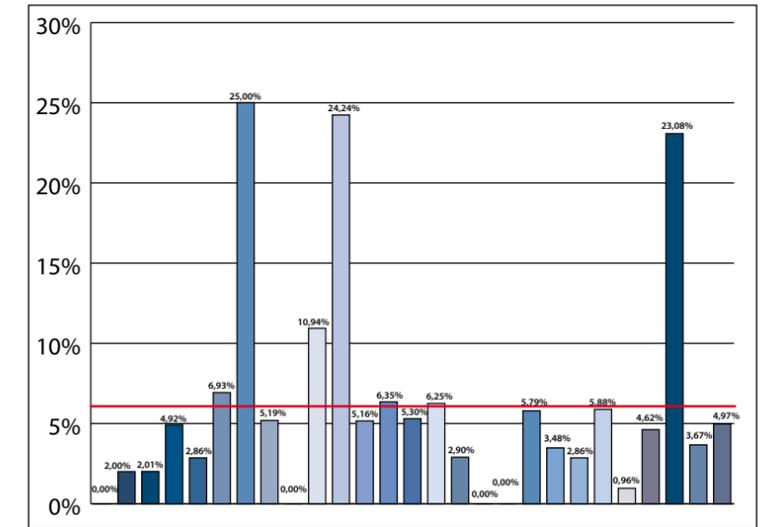
We therefore decided to award a “bollino” (“award stamp”) to the top 7.5% students of each BSc program, inviting them to apply to ASP *independently of their average mark*. The ranking inside the single class was determined on the basis of a parameter, the so-called Bernelli function², which depends on the product (average mark)*(number of credits) achieved at the end of the 5th semester – in a sense, a measure of the smartness and of the speed of the student. The use of this method allows us to perform an initial selection of students during the second semester of the third year, thereby informing the selected students³ that, if they will enrol in the MSc Program of PoliMi or PoliTo by December of the current year, they will be also admitted to ASP. Today this criterion has substituted the initial criteria for most of the students coming from either PoliTo or PoliMi BSc programs, which constitute about 2/3 to 3/4 of the typical ASP class, see Fig. 2.

It should also be noted, however, that the average BSc grade of students admitted to ASP and coming from PoliTo or PoliMi is, in the end, far above 27/30 (on average ~ 28.5/30), see Fig. 3.

The third major news concerning enrolment is that most of our foreign students are initially selected by the internationalization services of the two universities, rather than through a selection process initialized by responding to an ASP-specific call. Of course, we then select foreign students based upon their curriculum, a motivation letter, and an interview. Latin Ame-

² From the name of the inventor Franco Bernelli.

³ After providing motivation letter and English proficiency certification, and after an interview with us.

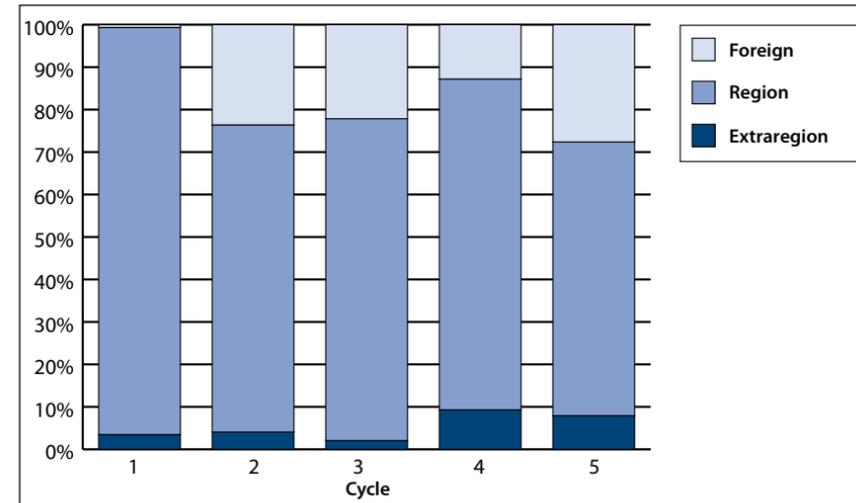


1 Distribution of admission probabilities in different BSc programs at PoliTo (4th cycle enrolment). The red line gives the PoliTo average for that year (see Table I)

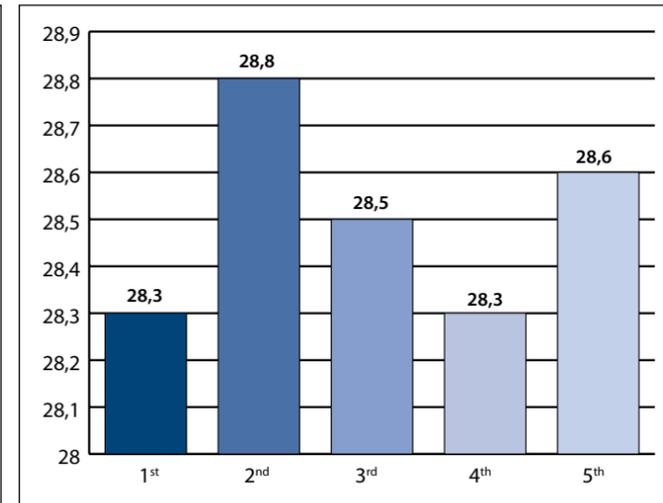
rica (20), followed by Asia (11) and Europe (10) constituted the most important basin for, e.g., the ASP 5th cycle.

Overall, *the 150 students of the ASP 5th year were selected in 2008 out of ~ 700 applications*, most of which already were highly qualified.

Concerning ASP **courses**, a new initiative was launched in 2008, namely a call for courses and/or contributions to courses among PoliMi and PoliTo professors. The initiative was discussed and agreed with the Deans of the 15 Schools of PoliMi and PoliTo and was important because it not only provided a tool for taking advantage of the amount of knowledge and know-how inside the two Universities (possibly unknown to us) but also because it served as an additional tool for attempting to strengthen the roots of ASP within PoliTo and PoliMi. A new course on global change and sustainability, coordinated by Profs. B. Betti, S. Consonni, M. Gatto of PoliMi, resulted from the call. The courses offered by ASP in 2009 are summarized in Table II (the top 3 are for the 5th cycle, the bottom 3 for the 4th one).



2 BSc origin of admitted ASP students



3 Average mark in BSc for students admitted to ASP coming from PoliMi or PoliTo

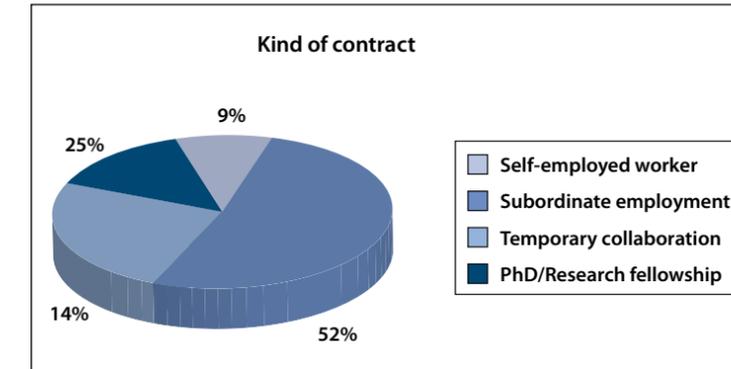
M. Bucchi	March 17-20	Bardonecchia
Innovation: Why, and for whom?	5 th cycle	Winter School
B. Betti, S. Consonni, M. Gatto	April 21-24	Bardonecchia
Global change and sustainability	5 th cycle	Spring School
M. Calderini	July 27-31	...
Management of innovation	5 th cycle	Summer School
B. Dente	March 16-19	Bardonecchia
Decision making	4 th cycle	Winter School
S. Rinaldi	April 21-24	Bardonecchia
The logic of modelling	4 th cycle	Spring School
A. Balducci	July 27-31	Torino
The dynamics of creativity	4 th cycle	Summer School

Table II ASP courses 2009

Out of six courses, two are new (besides that already mentioned above, also that coordinated by Prof. M. Bucchi, University of Trento) and a third one was completely revised (coordinated by Prof. B. Dente). The major issues related to the ASP courses remain twofold: the broad spectrum of disciplinary knowledge in the audience and the need to involve the students in active

sessions. Another contribution in this book, by Prof. M. Calderini, specifically addresses this point; a second contribution, by Profs. S. Benedetto and C. Ranci, who manage the courses inside the ASP Board, discusses the general philosophy of the ASP courses.

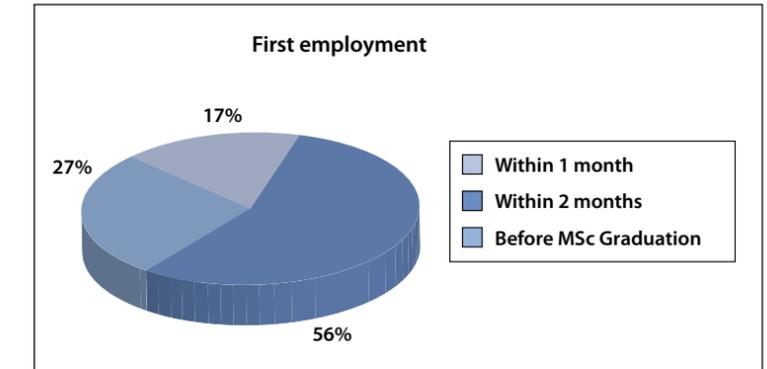
ASP **multidisciplinary projects** - to which the present volume is almost entirely devoted - have been so far arguably the most stable item inside the ASP program. However, some shortcomings are slowly but clearly showing up, such as the lengthy (2 yr) duration; this is relevant from the point of view of the external partners, which have to allocate part-time human resources to the project, as well as in terms of the efficiency of the entire process given that the teams may frequently only start the difficult part of the work in the second year. On the other hand, it is clear that the ASP keywords *education* and *innovation* appear in many contexts outside ASP as inextricably related to the third standard vertex of the triangle, namely *research*, and the population of ASP students land jobs in a variety of different sectors. A non negligible fraction (~ 25%) continues their



4 ASP 1st cycle employment: kind of contract

studies with a PhD; see Fig. 4. These aspects are currently being considered by the ASP board and it is quite likely that in the future we will revise the projects structure so as to overcome these critical issues.

The interaction of ASP with other actors and players in the context of excellence support is more and more vital for our school. It goes under the generic name of **networking**, i.e. establishing relations with other initiatives in higher education, but of course it is significantly affected by and related to the **placement** of our former students as well as by the extent to which we are able to build a living and proactive **community**. The ASP Alumni Association (AAA), on which we reported in the previous volume of this series, is providing a significant contribution to all of these fields. The Association is quite lively and is composed of enthusiast former students who are organizing social events, circulating newsletters, and helping us in assessing how ASP students are faring years after their graduation. A poll on the placement of 1st cycle students is being followed by a similar poll for the 2nd and 3rd cycles. The poll gave several interesting results, such as the type of contract that they currently hold, reported in Fig. 4. Perhaps the most important result, summarized in Fig. 5, is that all of our students found a job within two months from graduation, and almost 20% of



5 ASP 1st cycle employment: time for first employment

them already had a job before graduation. This may be compared with the results of a recent study [Sole 24Ore, 9 June 2008, Scuole di Eccellenza] according to which “one year from graduation the *broadest majority* of former students is working ...”, showing that we are also performing well with respect to our peers.

By means of AAA, ASP is establishing contacts with the College des Ingenieurs Italia, recently founded at Torino in a joint venture between Fondazione Agnelli, College des Ingenieurs, and other Foundations, as well as with Istituto de Empresa, located in Segovia, Spain, and with Unitech, a network for academic exchange and alumni activities which includes Politecnico di Milano. All seem to offer good opportunities where, on the one hand, ASP can provide a strong link to top level graduates for these post-graduate initiatives; on the other hand, ASP can benefit from the resonance of these worldwide initiatives to consolidate its brand and perhaps even share contributions to courses and/or project proposals with them.

The ASP community is a steadily growing body made of many different actors: the ASP students and Alumni, in the first place; the ASP staff that assists in the implementation of our initiatives in Milano and Torino; the professors and the tutors involved in ASP courses and multidisciplinary projects; the



6 Some members of the ASP Board meet before the 2009 Winter school

external institutions involved in the multidisciplinary projects and/or supporting us as investors; and the career, student and internationalization services of the two universities, which provide support to our program. Last but not least, the ASP Board, a team of colleagues sharing values, enthusiasm, and commitment, shown here - albeit in reduced ranks - in a somewhat different setting than usual, on the Sunday before the 2009 Winter

School at Bardonecchia, see Fig. 6.

The new Scientific Committee of ASP has been recently named for the 2009-2011 term. Its members are

- **Bob Armstrong**, *Chevron Professor of Chemical Engineering, MITEI Deputy Director, MIT, Cambridge (MA) USA*
- **Mauro Ferrari**, *Professor and Director of the Division of Nano-*

medicine, The University of Texas Health Science Center, Houston (TX) USA

- **Eric Goles**, *Professor at the Facultad de Ingenieria y Ciencias de la Universidad Adolfo Ibanez, Santiago, Chile*
- **Yongqi Lou**, *Deputy Head of Art & Design Department, CAUP Tongji University, China*
- **Konrad Osterwalder**, *Rector, UN University, Tokyo, UN Undersecretary General*

The duties of the Committee will include the oversight of the entire cultural program of ASP. The Committee will regularly meet with the ASP Board.

ASP only obtained start-up support from MiUR for the first three years, until 2008, and has been operational since that time with the support of institutional investors (Bank Foundations Cariplo and Compagnia di Sanpaolo), semi-institutional investors like Camera di Commercio di Torino and the European Patent Office as well as private companies. Sustainability of the ASP initiative therefore requires a careful consideration of the trade-off between **reduction of benefits** and measures to in order to **increase the support from investors**, which is obviously significantly affected by the present global economic crisis.

A major effort is placed on stabilizing the support from the Bank Foundations as well as on their participation through the launch of a series of multidisciplinary projects centered around the major events Torino 2011 and Expo 2015, in collaboration with the Mi-To Chambers of Commerce. We are working in tight collaboration with the career services of the two universities for convincing many private companies to become ASP investors, offering them benefits such as the possibility to propose ASP projects, the hosting of company presentations during ASP schools, and the opportunity of an early recruitment of ASP students (much before graduation). In addition, a possible joint effort with the MIT Energy Initiative, supported by ENI, is under study in view of the

intrinsically innovative and multidisciplinary nature of the energy problem, as well as of its dramatic relevance today and for the future.

However, considering that all of these efforts are still at a preliminary level, we have recently decided to introduce some cuts in the economic benefits for students, with particular reference to accommodation and MSc enrolment fees, given that these items contribute to a significant fraction of the total ASP costs; we also believe that ASP should slowly but safely establish itself as an initiative providing exceptional cultural - but not necessarily, and certainly not primarily - economic benefits.

In conclusion, ASP is a unique initiative of its kind (at least) in Italy, entering its 6th year of life with enthusiasm and awareness of the difficult challenges ahead. Based on that illustrated above, we confirm our belief that - at a rate of 120-130 passionate and innovation-conscious Architects, Designers and Engineers graduating each year in the top 5% of their PoliMi/PoliTo MSc classes. **ASP is going to provide a non negligible contribution to the Italian establishment within a few years.**

ASP Courses: vision and facts

Prof. Costanzo Ranci

Prof. Sergio Benedetto

The main goal of this brief article is to present the main contents of the ASP courses through a description of their distinguishing characteristics and the skills which these courses are intended to foster by complementing and completing the role of MS studies.

At the core of ASP courses, as a school that is part of two Politecnici, is the *design process*, a process by which specific problems are addressed and treated in order to find a technical solution. It is a tension field, where the designer is moving 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. In many cases, however, designers fluctuate between problem identification and problem solving activities for a long time before finding the “right solution”, or a solution which is just “good enough”.

ASP courses, first of all, aim at fostering the skills of ASP students in addressing complex problems and to solving them in an innovative manner. While the MS studies gives them extensive, deep, high-quality skills in focusing on a specific discipline, ASP allows the best students of our universities to broaden their competencies by developing the ability to manage complexity and promote innovation. Complex problems are difficult to address but at the same time serve as the best opportunity for innovation and change. But what do we mean by complex problems? What are the abilities and skills that are most needed to address these problems?

Complex problems

Let us start from considering standard design problems. These technical problems have a distinct solution that can be identified using standard design procedures and a linear problem solving method. 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 lowest 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. The best designer is the one who is the first to find out the solution. Specific and clearly framed problems are the kinds of standard design problems which students mostly address in their MS studies, where learning specific technical abilities allow them to not only to find good technical solutions to problem, but also to program and optimize the solving process. This competence is the solid background on which students can build their careers once they enter the labour market.

In many cases, however, real problems are not shaped in a way that allows the application of standard design procedures for their solution. There are, in fact, many technical problems where the technology to use is not very clear or it is partially or totally unknown, problems that have not been addressed before, or that have been addressed without finding good solutions. Think about projecting safe and efficient systems for the discharge of toxic waste, or inventing new electronic devices to give deaf people the opportunity to listen without compromising some other brain functions, or designing seismic architecture that balances safety and aesthetic criteria. All these problems share the same features: while the goals are pretty clear, technology is unclear or unknown at all. These are problems requiring a good aptitude for innovation and incremental designing (testing many options before finding the best one, and the adoption of multi-disciplinary expertises, i.e. combining and mixing different skills at the same

time). ASP is committed to supporting the ability of students in dealing with this sort of design problems. The most significant innovations come from an openness to new perspectives, the availability to change standpoints and combine a plurality of expertises.

Sometimes technology is clear but the design goals are not agreed upon. This happens, for example, when the introduction of new technological products results in social, technical or environmental disputes. Take the case of the high speed rail in Italy, or the case of the introduction of the Mose system of water control in the Venice lagoon, a sophisticated technological system by which water levels are controlled but with a potentially controversial impact on the precarious environmental situation of the lagoon. The social and political conflicts emerging from the introduction of these technologies can not be simply considered as boring distractions from the technical tasks of the designer. Unfortunately, technical solutions are often not neutral and have to take in account a complex set of social, environmental and economic interests. They call for designers who capable of taking into account the existence of multiple interests and actors, even though they are non technical actors; designers who know how to negotiate with these actors and how to manage conflict situations.

The skills of ASP students

Complex design is therefore an activity which develops in complex and dynamic environments and requires considerable cognitive capacities (aptitude for learning), talent for interpersonal relations (human and social interaction), 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. Three fundamental skills are to considered as the most

relevant ones and are addressed in the six courses that comprise the ASP program.

The capacity to understand the socio-technical and environmental environment where innovation takes place. Contemporary technical design takes place in an economic and social context that is in a state of profound change, characterized by the progressive internationalization of innovation, production, and distribution processes. Designers, increasingly involved in projects with ever-widening ranges of application, need to be aware of the socio-technical and environmental environment in which innovation occurs and develops. One ASP course is focused on the contribution of social sciences in understanding the role of techno-sciences in the innovation process, with the aim of fostering student capacity in *interpreting the socio-technical environment* in which innovation takes place and develops; their ability to understand how values and normative cultures shape and guide innovation and technical design; their attention to ethical issues and the effects of socio-technical innovation on society. Another ASP course, to be introduced in the 5th cycle, addresses the *trade-offs and dilemmas of sustainability*, focus on the ecological effects of technology solving problems such as the energy and water supply.

The ability to manage complex processes. Designing in complex environments requires the ability to mobilize and manage human and economic resources as well as organize the process in order to maximize efficiency and, at the same time, sufficiently comprehend needs and demands stemming from the external environment in addition to reinterpreting them in a non-conventional fashion, efficiently interacting with varied interests and strategically transforming external limits into opportunities. This is an array of skills that is often underdeveloped by standard professional education but which is, however, increasingly central to the process of innovation development.

Two ASP courses, focusing on *project management* and *decision making*, are aimed at providing students with these skills; the former presents methods and cases aimed at developing strategic analysis skills, project and innovation management capabilities, skills and experience in group work, external communication capacities. The latter is focused upon the management of decision-making processes, conflict resolution, and the ability to involve external actors in essential strategic decisions. Beneath 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 capacity to manage multiple design approaches. Contemporary socio-technical design involves complex problems which not only require 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, yet one of the most fascinating, in contemporary design is to provide keys for the definition of reality that make possible adequate and efficient solutions, and at the same time do not artificially diminish its inherent complexity. There are two main paths that were historically developed within our Politecnici 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, the development of bottom-up design skills, typical of architecture and design, which are based on *creativity* and the promotion of new visions. Two ASP courses, focused on these two different and complementary approaches, seek to not only provide participants with the skills to understand and appreciate these approaches but also to grasp and then possibly re-utilize the underlying cognitive frameworks.

Innovation Studies at Alta Scuola Politecnica

Prof. Mario Calderini

There are two main reasons why teaching the management of innovation to students from a highly heterogeneous background is a less daunting challenge than one would expect: first of all, managing innovation is itself the quintessential multidisciplinary activity, and secondly, we can rely on a long standing tradition of innovation management courses delivered in business schools, often within technology or science-based programs, where students typically come from a very broad range of studies and disciplines. Such courses offered in Technology Management School normally share two qualifying dimensions: the convergence between managerial and technological education and the ambition to form professionals capable of managing innovation projects in environments characterized by social, cultural, legislative, political and regulatory complexity. Moreover, on the research side, the emerging field of Innovation Studies (Fagerberg and Verspagen, 2009), embodies a vast corpus of literature including - just to provide a few examples - psychology, economics, legal studies, sociology, accounting and history.

The way technology-based management schools have managed heterogeneity - particularly in the US business schools tradition - is through the extensive use of hands-on programs and especially case studies class discussion, the most notable example of which is the Harvard Business School teaching method. In its extreme version, the way to manage classes is such that the role of the teacher is limited to encouraging and moderating the discussion of students in the class on the basis of an analysis of a case study. Quite differently, the European way of teaching innovation management is based on a more analytical

and theoretical approach. This is explained by the fact that, in many European schools, courses in the economics of innovation became widespread well before a proper tradition in innovation management teaching was consolidated. This implied that the analytical frame was directly derived from courses in industrial economics, based either on neoclassical orthodoxy or evolutionary heterodoxy, of which the economics of innovation was a sort of final appendix.

However, the case study approach is far better suited for heterogeneous classes, especially for short programs, and we need to consider that European students are rarely used to handling complex business stories and inferring general and abstract principles from such stories. This is why the summer school in innovation management at the Alta Scuola Politecnica is based on a balanced blend of case studies and theory-based lectures.

Finally, it is worth mentioning that there are two additional problems when teaching innovation management to students with background in engineering and architecture: one of *relevance* and one of *integration*.

The former consists in convincing students of the *relevance* of the things that they are going to listen in the next few days. In order to overcome the widespread skepticism that characterizes students used to learning paradigms which are well rooted in technological determinism, we usually start our school with a good number of stories in which the engineer, the designer or the innovator is the perfect loser. Such storytelling is aimed at convincing the students that the one who creates value through innovation is quite unlikely to be the one that is able to appropriate such value, unless specific strategies and managerial behaviours are put in practice throughout the long way that leads from the idea to the economic value of the innovation.

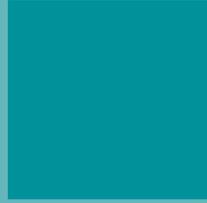
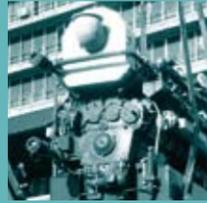
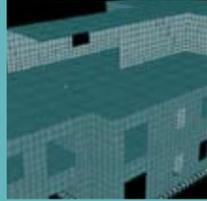
The latter approach is necessary in order to make our student fully aware of the fact that technological innovation is a process that is deeply *integrated* in a much bigger and complex management problem which involves corporate finance, accounting,



Students at the Summer School, Venice 2007

marketing and other core activities of the company. In order to do so, we rely on a simulation game in which students, gathered in several groups, are involved in designing, building and programming while using a very advanced version of lego, a self-parking brand new car, which they need to price and sell, trying to maximize their profits. The market is emulated by the students themselves by buying the different cars in a simulated big public exhibition which constitutes not only the week's peak of fun but also the very moment in which students learn a very important lesson: the economic dimension of technological innovation and the existence of market forces against which they will need to confront their creativity or their blind trust in engineering sciences.

Jan Fagerberg, Bart Verspagen, "Innovation Studies - The Emerging Structure of a New Scientific Field", Research Policy 38 (2009), 218-233



PROJECT

1

EnerCity



SUSTAINABILITY DESIGN OF MICRO-SCALE URBAN AREA



EnerCity

Sustainability design of micro-scale urban area

PRINCIPAL ACADEMIC TUTOR

Aldo Canova

Electrical Engineering, Politecnico di Torino

ACADEMIC TUTORS

Lidia Diappi

Architecture and Planning,
Politecnico di Milano

Marco Perino

Energetics, Politecnico di Torino

EXTERNAL INSTITUTIONS

Agenzia Territoriale per la Casa (ATC), Torino

Stadt Ostfildern, Sharnhauser Park, Stuttgart-Germany

Agenzia per l'energia della Provincia di Biella (AgenBiella)

EXTERNAL TUTORS

Luigi Fazari

ATC

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Zafh.net

Alberto Colucci

AgenBiella

TEAM A

Filippo Bolzonello [Team controller]

Civil Engineering

Matteo Bonardello

Mechanical Engineering

Rosa Castellino

Architecture

Luciano Rolando

Automotive Engineering

Gregorio Rossello

Environmental and Civil Engineering

TEAM B

Marco Bruno [Team controller]

Automotive Engineering

Grégoire Boutignon

Civil Engineering

project 1

The aim of the project is to design a micro-scale urban area with particular emphasis on sustainable energy and energy saving

Mario Buscaini

Building Engineering

Lara Rogantini

Management, Economics and Industrial Engineering

Sara Sanavio

Architecture

Fabio Taina

Materials Engineering

TEAM C

Roberto Guidotti [Team controller]

Civil Engineering

Elisabetta Carnevale

Architectural projects and management of constructive processes

Andrea Giordanino

[Project Communication Coordinator]

Automotive Engineering

Matteo Senesi

Mechanical Engineering

Angela Tagliaferri

Energy Engineering

PROJECT DESCRIPTION

The aim of the project is to introduce students to sustainable design in a urban environment. Sustainability is a key term of the project. It involves three aspects of the design process: not only environmental but also economical and social elements. As a result, the objective of the design is to put into a concrete form these three concepts by jointly considering architectural and engineering issues. The sustainability idea is expressed by the three teams in a different way: on the one hand Team A and Team B focused their attention on new areas and buildings respectively while Team C, on the other hand worked on an existing area which has to be improved.

Team A was mainly involved in the development of a particular software called “MatER”, specialized in the optimization of energy supply and demand within a micro-scale urban area. This instrument is able to implement a feasibility analysis among the main energy technologies and insulations while taking into account sustainability factors as well as the main architectural features and the specific characteristics of the concerned area. The efficacy of the software was carefully demonstrated by the case study of Calusco d’Adda, a small town situated in Lombardia region.

Team B worked on a single building design in Cirié. ATC Torino proposed the design of a passive house for aged people. As a result, the constraints of the project are: costs have to be low because it is a social housing; energy consumption has to be limited to a very low level in order to be stated as passive house; it has to be planned for aged people which are not accustomed to the behavior required by passive houses.

The sustainability concept is the way to overcome such constraints and fulfill the aim. Sustainable use of energy starts from the definition of a highly insulating building envelope; renewable energy production is then determined by calculating the energy loads. A particular emphasis on the habits of aged peo-



ple is given to the project. Their social integration is pursued as well. Moreover, an economical analysis is performed in order to match environmentally friendly technologies and costs.

Team C focused on the existing district of Arquata, in Turin, analyzing the energetic, plant and construction aspects while considering also the complex social context. The team, composed by engineers and architects, allowed for a global understanding of the problem, recommending innovative solutions for a sustainable development of the studied urban area, such as the implementation of a software for the economic and environmental optimization of the tri-generative plant in addition to a web-site in order to inform and make aware the inhabitants to energetic issues.

To sum up, the goal of the project is achieved for all the three teams. Students have acquired the knowledge and the awareness of how sustainability concerns economical, environmental and social factors. As illustrated by the following description of the work done by the three teams, they realized three different solutions for a common theme: sustainability.



MatER Materials and Energy Recombination

TASKS & SKILLS

Filippo Bolzonello worked on the MatER (Materials and Energy Recombination) software development with inputs-outputs definition. He focused on cost-benefits analysis and scale elements in depth.

Matteo Bonardello & Luciano Rolando focused their attention on the primary technical and economic energy factors, carrying out the sustainability analysis of different solutions to produce energy.

Rosa Castellino evaluated the architectonic variables relevant to the energetic parameters and developed three main urban solutions for the case study (Calusco d'Adda) in order to optimise spaces in a complex urban area context.

Gregorio Rossello analysed the energetic performances of the building components; he studied economic and environmental peculiarities in relation to the degree of insulation.

ABSTRACT

Nowadays the problem of energy saving has become more and more important. Even if there are a lot of technologies capable of generating energy in very different ways, there are some rules that have to be considered to improve the overall behaviour.

In fact in a context where the Government documents of economic and financial planning define the need for adopting a strategy for energy demand control and reduction, it's necessary to understand some guidelines in order to design not only new isolated buildings, but also extended and more articulated sustainable areas starting from the fundamental micro-scale level. In spite of a wide knowledge on individual buildings, the global approach is often neglected in both regulatory and technical environments.

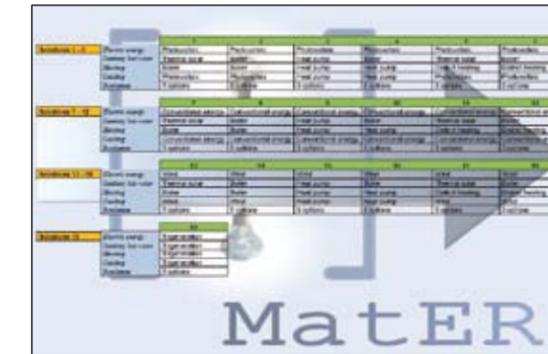
This study investigates and traces design guidelines for merging energy, technical and architectonic factors,, aiming at obtaining real improvements from both an economic and environmental perspective. In particular, the work is devoted to the development of a new software, named "MatER". Based on urban area energy demand under investigation, preliminary building performances can be obtained by assuming different plants and insulations configurations. The number of inhabitants, weather data, and site energy resources such as a forest for wood chip production or factories suitable for district heating are some data requested in input.

Besides MatER provides the most sustainable solutions achievable by performing a cost-benefits analysis. A deeper and more accurate solution could be obtained by adopting additional technical parameters. To validate the model, the software has been tested on an already existing urban environment under study.

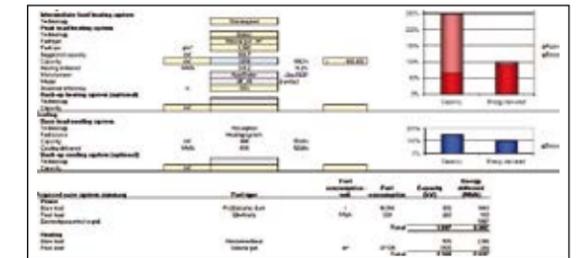
General design solutions have been proposed for a new area in Calusco d'Adda, industrial town in Milan province (Italy) as well as an energy consumptions analysis. Each of them considers one out of three main building typologies (towers, sprawl and in-line edifices); territorial parameters identify both the energy sustainability and area liveability of the examined solution.



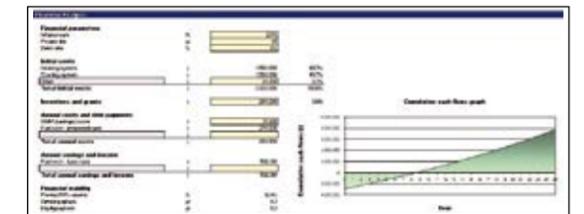
1 Logo of the software MatER



2 Software MatER. Possible solutions



3 Software MatER. Plant study



4 Software MatER. Financial analysis

UNDERSTANDING THE PROBLEM

The first stage of the study focused on the background acquisition of available energy production technologies, suitable for a micro scale urban area. Following a general overview of the project, each team member concentrated on a particular field, according to his/her own specific competences. Applications at micro-scale level were analyzed in depth in order to determine suitable design parameters.

Bonardello and Rolando examined technical aspects of cogeneration, trigeneration, district heating and conventional energy technologies. Particular attention was dedicated to renewable ones such as photovoltaic and thermal solar energy.

Rossello focused on insulator properties and factors influencing thermal load. A calculation procedure to evaluate the building energy demand was also proposed.

Bolzonello and Castellino examined architectonical and territorial parameters, i.e. green areas, functional mix, buildings shape ratio, mutual position and orientation to avoid possible wind

turbulence. Infrastructures and transportation problems within the micro-scale urban area were also considered.

The greatest challenge the team was asked to face was the identification of the relevant variables affecting the energy performances. In fact, when considering more than a single construction, the number of parameters significantly increase along with the complexity. Characteristics such as height, mutual distances, solar exposures as well as the degree of insulation and heating/cooling efficiencies have been recognised as playing a crucial role for finding the best mix of parameters.

A second key characteristic relies on the environment available resources; for instance the presence of district heating or biomass plants strongly influenced the energy production technology choice both for the neighbourhood upgrading and good economic returns.

Calusco d'Adda district case study provided the team with the challenge of coping with a real applicative experiment in order to find a tool capable of accounting for the numberless inputs of an urban area.



4 Calusco d'Adda, Bergamo. A street in the historical centre; at the end it's possible to note a part of the enormous Italcementi plant



5 Calusco d'Adda, Bergamo. The area object of the case study



6 An Italcementi truck. The area is interested by a continuous flux of trucks' traffic linked to the presence of a mine in the neighbourhood



7 An aerial photo of Calusco d'Adda with the area put in evidence



8 The area and the relevant masterplan



9, 10, 11 The solutions proposed in the area under study and considered for MatER simulations. It has been decided to only vary the residential buildings typology in order to obtain software outputs linked to their use



EXPLORING OPPORTUNITIES

After the project context analysis, the variables to be used for the *MatER* algorithm implementation have been defined. Their significant number, along the necessity of writing a flexible software, led to challenging work for the team.

To make the problem analytically treatable, simplifications have been incorporated into the proposed model. With regard to the building shape, for instance, *MatER* first order analysis approximates the profile. Precise architectonic characteristics are left to more detailed second phase investigation.

With regards to building insulation, the surface heat transfer represents a complex phenomenon to be described. Thus out of different evaluation approaches, a complete one was developed, able to account weather conditions. With respect to the building energy efficiency, several opaque, transparent, internal, external

and structural elements can be chosen by respecting law in force limitations.

Cost-benefits analysis has been implemented in the software, considering the opaque surfaces performances as free variables and maintaining all the other constants. Additionally, considering electric energy, domestic hot water and heating/cooling demands of a micro-scale urban area, greater attention was dedicated to environmental friendly and economically worth technologies.

The study investigates the following energy production technologies: photovoltaic, thermal solar, geothermal heat pump, wind energy, district heating, cogeneration, trigeneration, grid connected system, and traditional heating systems fuelled with LPG (liquefied petroleum gas), methane, wood chip, vegetable oil.

SOLUTION GENERATION

The main purpose of this work was the design of a micro-scale urban area software capable of optimizing investment and running systems costs, overall energy consumption and environmental conservation. 19 combinations of energy production technologies were found as significant, together with three possible solutions of insulation. Therefore by means of the user data inputs, the *MatER* tool estimates the annual energy demand, and then determining the more sustainable strategies by combining existing technical solutions. A list of the interesting ones is provided as output.

MatER permits so to obtain a preliminary estimation of overall plants costs, insulations and energy consumptions. Besides the more advantageous economic solutions, *MatER* incorporate filters, giving the opportunity to the users to insert some restrictions concerning environmental and sustainability aspects. Minimal amount of renewable energy adoption is an example; therefore all solutions not respecting these limits are excluded.

The last part of the project focused on the software test by mean of a micro-scale urban area in Calusco d'Adda. To shape the general framework of the new area, architectonic and technical hypotheses about building typologies were made as well as energy technological solutions suitable for the site. By introducing these hypotheses into *MatER* system, the most sustainable and feasible solutions out of a universe of possible ones come out. The chosen combinations will be submitted to a more detailed study aiming at finding the final result. *MatER*, the "mother matrix", is a new software able to optimize time, energy and consequentially resources: due to its system, technicians could concentrate on the more suitable system, avoiding so useless long run simulations.



Passive House in Cirié

TASKS & SKILLS

Mario Buscaini and **Sara Sanavio** focused their attention on the design of the architectural project for the purpose of complying with the varying needs of users and purchasers and assuring the requirements of energy saving and economical and technical feasibility while verifying the effectiveness of the solution through calculation software.

Fabio Taina dealt with the definition of the building insulation, formulating a materials choice inherent with the structural, energetic and economical requirements.

Marco Bruno worked on the design of the solar thermal energy, solar power and water saving systems in order to meet the energy independence objective for the building.

Grégoire Boutignon tested the architectonic plans of the building under the action of the usual static and seismic loads.

Lara Rogantini analyzed the economic and financial aspects of the project, elaborating a life cycle cost analysis to test the economic feasibility of passive social housing.

ABSTRACT

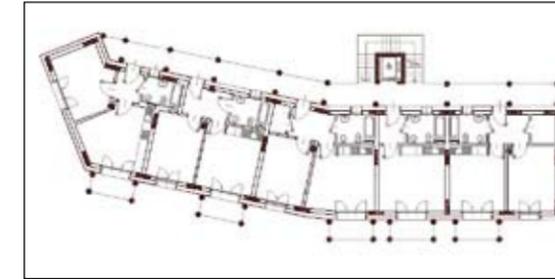
A sustainable urban area is made of sustainable buildings: that is the reason why we focus our project on a single building. After that, the objective of our project is defined: the design of passive social housing for aged people.

In the first phase of the work, we analyze what we have to pay attention on. So the key terms we have to keep in mind in order to deliberate our design decisions are: social, passive and aged people. Because ATC Torino is the purchaser of the building, costs have to be low. Furthermore, we are obliged to accomplish the standards of a passive house in terms of energy consumption. At last, we have to remember that old people have their own habits so as to design their own home properly.

Such three restrictions lead to different design decisions: as a result a good trade-off is needed in order to comply with the objectives in the best possible manner.

Our solution to reach the objective is sustainability. We express this concept through economical, environmental and social elements. From the economic point of view, building a passive house cheaper than conventional buildings is a challenge. With regards to the environmental issue, the challenge of sustainability deals with the energy production and the reduction of energy consumption. Furthermore, the social factor is essential too: we design a passive house, which requires more attention than a traditional one, for old people. They are familiar with certain bad practices from an environmental point of view: the third challenge is to train them to live in a passive house.

In the following part we explain how we match economical, environmental and social sustainability together.



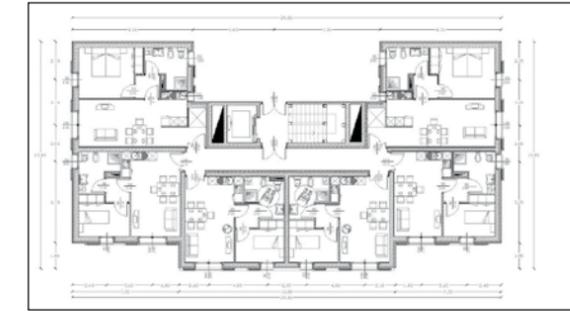
1 Plan of the preliminary solution suggested by ATC Torino

UNDERSTANDING THE PROBLEM

Reviewing literature and case studies, we identify the fundamental criteria of sustainable design at micro urban and architectural scale. Every choice oriented to energy saving results in social and economical consequences that have to be considered toward the feasibility and the effectiveness of the project.

The first stage of our study on the building aspect consists of a general analysis of the “passive house” concept and how it could be implemented in a building for old people. The main requirements for a passive house are made up of a net useful energy demand for heating of 15 kWh/m²/year and a total primary energy consumption of 120 kWh/m²/year. This energy requirement can be met cost effectively due to a set of preferred passive systems including compact form and good insulation, proper positioning and shading, energy efficient window glazing and frames, airtight building envelopes, highly efficient heat recovery from outgoing air, the use of air-to-air heat exchanger and hot water supply using regenerative energy sources.

As concerning insulation, it is a key element for a more comfortable and energy efficient home. It is important to have a continuous boundary of insulation between the conditioned, indoor spaces and the unconditioned, outdoor spaces. Such boundary is referred to as the “building envelope” which is a total system of construction materials and design components that control the temperature, movement of air, and moisture both into and out of the building. Thermal insulation is most effective when applied as a continuous and even layer, without penetrations or breaks. Penetrations form thermal bridges and breaks permit air



2 Plan of the adopted solution

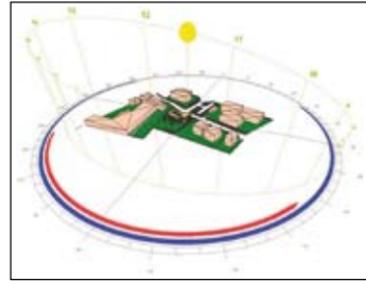
flow within and through the insulating layer, both of which reduce its effectiveness.

Therefore, building designers can contribute to solving the energy problem if proper early design decisions are made regarding the selection and integration of building components. Usual materials like concrete or steel are not relevant in the projection of a passive house: it is essential to find and explore all the possibilities combining high insulation efficiency with strong mechanical strength.

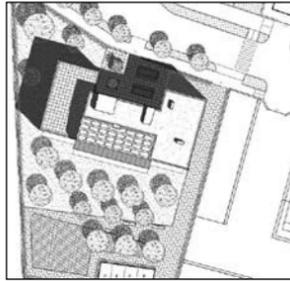
After understanding the importance of the building envelope for a passive house, we focus our efforts on the energy and water needs of the building. From the energetic perspective, we determine what energy loads are necessary and what are avoidable because of their high energy consumptions. In addition to this, water heating for domestic use has to be considered for inner needs, while water recovery has to be pursued for the outdoor needs of the garden and the indoor ones of WCs.

Although our passive house is placed in a low seismic zone, the resistance to the earthquakes could create problems for the ductility checking: in this case a seismic analysis is essential.

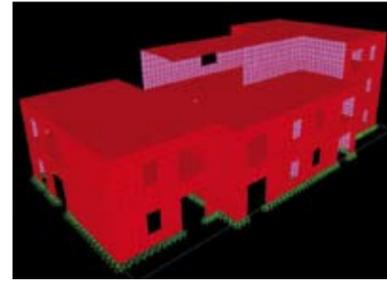
The first phase of the economic analysis deals with the study of the present economic and environmental scenario. Specifically, the analysis deals with current laws and regulations relating to the energy performance of buildings as well as pollution and energy consumption due to civil thermal plants and domestic devices, energy products and electricity, renewable energy sources, district heating and cogeneration.



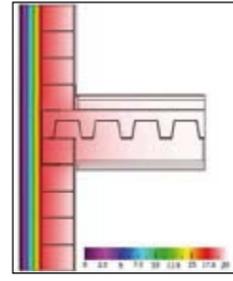
3 Environmental analysis – Solar path on March 21st



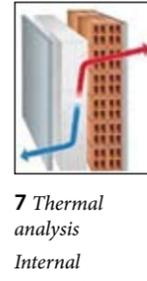
4 Plan of the roof and layout of the garden



5 The stratified building envelope



6 Structural checking by SAP2000 software



7 Thermal analysis
Internal temperature profile

EXPLORING THE OPPORTUNITIES

After analyzing the preliminary solution suggested by ATC Torino, which stands for “Agenzia Territoriale per la Casa”, we point out some drawbacks, especially those impinging on the quality of life of the users. Although this building configuration (balcony structure) manages energy savings (reducing the surface-to-volume ratio of the building), it does not meet some of the old people’s needs: for example it does not supply a sheltered place where people can get together and forces them to radically change their habits providing bed-sitting rooms.

Many parameters should be considered when selecting thermal insulation, including durability, cost, compressive strength, water vapour absorption and transmission, fire resistance, ease of application, and thermal conductivity. However, the thermal resistance of insulation materials is the most important property that is of interest when considering thermal performance and energy conservation issues.

There are a wide variety of insulation materials, facings, and accessory products available for use on mechanical systems. Not unlike retro-fit installations, new constructions primarily use cellulose, fibreglass, rock wool and spray foam. The list changes continuously as existing products are modified, new products are developed, and other products are phased out. The task for the insulation system designer is to select products or combinations of products that will satisfy the design requirements at the lowest total cost over the life of the project.

Standard houses let outside air leak in through cracks and openings, such as between window frames and walls. The use of super-insulation and high performance windows and doors means the heat lost through the walls, roof, floor and windows is minimized. This also means that the heat lost due to cold outside air coming into the house becomes insignificant. It follows that this air leakage is one of the most critical factors in making a low energy house work without a heating system.

With regards to solar thermal energy, there are many types of collectors to choose. Moreover, several classes of photovoltaic modules exist. Relating to water saving system, we compare different solution in order to store water.

The building sector accounts for more than 40% of total energy consumption, yet with estimated economic saving potentials of 28%, which represent a massive 11% of total EU final energy use. Each year roughly 2.5 millions new homes are built in the EU. Though ensuring homes meet new regulations can slow the growth of CO₂ emissions, low energy and in particular passive homes offer a radical but feasible step to reducing and eventually curtailing emissions.

GENERATING A SOLUTION

By merging all the different issues, we design a building form that is sufficiently compact for both reducing energy dispersion and optimizing the distribution of rooms and walk paths. The project provides two-roomed flats and a solar greenhouse to



8 A southeast rendering



9 A southwest rendering

conciliate renewable energy production and the needs of both the purchaser (maximize the number of lodgings according to the building code) and the users (habitability and social aggregation). It is not actually a residential building: it looks like a retirement home too. Consequently we have to compare it with reference parameters while taking into account that common areas are more important than in a residential building.

To formulate a unique solution in terms of materials choice, we do not look at insulation as a single item but rather have a strong team cooperation looking at the importance of the structural resistance, design needs, technological systems compatibility and costs. For thermal insulation, we decided to employ rigid polyurethane foam (PUR/PIR) which is one of the most efficient insulation materials. Focusing on the structure definition, we use expanded clay blocks which are characterized by high performances in terms of thermal comfort and reduced building time. Our aim is to couple the use of high insulating and dense building materials to exploit their thermal mass. In winter, heat gains are absorbed and stored in the thermal mass during the day and released into the room at night to maintain comfortable temperatures. In the summer thermal mass retains comfortable conditions.

During the design phase, we decided to use the Ecotect software to implement some microclimate analysis and to choose the best positioning for solar heat gain during the winter season.

After having definitively decided on the architectural plans, the structural review of the building is executed with the SAP2000 soft-

ware. Even though this sort of innovative materials does not have a perfectly defined normal framework, the review is mainly implemented with the “Eurocode 6 - Design of masonry structures”.

Rigorous calculation of thermal bridges and their effect on the average U-value requires 2D and 3D heat flow analysis. The thermal assessment of the overall U-value of the building envelope is developed with the THERM 5 software.

With regards to the solar thermal system, we analyse all the losses, ranging from the energy needs in flats to the energy production on the roof. An interesting collector we decided to adopt was an evacuated tube which integrates solar thermal energy and the power needed for fluid pumps in the system. In relation to the material of the photovoltaic modules, we determined that polycrystalline silicon is the most suitable technology for the weather conditions in Cirié. With regards to water recovery, we designed two different distribution systems in order to separately provide water for outdoor and indoor needs. Our building is designed to accomplished the energy standards of Passivhaus Institut, a prestigious independent research institution.

The introduction of high energy performance buildings in social housing constraints implies a careful attention to costs. A Life Cycle Cost Analysis (LCCA) is performed to explore the correlation between initial major costs and persisting future energy and economic savings. Life Cycle Cost Analysis shows our effort to reduce costs from what ATC requires to a lower amount of money. Moreover, specific attention is given to comfort for elder people and the addictive non-monetary value of the building.



The case of Arquata district

TASKS & SKILLS

Angela Tagliaferri, worked on the development of the software to simulate the tri-generative plants and on the economic comparison between the different technologies of plants.

Andrea Giordanino and **Matteo Senesi**, focused their attention on existing solutions for cogeneration and district heating while evaluating the environmental impact.

Roberto Guidotti, analyzed the aspect related to the buildings of the district, evaluating potential intervention techniques for their energetic optimization.

Elisabetta Carnevale studied the social impact of the technologies brought into the district, focusing on the informative and communicative aspects.

ABSTRACT

In the Sustainability Design of a micro-scale urban area project, our team worked on an energy analysis of the Arquata district in Turin, focusing on plant, buildings and social aspects. The work is part of an already existing project, called Polycity, sponsored by Politecnico di Torino, Centro Ricerche Fiat and Agenzia Territoriale per la Casa (the Italian Institution for Social Housing). At first it was carried out as an accurate study of state of the art of the current green technologies. It was characterized by bibliographical research activity as well as by attending seminars on rational use of energy and visiting other districts with similar issues to our site, first of all the Ostfildern German district. Subsequently, available alternatives were explored in an attempt to achieve optimal and innovative solutions for stakeholders requirements. In particular, a software for the tri-generative plant simulation was developed. Its task is to determine the best plant setup in terms of economical, energetic and environmental criteria. As far as buildings are concerned, solutions integrating current ones were proposed with the aim of improving the energy efficiency of the district. From a social point of view and in response to the lack of communication between the district players (i.e. plant administrators and final users), a web site was build up to collect urban and social district projects, promoting environmental awareness and communication by the parts.



1 Arquata, Torino. Top view of the district

2 Arquata, Torino. Typical popular building of the district



UNDERSTANDING THE PROBLEM

To provide a district energetic demand is a matter that emphasizes numerous correlated aspects. There are plant issues relating to the way in which the electricity, heat and cool requirements are met in addition to building issues about shape, position and envelope and social problems, concerning citizens' skepticism on innovative technologies introduction, often due to a lack of information.

The most critical plant aspect is the absence of a well defined set of rules to manage the trigeneration system, which actually is controlled by the station operators' sensitivity. The buildings, raised at the beginning of the 20th century without any technical solution in matter of energy saving, underlie a penalty to the economical and energetic balance considering both the global district and above all the single users point of view.

Arquata district, located in a geographic confinement contest, shows a problem of a difficult and often distorted communication between utilities suppliers and users; the refusal expressed by some users to the photovoltaic panels' free installation explains this concept well.

To tackle these issues, following the requirements expressed by the stakeholders, the team selected a series of targets in order to allow a sustainable development on the analyzed area. The



3 Ostfildern, Stuttgart. The high energy efficient district, powered by a biomass plant and PV panels

most important point is the technical, economical and environmental optimization of the trigenerative plant in order to provide an efficient management criterion to the station operators. Another target is to reduce district buildings energetic consumption while considering the technical and economical constraints imposed by the already existent architecture. With regards to the social aspect, a more effective information accessibility was pursued, especially to explain and spread Arquata district projects through the users. In this way the inhabitants can be more aware about energetic issues and more involved in the district social dynamics.

EXPLORING THE OPPORTUNITIES

In order to answer the highlighted problems, different opportunities were explored, many of which were representative of the state of the art solutions. The first phase of the project was dedicated to the acquisition of specific knowledge through bibliographical research, training courses of specialization and guided visits to sites with similar problems in order to study adopted solutions. The team's visit to the German district of Ostfildern in Stuttgart - involved in the same European project PolyCity - has been viewed in this context in addition to visits to other highly energy efficient districts; these visits were used to analyze adop-



4 Ostfildern, Stuttgart.
Andrea Giordanino is observing the plastic model of the district



5 Friburg, Germany. Insertion of PV panels



6 Arquata, Torino. CHP engine

tedinnovative plants and constructive solutions.

In particular and with regards to the plant, an economical comparison between the main technologies for power generation (i.e. IGCC, HDGT, ADGT, PWR, PCSC) was implemented. This analysis allowed us to evaluate product energy costs while also considering the influence of green certificates and externalities. According to the global growing attention to the environmental impact of new technologies, we identified the most innovative ones among the existing emissions fall technologies, also in anticipation of the limits imposed by Kyoto protocol (i.e. CO₂ capture and storage, carbon gasification, OTM).

With regards to the building aspect devices for energy saving were identified - both passive ones, linked to the shape, the shell and the orientation (i.e. ventilation, solar irradiation, shading) and active ones (PV panels, solar collectors, high efficiency plants). In particular, considering that district's buildings were already built, we focused on the active aspect, optimizing existing plant solutions.

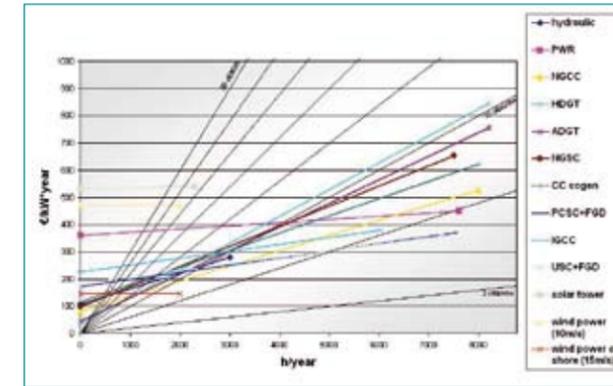
Interviews at inhabitants of Arquata district and meetings with district committees highlighted an inadequate information

trade. Therefore we tried to overcome local conflicts in the most efficient way, adapting to the Arquata social context the available innovative solutions.

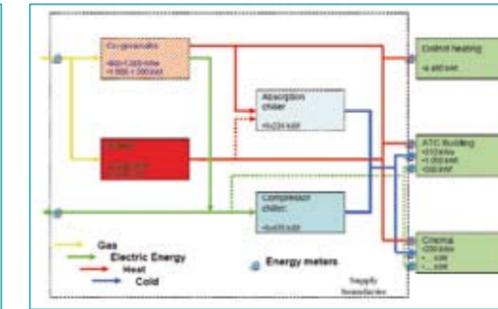
This phase of the work allowed to underline some of the most important critical elements, including the impossibility to apply lots of studied technologies because the technical and environmental sustainability elements often clashes with economical requirements and with the necessity to work with the constrain of an urban context already existing.

GENERATING A SOLUTION

On the basis of implemented studies and analysis, the team focused its attention on the plant of Arquata district, and believes that the optimization of this one, made in technical, economical and environmental terms, is the most important and innovative aspect of the project. Particular attention was dedicated to the social aspect of the Arquata district given that it was believed that in this case it could be possible to identify a significant element of innovation, in particular through the creation of a dy-



7 Costs of the electricity for different technologies of power generation



8 ATC building. Tri-generation scheme



9 Graphics interface of the software for the simulation of the tri-generation plant

namic network among inhabitants, managers, authorities and simple visitors.

In particular and with regards to the first aspect, a software was developed for the simulation of the tri-generative plant, using Visual Basic and Fortran language; this software calculates energetic balances, looking for the optimal working point. The whole plant includes the following components: primary engine with heat recovery, compression chiller, absorption chiller, boilers. Our aim is to determine when and how much is advantageous to use each of them. The software compares, for each considered hour, all possible working alternatives, in order to detect the best mix of plant components and the best working strategy.

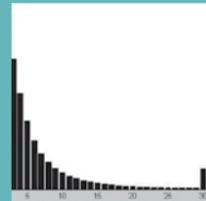
The software, executing an economical comparison about electrical energy and heat, searches for the best solution, taking into account two possible strategies: economic optimization (choosing hour by hour the strategy that maximizes entering cash flow); and crossing, in each working hour, of the threshold of IRE (Energy saving Index) assigned in input. With the software it is also possible to enhance the saved CO₂, to compare plant emissions to BAU and BAT scenarios and to calculate the fixed and variable values of the energetic saving certificates (TEE or white certificates). The software permits the evaluation of potential plant improvements through the introduction of addi-

tional components, such as a low-temperature heat accumulator. Among different studied plant configurations, the optimal one consists in the use of a CHP group coupled with the absorption chiller during the day and in its power off in the night, when the price of energy is lower. So, during the night, the heat production is supplied by auxiliary boilers while cooling production is committed to compression chillers.

Moreover, and with regards to social elements, we answered the need for sensibilisation, by developing a divulgation and advertising strategy aimed to increase the number of visitors and to enhance the possibilities of interacting with the neighbourhood, and on posters, in order to communicate to the inhabitants the keypoints of the Policity interventions. An interactive web platform was developed on the basis of WIKI technology and which could act as an archive for the different urban and social projects involving the district. The web platform has then been further developed, so to also act as a network for the different associations involved in the district, but also as an interface that allows citizens to communicate their needs and opinions about past and present interventions. Finally, the website is also conceived as a showcase that can advertise the peculiarity of Arquata as a multidisciplinary case-study and generate new collaborations, studies and visits.



PROJECT 2



AMuPreMo



ADVANCED MULTISENSOR PRECIPITATION MONITORING



AMuPreMo

Advanced Multisensor Precipitation Monitoring

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Alberto Canni

Mechatronics Engineering

Isabella L'Abbate

Telecommunications

project 2

It is a study of a statistical-mathematical model and its implementation to match data collected with rain-gauges and radar to forecast precipitation events

PROJECT DESCRIPTION

The AMuPreMo project deals with multisensor assimilation and fusion of the data observed using different sensors and carriers, including satellite-borne sensors, radar and ground-truth raingage networks with differing spatial and temporal scales, resolutions and accuracy levels.

The identified problems include:

1. errors of radar measurements in presence of orographic controls;
2. variability of the relationship between radar reflectivity and rain rate;
3. integration of data from multiple sources.

The results of this project include:

1. a method for radar data correction. This reduces the clutter effect in radar data associated with orographic controls. Applications of this method to the Spino d'Adda radar telemetering system are included;
2. a real time calibration procedure to detect the relationship between radar reflectivity and rain rate has been assessed. This is based on a heuristic approach. It can enhance current practice for short term forecasting of precipitation rates, and storm tracking in the Po river valley;
3. the bayesian approach has been use to assess a generalized Kalman filter technique for multisensors data assimilation.





TASKS & SKILLS

Alberto Canni focused on the weather radar device, how it works and how manipulate its data to obtain a good reflectivity measurement.

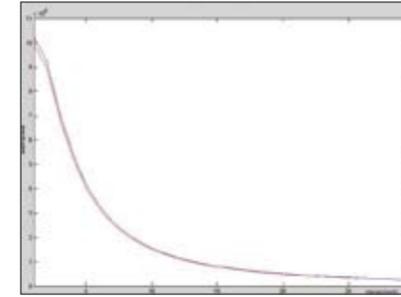
Isabella L'Abbate worked on the Z-R relationship, analyzing a real-time calibration of its parameters to produce an accurate reflectivity estimate starting from rain-gauge data.

Alessandra Pascale studied how to forecast snow high in the Mallero basin using data coming from snow-gauges and satellite.

At the beginning the project involved six persons and was more structured in its aims and tasks.

ABSTRACT

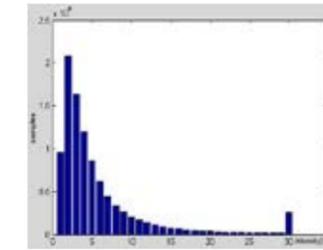
Accurate precipitation estimates and quantitative precipitation forecast are very useful for weather and flood forecasting; it is therefore of crucial importance to obtain rainfall measures as correctly as possible in order to derive an acceptable estimate. The stakeholders of this project are ARPA Lombardia and ARPA Piemonte (Agenzia Regionale Previsioni Atmosferiche) who are interested in rainfall forecasting. The required measures could be provided by ground based radar as well as active and passive sensors on board of satellite and rain-gauge networks but it is necessary to merge them in order to overcome the limitations and partially correct information that each instruments itself can offer. This differing information can be related by means of the Z-R relation, a mathematical exponential equation which parameters must to be accurately chosen in order to provide a low-biased rainfall rate estimate R starting from a known data set of measured radar reflectivity Z. Besides, a backward analysis is possible by matching the rainfall estimate with the rain-gauge networks data while taking into account the two different system of reference. The purpose of our project was first of all to understand how a radar works and how it collects data as well as the manner the Z-R relation can describe it and the way to use data. After this joint study-understanding phase, we follow three main specific aspects, each of which is based on a different algorithm. The first one focuses on the instrument radar- both on its features and on the way it produces data as well as how they could be rightly considered and used. The second task concerns the analytical methods which are adopted for using the set of data provided by radar. This consists in a real-time calibration of the Z-R power-law relationship for producing accurate radar-based estimates of rainfall intensity by recalibrating the Z-R relationship continuously in time considering short calibration periods. The last task concerns the developing of an algorithm that in specific situations can merge these different types of data. The specific situation chosen is a simpler one and it is the monitoring of snow high in the Mallero basin using data from snow-gauges and from satellite.



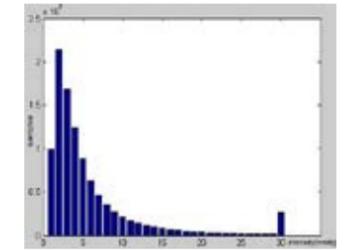
1 Different rain distribution between the first and the second algorithm



2 Logo Arpa



3 Number of samples vs. rain intensity, first algorithm



4 Number of samples vs. rain intensity, second algorithm

UNDERSTANDING THE PROBLEM

To provide an accurate precipitation measure it is possible to use different means as a network of rain-gauges, a ground based radar or a radar on board of satellite. Each one is linked to the rainfall rate in appropriate and different ways; their interpretation and matching is difficult.

The adoption of a unique climatologically relationship to link Z and R is a widespread practice for estimating rainfall fields, due to its simplicity of use and its ability to provide, on average, low-biased estimates. The literature reports several different Z-R relationships between radar reflectivity (Z) and the corresponding rainfall rate (R) in the form of power-laws, e.g. that proposed by Marshall and Palmer (1948):

$$Z = a \times R^b$$

where $a=316$ and $b=1.5$ and Z and R are defined as follow:

$$Z = \sum_i N_i D_i^6 = \int_0^\infty N(D) D^6 dD$$

$$R = \frac{\pi}{6} \int_0^\infty N(D) D^3 V_t(D) dD$$

The measure of reflectivity (Z), obtained by the radar in a polar system of reference, is due to the reflection of a number of N particles with a variant diameter. This measure has to be related to the rainfall rate (R), which is an integral one in a cartesian system of reference, linked to the distribution of the diameters of rain particles.

The heart of the matter concerns the choice of the right parameters in the Z-R equation, with a low bias. There are two approaches that arise from considerations on the origin of errors

in the Z-R relation:

- a statistical one in which the parameters derive from deductions on the distribution of the rain drops in a volume. Both the rainfall rate and the reflectivity follow from the distribution of the rain drops
- an objective one which infers a and b parameters from observations of the rainfall rate on the ground

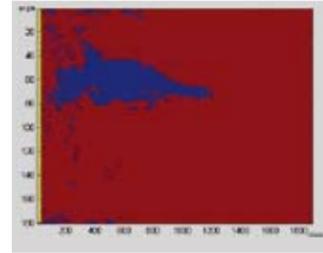
Errors derive from radar calibration, beam-spread propagation in the atmosphere, time-variance of the distribution of drops, and independent motion of rain particles in the volume. A solution to reduce the effects of errors involves the technique of integration in time and space. It is critical to establish the intervals in time and space.

The fundamental problem is the difference of the measures and it arises matching them with the Z-R relation. The radar measures are made in discrete intervals of range and angle, starting from a low elevation angle and scanning with discrete intervals up to cover all the region. Then, the measure of reflectivity is turned into rainfall rate and transformed in rainfall depth by integrating over a time, introducing a grade of decorrelation between data.

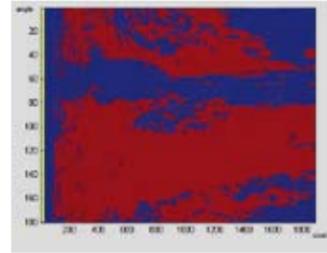
Errors due to rain-gauge device derive from wind and turbulences and the limited spatial sampling of interest. These factors reduce with the increase of the rain, of the area of interest, of the integration time and of the density of rain-gauges.



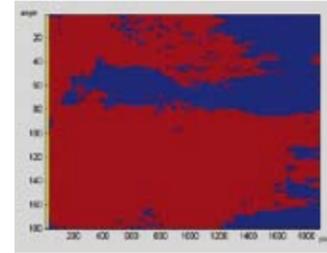
5 Rain gauge



6 Raw map



7 Rain map using the first algorithm



8 Rain map using the second algorithm

EXPLORING THE OPPORTUNITIES

Having defined the aim of the project, our work entered a new phase concerning the choice of the best instrument to measure precipitation.

We based our work on rain gauge and weather radar, the most important devices used to measure the precipitation.

A rain gauge is a type of instrument used by meteorologists and hydrologists to gather and measure the amount of liquid precipitation in a localized area. A weather radar can produce from a single location, detailed precipitation information of large areas in real time.

Unfortunately, radar does not measure rainfall rate directly but rather the backscattered energy from precipitation particles in an elevated volume, producing a source of errors. In fact, radar data interpretation depends on many hypotheses – which are not necessarily true – about the atmosphere and the weather targets:

1. The volume scanned by the radar beam is full of meteorological targets (rain, snow...), all of the same variety and in a uniform concentration
2. There is no attenuation of the radar beam (these hypotheses take a underestimation of the rainfall)
3. There is no return from multiple reflections
4. Return from side lobes of the radar beam are negligible

Therefore, radar data need to be processed to have a good precipitation measure.

Rain gauges also have their limitations. Attempting to collect rain data in a hurricane can be nearly impossible and unreliable due to wind extremes. When the temperature is close to or below freezing, rain may freeze on the funnel and does not permit any subsequent rain to pass through.

The increasing demand for accurate precipitation measures in large areas suggests the use of weather radar data. The most important technique for improving radar rainfall estimates has been to calibrate the radar with rain gauges. Simple techniques that combine sparse gauge reports (one gauge per 1000-2000Km²) with radar produce smaller measure errors than either system alone. Increasing the number of the rain gauges increases the accuracy of rainfall measures.

GENERATING A SOLUTION

The radar data must be corrected in order to obtain good reflectivity measures. In order to eliminate clutter, two algorithms have been developed. These differ according to results and utilized resources. The first algorithm only uses reflectivity Z, while the second one uses Z, V and W (the moments of the power). The first works on bins, instead the second on a cell (the cell reflectivity is the average of 12 bins reflectivity), so there is an underestimation of rainfall coming from the first algorithm.

The raindrop size distribution shows a great variability during rainfall events and the actual Z-R relationship changes continuously in space and time. The major drawback of using a unique relationship is that it can not take into account the broad variability of the true Z-R relationship in the presence of different types of precipitation (e.g., convective or stratiform), as well as the variations that occur within each rainfall event. A real-time calibration of the Z-R relationship is then used by considering the radar-gauge pairs of the previous month with non-zero rainfall in order to account for seasonal fluctuations of precipitation and for possible drifts of the hardware calibration. The procedure was tested on 19 rainfall events that occurred in the north-western Italy between 2003 and 2006, utilizing reflectivity measures from a weather radar and rainfall data from a network of 20 rain-gauges, integrated on time and space.

To reach a solution to the problem of matching radar and rain-gauge data, a simpler situation has been studied developing an algorithm. The selected situation is the forecasting of high-altitude snow in the Mallero basin, a simpler situation because of the limitation of area and the amount of data available. This is an area monitored by ARPA to control the formation of avalanches.

In previous works the topic of monitoring snow height has been developed using only data coming from snow-gauges. The algorithm of Kalman filter is used and its limitations are:

- snow-gauges give a very rarefied information about the height of snow. On the other hand they are a very reliable devices with a very small measurement error margins.
- the algorithm is only valid and optimal for Gaussian distribution and linear relation for model and measures

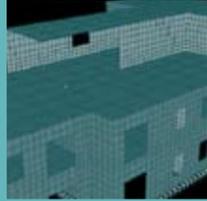
The algorithm that was developed abandons the hypothesis about linearity of relations and gaussianity of distributions. It uses the theory about bayesian rule and forecasts snow height by using a progressive updating of a-priori and a-posteriori statistical distribution of state variable. In this way it becomes more flexible that the other precedent works.



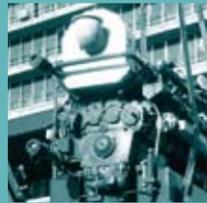
9 Spino d'Adda experimental station, ARPA Lombardy



10 Weather radar in Piedmont, Monte Settepani



PROJECT **3**



InfMed



QUANTITATIVE METHODS IN CANCER TREATMENT:
ENGINEERING SUPPORTS THE CLINICAL ANALYSIS



InfMed

Quantitative methods in cancer treatment: engineering supports the clinical analysis

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Candido Pirri

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Lamberto Rondoni

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RGI-Ivrea

EXTERNAL TUTORS

Vito Rocca

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Guido Serini

IRCC

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Biomedical Engineering

Marco Branca

[Project Communication Coordinator]

Computer Engineering

Vincenzo Carbone

Mathematical modelling in Engineering

Gabriele Martinelli

Mathematical Engineering

Valeria Vitelli

Mathematical Engineering

project 3

Emerging IT applications are investigated to support decisions and research in medicine. The project is supported by RGI and IRCC

TEAM B

Alessio Montone [Team controller]

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Matteo Lesinigo

Mathematical Engineering

Lorenzo Montrucchio

Computer Engineering

PROJECT DESCRIPTION

The project was created on the basis of evidence suggesting that the use of quantitative methods in medical diagnostics is a rapidly growing field. There is a common consensus that qualitative methods, based on past human experience and pictorial descriptions, can be supported by quantitative measures and analysis. For instance, image segmentation, statistical data analysis, database management and mathematical modeling are tools that are beginning to enter the medical practice.

The initial idea of the project was to then exploit the interest and participation of the “Istituto per la Ricerca e la Cura del Cancro” (IRCC), an outstanding center in cancer research and treatment and “Gruppo RGI”, a big software enterprise located in Ivrea, in order to link together the two souls and pillars on which bio-informatics is founded. Specifically, IRCC was interested in understanding how informatics could help in managing their experimental data and figures and in developing mathematical models and computer simulations to attain insight in the experiments they were running. RGI was interested in identifying what was the sub-field of bio-informatics being the most promising, useful and productive. Their interests spanned over the entire field, ranging from the development of image analysis tools to managing huge genomic and proteomic databases, developing a medical decision support system and electronic health (e-Health) management as well as constructing the virtual physiological human (VPH) and focusing on protein folding visualization tools. All this also involved a decision on the type of business to build, e.g., B-to-B or B-to-C (business to business or business to customer). Starting from this common background the activities of the two teams differentiated in the sense that one looked more closely at the needs of IRCC research by trying to find what could have been the most valuable contributions of informatics while the other looked more closely at the ICT applications in the field of bio-informatics that could be developed by RGI. In the former case IRCC was the leading industrial partner and RGI acted as a support and consulting



partner, in the latter case it was the opposite. Focusing on pancreatic cancers as an application, Team A identified two possible modeling approaches and soon run into the problems of evaluating all required parameters and classifying all the figures of the experiments. This originated the idea of building an ontology-based database. Team B identified a Wikipedia-like approach as the most promising tool to build a worldwide accessible e-Health database system.

One of the outcomes of the project, unwillingly mediated by the two groups, was to bring together the two partners above, so that each one now knows what the other can offer, what are their expertises and what are their needs. Another valuable result was that RGI decided to found a new company of the group that will be located in Pont S. Martin, explicitly focusing on bio-informatics.



Mathematical modeling, collaboration and knowledge sharing for cancer research improvement

INFMED QUANTITATIVE METHODS IN CANCER TREATMENT: ENGINEERING SUPPORTS THE CLINICAL ANALYSIS

TASKS & SKILLS

Annarita Bernardini was responsible for the general understanding of the biological problem: the physiology of pancreas, the development of tumors, experiments on mice.

Marco Branca was responsible for the design and feasibility study of the data management system and of the applications for supporting research activities.

Vincenzo Carbone was responsible for the design of the mathematical model proposed to describe tumor growth from a mechanical point of view.

Gabriele Martinelli was responsible for an analysis of state-of-the-art mathematical models of cancer and islets dynamics and its linkage to pancreatic physiology.

Alessandro Satriano was responsible for the analysis of techniques and methods to be used in order to obtain quantitative information for the most relevant parameters.

Valeria Vitelli was responsible for the development of statistical tools for pancreatic cancer and for the analysis of current techniques for early detection of the disease.

ABSTRACT

Efficiency and effectiveness are two important parameters influencing time and effort needed to reach objectives and to find solutions. They become far more meaningful when the problem is finding new drugs and treatments to stop cancer development. Increases in the efficiency and effectiveness of processes is one of the fields where engineering can contribute.

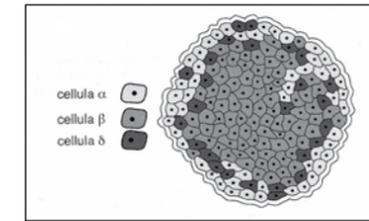
The aim of the team, in collaboration with “Istituto per la Ricerca e la Cura del Cancro” (IRCC) in Candiolo, was to design a set of tools designed to support researchers in their activities. In particular, the team focused on pancreatic Islets of Langerhans cancer, a very fast spreading and malicious tumor.

Two mathematical models have been proposed.

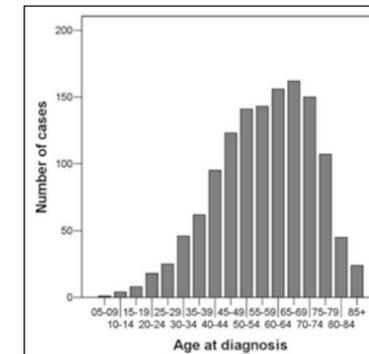
- a. The first model represents a diagnostic tool, providing researchers with the capability to statistically measure tumor progress according to easy-to-measure parameters in patients.
- b. The second model supports researchers in new drugs and treatments experimentation, describing Islets tumor growth from a mechanical point of view.

The team analyzed the opportunities about the most suitable experiments providing quantitative data necessary to correctly set the designed models.

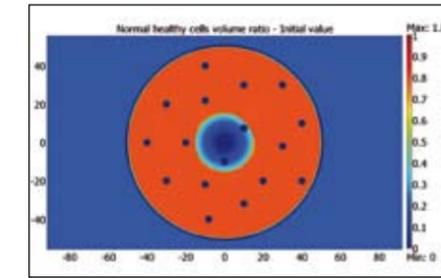
In order to make models and data obtained through experiments really useful for research activities, the team designed a system for data management and information sharing in IRCC. The system also allows researchers to share new findings with the worldwide community and to automatically find useful data among the most important published researches. In particular, we proposed a database and an application capable of collecting data from the database in order to set the parameters of the model accordingly. The team designed an ontology-based framework capable in assist researchers in their activity because “standardization” and “collaboration” are key-words for the development of research in quantitative fields like chemistry and biology.



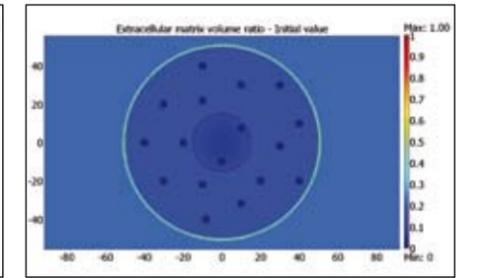
1 Islet of Langerhans: distribution of α (12-20%), β (65-80%), and δ (3-10%) cells within a membrane



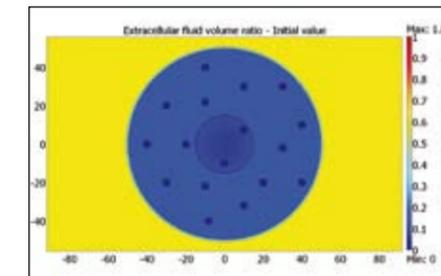
2 Age at diagnosis of 1310 cases of islet cell carcinoma. The median and mean (SD) ages at diagnosis are 59 and 58 (15) years



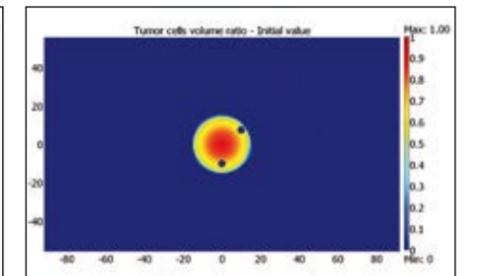
3 3D multiphase modeling framework - Normal healthy cells volume ratio - Initial value



4 3D multiphase modeling framework - Extracellular matrix volume ratio - Initial value



5 3D multiphase modeling framework - Extracellular fluid volume ratio - Initial value



6 3D multiphase modeling framework - Tumor cells volume ratio - Initial value

UNDERSTANDING THE PROBLEM

The Islets of Langerhans are groups of pancreatic cells producing hormones controlling glucose homeostasis. Each islet contains insulin-producing *beta-cells*, glucagon-releasing *alpha-cells*, somatostatin-producing *delta-cells* and pancreatic polypeptide-containing *PP-cells*. All of them can influence each other in the local area.

Tumor of Islet develops in four stages:

1. *Physiologic state*: number and dimension of islets are constant;
2. *Hyperplasticity*: random increase of dimension of 50% of islet;
3. *Angiogenesis*: growth of new blood vessels structurally and functionally abnormal leading to hypoxic and acidic regions in 8-12% of hyperplastic islets;
4. *Carcinomas and metastasis*: small tumor masses develop into adenomas or invasive carcinomas.

These are the phases that require modelling in order to understand the tumor growth process. In order to reach this objective,

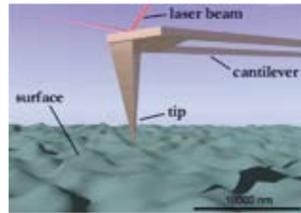
the team analyzed the experiments, models and infrastructures needed to provide IRCC with a framework to simulate tumor development and its reaction to drugs and treatments.

EXPLORING THE OPPORTUNITIES

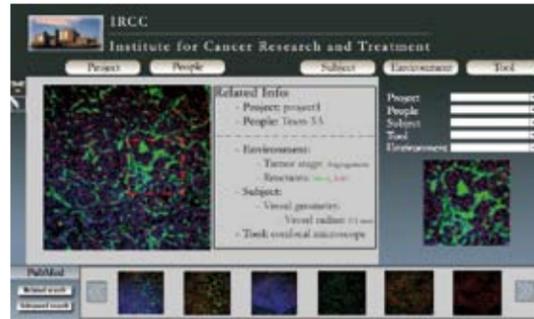
Literature proposes cancer models and pancreatic islets models, but it is necessary to join these two aspects, now uncorrelated, to provide scientists with a unique model in order to allow them to exploit all available information and obtain the best predictions about cancer development.

The main approaches in cancer modeling at a tissue level are the Macroscopic and the Cell-Centered models.

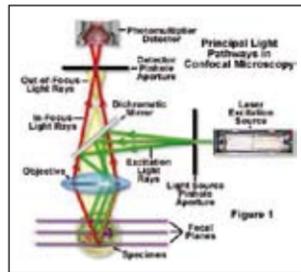
- *Macroscopic models* treat tissues as continuous substances with bulk mechanical properties and reproduce many biological phenomena but fail when structure develops or acts at the cell scale.



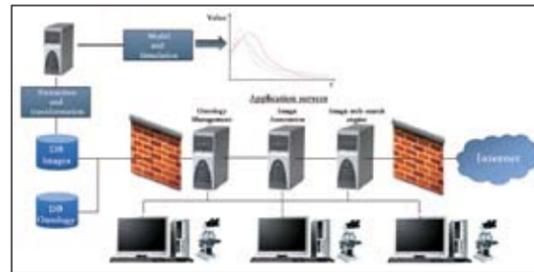
7 Basic scheme of an Atomic Force Microscope imaging principle



9 Graphical User Interface of the application proposed for image management



8 Basic scheme of an Atomic Force Microscope imaging principle



10 Architectural view of the system for data management and knowledge sharing



11 Candiolo, September 16th, View of the confocal microscope in IRCC laboratory

• *Cell-Centered models* describe individual cells to study how the collective behavior of multiple simplified cells drives higher-level processes. This approach turned out to be attractive for whole-organism simulations on parallel computers.

As far as pancreatic islets models are concerned, the team found that the main modeling efforts in this field are concentrated around three problems:

1. Diffusion of glucose through a pancreatic islet.
2. $[Ca]^{++}$ dynamics.
3. Oscillations in insulin secretion.

This last aspect is particularly interesting within the aim of our project because it could be related to cancer growth and its diffusion speed.

One of the problem experienced in the problem-setting phase was the lack of quantitative data needed by models in order to provide realistic predictions.

Several people tried to create public databases for storing experimental data. One example consists in the “Quantitative Cancer-modeling Data Base” (QCDB) that did not achieve the hoped success. According to the results of interviews with developers, the main reason for such a failure was the amount of time required for filling in the database with numerical data and this is one of the issues the team took into consideration in the proposed solution.

The lack in quantitative data brought the team to a third analysis about the opportunities in terms of experiments and equipments in IRCC. The institute is equipped with a confocal microscope for measuring geometric properties of blood vessels that are essential for the analysis of tumor vascularization. Besides, IRCC performs microarrays experiments in order to check and recognize the presence of specific proteins in selected environments. Other measurements, on the other hand, cannot be ob-

tained with the technology the institute is provided with. For example, due to cost reasons, technologies for oxygen partial pressure measurements and blood flow monitoring are not currently available at IRCC. These experiments, together with the ones aiming at characterizing mechanical features of tissues, result to be too expensive for IRCC. Besides, these experiments have to be considered while designing the solution in order to provide all the data needed by mathematical models.

GENERATING A SOLUTION

The solution proposed by the team consists of:

- a. a renewal in the research approach based on mathematical models;
- b. collaborations for advanced experimentation;
- c. a framework for the full exploitation of efforts in both research and modeling activities.

The modeling contribution to the solution is composed of two parts. The first one consists in a new 3D multiphase modeling framework, where tumors are described as soft tissues mainly constituted by a mixture of tumor and host cells within a porous structure constituted by an extracellular matrix (ECM) and surrounded by a physiological extracellular fluid. The novelty of this formulation consists in taking into account the ECM remodeling through the production of matrix degrading enzymes as well as the mechanical behavior of cells weakly bounded to each other and the mechanical interactions of the growing tumor with the host tissue via concepts deriving from elastoviscoplasticity.

The second modeling solution has diagnostic purposes. It aims at identifying the covariates that are most related to cancer development in order to improve the clinical models, perform predictions and to develop novel treatment strategies.

In order to exploit the proposed models as much as possible, the team designed a framework for providing IRCC with the technological support necessary for taking advantage of both human and economical efforts invested in research activities.

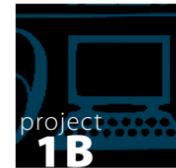
First of all, many of the collected data in IRCC are images, but



12 Candiolo, 16th September, Team - A at IRCC in Candiolo with Enrico Giraudo and the principal tutor Luigi Preziosi

this kind of data is difficult to automatically process by computers. For this reason, our proposal is a tool allowing researchers to annotate images with semantic information while analyzing them, without slowing down their work. These annotations are related to the ontology provided by the “National Cancer Institute for Oncology”. In this manner, information is stored according to a standardized vocabulary and is potentially shareable with the whole web community. Besides, the team designed a database for both storing such information and for feeding the proposed mathematical models. Finally, researchers in IRCC are interested in having rapid access to literature about their research activity. This requirement can be fulfilled by RGI, a leader software house which aims to enter the biomedical field, thereby providing a tool for rapidly accessing an indexed version of literature in biological research.

The team also proposed a set of collaborations with other research institutes in order to face the lack of technologies in IRCC. Measurements of oxygen partial pressure and blood flow can be conducted in Istituto Europeo di Oncologia (IEO), San Raffaele Hospital and Mario Negri Institute in Milano, while characterization of mechanical properties of tissues are deeply studied at the “Politecnico di Torino” by professor Pirri. For this purpose and for further protein recognition, a collaboration has been initiated between the university and IRCC. This represents a starting point for obtaining the data required for the mathematical models.



weHealth

A patient-centric scalable framework to support healthcare decision-making

ABSTRACT

The aim of this project is to address how recent results obtained by Information Technology can be used, exploited and applied in order to support and enhance the Healthcare Systems both on a national and an international range.

Our team proposes a new conception of Health Care System, focusing on the importance of patients' clinical records and collecting them in a large clinical record database which is accessible (through an access control system in order to manage privacy issues) by different physicians in different hospitals regardless of their location and the access medium (e.g., Smartphones, PCs, and so on). We propose a Wikipedia-like approach in order to allow patient to contribute to the database with his data (that may be also validated by a physician).

Once such a huge database of clinical records has been defined, we propose an entire framework covering the three main actors related to these records: patients, doctors and researchers:

- different applets of the framework help patients search information about diseases, recalling the assumption of drugs while constantly monitoring their health conditions and creating social networks of people affected by the same diseases and communicating with doctors.
- the proposed framework focuses on helping doctors during the diagnostic phase by providing applets exploiting modern data mining techniques run against the database of clinical records, e.g. a doctor inputs a set of symptoms and the applet returns a set of possible diseases the patient is affected by with hints about exams being useful to better identify the disease. Furthermore, patients management is provided.
- researchers, like doctors, are helped by data mining applets built on the huge database.

Conclusively, our team proposes a health care process reengineering, focusing on patient clinical records and building an entire framework for managing such data and extracting knowledge from them.

TASKS & SKILLS

Matteo Lesinigo contributed to the design of the framework. He focused on designing the interactions between people and the framework.

Alessio Montone contributed to the design of the framework and collected multiple feedback from physicians both in Europe and United States.

Lorenzo Montrucchio contributed to the design of the framework. He mainly performed the feasibility study from a technological point of view. He is the expert in data mining and knowledge discovery.



1 Concept of the whole WeHealth Framework



2 Concept of the WeHealth Framework: Physicians side



3 Concept of the WeHealth Framework: Patients side



4 Concept of the WeHealth Framework: Researchers side

UNDERSTANDING THE PROBLEM

In the last decades several investments have been approved by local authorities as well as by the European Community as part of the Sixth Framework Programme (from 2002 to 2006) in order to improve Healthcare Systems and Medical Research. Such investments often resulted in some improvements involving a temporal limited term or, similarly, referred to a specific geographical region, e.g. a 5-year research project on a particular cancer disease involving different institutions from the European Community. Without ignoring the importance of a pure research and recognizing it as one of the corner stone of the Modern Society and its wealth, what we were looking for is a

proposal aiming to redesign the Healthcare System and concurrently provide new opportunities to Patients, Doctors and Researchers. Furthermore, our main industrial sponsor was RGI, a public company born from Olivetti and currently one of the market leaders in providing database systems for banks and insurance companies. RGI is strongly interested in entering the health care business; as a result, we were looking for a modular and scalable design in order to allow RGI to independently choose whether to implement a stand-alone module of the design (having an immediate return of the investments and a low-risk) or the entire design (having a project spanning along several years with a high business risk).



5 Vancouver, 3-8 May, 2008. Some pictures taken by Matteo Lesinigo while attending the Vancouver International e-Health Conference and Expo 2008



6 Athens, 8-10 October, 2008. Some pictures taken by Lorenzo Montrucchio and Alessio Montone while attending the IEEE BIBE Conference 2008



7 GUI Concept. This concept represents the Shared Login through which physicians, patients and researchers can access WeHealth Services



8 GUI Concept. This concept represents the interface through which patients can search for doctors in order to ask consults, fix appointments, etc.

EXPLORING THE OPPORTUNITIES

In Europe and in the most industrialized countries, Information Technology has currently not had such an impact on Healthcare Systems with respect to the deep revolutions obtained in other sectors. For example, simply compare how communication among people changed in the last decade with respect to the small changes occurred in patient-doctor interactions. Furthermore, consider how the management of clinical data is slowly changing with respect to the mostly immediate digitalization of address books performed by everybody at home through a simple mobile phone. These two examples underline how much room exists in the Healthcare systems for a digital revolution.

GENERATING A SOLUTION

Starting with the observations provided above, we interviewed several Healthcare operators (i.e., Researchers and Doctors) and users, looking for technological weakness in the actual system and analyzing in depth the existing processes inside Hospitals, small structures (e.g., single doctor's office) and Research Centers (both in Europe and in the United States) in an attempt to redesign them as a whole. Furthermore, we began by observing that Healthcare System's focal point is, trivially, people's health, hence we put in the center of our solution what really concerns the healthcare system: individual health and the patient's own clinical data.

After combining the results of all this work, we designed we-Health, i.e. a new conception of healthcare systems strongly powered by information technologies and based on a database of clinical records as well as a framework of several independent applets accessing such a huge database. The description of these two components are hereby provided below:

1. The database. It is built by collecting clinical data and organizing it in order to create a large database which transcends the boundaries of hospitals and of other healthcare points. Such a huge database will allow each single patient to have one, and only one, collection of clinical records that can be accessed by every doctor regardless of the hospital. Furthermore, every doctor may modify these clinical records in order to add information about new symptoms and the related diagnosis (if available). In such a way and for each patient, there will no longer be a clinical record for each hospital (or doctor) he has visited, but there will be only one clinical record for each patient that can be accessed by every doctor. Obviously, the doctors must be previously authorized by the patient himself; in fact the patient is allowed, according to a privacy issue, to prevent doctors from accessing particular data (concurrently a patient will be informed that he is going to prevent doctors from accessing data that may result useful or necessary for a

better diagnosis). With such a system the patient stands in the center of the Healthcare Information Systems; in particular his own clinical records are stored in a centralized manner in order to reduce the possibility of losing important historical clinical data and information, resulting, for example, in a better doctor's diagnosis. For each patient, current and historical data are stored and structured into three groups: Quantitative (e.g., blood test results), Qualitative (e.g., head ache) and Complex (e.g., DNA micro-array, PET exams, and so on).

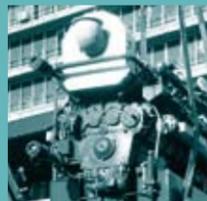
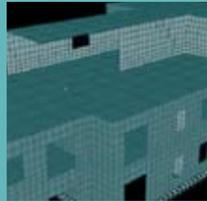
2. The applets. Several independent applications have been designed exploiting the previously introduced database of clinical data. The applets composing the whole framework are divided into three categories, depending on the main users of each category: patients, doctors and researchers.

a. Patients. The applets in this category are tailored for monitoring the health conditions of the patients through portable healthcare devices (e.g., blood analyzers), updating records stored in the database and giving immediate feedbacks to them about their health conditions. By exploiting this immediate feedback system, the applets can provide hints to improve the current health condition, helping and motivating people to follow these hints. Furthermore, people may be able to update their own clinical data with new information

(that can be confirmed by a physician in order to label data inserted by an expert and data that are not).

b. Doctors. The applets in this category are used by doctors in order to remotely check the health status of their patients, query the information systems about changes, accessing the historical data of their patient (previous, present and new ones), check for useful information to perform a diagnosis, and finally obtain statistical support to perform diagnosis. Doctor and Nation Healthcare systems can use these applets to perform screening by mining the database, looking for patients' category having the highest probability of being affected by a given disease; once that such a category has been addressed, then the system can advice such patients to perform certain exams in order to check whether they are or not affected by such a disease.

c. Researchers. The applets in this category are mainly based on the most modern data mining techniques which aid researchers in extracting as much information as possible from a huge database, similar to the one previously introduced. By means of such applets, the researchers may also be able to validate their theories on such a large database that can be considered a large collection of experimental data.



PROJECT 4

AdMIRE



ADVANCED MOBILE INTELLIGENCE REACTIVE ENVIRONMENTS



AdMIRE Advanced Mobile Intelligence Reactive Environments

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Casa Modigliani Museum, Rome

City of Lugano

Herman Hesse Museum, Lugano
IBC - Istituto Beni Culturali della
Regione Emilia Romagna
Museo Archeologico di Milano
Space S.p.A.

Studio di Architettura Tolozzi

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Giorgio Maric

City of Lugano

Maria Pia Guernardi

IBC

Massimo Riposati

Casa Modigliani Museum, Rome

Flavio Tariffi

Space S.p.A.

project 4

AdMIRE combines the “universal presence” of ICT and the relevance of mobile devices, thereby becoming a “personal” technology tool

Giacomo Tolozzi

Studio di Architettura Tolozzi

TEAM A

Leonardo De Robertis [Team controller]

Management, Economics and Industrial
Engineering

Aviva Bruckmayer

Architecture

Sinem Sürücü

Architecture

TEAM B

Valeria Mapelli [Team controller]

Management, Economics and Industrial
Engineering

Ane Etxezarreta

Environmentally friendly product Design

Francesco Malandrino

Computer Engineering

Alessandro Pradelli

[Project Communication Coordinator]
Mechanical Engineering

PROJECT DESCRIPTION

The project AdMIRE combines existing (or forthcoming) solutions and technologies with an innovative vision centered around the use of modern mobile devices: cellular phones, iPhones and alike.

The acronym, Advanced Mobile Intelligence and Reactive Environments, emphasizes the vision that “core” operations focus on the mobile device, in a number of different meanings:

- it “holds” most of the content interesting for the users;
- it can (interactively) “play” the content directly or through the environment (e.g. using a screen and speakers of the environment);
- it holds the user profile and preferences (see below);
- it “controls” the environment, by acting on digitized features (e.g. controlling lights, screens, temperature of the shower or the tub, colour, screen, ...);
- control over the environment can be direct (controlling explicitly the different devices), or may utilize predefined settings, or may match user goals/preferences (e.g. “I want to make a presentation”, thereby resulting in coordinated control of windows, light, screen, projector, speakers, etc.).

The environment, on the other hand, includes a number of “digitized features”:

- it can “play” content, even in places as cafeterias, traditional restaurant, wellness places, public squares, etc;
- the environment can physically control a number of features (e.g. lights, windows, screens, bathtubs, walls, ...);
- the environment, through a proper interface, can react to a unified control, based on a cellular phone;
- the environment can be previously known to the user, so that predefined settings can be created in his/her mobile device, or it may be unknown; in this latter case a more sophisticated match between user goal and actual control is necessary;
- the different installations may have different styles, including “techy look”, designer versions, “invisible technology”, etc.



The ASP projects deals, in multidisciplinary manner, with different issues:

- technology for content authoring and playing;
- technology for moving content from/to the environment;
- technology for controlling the environment;
- design for the different installations in private, semi-private and public spaces;
- business models for deployment of ADMIRE installations (on an Urban scale);
- business models for evolution of the industry in order to fully implement the “ADMIRE vision”.



Home Automation and Industry Evolution

TASKS & SKILLS

Aviva Bruckmayer, Architect, contributed in defining the needs and problems of Home Automation's users, analyzed the existing solutions and explored new possibilities for AdMIRE environments.

Leonardo De Robertis, Business Engineer, performed market analysis and concept definition, eventually he worked on alliance building and defined the principal objectives of AdMIRE project.

Sinem Sürücü, Architect, dedicated to architectural R&D, exploring new possibilities for using the home environment and creating a new design for these possibilities.

ABSTRACT

Home automation (domotics) is a field specializing in the specific automation requirements of private intelligent homes. The main issues that affect further distribution of home automation are:

- Standardization: providing compatible equipment.
- Emergence of partnerships : cooperative development of integrated systems can benefit all participants.
- Integration: potential complexity of home automation at the fully integrated level has not been addressed.
- User interface: system's easiness to use.
- Installation and set up: not just physical installation, but also the setting-up of each device into a network.

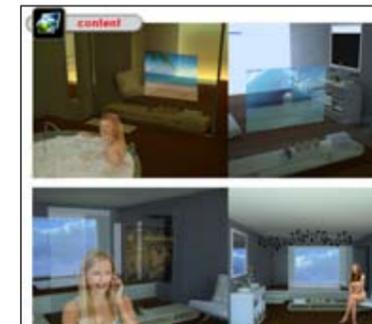
AdMIRE is the automation system which faces these issues by connecting appliances: a user-friendly, ready-to-program, Internet-accessible, secure wireless network capable of controlling everything from sprinklers to the chandeliers. AdMIRE is a flexible framework to control every domestic appliance using the smartphone like a universal remote control, transferring intelligence from the single appliance to the smartphone.

AdMIRE's characteristics include the:

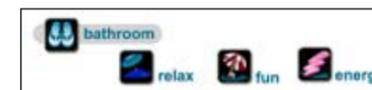
- Ability to control every device and to extract information from with the latter by means of a user-friendly interaction.
- Use of a wireless network that is easy to use and safe and doesn't need specific installation and successive addition.
- Cost reduction and service improvement: it puts home automation into the realm of off-the-shelf consumer electronics.

A strong industry alliance must include all the different appliance manufacturers in order to enable a complete home automation installation. In the first period, the leading position is held by the firm owning the patents; in this manner, the entire alliance is built around the company that enabled market penetration, that establishes development direction.

Into AdMIRE alliance participation is for free. Every company that desires to join the alliance must subscribe an agreement stating that, for every intelligent product they'll sell, they will deposit an established price to AdMIRE Company.



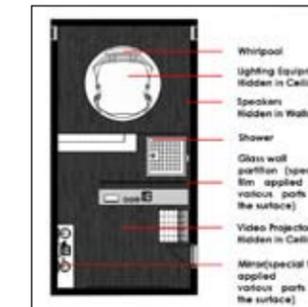
1 Bathroom: Application of Admire situations



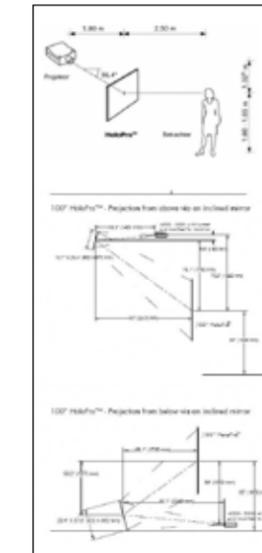
2 Bathroom interface



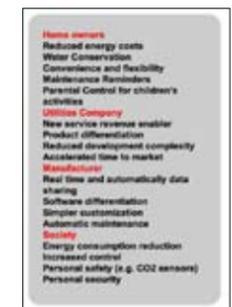
3 Admire permits the interaction of data through device and home



4 Admire Bathroom elements



5 Technical details



6 Admire's Objectives

UNDERSTANDING THE PROBLEM

Home automation diffusions must be analyzed both with quantitative market research as well as with a qualitative analysis of the main issues affecting its deferred introduction. In fact technology development allows us to create a smart house that enables the integration of all devices and systems, controlling and coordinating them with a central unit that can decide to activate them according to information coming from other components of the system, in an easy and user-friendly way. But it is still too costly because firms have never reached a high level of market penetration. Research firm WTRS forecasts that home automation shipments in 2013 will be at least 35.9 million, at most 133 million.

Standardization is important for home automation distribution so that a customer can buy compatible equipment from different manufacturers, a factor of importance in creating customer confidence.

One of the more interesting developments in the industry is the emergence of partnerships between manufacturers of different systems. The first pilot projects demonstrate how the cooperative development of integrated systems can benefit all partici-

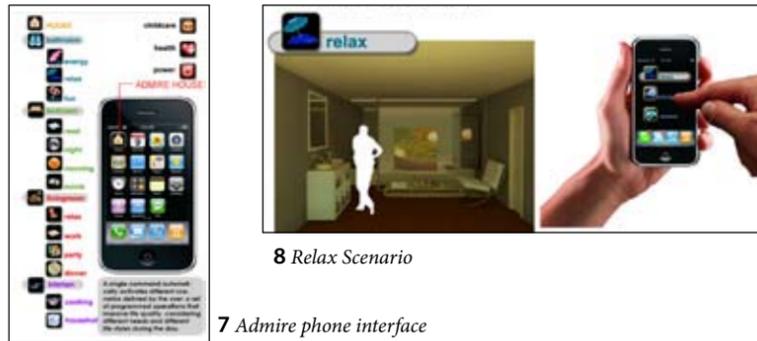
pants. Partnerships allow manufacturers to take advantage of each other's strengths and technologies and also to widen their marketing networks.

Among the different areas in which automation could be introduced there is little integration. If appliances don't communicate together, the quantity and complexity of their functions complicate their use. If, on the other hand, all individual systems could utilize the same interaction model, then it would be easy for consumers to add new modules to the domotics system.

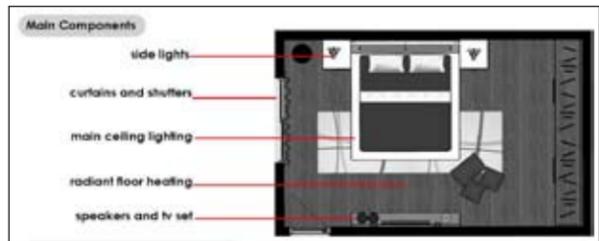
The full potential of home automation systems will not be realized unless the equipment is made easy to use for all classes of users, expert or naïve.

Installation techniques are also important because they just involve also the setting-up of each device with a different address and the registration of this address within the system.

The rising dominance of converged smartphone devices continues within the market place . Smartphones are a hybrid of the functionalities of PDAs (Personal Digital Assistants) and mobile, or "cellular", phones. At the same time, the share of the "pure" PDA device declines.



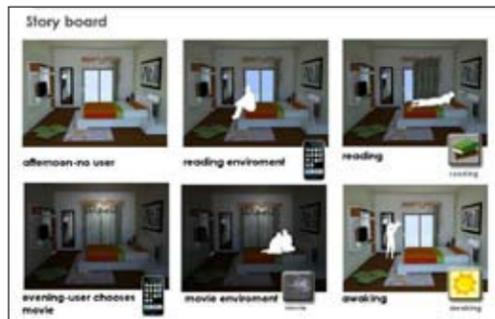
7 Admire phone interface



9 Bedroom elements



10 Bedroom: explanation of Admire possibilities



11 Bedroom: Application of Admire situations

The competition in wireless Home Networking concerns offering a connection between a handheld device and a fixed base-station connected to the Internet (an access point). It is essentially limited to Bluetooth and ZigBee. There are some options being proposed which utilize Wi-Fi technologies, such as IEEE 802.11b, however many researchers neglect this solution because, in many cases, the battery-hungry nature of Wi-Fi is not well suited to the application.

According to a qualitative approach, it is interesting to realize how a large part of the market share is not interested in home automation.

It's a problem of "appeal": an automatic home seems to be a "cold space" for the user, a home - and this is the paradox - that goes out of the control of its owner.

Often every kind of technological innovation has this impact on the mentality of people, above all for the older one. It's important to learn and make people understand the great advantages of a domotic house.

An installation for home automation is very expensive and is not affordable for many people. At the same time, existing technologies often require invasive works for the installation of cables and switchboards: most of the houses, in fact, are not ready to host - in their tube's cables - the space that is needed by the cab that connects every appliance to the system. At the same time, the installation of high-tech objects as monitors and sensors could strongly modify the perception we have of an environment.

GENERATING A SOLUTION

AdMIRE's characteristics include:

- The ability to control every device and to get information from it, with an user-friendly interaction.
- A non-invasive installation: Use of a wireless network that is easy to use and safe and doesn't need specific installations and subsequent additions. An AdMIRE environment is quite similar to a non reactive environment. The system of connection between

the appliances and the center of automation is directly inserted in them, communicating by wi-fi with the smart phone.

- Cost reduction and service improvement: it puts home automation into the realm of off-the-shelf consumer electronics.
- Strong psychological impact: choosing phone as the device that can control the house gives a new perception to the idea of home automation. This familiar object has only to be implemented by a software characterized by an user-friendly and extremely simple interface.
- Design and services solution: the user can focus on placing specific furniture or special interior solutions without worrying about technological problems. AdMIRE can also be easily updated with a particular service, such as control of children inside the house or control of the level of energy consumed by the appliances at any given time.

ADMIRE ADVANTAGES

Home owners minimize energy expenditures, thereby also creating social benefits; moreover this solution, that offers energy use and management of wireless control units in the home, allows utilities and homeowners to monitor usage patterns and reduce demand during peak periods.

This new global network allows every appliance to be immediately uploaded, provided that it has an IP address, so producers can differentiate products using their software, even remotely, eliminating a lot of manufacturing customization problems. As a result, producers will provide a service instead of a product, and they will be able to modify product characteristics according to the customer's needs, creating a new supply chain that dynamically will respond to demand changes. Control systems that enable status checking of appliances and lights support maintenance because they gather performances data from embedded sensors. This feature adds value to the service provided by an appliance manufacturer and could offer a 100% product availability.

AdMIRE increases control on many aspects of everyday life, improving personal safety, for instance detecting CO₂ into a room, as well as personal security by deterring thefts.

INDUSTRIAL ALLIANCE

A strong industry alliance must include different appliances' providers in order to enable a complete home automation installation. Moreover it is important to introduce one or more smartphone producers into the alliance in order to be assured that the communication module will work on at least one or two smartphone brands. In the initial period, it is fundamental that the leading position is occupied by the company which owns the patents, thereby centering around the company that enabled market penetration, and which can establish development direction.

The alliance must focus on:

- Promoting the AdMIRE brand globally to build market awareness;
- Managing the evolution of the technology.

Interoperability is guaranteed by the leading company, that builds communication modules for every device, moreover, the AdMIRE company is in charge of defining the network, improving its security and developing application software layers.

AdMIRE's standard power remains its ability to address an almost endless number of applications and market segments.

Every company that desires to join the alliance must undersign an agreement stating that, for every intelligent product they'll sell, they will pay an established price to AdMIRE Company. In this way, the parties which built the alliance receives money from the producer, who, on the other hand, can exploit AdMIRE's ability to simply improve their services, by transforming the latter to an automated and remotely controlled ones. All sensors will be put into every appliance by the producer, who does not pay anything for entering the alliance; the driver will allow communication between appliances and smartphones.



Discovering Content in Urban Environment

TASKS & SKILLS

Ane Etxezarreta, Design of the Eco-Compatible Product, Politecnico di Torino: after studying existing interacting services in public spaces, she developed the design concepts for AdMIRE Infopoints.

Francesco Malandrino, Computer Engineering, Politecnico di Torino: he was in charge of studying the state of the art of existing wireless technologies and developed the prototype for AdMIRE Infopoints.

Valeria Mapelli, Management Engineering, Politecnico di Torino and **Alessandro Pradelli**, Mechanical Engineering, Politecnico di Torino: they analyzed management and business aspects of the project and developed an economic model for AdMIRE Infopoints.

ABSTRACT

The project “Discovering Content In Urban Environment” is focused on urban scale AdMIRE applications for outdoor and public spaces. The objective of our project is to find an innovative application of wireless technology for an urban environment.

The result of our project basically consists in information points or Infopoints. Infopoints are positioned in “strategic” city spots, where they can interact with the mobiles of passers-by to broadcast news, information and other helpful data. This new concept of Infopoints comes from three different work streams:

- **Business:** we propose an econometric model and a planning model that has been tweaked and validated directly with the support of the Municipality of Lugano. Our methodology foresees a specific structure that can be implemented for every AdMIRE installation.
- **Technology:** we present a fully functional prototype, featuring information retrieval, download and streaming. The prototype is built upon the most promising present and next generation technologies.
- **Design:** we illustrate a wide number of installation concepts through a set of detailed renderings. They cover several examples of urban environments.

We started our work by considering a generic city and of the variety of services that can be implemented using wireless technology. Among all options, we chose to concentrate on offering an innovative service to tourists, business people and citizens: our scope was to give useful information and interesting contents to AdMIRE users by means of wireless technology and the mobile devices of users. We state that implementing a network of AdMIRE Infopoints can help touristic experience as well as citizens’ everyday life since a wide variety of information can be stored in information points and sent to mobiles when requested. Infopoints can store and broadcast text, images and media contents. Some examples of these contents are: public transport timetable, city maps, museum and art exhibition guides, historic background of a city/area, shopping malls location.



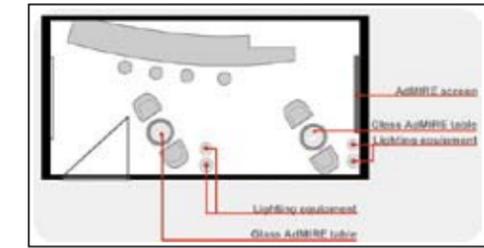
1 A single command activates different functions and environments defined by the users: a set of programmed operations that consider different needs and different life-styles during the day

WHAT IS AN ADMIRE INFOPOINT?

Infopoints are not a radically novel concept, and neither are mobile devices. The novelty – and the value – of AdMIRE lies in the roles played by Infopoints and mobile devices. Infopoints serve three main purposes:

- at a technology level, they provide connectivity to mobile devices;
- at a semantic level, they work as content repositories;
- at a physical level, they point out that a certain place is AdMIRE-enabled.

AdMIRE is a device-centric concept. The content is browsed, displayed and downloaded using the users’ devices: in principle, the users are not even required to interact with Infopoints. This marks a major evolution from the concepts that are more closely related to AdMIRE, tourist information points and audio-guides in museums. Users do not need to learn how to use new devices, as AdMIRE contents are simply embedded inside the interaction paradigm they are used to. The device centric approach is complementary to the concept developed by Team A which is mainly focused on domotic applications.



2 AdMIRE Main Components

TECHNOLOGY OVERVIEW

One of the key lessons emerging from our state-of-art review is that the most important success factor for a digitally augmented environment solution is the device which the user is expected to use. In this respect, AdMIRE foresees a radically innovative approach: the user interacts with the augmented environment using *his/her own device*.

As an outcome of this concept, the design of AdMIRE is essentially device-centric – i.e., AdMIRE can rely on pre-existing or independently-built infrastructure, if available. With regards to technology aspects, we have identified the hardware and software platforms which can be expected to run AdMIRE, both from a middle- and long-term perspective. We have selected more appropriate wireless technology and network protocols, and have finally designed a generic, extensible, XML-based semantic wrapper for the contents.

The AdMIRE infrastructure consists of a set of interconnected AdMIRE points (resembling, in a way, the old-fashioned tourist information points), which provide both connectivity (integrating an IEEE 802.11 access point) as well as access to the contents provided by the infrastructure owner (e.g. a museum or a municipality). AdMIRE devices are able to explore the contents of AdMIRE points via a web interface or a stand-alone program, the latter automatically discovering AdMIRE points within a given range. Once found and selected, the contents can be either viewed directly (in streaming, when appropriate) or downloaded on the device for later use. Finally, authenticated users are also enabled to create and upload their own contents.



3 Story Board



4 Story Board

as: strategic variables (upcoming events, number of hotels and museums), economic variables (sponsors for the project, potential number of users, budget), demographic data (population, number of visitors).

ADMIRE CONFIGURATOR AND MODELS

These tools include a list of steps to be accomplished; the project team will collect data and insert them in the model which will calculate the total cost and the number of potential users. In order to study our investment in a more specific manner, we prepared two mathematic models, one calculating overall investment needed for the project and another calculating the number of users of each AdMIRE point. In the first model we consider the important role of *scale effect* when buying a large number of components. Using our estimation on the reasonable maximum number of AdMIRE devices in a city, we assumed that the function representing scale economy is a Logarithmic and therefore we calculated the parameters of all the curves. This allows us to directly know the amount of the investment, knowing how many AdMIRE points a city needs.

In order to estimate this second fundamental variable, the po-

tential AdMIRE users, we built up a second model which consider the number of possible AdMIRE users. Our first thought has been to decide which places to take in account to calculate users. We choose to include: hotels, museums, temporary expositions' spaces, universities and touristic sites. Benchmarking data of hotels, museums, etc. from Milan, Turin, Florence, Rome and Naples, we calculated the number of users for a single unit (e.g. for a single hotel) and the average yearly utilization frequency of each one of these, we designed the model. Input needed is the number of hotels, museums, etc. of an Italian town and the output is the number of overall potential users.

TESTING OF MODELS

The last phase of our strand was focusing on a real case study, that is the city of Lugano. We used data provided by this city to test the economic models. These data were collected during personal interviews. We set a list of questions that are both simple and precise to help the project team and the commune in their interaction. Our meetings with the Lugano Commune have also been used as a test for our general interview schema. The final achievement of our project was a critical analysis of the results we obtained by our models to suggest alternative approaches and further work on this topic. The relationship with Lugano will also last after this project ends since we are currently studying and evaluating with them how to implement physically AdMIRE in Lugano. The deadline for the conclusion of the project is 2012, when the new Cultural Site will be opened.

DESIGN OF INFOPOINTS

The design part of our project is meant to give an idea of how the Infopoints can fit into an urban environment. Some conceptual examples have been created by means of the rendering images which illustrate how people will use Infopoints, the components of the space, the information that can be downloaded and the experience that user can live within an AdMIRE environment. The environments in which the conceptual examples have been

realized are: the university, the bar and in the city in general. Later we will see these conceptual examples and one of them to the detail.

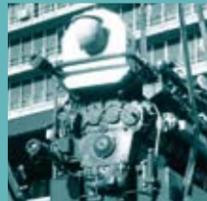
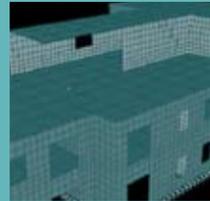
However, the graphic design of the infopoints is more than just aesthetic. Designers must think in terms of information, concepts and impressions when they design through the medium of print to ensure you get the right message across. It refers to a creative process that combines art, technology, layout and messages or concepts. Various methods and elements have to be combined in order to create these concepts including images, text, layout and composition. That's why the design of infopoints has to be easy to use by providing understandable information for the diverse users in order to make it reachable by the targets.

ADMIRE FRAMEWORK

Our project was aimed at developing a framework that should be followed in order to design an exhaustive AdMIRE implementation. The output of such a framework is a complete design of AdMIRE installation: costs, number of Infopoints, list of places to install Infopoints. In order to achieve these results we used our assumptions and models.

Project guidelines: the project team should follow the framework, but there are some key points that must be known in advance and taken into consideration during the whole process. These aspects are: AdMIRE potential users, potential sponsors/partners, AdMIRE project size.

Project framework contents: in order to apply this framework, the team needs to know a series of data concerning the city, such



MUFFA



PROJECT 5

A MULTIFUNCTIONAL FUTURE FOR AGRICULTURE



MUFFA

A multifunctional future for agriculture

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project 5

The MUFFA project pursues the opportunity of increasing the efficiency of agri-enterprises to defend their traditional role while pursuing economic diversification

PROJECT DESCRIPTION

The Challenge EU rural areas cover over 80% of its surface; the per capita income in these areas is, however, up to 30% lower than the EU average. The rest of the community pays for the environmental, social and economical conservation of these rural areas. In the long term, according to WTO rules, the EU works towards a substantial and progressive reduction of its support and protection of agricultural activities in member states. In this scenario, the survival of rural areas, including the preservation of the unique environmental, social and productive local contexts, depends on the shift from traditional agricultural paradigms to new economic models. This requires the promotion of processes focused mainly on increasing the efficiency and added-value of rural activities. The concept of “Multifunctionality” is central to the development of these initiatives. “Multifunctionality” in agriculture refers to the concept that agriculture can have many functions in addition to those traditionally which are recognised: the production of non-commodity goods such as energy, the promotion of high-quality and safe food and non-food standards, the protection of the environment, the conservation and improvement of rural landscapes, the supply of educational, touristic and recreational activities. The project aims at studying, recognising (existing) or conceiving new (not yet existing) productive/economic opportunities to increase the income of rural businesses while defending their traditional role within the territory. The work is developed in partnership with the Confederazione Italiana Agricoltori, the Parco Agricolo Sud Milano and local administrations.

The Team The team was made up of students with different engineering specializations. Each one contributed with his/her own personal background as well as his/her understanding of the various multidisciplinary ASP courses held during the two years.

The Results In the first place, a general approach to multifunctionality in agriculture was necessary to understand the different possibilities available to work towards diversification. Subsequently, in accordance with the indications of external in-



stitutions and with the intention to exploit the technical competencies present in the team, the project was oriented towards the study of a particular area of multifunctionality: agro-energies. Comprehensive research on the technological state of the art and the best practices in terms of agro-energy in the Italian and European context was performed. To move from the recognition phase to a solution implementation phase, a specific territorial framework was chosen to perform a pilot-type application. The Province of Lodi was chosen to develop a Strategic Plan for Agro-Energies (PSAE). Different scenarios for multifunctional agro-energetic development were analysed and integrated with the study of other elements considered fundamental for the execution of the strategy: Decision-making, and local conflict processes, virtuous economic cycles, leveraging of important events (EXPO 2015). The plan is intended as a pilot model applicable to different territorial contexts and ideally meant to be integrated with the existing governance and planning tools for rural areas.



TASKS & SKILLS

Helin Balliktas worked on the biomass/biogas availability and energetic properties. She also focused on the logistics of agro-energetic processes.

Lorenzo Colombo at first worked on the area of mini-hydro. Subsequently he led the study of decision making processes and management of local conflicts.

Mahael Fedele was responsible for mini-wind. He then dealt with the overview of the Lodi area and the definition of applicable practices and economic models.

Dario Mostarda focused on the use of the various forms of bio-combustibles and led the survey of the Lodi province agro-energetic potential.

ABSTRACT

In the near future, the PAC subvention and protection system for EU agricultural economy will be deeply revised and reduced. This will be done to comply with WTO policies on free markets and avoid the perpetuation of a number of market distortions and inefficiencies that characterise the functioning of EU agriculture. In this framework, a process of evolution and diversification of rural activities is necessary to preserve the unique social, environmental and productive qualities of the EU's and particularly Italy's rural areas. The focus of the work is on "multifunctionality". This means working to develop various higher added-value economic activities alongside traditional commodity goods production. Having screened a number of possibilities during the preliminary phase, the Team decided to focus the project on a particular form of multifunctionality of high economical and environmental relevance: Agro-energy. The approach to Agro-energy adopted in the work, in contrast to the extensive energy-crop plantations model for bio-fuels production, is that of a local, decentralized valorisation of all sources, including high energy-content side-products/wastes of traditional agricultural and zootechnical activities. Amongst the panorama of available technologies for energy production, the team focused on three main sources specifically related to an agricultural context: Small biomass, Mini-wind, Mini-hydro. A comprehensive state of the art research was performed in relation to the mentioned technologies before selecting a specific territorial area to implement a concrete case-study. The Province of Lodi was targeted to perform this pilot study, with the aim of providing a Strategic Plan for Agro-Energy. This document, intended as a helpful tool for territorial governance, was structured in the following way: - Overview of the geographical and agricultural context; - Evaluation of agro-energetic potential; - Proposal of models for integrated use of agro-energetic technologies and instauration of virtuous energy production/use cycles; - Analysis of decision making processes and potential insurgence of local conflicts; - Roadmap to use an important event such as Expo 2015 as a lever of change.



1 Artificial canal for fields irrigation in the Province of Lodi



2 Example of Mini-Hydro power plant in the Province of Sondrio



3 Useful magazines and publications on innovation in agriculture and renewable energies



4 Example of direct bio-methane commercialization at Gas stations (Sweden)



5 Poplar short rotation forestry plantation in the Province of Cremona



6 Milk Cow stable in the Province of Cremona



7 Artificial irrigation canal and short rotation forestry plantation in the distance (Province of Lodi)



8 Mini-wind production systems in rural context (Tuscany)

UNDERSTANDING THE PROBLEM

Our main external interlocutor and stakeholder, the Confederazione Italiana Agricoltori, highlighted the widespread necessity - for the future of Italy's rural areas - to develop and implement new ideas and strategies to promote change and innovation. The particular structure and size of Italy's agricultural sector is such that competitiveness in today's globalized market is only possible through diversification and focus on specific areas of excellence.

The idea of diversification is intended in the sense of "multifunctionality": rural areas have a lot more to offer than simple commodity goods production. To support the consciousness of this richness and to concretely develop schemes for its valorisation requires working towards multifunctionality.

In conjunction with internal and external tutors the team decid-

ed to concentrate the project on the valorisation and promotion of a particular area of multifunctionality: Agro-energy.

It was fundamental to understand that - in parallel with the objective of economical self-sustainability of rural businesses - great attention is being devoted to the objectives of environmental/landscape conservation and rural heritage regeneration. For this reason, the approach to agro-energy adopted in the project was completely different from the idea of extensive energy crops cultivation, entailing severe disruption of social, economic and environmental equilibrium in territories (such as Italy's) with a relevant traditional heritage and very specific characters and qualities. The concept was instead that of agro-energy as a side-activity aimed at maximising capitalization of the mainstream activity's wastes and side products.



9 Maize harvesting in Province of Lodi and detail of residual stems



10 Example of biogas digester detail of residual stems



11 Maize field in the Province of Lodi



12 Biomass heating plant in an Agri-tourism in the Province of Cremona

Another essential aspect of the topic under study is related to the fact that developing a strategy for change and innovation can not be limited to finding concrete technical solutions and sketching new processes. The contextual conditions for change must also be researched. This means, on one hand, analysing the social and cultural agricultural context, understanding the main actors' vision and goals, collecting elements on the cooperative structures in place and subsequently suggesting education and public awareness programs. On the other hand, it means understanding the institutional framework, highlighting bureaucratic bottlenecks.

EXPLORING THE OPPORTUNITIES

Before focusing on agro-energy, the team conducted research on the existing areas of agricultural multifunctionality. The choice to focus on a specific sector is based on two main reasons. Firstly, to restrain the scope of the work to an adequate size and to avoid the risk of remaining vague and inconclusive. Secondly, agro-energy was preferred because amongst the other multifunctionalities it is, from an economic point of view, the most "solid". In fact, working towards recreational/educative services or betting on enogastronomic excellence means promoting development that is highly dependent on the public's demand and sensibility for the specific territorial offer. Instead, the long term demand for energy is invariant with respect to the local context and the recreational/culinary taste of the public. This is increas-

ingly true for territories that do not have a particularly attractive naturalistic/cultural heritage to offer.

Based on the assumptions described above and given the numerous energy production technologies applicable in a rural context, the project was oriented towards those that are directly linked with already existing agricultural activities: mini-eolic, mini-hydro, small size biomass/biogas. The basic forms of energy output from these sources are: Mechanical, Thermal, Electrical. Three main categories of use for agro-energies were identified: direct supply of internal rural businesses energetic needs (thermal, mechanical, electric), the sale of energy (thermal, electric) to third parties or to the national grid, and the sale of processed high energy content material (ready for use bio-combustibles) for valorisation by third parties.

The selection of logistic and organizational schemes for production and use of agro-energy was conducted by bearing in mind the small size of the plants, and therefore the prevalence of the local factor when suggesting models for integration with existing activities and structures.

GENERATING A SOLUTION

In collaboration with tutors and stakeholders, it was decided that the solution generation be carried out in the form of a pilot study on a specific territorial context. The idea was to develop a Strategic Plan for Agro Energy (SPAЕ) applicable within a specific

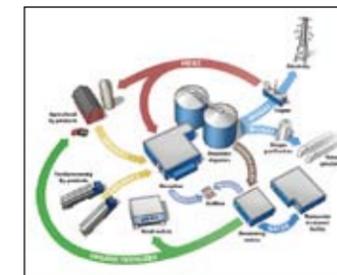
provincial area but also intended to serve as paradigm for the approach to other territorial areas. The Province of Lodi was selected for a number of reasons: Interest of stakeholders for an area in which the process of shifting to a new concept of agriculture is still slow; closeness and availability of direct contacts provided by tutors; homogeneity of the rural context and particular predisposition for agro-energetic multifunctionality with respect to other multifunctionalities.

SPAЕ is meant to be a specific innovative planning tool associated with the PAT (Piano Agricolo Triennale) and is useful in the framework of existing schemes for rural/territorial governance. The proposed SPAЕ for The Lodi Province is structured in the following manner:

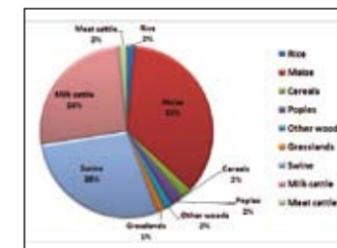
- overview of the territorial, productive and social rural context. Particular attention dedicated to the definition of representative models of agriculture businesses in terms of ownership, size and productions;
- quantification of the overall agro-energetic potential of the area. This phase required the definition of different scenarios and hypothesis for utilisation of agricultural wastes side-products;
- definition of viable agro-energetic sources and technologies. In this phase the mini-eolic and mini-hydro options were primarily discarded because of the geographical characteristics of the area. All attention was then devoted to biogas/biomass valorisation;
- study of integrated models to maximize capitalization throughout satisfaction of internal energy needs or distribution/selling on a local scale;
- analysis of authorization procedures, decision making processes, potential insurgence of local conflicts. Focus on opportunities to knock down bureaucratic barriers, support decision making and avoid conflicts;
- evaluation of promotional/education schemes to stimulate innovation amongst local players. Example of EXPO 2015 as an occasion/event to use as a lever for change.



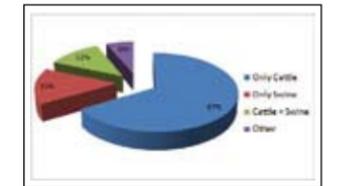
13 Lodi Province localization with indication of main rivers and transport ways



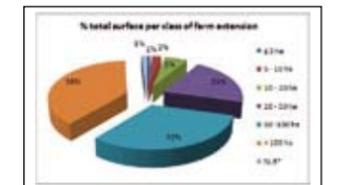
14 Biogas production and utilization lifecycle



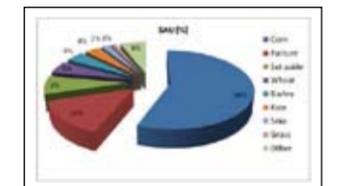
15 Province of Lodi potential agro-energetic production distribution (Scenario 1) amongst various sources of cultivation and zootechnical side products



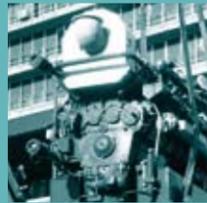
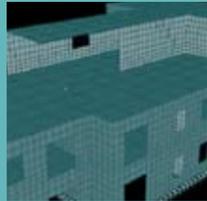
16 Zootechnical farm business distribution per type of activity in Province of Lodi



17 Total agricultural surface distribution per class of business surface extension in Province of Lodi



18 Total agricultural surface distribution per type of cultivation in Province of Lodi



PROJECT

6

Italia 150/Torino 2011



TESTING THE ARCHITECTURAL, URBAN AND TERRITORIAL EFFECTS OF A CELEBRATION EVENT



Italia 150/Torino 2011 testing the architectural, urban and territorial effects of a celebration event

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project 6

*Torino2011-Italia150: an urban
renewal project created in
collaboration with the Urban
Center Metropolitano for the
celebration of the 150th anniversary
of the unification of Italy*

PROJECT DESCRIPTION

The organization and planning of special events for ITALIA150 in 2011 represent an enormous opportunity for Torino and the whole country, particularly due to the great visibility of the town in the media. Due to the celebration of Italian Unification, a unique experience - passing through past and present - will take place in Torino: this special event will, similarly to what happened with the Winter Olympic Games in 2006, serve as a powerful catalyst for future development.

The complexity of such an event requires a multidisciplinary, innovative and flexible approach, capable of generating a successful strategy with long term results. How should the great event be planned, and how should post-event uses and urban transformations be planned? The initial challenge involved focusing on the effect that will be produced by the celebration at the metropolitan scale, from the architectural, urban and territorial point of view. Through the analysis and comparisons with other Great Events (with a special attention to the “Water” Exhibition in Saragoza, visited by a part of the project group), the students had to identify a quality system for infrastructure, landscape and urban renewal in Torino; and they would define a catalogue of feasible solutions that would get on well with both the specific project site and the urban complexity. Soon a huge area (“Basse di Stura”), limited by its features of decay, where environmental issues would be experimented, became the core theme of the students’ project. The stakeholders (Comitato Italia 150, Urban Center metropolitano) wanted a big open-minded approach, capable of providing a durable strategy that would become an added value to these Celebrations and, hopefully, for the following ones.

As there was only one team working on the project, students had to deepen both the specific knowledge on the limited site and the research activities to find out an innovative solution. The hard work of confrontation between the students and the stakeholders was fundamental in creating a productive synergy, a base of common perspectives towards a cultural renewal.



A significant effort led the team to widen its horizons, transforming the project into an ethical mission, which even goes beyond some Committee’s expectations. After the inputs of two still existing concepts in territorial planning – the Ecological Footprint and the Preventive Ecological Compensation method - the idea of a virtuous approach that considers the human impact on the environment grew stronger and stronger. Students think of the event as the first step in a wider revolution which can promote a sustainable model, even in a slow-moving country like Italy. Their idea acts on visitors and promoters of the “great events”, seen as human resources to a big improvement into the planning and identity fields. By means of the events, they aim to promote a new way in planning and visiting events, paying attention to the impact and to the real possibility to compensate nature for losses. This innovative method could be applied, in a same way, even for “small events” (sport events, film festival, all kind of ephemeral activities), searching for a “self-compensation” of the negative ecological effects. A shared responsibility could be a successful key to create a more optimistic scenario in the future, a glimpse of hope in the face of the worrying status of the planet.



Planning Great Events: the Ecological Footprint challenge

ITALIA 150/TORINO 2011_TESTING THE ARCHITECTURAL,
URBAN AND TERRITORIAL EFFECTS OF A CELEBRATION EVENT

TASKS & SKILLS

Michela Bongiorno: according to her background as a planner, spent her role in understanding and structuring the problem in all the fields, both theoretical and operative.

Giorgia Brusadin: dealt with the ecological footprint calculation, the readability of project results, the interactive manual design and the communication process.

Mauro Fassino: gathered information about the specific context of Torino, the projects of forecasted urban regeneration works and acts on the Floriade park design.

Tiziana Giannetto: deepened the analysis of the theoretical concepts, the strong ethical mission of the project and the possible way of future implementation.

Rositsa Ilieva: was responsible for the state of art analysis and the technological knowledge requirements, paying attention to the post-event implications.

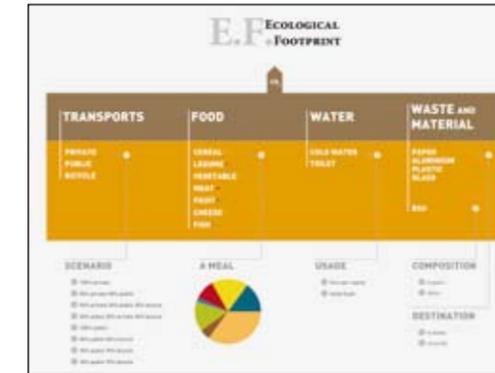
ABSTRACT

The most important guiding strategy of the 150th Italian Unification Anniversary celebrations, according to the team's vision, is the increase awareness of environmental issues amongst both visitors and in the organizational committee. The event's impact on the city was considered a means to this end so as to make the understanding of the problems more tangible to citizens. The mission of our project is to encourage a responsible visitors' and events' promoters model through a laboratory-shaped event. The Celebrations would test an innovative approach and leave a cultural heritage that can be spread and implemented by sustainable actions. The starting point was the leading concept of "Experience Italy", built up on a new idea of national identity and quality life capable of widening the exceptional brand of "made in Italy". Our researches dealt with an overview of the state of the art of the Great Events' paying attention to post-event prospectives and the environment, given that our project soon concentrated on a park area (where Floriade2011 will take place). Subsequently, the analysis of the Ecological Footprint concept and the Preventive Ecological Compensation method gave us inputs to project ITALIA150 into a wider dimension: visiting Floriade in 2011 can be a cultural prototype, similar to an ethical code that applies to the public spirit. Moreover it could permeate the whole event organization or, furthermore, it could influence strategic choices.

The team also carried out practical activities that consist in:

- simulating scenarios of compensative areas extension;
- designing an ideal mix of functions, services, materials of the park area;
- prototyping an interactive manual.

The estimation of a forecasted visitors' Ecological Footprint was converted into compensative areas capable of compensating the event's impact. The scenarios highlight the event's range and lead to the structuring of Floriade Park as an ideal event's place that embodies a possible solution. A big effort concerned the creation of an interactive manual that could summarize the basic concepts and provide the event's managers with a simple tool for simulating and practicing the visitors' impact.



1 The main factors considered for the Ecological Footprint calculation of Italia150



2 Some rows of the calculation matrix



3 The best-case and the worst-case scenario for Italia150

UNDERSTANDING THE PROBLEM

In order to understand the problem we decided to fix some starting points: the first one is to identify our main stakeholders – the 150th Anniversary Committee, the Torino Urban Center and the ASP board – and, at the same time, their needs and expectations. Nevertheless, this revealed to be a quite difficult mission to solve: since the event depends on national policy dynamics and decisions, its significance and vocation has changed a lot compared to its layout in the beginning. These factors led us to set some of our own additional objectives. First of all, our aim is to understand the meaning of this great celebration event both for Italy and for Torino. After some discussion and debate it was concluded that our mission might concern the renewed role of Torino in the celebration context -exactly as it happened 150 years ago- and the innovative expression of the event's significance and importance. These are the main reasons why the team decided to improve the role of Torino as a vehicle for a strong message relating to Italian development and which are strongly related to the environmental issues under discussion.

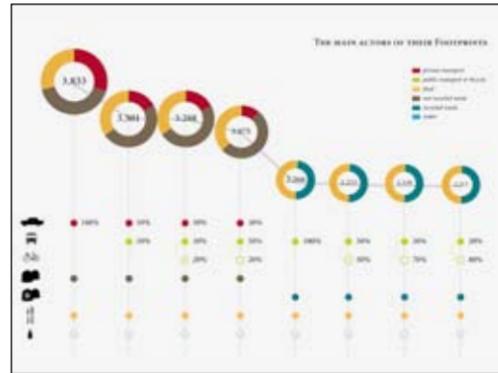
EXPLORING THE OPPORTUNITIES

It was necessary to point out the complexity of the project con-

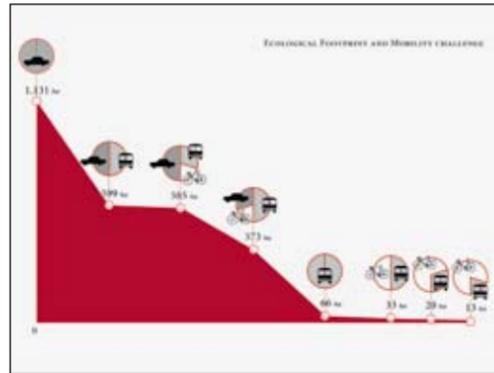
text: given its breadth, several different alternatives and solutions are possible.

The first important issue was defining specific project challenges in order to purpose feasible solutions. This revealed that the project would deal with two main objectives and would imply a double challenge; the first one is tangible, dealing with the organization of the event and the comprehension of the celebration effects both on the metropolitan and on the architectural scale. The second challenge is, on the other hand, more intangible: not only to celebrate the event, but also to provide and guarantee a valuable heritage, whose basic assumptions could promote the future development of the Country.

After these statements and discussion with our stakeholders, some alternatives were proposed. It should be noted that the environment played a central role in all the explored alternatives. Our first steps in the event's organization moved from Basse di Stura: a highly damaged and problematic area, as can easily be demonstrated by its vocation – a refusal discharge. After a few months, actions on the discharge site appeared very difficult since the Committee wasn't interested in the implementation of such interventions and technologies in the area. This is the reason why we moved to a nearby area where a 'Floriade' -that is to say a landscape and flowers exhibition similar to the German



4 The main actors of their footprints



5 Ecological footprint and mobility challenge



6 The first part of the solution: to create a Floriade in order to compensate part of the Ecological Footprint

BUGA- would be realized. The team's aims concerned a broader vision of the urban system related to the net-shape structure of the event as well as something more impressive. The idea of the sustainable mobility raised the issue of an integrated transport system for visiting the exposition sites and improving Torino's mobility was seriously considered as a feasible solution. Nevertheless, the team was looking for something different and more innovative; the analysis of these alternatives revealed to be strictly necessary to find out the final solution: the Ecological Footprint calculation and the Preventive Ecological Compensation of the event's impact. The Ecological Footprint is a useful indicator for comparing the human impact, that is to say the consumption of natural resources by human beings, with the biocapacity of nature. The Preventive Ecological Compensation is a method for compensating nature of the soil consumption, due to the building activity.

GENERATING A SOLUTION

The final solution seems to meet the challenge from both a practical and the theoretical point of view: as a matter of fact, if compared to the previous alternatives, the Ecological Footprint and the Preventive Ecological Compensation appear to be the best solutions for the project and for stakeholder expect-

tations at the same time.

After the theoretical analysis of the concepts, it was decided that a "zero impact" event would be promoted through the evaluation of the waste production and the preventive providing with green areas to compensate the CO₂ produced by the event. As a matter of fact, the basic idea is to give back to nature what is going to be stolen from it (in terms of soil consumption) by the means of preventive ecological compensation. That method considers the ecological balance as a *conditio sine qua non* for a sustainable future development. The existing concepts of Ecological Footprint and Preventive Ecological Compensation represent the innovative vision of a Great Event role, acting as an experimental prototype. The post-event prospective is to widen this idea beyond the event and to transform this celebration into an opportunity for promoting a new way of conceiving urban and infrastructural transformations. The great event will provide a guideline manual and a digital simulation system for private and public institutions in order to understand and implement the mechanisms that could generate a real cultural change.

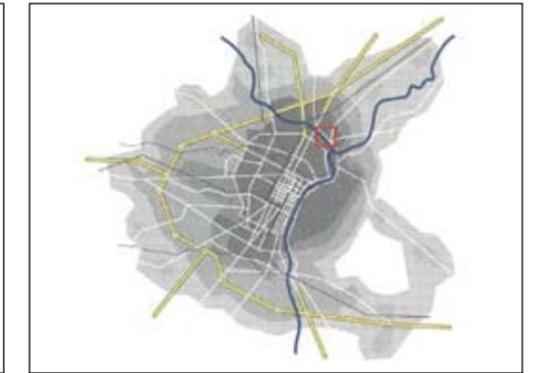
To sum up, the approach proposed can be defined innovative for several reasons. First of all, the concept of Preventive Compensation implies a new way of conceiving a project that, beyond the external and superficial *façade*, focuses on the process by which



7 A picture of the Floriade in Canberra, Australia, 2008



8 The main locations of Italia150 event would take place in Torino



9 The location of the Floriade, in about 90 ha near the river Stura, in the nord of Torino

the present result has been obtained and leads to a responsible method of producing and thinking. Secondly, innovation consists in celebrating a great event not only by itself, but also to develop an innovative model in the new building conception. However, it is proper to admit that there are some disadvantages in this method as well. One of them is the difficulty in spreading and promoting the idea, whose approach implies a profound cultural change in planning activities. The second one takes into account the fact that the compensation of the celebrations' environmental impact could only be possible through the adoption of the most sustainable technologies and strategies: a huge quantity of green areas is already required in the most optimistic scenario to compensate new constructions. Finally, the interactive manual addressed to the event's promoters summarizes our project approach and encourages further experimentation; the team truly hopes that it could become a step towards a new responsible way of relating to and interacting with the environment, a simple tool for the organization of next great events.

NOTE

The project was involved in the international exchange workshop between the Politecnico di Torino and the Graduate School

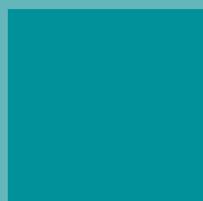
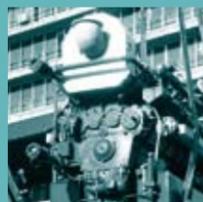
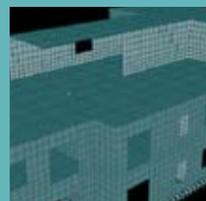


10 The Italia150-Torino2011 Great Event

of Architecture Konkuk University of Seoul. Our researches were presented during the UIA World Architecture Congress [Torino 30/06-03/07/2008].

MAIN BIBLIOGRAPHIC REFERENCES

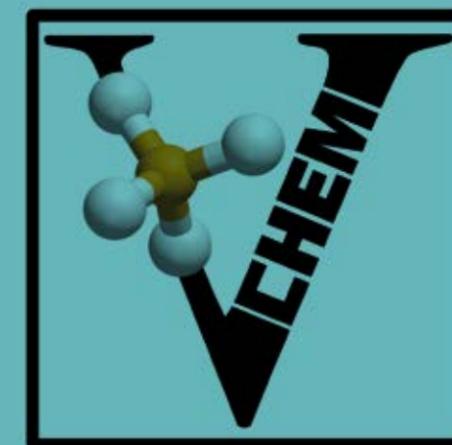
Pileri P., *Compensazione ecologica preventiva*, Carocci editore, Roma, 2007
 Progetto Italia 150 - Associazione Torino Internazionale, *Esperienza Italia: Torino e il Piemonte*, Torino, 2007
 Chambers N., Simmons C., Wackernagel M., *Manuale delle impronte ecologiche*, Edizioni Ambiente, Milano, 2002



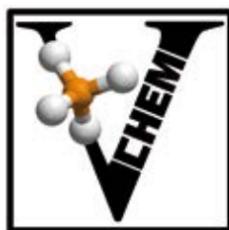
PROJECT

7

ViChem



NEW MATHEMATICAL MOLECULAR DESCRIPTORS
IN DRUG DESIGN AND RISK ASSESSMENT



ViChem

New mathematical molecular descriptors in drug design and risk assessment

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project 7

ViChem, with the support of Negri Institute, investigates the mathematical side of chemistry in order to provide virtual tools for discovery and analysis

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PROJECT DESCRIPTION

ViChem investigates the mathematical side of chemistry to provide tools for discovery and analysis, in addition to integrating these within the new stream of e-science. In fact, the mission of this project is to find new opportunities for improving everyday life through scientific results. ViChem is sponsored by the Mario Negri Institute for Pharmacological Research.

The challenge The chemical structure of the materials determines their physical and biological activity. Active substances interact with biomolecules, triggering specific mechanisms such as the activation of enzymes or the opening of ion channels, which finally lead to a biological response. Since those mechanisms are largely unknown, the option is to either spend years in experimentally studying a single compound or we develop predictive models. Algorithms are available to optimize molecular structures, to compute descriptors, to simulate biological pathways; data mining could find relevant correlations. Such methods could change the scale of the problem and allow for the potential screening of thousand of entities. It is well recognised that chemicals may pose a high risk to the environment and to humans. Unfortunately our knowledge of the environmental impact of chemicals is limited to less than 10% of the 28 millions registered chemicals. In this scenario, EPA¹ has established a program to characterize exposure, hazard, and risk through the use of information technologies. Recently the OECD² has also started a project.

The team Knowledge and expertise in mathematics, chemistry, biology, and computer science was the key to a productive approach to the field. While mathematics and science skills are always needed, the introduction of computer science experts played an important role. A new synthesis is occurring at the intersection of the computer science and other scientific fields

¹ Environmental Protection Agency of USA

² Organization for Economic Co-operation and Development



that has the potential to impact science by introducing basic computer science concepts and methods.

The results During the duration of the project, the activation of the European REACH regulations are worth noting; these regulations require a characterisation of the environmental properties of each chemical placed in the European market in the amount above 1 ton/year. To comply with these regulations, billions of euros and millions of animals are needed in the next 3 years. The good news is that REACH accepts alternative methods, both in-vitro and in-silico. Our challenge found a precise target to work on.

According to Federchimica and its “Centro REACH”, we identified small industries as the important players; we understood how difficult it was for them to delegate the burden of REACH to someone else, and concluded that putting things at the user’s fingers was an important objective. We developed a web service to guide users in understanding the regulations, to give them the opportunity to understand available methods, and to strengthen the use of alternative methods.

However, it remains a scientific challenge to evaluate the biological effects of compounds using only in-silico tools, and more research is needed. No public model under REACH still exists; we hope to be a catalyst in this direction.



TASKS & SKILLS

Luigi Cardamone: analyzed the CDK package with the standard for descriptors representation and developed the main part of the web platform of the project.

Magdalena Gocieva: studied molecular descriptors and CDK Java libraries, and wrote all the source code developed in the project for descriptor calculations.

Marina Mancusi: studied the general aspects of REACH legislation, focusing on computational tools and databases available for the calculation of molecular descriptors.

Rima Padovani: studied the main topics present in the REACH legislation, focusing on the QSARs validation and usage for legislative purpose.

Lorenzo Tamellini: team controller and project coordinator. Worked on mathematical aspects of QSARs, Open Source Licences, descriptors implementation specifics and website construction.

ABSTRACT

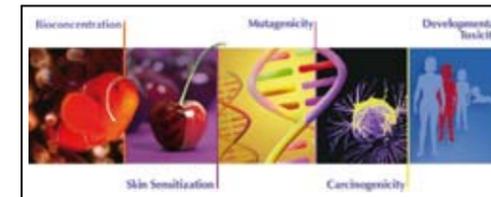
In our everyday life we have to deal with an exponentially increasing number of different chemical compounds, whose toxicity therefore has to be assessed.

Animal testing is of course time consuming and expensive; as a result, interest has emerged in the last decades amongst chemical firms and the scientific community with regards to QSARs, mathematical models that could provide useful information on compounds' toxicity.

The usage of these models is growing, since they aim to provide fast, reliable and quite accurate forecasting of chemical activity; these features also make them suitable for legislative purposes, and that is why they have been included in the new European legislation on chemical production.

Given the above, it is evident that owning the "know-how" related to these mathematical analysis is becoming a strategy for chemical firms; on the one hand, this leads to Copyright and patenting issues on software and models, but on the other hand the need for information in order to face the new European legislation is producing a tremendous amount of unstructured knowledge on the subject.

We believe that creating an Open Access/Open Source framework with well-structured information is the key to overcoming the current situation, and our project aims to provide tools and channels for achieving this goal.



1 Some endpoints of interest in QSAR analysis



2 It is possible to conduct at least three different kind of experiments: "in vivo", that is animal testing, "in vitro", that is using tissue culture cells, and "in silico", which refers to computer simulations



3 Common species for animal testing: bee, daphnia, quail, rainbow trout, fathead minnow, rabbit, mouse

UNDERSTANDING THE PROBLEM

The scientific area of this project is QSAR (Quantitative Structure-Activity Relationship) analysis, whose aim is to look for statistical models capable of linking the toxic activity of a molecule with its chemical composition.

The input variables are quantities calculated on the basis of the chemical formulae of molecules (e.g. mass, electro negativity) and are called descriptors; the output variable is called end-point and represents a quantity somehow related to the toxic activity of molecules, often expressed as a Lethal Concentration.

The underlying hypothesis is that similar compounds show similar toxic behaviour, and a way to define similarity between a set of compounds is to compare values of different descriptors calculated on the respective formulae: the closer the values, the more similar the molecules.

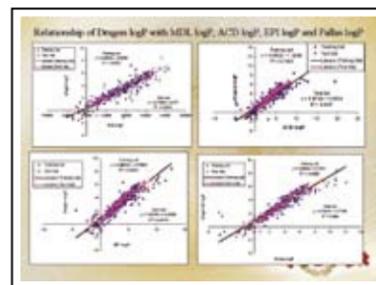
The tremendous impact of these analyses is evident: if the chemical industry was provided with models capable of accurately predicting these end-points, it would be possible to stop animal testing, considered ethically unacceptable by a growing majority of

people and also expensive in terms of time and money.

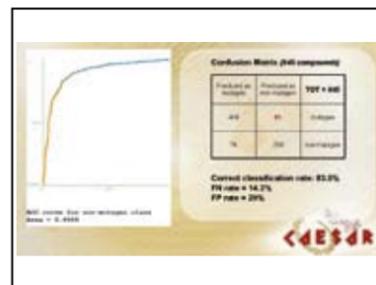
Given that QSARs provide quantitative methods to state the toxicity of a molecule, they can also play an important role in legislative activities. This is why the European Community decided to include them in REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals), the new European regulations for chemical substances that entered into force on June 1st 2007.

To underline its broadness, it suffices to say that it is 849 pages long and international mass-media defined it as "the most important legislation in European Union in 20 years" (BBC News, 28 November 2005).

One can identify several problems in this general framework. The most important one is a matter of non-free knowledge: as QSARs represent a strategic point for companies, most of the research done in this field is not shareable. This is not only true for research papers and publications, but also for software packages that calculate descriptors and models. This aspect appears to be rather critical as one can observe that different software packages give different values for the same descriptors: the source-



4 This picture shows that different software applications produce different values for the same descriptor. Taken from CAESAR Project by Istituto Mario Negri



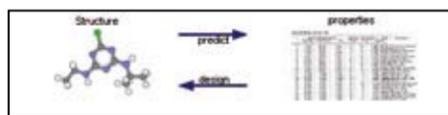
5 Results of QSAR analysis on mutagenicity. Result from CAESAR Project by Istituto Mario Negri



6 Predicting error of a model as a function of its complexity



7 An example of neural networks that can be used in QSAR modelling



8 Relations between structure and properties

code is almost never open source so there is no way to choose the best implementation.

Besides, the fact that REACH involves QSARs is becoming a real issue for many small factories which do not have the “know-how” needed to use these techniques. In fact, REACH foresees the use of QSARs when testing does not appear necessary because the same information can be obtained by other means. At the same time, QSAR results can be used on their own for regulatory purposes only if they are considered reliable and adequate for the purpose, and if appropriately documented.

EXPLORING THE OPPORTUNITIES

The first part of our work was devoted to exploring and evaluating different strategies in order to tackle the previously mentioned issues. The main question was: what can be done to develop tools that could be useful in this complex framework?

We soon realized that there is no lack of mathematical tools: the mathematical settings of statistical inference are well known and robust, and there are a number of different techniques, such as linear regression, neural networks, classification trees, etc. that can be successfully used in this field.

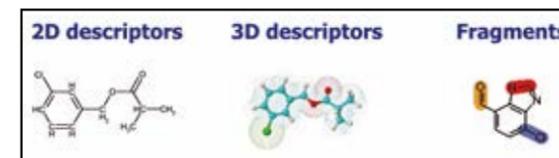
Problems in building models are more linked to other issues,

such as difficulties in getting reliable experimental data for models calculation and calibration, and the fact that it is difficult to reduce the choice of descriptors to subsets of always meaningful ones that have good forecasting properties for any given endpoint. The predicting capabilities of descriptors seem to be strictly linked to the real poisoning mechanisms and therefore vary from case to case. These mechanisms can be captured by some mathematical tools (e.g. local expert mixtures) that can be “trained” to mimic the underlying biological rational, even if this is not yet well assessed.

Even when building models for a single endpoint, one has to face the uncertainty of the descriptor values since there is no way to choose the best way to calculate them, as previously pointed out.

The problem with the freedom of source-code usage is by far the most interesting issue and that is why we decided to focus our work on looking for ways to enhance the spread of open-source philosophy between researchers.

Another challenging aspect to add in this context is the absence of a clear, user-friendly and free help-desk that is usable by companies for R.E.A.C.H. legislation. This does not mean that there is in sufficient information on the matter but that there is too



9 Different ways to describe a molecule

much information which is becoming disorganized and uneasy to manage. In other words, there is a lack of clear and structured information.

In this broader perspective of “missing knowledge”, these two aspects can be faced as a single problem, and the solution we designed exploits the link between the two areas.

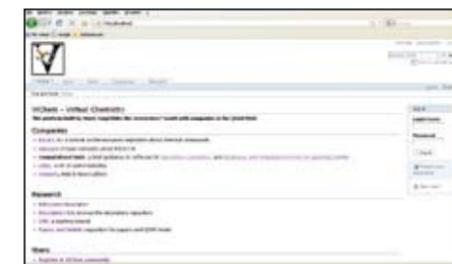
GENERATING A SOLUTION

The solution we implemented takes advantage of different innovations in various fields that can be conveniently used for our purpose. The main idea is quite simple: designing a web platform that provides services for both the researchers’ and the companies’ needs.

The section for companies is a guided journey through REACH legislation. It is not an all-comprehensive guidance to its application but aims to provide the most useful information in a simple and brief way. The focus is on the regulatory obligations referring to QSARs: how the validation process has to be carried out, which documents have to be submitted, which are the tools for descriptors calculation and where one can find them, etc.

The section for researchers is an interactive repository, where people can upload and download open-source code for descriptors calculation and model development, as well as research papers. For this purpose, the GNU-GPL licence and the new copy-left policies (by *Creative Commons*) appear to be the perfect tool for both knowledge protection and spillover.

The critical aspect of the web platform is therefore the flexibility required in order for it to be effective. To achieve this, we con-

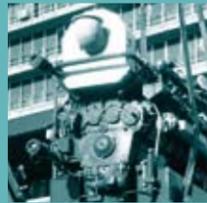
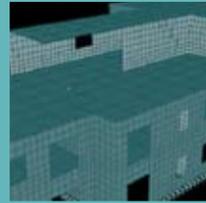


10 Homepage of the implemented website

sidered various implementation options, and we decided to use the W.C.M.S. (*Web Content Management System*) technology which allows for easy management of a system of users with potentially different rights (right to upload/download code, to create/modify/delete pages, etc.). At the same time, it allows users to add pages with various contents (code, articles, news, events) in a simple way.

With regards to the technical aspect of descriptors encoding, the choice of a standard language was necessary; the final decision was to use Java, taking CDK library (Chemical Development Kit) as a basis. CDK is an open-source library for Computational Chemistry developed in Java, and it provides a robust object-oriented set of classes for descriptors calculation; it is still simple enough to be used by people which are not expected to have good programming skills. Currently 33 descriptors are present covering topological, geometric and electronic descriptor classes. We implemented 19 additional descriptors based on the distance and adjacency matrices, compliant with the standard imposed by CDK.

CDK is maintained as a SourceForge project under <http://www.sourceforge.net/projects/cdk>. Using the development section of this web site, we submitted the source code of these 19 descriptors to the CDK developers. We hope that we will get a positive response from them in the near future, and that our source-code will be added to the CDK library.



DWARFe



PROJECT 8

ENVIRONMENTAL NANOTECHNOLOGY: APPLICATIONS, FATE AND RISKS OF ENGINEERED NANOPARTICLES



DWARFe Environmental nanotechnology: applications, fate and risks of engineered nanoparticles

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project 8

*The project aims to study
Nanoscale Zerovalent Iron (NZVI)
for the restoration of contaminated
aquifers*

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PROJECT DESCRIPTION

The challenge This project combines two major topics. The first relates to the dramatic growth of the importance of nanotechnologies in science and engineering in the last few years; the second refers to the impact of human activities on the environment, which is becoming increasingly serious, and the stemming interventions which become necessary to reduce and control it.

In the field of environment, nanotechnologies and nanosciences have a wide range of potential applications: they include pollution prevention, detection of specific contaminants, and remediation of contaminated sites.

With regards to the latter application, it is known that nano-sized zero-valent iron (NZVI) particles are capable of treating groundwater contaminants. NZVI is a promising development as well as an improvement of a well known and successful remediation technique (i.e. the use of millimetric iron in permeable reactive barriers for the treatment of diffused groundwater contamination).

The team The group brings together various fields of knowledge, being composed of students with physical, chemical, aeronautic and mathematical engineering backgrounds. Although the team did not include students with specific economical or marketing skills, both these two aspects were carefully analyzed as well. Part of the work focused on the assessment of the state of the art in the field of contaminant remediation, and on the risks related to the use of nanoparticles (health effects due to the contact with engineered nanoparticles). One student worked on the evaluation of the applicability of NZVI to the test site located in Avigliana, near Torino, while others focused on the development of a numerical code for modeling the transport and fate of nanoparticles in subsurface environments. The identification of stakeholders as end users of the technology was a common effort made by all the members of the group.

The results With regards to the more technical aspects of the project, the chemical and morphological properties of nano-scale zerovalent iron particles were investigated, as well as their



behavior in saturated porous media. A laboratory transport experiment of engineered nanoparticles in a saturated porous column was conducted at the Polytechnic of Milan. The project included participation in the development of a novel numerical code for the simulation of the mobility of these particles in the subsurface, under various hydrochemical conditions.

The feasibility of the application of remediation techniques based on NZVI was evaluated from both an economical point of view, and also by taking into consideration the human toxicity aspects and the potential impact on the regional and national situation in terms of the number and typology of contaminated sites which could be treated with NZVI.

The study of the possible application to the test site of Avigliana – in addition to the analysis of the prospective impact of this technology on the existing contaminated sites - highlighted the fact that NZVI has a huge remediation potential. However, because it is quite a novel and not yet established technique, to date the related application costs are relevant. Finally, a careful evaluation of the perspectives for the future of NZVI with respect to technical and economical aspects and improvements as well as to toxicity was performed. Future perspectives for technical, health and economical aspects concerning the use of NZVI were evaluated as accurately as possible.



TASKS & SKILLS

Roberto Lecca (Aerospace engineer) employed his fluidodynamic knowledge to explain and solve problems related to aggregation and transportation of the nanoparticles.

Marta Barberis Pinlung (Chemical engineer) focused her contribution in the feasibility analysis of Avigliana site by studying the amount of nanoiron necessary for the reclamation.

Eleonora De Re (Physical engineer) investigated state of the art groundwater remediation technology. She took part in the characterization of iron nanoparticles and explored their capabilities.

Simone Maggiore (Physical engineer) concentrated on the characterization of the properties of iron nanoparticles as well as understanding of health and safety issues related to them.

Michel Cancelliere (Mathematical engineer/Petroleum engineer) focused his work in the characterization of the NZVI, the state of the art in the iron nanoparticles synthesis and the aggregation problem.

Alberto Marnetto (Mathematical engineer) investigated the mathematical models for particles diffusion and collaborated in developing the numerical code for simulating the phenomenon.

ABSTRACT

In the last years, the attention devoted to environmental issues has grown enormously: everyone has heard about the dramatic effects which global warming and the exhaustion of water resources could have on our existence.

However, there are many other global phenomena that may affect human quality of life: an equally important problem can be considered more local than the ones quoted before, and it is represented by the contamination of land and groundwater by chemical compounds which are residuals of industrial or agricultural activities. A polluted ground is damaging to the entire community: the former, together with its surroundings, become unhealthy and therefore worthless, while the pollutants that reach running water streams may be transported away, contaminating even locations far away from the source.

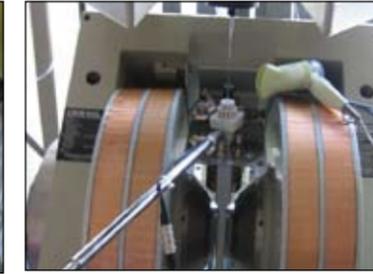
In this context, the development of new techniques for neutralizing pollutants and reclaiming grounds has an important social and economical value. In this work the potentialities of a promising method will be analyzed: the direct injection of nanoscale zero-valent iron particles in a contaminated ground. This technique, as testified by preliminary experiments, offers several advantages in comparison with the older ones, but it also presents some drawbacks that must be overcome.

The team's work aimed to reach a deeper comprehension of the characteristics and the implications of the technology, in order to develop the knowledge and the instruments needed to effectively implement it. The final result of this research is a preliminary plan for the remediation of a polluted ground in Buttigliera Alta, near Avigliana, including a quantitative prediction of the time and money needed for its realization.

The proposed activities aim to be an example of application of an innovative technique. This work might be a significant step towards transforming a promising opportunity to an established technique, since it deals with the issues related to the problems linked to the legal and medical fields, common to many nanotechnologies, as well as the technical and organizational aspects.



1



2



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UNDERSTANDING THE PROBLEM

Nanotechnology is one of the fastest-growing fields in the context of applied sciences. The task given to the group was to investigate one of its promising implementations: the use of nanoscopic iron particles to neutralize some classes of pollutants dispersed within groundwater.

The preliminary activities we took part in were therefore dedicated to giving us a brief but complete overview of the state of the art of the technology. What emerged is that the issue was not totally new, since the first studies in this direction date back to over ten years ago, but the research is still in an embryonic stage, with very few field scale experiments carried out to date. This is due to the fact that the issues related to such kinds of interventions are complex and manifold, concerning not only the technical aspects but also include economic, political and medical factors.

Hence, the group decided to develop the project in such a way to have the opportunity to investigate all these fields. The best way to do this turned out to be the planning of a real intervention in a test location. A suitable site was found to be a polluted ground near Avigliana: this was already the object of a remediation, performed with micrometric iron, i.e. the technique against which this nanotechnology should be compared. The technical data gathered during the previous intervention constitutes a valuable reference frame to develop our planning, allowing us to estimate the costs of a nanoscale intervention and compare its advantages, costs and risks with those of the old one; this will

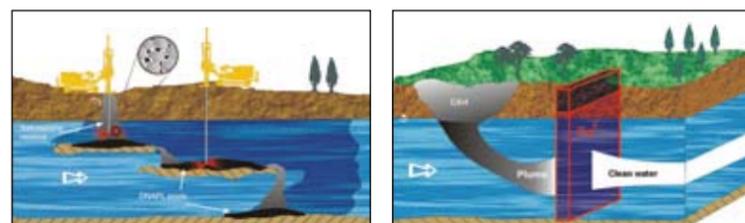
also be implemented with the aid of bibliographical studies and interviews with possible stakeholders.

EXPLORING THE OPPORTUNITIES

The treatment methods for groundwater remediation can be classified in two major categories: in situ and ex situ. In situ treatments allow groundwater to be treated without being brought to the surface, thus reducing costs and risks, but offering less certainty about the uniformity of results; ex situ treatments generally ensure more control on the outcomes, because it is simpler to monitor them, but they require pumping of groundwater, thus leading to an increase in the cost.

A typical ex situ treatment is pump and treat, which consists in pumping contaminated water out of the aquifer, treating it and then reinjecting the clean water; however, this method has often proven to be inefficient due to long time periods and elevated costs. Therefore, many novel in situ technologies have been developed; the most innovative seemed to be the construction of permeable reactive barriers (PRBs) filled with micrometric zero-valent iron: the contaminants are naturally carried through the wall containing the permeable reactive material. However, this technology also presents many drawbacks.

We have identified a potential solution for the issues posed by the traditional remediation technologies in the use of nanoscopic zero valent iron: the smaller dimension of the particles allows a greater reactivity, hence shorter cleanup times and the direct injection of the iron reduces the costs involved. Moreover, the



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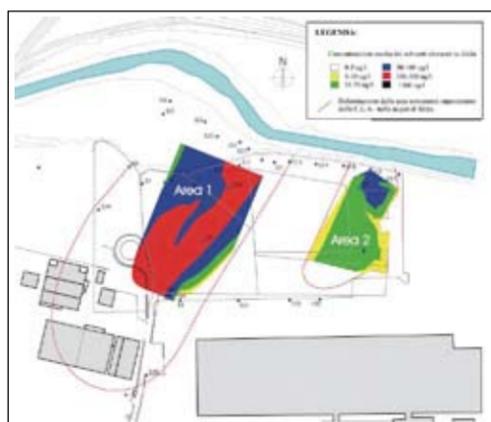
enhanced mobility of these small particles will lead to the possibility to remediate not only the contaminated plume, but the entire zone source.

However, before being able to perform a feasibility study, some problems must be addressed: a detailed characterization of the hydrogeology of the site is necessary, since natural geochemical conditions can destabilize the particles, facilitating aggregations. Possible methods for the disaggregation have been proposed: acting on inter-particle forces; using additives; operating with tanks, where fluid motion and velocity gradients are used to break up aggregates; exposing the nanoparticles to sufficiently high temperatures, in order to demagnetize them.

One of the most critical passages of this technology is related to the fact that in many countries the use of nanoparticles is not permitted. From the health perspective, the effects of these particles have not yet been completely studied, they could be dangerous because of their capability to penetrate cells and because of their capability to provoke inflammation by releasing free radicals in dose which are high enough to overcome the natural defences of the body.

GENERATING A SOLUTION

The aim of our project is the feasibility study about the reclamation of Avigliana site using nanoiron. In order to plan this activity we have to characterize the intervention area, so we investigated about the history of the site, its problems and the relative solution. Avigliana is the first area in Italy where permeable reactive barriers for groundwater reclamation have been applied. We had collected a lot of information about the whole area, including



7 Definition of the areas contaminated in Avigliana site in accordance with the Ministerial Decree 471/99

the water-bed and the pollutants, all essential for the evaluation of the implementation of the nanoiron technology.

The crucial point of the feasibility analysis was the calculation of the iron necessary for the reclamation of the area: we obtained this value by using the data of the pollutants' concentration in the water-bed.

The amount of iron essential for the pollutants degradation allowed us to estimate the cost of the intervention in terms of the reagents; this represents the main cost of the whole activity.

According to such a value, we have made some considerations about intervention feasibility: we compared the PRB technology with the new one in order to point out the pros and cons in each case. We noticed how PRB technology is cheaper, but we cannot make an evaluation on the basis of only the economic factor. It is important to also consider that the use of nanoiron is in an embryonic stage and so the reagent cost is high; in the next future, if the technique will work up, this price will rapidly decrease, lowering the cost of the intervention too.

For an effective implementation of the intervention, it will be necessary being able to foresee the dynamics of the propagation of the nanoiron particles in the water-bed. For this reason, we have collaborated in the development of a code which models this phenomenon.

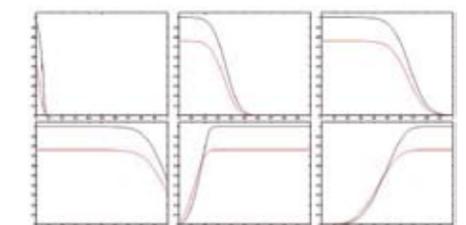
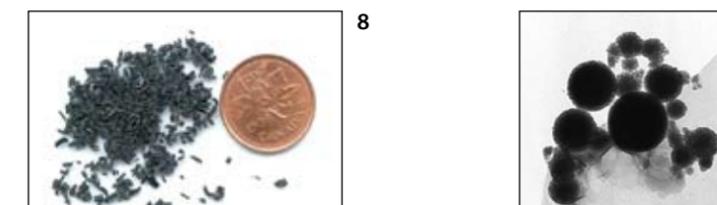
Data		
Pollutants	AVERAGE	9,72 E-03 g/s
Pollutants	MAX	1,78 E-02 g/s
Time		20 year
		630720000 s
Calculate		
AVERAGE	Required stoichiometric Fe	7,77 E-02 g/s
	Overestimated Fe	1,29 E-01 g/s
MAX	Required stoichiometric Fe	4,29 E-02 g/s
	Overestimated Fe	2,33 E-01 g/s
Calculate		
AVERAGE	Total required Fe	2,70 E+04 kg
	Total overestimated Fe	8,11 E+04 kg
MAX	Total required Fe	4,90 E+04 kg
	Total overestimated Fe	1,47 E+05 kg

Table 1 Amount of Fe⁰ necessary for the water-bed reclamation

Data		
Water density	1000	g/dm ³
Fe ⁰ aqueous suspension prize	20	€/kg
Calculate		
AVERAGE	Fe ⁰	8,11 E+04 kg
	Fe ⁰ aqueous suspension	5,41 E+05 kg
	Total expense	1,08 E+07 €
MAX	Fe ⁰	1,47 E+05 kg
	Fe ⁰ aqueous suspension	9,80 E+05 kg
	Total expense	1,96 E+07 €

Table 2 Total cost of the reagent for the intervention

At present, the program is able to analyze the data of diffusion experiments carried out in an experimental column. In such tests, the column is filled with sand, then a solution containing nanoparticles is injected at one end and is forced, via a pump, to travel across the column. The concentration of the particles exiting from the column varies with time forming what is called a breakthrough curve.

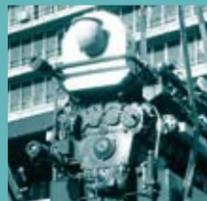
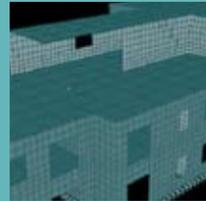


From such a curve, the program is able to estimate many physical parameters of the sand and the particles used in the experiment. On the contrary, if these data are known, the code may simulate a diffusion experiment without the need for effectively performing it. This is useful, for example, for analyzing how the tendency of the particles to adhere to the sand influences their behaviour.

Future developments of the program should be able to reproduce a full remediation intervention, predicting the distance to which the injected particles will flow in a specific soil. This will be very useful for determining the location of the injection wells as well as detecting potential hazards coming from the propagation of the particles beyond the polluted area.

MAIN BIBLIOGRAPHIC REFERENCES

A. Di Molfetta, R. Sethi, Barriere Reattive Semipermeabili. In: Bonifica di siti contaminati. Caratterizzazione e tecniche di risanamento (ed. L. Bonomo), pp. 562-605. McGraw-Hill, New York (2005)
 M. R. Wiesner, J.-Y. Bottero (eds.), Environmental Nanotechnology. McGraw-Hill, New York (2007)
 W.-X. Zhang, Nanoscale iron particles for environmental remediation: An overview, Journal of Nanoparticle Research 5 (2003), pp. 323-332.



SmartCopter



PROJECT 10

SENSOR-VISION-ENABLED AUTONOMOUS ROBOTIC HELICOPTER FOR CIVIL APPLICATIONS IN URBAN ENVIRONMENTS



SmartCopter

Sensor-vision-enabled autonomous robotic helicopter for civil applications in urban environments

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Automotive Engineering

project 10

The project responds to the challenge of designing a sensor-enabled autonomous (smart) helicopter which is capable of supporting civil applications in urban environments

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PROJECT DESCRIPTION

Unmanned Autonomous Vehicles (UAVs) are being developed by the aeronautical community at a fast pace and for a wide range of applications due to advances in sensor technology and automation.

Missions which are best suited for UAV platforms are typically “dull, dirty and dangerous”. Among such missions, there are a number of operational scenarios which could be performed by smart, compact, highly autonomous, vertical take-off and landing vehicles, capable of navigating without or with very limited human supervision in complex, unknown urban environments. In fact, rotorcraft UAVs can maneuver in small, restricted areas and can hover in place, something which can not be accomplished by other flying platforms.

The design of smart, compact, safe rotorcraft UAVs with rapid deployment capabilities and an intuitive and effective human-machine interface to support complex operations in highly dynamic situations, is an extremely fascinating challenge, with great potential rewards.

The scope of this ASP project is the analysis of mission scenarios and the study of enabling technological solutions for sensor-enabled robotic helicopters capable of performing missions in a highly autonomous fashion, with a special emphasis on applications in urban environments.





Would you be Mine?

TASKS & SKILLS

Fabio Biscani defined the *Shooting* scenario and the flight plan of the *Mine detection* scenario. He had role in characterizing all the scenarios and in *Mine detection* sensors research.

Andrea Fogante defined the *Baywatch* scenario and, together with AgustaWestland, the platform of *Mine detection*.

Raghavendra Kempanna did the market analysis of *Mine detection* and participated in the definition of the *Search and Rescue* scenario.

Alberto Laratta contributed to the determination of scenarios and defined the two sensors sets of *Mine detection* over dry and wet soil, after a deep research into all the available sensors.

Saverio Ricci defined the *Agriculture* scenario, and contributed towards defining the *Mine detection* sensors characteristics and the market analysis.

ABSTRACT

An Unmanned Aerial Vehicle (UAV) is a flying vehicle without a pilot which can be remotely controlled from a ground control station, but also retains the ability to operate semi-autonomously or autonomously or in any combination of the above modes. The vehicle is equipped with diverse sets of sensors and other electronics necessary to complete specialized goals. Compared to traditional air vehicles, UAVs may offer significant advantages in terms of human safety (especially in dull, dirty and dangerous missions), operational cost reduction and work rate efficiency.

Among the many typical civil UAV missions, there are scenarios which could be performed by smart, compact, highly autonomous, vertical take-off and landing vehicles, capable of navigating without human supervision in complex, unknown environments. Examples include fire fighting detection and support, law enforcement, road traffic emergency management, agricultural applications, search and rescue, and mine detection. In all such cases, a specialized staff could rapidly deploy a robotic rotorcraft on-site to support operations and increase situational awareness by streaming integrated real-time information gathered by on-board sensors to the ground.

The objective of the project was the design of a sensor and vision-enabled robotic rotorcraft for civil missions. In particular, the scenario of landmine detection, which could be greatly improved and simplified through the use of unmanned airborne vehicles, was analyzed. The selected platform to implement the system was derived from the CAPECON (Civil UAV Applications and Economic effectiveness of Potential CONfiguration solutions) program, in which our main stakeholder (AgustaWestland) is involved. One important aspect was the integration of all necessary sensors, sub-systems and enabling technologies to the UAV world, therefore many accessible, proven and cost effective technologies were identified, ready for application in the short and mid term.



1 The SCHIEBEL CAMCOPTER S-100 is built around a compact helicopter aerial vehicle that can be fitted with a wide variety of payloads tailored to meet diverse user requirements. It is a versatile platform for a great number of applications, both military and civilian

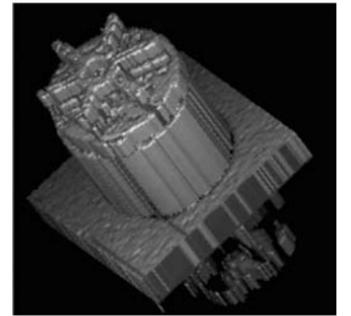
UNDERSTANDING THE PROBLEM

During wars and even many years after their end, some of the longest lasting effects on the civilian population are those caused by antipersonnel mines, cluster bombs and other explosive devices that remain active even decades after the conflict has ended. These weapons, usually simple and cheap to manufacture, are widely used and are very easy to deploy over large areas. Landmines have a highly negative economic, medical and social impact on the local population and their removal is costly, highly time consuming and extremely dangerous. Yet demining is a necessary step for the affected populations to recover.

In order to tackle this problem we believe that two complementary and parallel research areas have to be considered. Firstly, a robotic platform has to be developed that is suitable for working in areas that are inaccessible to humans or unspecified environments and which offers the user the safest possible operation. Second, among the great number of technologies of potential use to this problem, an appropriate sensor technology has to be employed, providing an efficient explosive localization.



2 The ATMID is a highly reliable and sensitive lightweight mine detector (EMI device) capable of detecting very small amounts of metal in any type of soil



3 Three-dimensional image of an AP mine in water, obtained through a scan with an ultrasound detection system



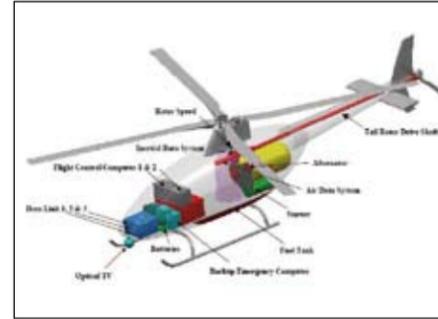
4 Mines detected by airborne thermal IR remote sensing

Remote sensing information can contribute to the mapping and identification of suspect areas as well as the determination of the minefield boundaries and localization of individual mines. Airborne sensor-based techniques may offer efficient and safe detection of mine fields. Research in this area is still in its infancy and the aim of our work is to identify a technological platform that is capable of detecting antipersonnel mines in all weather and under all soil conditions, by using the most innovative and promising tools and knowledge.

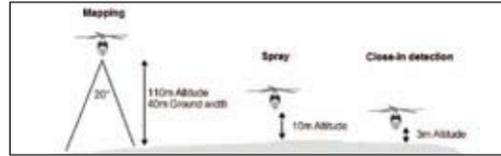
Up until this point, few platforms capable of limiting the interested area of investigation have been developed, but the utilized technologies can not provide a high enough probability of detection and can operate in limited conditions, thus making them unsuitable for humanitarian demining.



5 FLIR TALON is a high performance airborne multi-sensors thermal imaging system in a compact lightweight package



6 Inboard layout of the platform designed by AgustaWestland for the CAPECON (Civil UAV Applications and Economic effectiveness of Potential CONfiguration solutions) program



7 Flight plan for wet soil environment is composed of three distinct phases. Close-in detection is the most time demanding



8 Rotax 912 ULS. Engine adopted on the platform developed by AgustaWestland for the CAPECON program



9 Micronair Au6539 Electric Atomiser. It is used to spray a solution of bacteria that fluoresce in the presence of explosives

EXPLORING OPPORTUNITIES

To give an insight about the UAV market, an in-depth study of existing literature, which reflects the data and research carried out by some of the most credible organizations, was carried out. The objective was to identify potential markets and evaluate potential business models with a view to provide affordable use of UAVs for demining and other civil and science missions.

The work methodology leading from customer needs to the final Rotary Wing UAV (RWUAV) configuration consists of a sequence of logical steps. In the first step, applications suitable for a RWUAV have been analyzed and a selection of the most innovative scenarios have been investigated in depth after the market analysis. The following step was the study of pros and cons of the different configurations.

Another important challenge of the team project was the modular approach involved in defining the payload for mine detection in order to have a set of sensors capable of identifying antipersonnel mines under all conditions. A large number of sensors have been used in hand-held landmine detectors, but very few of them can be used on airborne platforms because of high weight or dimensions. The sensors' characteristics which should be noted include:

- airborne capability;
- weight;
- effectiveness (detection capability, false alarm rate and type of

detected landmine);

- maximum detection depth;
- speed of clearance;
- cost;
- synergy among different sensors;
- technological maturity.

In state of the art applications, only a single detector is used, limiting the potential of a stand-off platform and with a performance level that is not acceptable for humanitarian demining. The aim of the project was the development of a multi-sensor system capable of improving the efficiency in detecting landmines under all soil and weather conditions.

The CAPECON program is using a platform, developed by AgustaWestland, in which the payload can be modulated to become suitable for different applications: local surveillance, search, traffic monitoring, power lines and pipelines monitoring, agriculture. Our idea is to understand if this platform can also be functional for mine detection, in order to exploit even more the modularity approach and to reduce costs.

GENERATING A SOLUTION

Among all possible RWUAV configurations that have been evaluated, the best suited are:

- heavy conventional helicopter;
- shrouded rotor;
- four-rotors.

In order to correctly relate applications with different airborne platforms, a decision-making process called *matrix method* was used. For mine detection scenario, the conventional helicopter configuration was chosen: helicopter-based systems can fly very low and slowly and have a better control.

The CAPECON project platform is such a conventional platform. The identified payload, fuel mass and flight plan are comparable with the ones in this platform; as a result, it was possible to use the CAPECON platform. Its main characteristics are as follows:

1. main rotor with 4 blades and 4.2 m diameter;
 2. tail rotor with 2 blades and 0.7 m diameter;
 3. empty weight of 180 kg;
 4. fuel and payload mass equal to 80 kg (take off weight of 260 kg).
- The selected combination of sensors for mine detection in dry soil conditions is composed of the following:
1. microwave system;
 2. thermal infrared imager;
 3. optical sensors;
 4. MEMS.

This selection can satisfy all requirements for a reliable demining procedure, allowing the detection of mines at different depths and reducing the false alarm rate due to the possibility of recognizing both the presence of targets in the soil and the amount of explosive. On the other hand, a potential collection of sensors to be used in wet conditions is composed as follows:

1. biological system;
2. chemical system;
3. ultrasound system;
4. optical sensors.

As a result, the possibility to identify mines at a great depth and in small time is feasible and the fusion of many sensors, whose regulating algorithm's definition represents the natural future development of the project, allows for improvement in the probability of detection.

These two sets have been designed in order to have the same requirements and performances, allowing using a unique platform and simply exchanging the payloads.

Two different flight-plans, based on the characteristics of the combination of sensors and the typical characteristics of mine-fields, were developed for the two types of soil conditions. The flight-plan in dry soil conditions is divided in two phases:

1. area reduction and mapping;
2. close-in detection.

The flight-plan in wet soil conditions instead is composed by three phases:

1. mapping;
2. spraying;
3. close-in detection.

The area reduction phase is missing because of the characteristics of the selected sensors. The close-in detection phase is the most time-demanding phase: it is carried out by hovering few meters above ground level. Other phases are performed while moving at greater altitudes. This usage of the UAV in different phases of the mine detection operations was not considered in other dedicated airborne solutions.

At this moment there is no such system capable of operating in all soil conditions and exploiting sensors fusion of many different technologies; for this reason, our project may be considered significant.

MAIN BIBLIOGRAPHIC REFERENCES

- [1] J. MacDonald, J. R. Lockwood. *Alternatives for landmine detection*. RAND. 2003.
- [2] G. M. Saggiani, B. Teodorani. *Rotary wing UAV potential applications: an analytical study through a matrix method*. DIEM, University of Bologna. 2004.
- [3] M. L. Preatoni, R. Pretolani, G. M. Saggiani, B. Teodorani. *An integrated simulation environment as a strategy in rotorcraft UAVs preliminary design*. Helicopter System Design Dep., AGUSTA; DIEM, University of Bologna. 2005.



R.U.M.S. Modular Shrouded Rotorcraft UAV

SMARTCOPTER_SENSOR-VISION-ENABLED AUTONOMOUS ROBOTIC HELICOPTER FOR CIVIL APPLICATIONS IN URBAN ENVIRONMENTS

TASKS & SKILLS

Stefano Agostoni worked on scenario analysis and definition in the first phase in addition to contributing to the definition of the modular concept and focusing on payload analysis and definition and platform sketches in the second phase.

Laura Mainini worked on scenario definition and market investigation in the first phase in addition to contributing to the definition of the modular concept and focusing on weight breakdown, sizing the aircraft providing an analysis of the solution space, 2D-aerodynamic analysis and aircraft performance in the second phase.

Giulio Molinari worked on payload analysis and contributed to the definition of the modular concept. He also planned the shape of the platform using a CAD model and designed the aircraft structure by means of FEM analysis.

Marco Rubino worked in scenario definitions and market analysis. In the second phase, he contributed to the definition of the modular concept and its market assessment. He also contributed to technical design in engine and payload definition.

Eleonora Zeminiani worked on scenario definition, market investigation and legal issues analysis in the first phase in addition to contributing to the formulation of the modular concept and focusing on sizing the aircraft providing an analysis of the solution space, 2D-aerodynamic analysis and aircraft performance in the second phase.

ABSTRACT

In response to the assigned theme, Team 10 worked as a whole for most of the first year.

During this period, requirements were discussed in detail, the market was sounded out and new applications were investigated. At the end of this preliminary joint exploration of the topic, the Team highlighted three possible platforms responding to the requirements: a mid-sized conventional configuration, a mid-sized shrouded rotor and a 4-rotors. Each of these solutions was assigned to one of the three sub-teams, together with its legacy of missions and restraints.

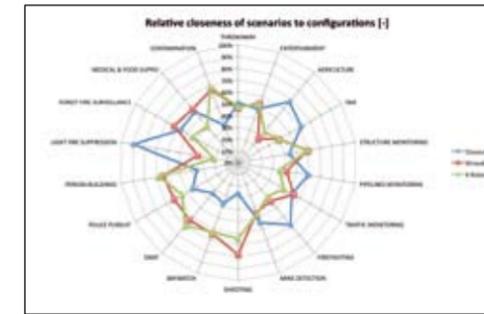
Team 10 B developed the shrouded rotor version of the RUAV (Rotorcraft UAV), assigned to four scenarios: police pursuit, (camera)shooting, traffic monitoring and structure monitoring.

This configuration is interesting from several points of view:

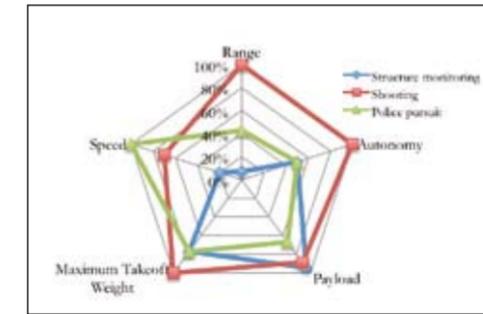
- this layout is the less explored and therefore, besides the obvious difficulties in finding a proper approach to technical design, it has also great potentialities to be discovered;
- from an operational perspective, the elimination of exposed blades allows innovative scenarios, offering a certain degree of confidence when deployed in crowded spaces;
- from a social impact perspective, the related scenarios are of strong appeal and can help building trust in Unmanned Systems, paving the way to their integration in urban areas;
- from a regulatory perspective, UAVs are a big challenge worldwide and legislations are under discussion in a great number of Countries.

Our sub-team developed additional further market analysis, defined UAV technologies and degree of autonomy, sized the main parameters of the machine and explored its interaction with human beings.

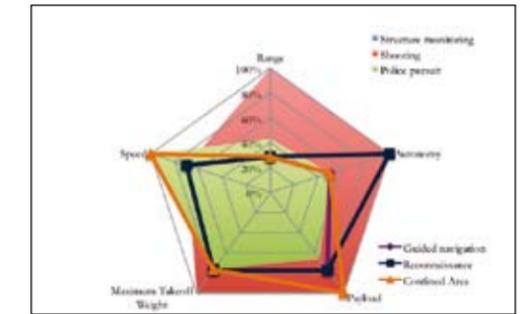
Given that our machine is devoted to different missions, payload is accommodated with a modular approach: a quarter of the shroud fairing is made fully interchangeable and fluid transfer helps damping the variations in centre of mass location in different applications.



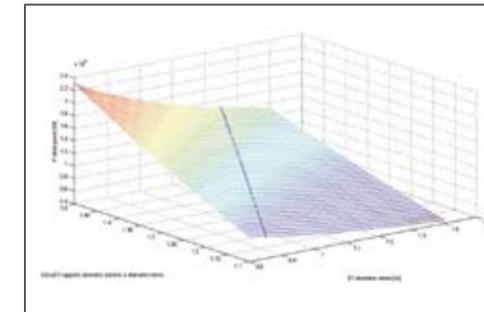
1 Graphical representation of the results obtained through the Matrix Method



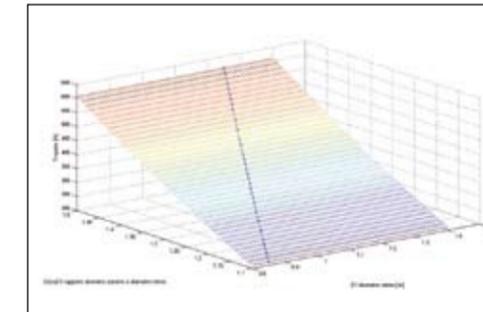
2 Analysis of the requirements of each scenario



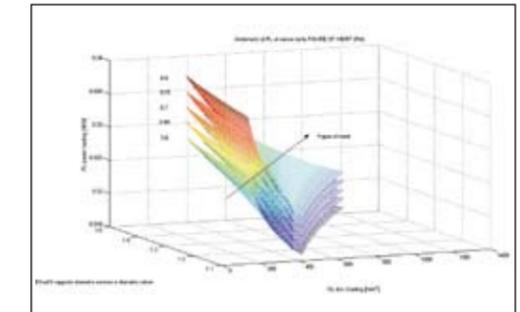
3 Platform use for additional missions



4 Ideal power surface defined with respect to rotor diameter $D1$ and external/internal shroud diameter ratio $D2suD1$; focus the attention on the star line that stresses the solutions that give a 0.25m thick shroud



5 Thrust surface defined with respect to rotor diameter $D1$ and external/internal shroud diameter ratio $D2suD1$; focus the attention on the star line that stresses the solutions that give a 0.25m thick shroud



6 Power loading surfaces at different values of figure of merit FM defined with respect to disc loading DL and external/internal shroud diameter ratio $D2suD1$; focus the attention on the star line that stresses the solutions that give a 0.25m thick shroud

UNDERSTANDING THE PROBLEM

Project 10 had a great number of interesting peculiarities.

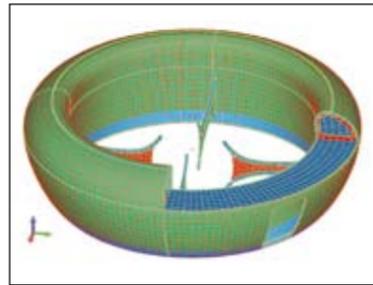
First of all, it dealt with UAVs, a field in which the most challenging and thrilling innovations are still to come. UAVs are complex systems made up of an autonomous flying machine (in our case a non-conventional rotorcraft), a ground control station and the structure of personnel and procedures that allow it to be operated.

A second demanding task was to identify the possible different meanings of the word “autonomous” and, as a consequence, start to assess the degree of autonomy for our application.

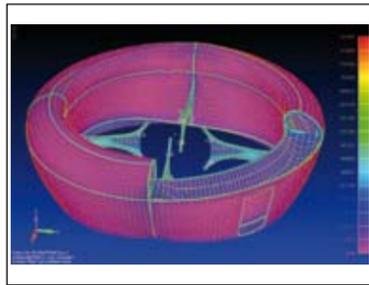
A third key issue was the definition of civil applications within an urban environment. The project requirements were so wide

and unbounded that we could exploit them as a source of innovation: we rose a number of possible interesting new applications, adding social and economical value to the technological product itself.

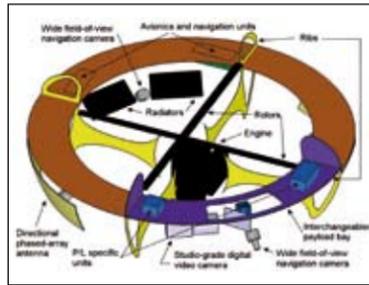
From an engineering perspective there were a lot of entanglements, given that current technology is still immature to cope with our concept solutions. Moreover, dealing with a completely new product - that was due to operate in a complex environment - led to a considerable amount of integration and legal issues which had to be explored and solved prior to marketing. We invested a significant amount of time and resources in thoroughly understanding our assignment, becoming acquainted



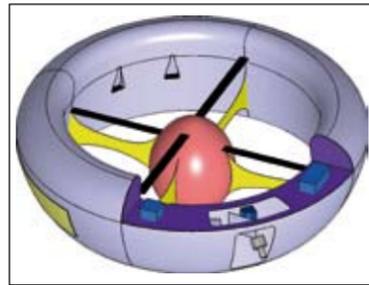
7 Model used for the FEM analysis: the various types of structural components are easily recognisable



8 Results of the static analysis (UAV subjected to its own weight plus a full load of fuel). Measures expressed in SI (m, kg, s). Graphical deformation exaggerated



9 3D model of the platform carrying the film shooting payload (with payload area cover removed)



10 3D model of the platform with (structural) external panels removed to show the layout of the various internal elements

with the technical details and exploring all externalities of the pure engineering activity.

The interdisciplinarity of the team helped analyzing the task from different perspectives and was effective in highlighting the main topics requiring development during the two years of work. Although the limited number of team members and their scattered background limited the depth of preliminary design, they proved to be effective in exploring new solutions, yielding a research & design activity that covers many different fields.

EXPLORING THE OPPORTUNITIES

The first step of our work consisted in a wide research activity about the state of the art. The outcome of such a research phase included a great number of different platforms, each one with its performances and characteristics, as well as various scenarios, with their specific requirements.

At this level of the analysis it was not possible to exclude all military applications a priori because of the fact that most of UAV platforms are developed for military purposes.

On the other hand, the part of the research which focused on the scenarios was strictly concerned with civil application in urban environments, leading to the proposal of several possible innovative scenarios. For each of these new scenarios, a more detailed market analysis has been carried out through interviews with experts or firms in order to better understand the

potentiality and feasibility of these new applications. This study about the state of the art took great advantage of an enlightening attendance of some ASP students at the AIRTEC world conference 2007 in Frankfurt.

After this phase it became possible to select those UAV platforms that could optimally fulfil the requirements of many scenarios, considering a modular conception of the rotorcraft: a mid-sized conventional configuration, a mid-sized shrouded rotor and a 4-rotors. The shrouded configuration allows for a very silent, stable and nearly vibrations-free platform, with reduced mechanical complexity and great portability. The safety of the platform is among the best possible, as all the major moving parts are protected from the surroundings by the shroud. On the other hand, the flight performances of this platform are limited; as a result, it doesn't properly suit all scenarios.

The selection of the most appropriate scenarios has therefore been carried out by using a matrix method, a technique developed by the Georgia Institute of Technology, which allows the suitability of the platform to be determined for each of the different applications due to comparisons between the values of an appropriate matrix. This method involves an appropriate rating of the importance of each requirement (eg. range, speed, payload...) for every application, and a similar rating for the capabilities of the platform in satisfying each requirement. With appropriate weightings, a ranking can be attained, from which



11 Artistic render of the UAV helicopter



12 Artistic render of the UAV helicopter



13 Artistic render of the UAV helicopter

Characteristics of the UAV	
Weight	8.20 [kg]
Length	1.20 [m]
Width	1.20 [m]
Height	1.20 [m]
Max. Speed	100 [km/h]
Max. Altitude	1000 [m]
Max. Endurance	30 [min]
Max. Payload	2 [kg]
Max. Fuel	10 [l]
Max. Fuel Consumption	10 [l/h]
Max. Fuel Efficiency	10 [km/l]
Max. Fuel Cost	10 [€]
Max. Fuel Value	10 [€]
Max. Fuel Weight	10 [kg]
Max. Fuel Volume	10 [l]
Max. Fuel Density	10 [kg/l]
Max. Fuel Viscosity	10 [cP]
Max. Fuel Boiling Point	10 [°C]
Max. Fuel Freezing Point	10 [°C]
Max. Fuel Flash Point	10 [°C]
Max. Fuel Auto-ignition Temp.	10 [°C]
Max. Fuel Oxidation Temp.	10 [°C]
Max. Fuel Decomposition Temp.	10 [°C]
Max. Fuel Polymerization Temp.	10 [°C]
Max. Fuel Crystallization Temp.	10 [°C]
Max. Fuel Melting Point	10 [°C]
Max. Fuel Glass Transition Temp.	10 [°C]
Max. Fuel Softening Point	10 [°C]
Max. Fuel Hardening Point	10 [°C]
Max. Fuel Modulus of Elasticity	10 [GPa]
Max. Fuel Poisson's Ratio	10 [0.3]
Max. Fuel Thermal Expansion Coefficient	10 [1/K]
Max. Fuel Thermal Conductivity	10 [W/mK]
Max. Fuel Thermal Diffusivity	10 [m²/s]
Max. Fuel Thermal Capacity	10 [J/kgK]
Max. Fuel Thermal Stability	10 [h]
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4 Rotors 4 Safety: a quadrotor safety package development for new operation opportunities

SMARTCOPTER_SENSOR-VISION-ENABLED AUTONOMOUS ROBOTIC HELICOPTER FOR CIVIL APPLICATIONS IN URBAN ENVIRONMENTS

TASKS & SKILLS

The team worked together in the main phases of the project; decisions relative to as industrial partnership and work breakdowns were shared together. The group thanks **Carmelo Truscello** for his passionate work.

Tiago Vieira Cavalcante was in charge of analyzing the characteristics and requirements of a new safety and security package for telecommunications between GCS and UAV.

Luca Natale and **Francesco Ricci** carried out an investigation of innovative scenarios, analyzing market opportunities and technical requirements. They also studied technology chances for safety improvement, and actively worked on design, feasibility and structural analysis of the solutions.

Divide Rizzo focused on the aeromechanical characteristics and behaviors of UAV configurations. He managed the group financial resources.

Alberto Torasso worked as system engineer, studying the multidisciplinary aspects such as the state of the art, the UAV platform, safety requirements and flight simulation.

ABSTRACT

The highly innovative context of UAVs has several facets because of the versatility of this vehicles; a single product may in fact perform many different tasks and accomplish numerous missions. In order to exactly identify the most suitable solution to the main requirements of a mission it is advisable to carry out careful and specific analyses and - not later - multidisciplinary studies and enquiries.

The activity of the group was addressed to the analysis of different scenarios and the selection of flying platform capable of meeting the requirements imposed by the reference missions. The platform definition process has been guided by the driver of modularity, i.e. the development of a UAV which can be capable of accomplishing different missions with only minor setting changes. Among a range of opportunities a quadrotor platform was selected as the most innovative solution due to its versatility and the ability to fly indoor missions. A partnership with the company Aermatica was started for the development of a family of quadrotors. The cooperation was focused on all aspects of safety and integration in the operative environment; it was selected since it is really multidisciplinary as it impacts all aspects and all subject of design. Outputs of this collaboration are a redefinition of safety requirements, design of components such as the landing gear, definition of safety procedures through the simulation of failures and a preliminary analysis of the effects of shrouded rotors on performances.

The techniques used during the project have been varied; with regards to scenario definition, they range from search through articles to participation to conferences where experts have met. With regards to trade-off processes, advanced multi objective optimization methodologies have been used such as matrix methods and the house of qualities. In the design process 3D modeling, structural simulation and flight simulation have been extensively used.



1 examples of quadrotors and technical solutions for landing gears

2 The quadrotor presented by Aermatica at SMAU 2008



UNDERSTANDING THE PROBLEM

The problems faced by the team have differed throughout the project's duration. The highly innovative context of "UAV world" required a preliminary phase to attain awareness of issues and problems. The complexity of such a constantly developing field is bound to a lack of standardization and legislative references which lead to a non-uniform design methodology. Therefore a multidisciplinary approach is needed to meet economic, marketing, legislative and technical issues.

In order to develop a competitive product, from both a commercial and a technical point of view, market research was required to establish possible users needs. This was implemented in a first phase through a state of the art analysis and an operative scenario investigation. By means of brainstorming, a list of possible scenarios has been created, exploring both already existing and new customer needs. Soon after, the feasibility of each scenario has been evaluated in accordance with qualitative and quantitative drivers. The former includes: possible uses and users, existence of a market, required technologies and degree of autonomy, man-machine interface and safety requirements. The latter are: size, weight, payload, range endurance, rate of climb and speed performances of the vehicle. Legal issues have also been included in the analysis.

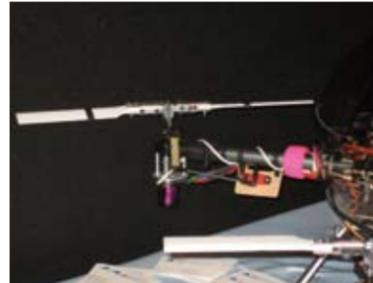
The analyzed scenarios cover the main areas of: law enforcement and civil protection, life quality improvement, entertain-

ment, structure monitoring and environmental missions. The tools used in this research activity have been the following: interviews of experts in the field of each scenario (e.g. firefighter corps, policeman, TV companies, etc.), reading of books and papers, participation in the 2007 and 2008 UAV-World conferences (the reference meeting for the European UAV community) and an in-depth online search. This enabled us to build knowledge on the basis of the state of the art and future trends of scenarios, flying platforms and payloads.

EXPLORING THE OPPORTUNITIES

Rotorcraft platforms may have different configurations; in particular, the number, position and type of rotors enormously influence aeromechanical behavior and therefore overall performance. Each helicopter configuration (with conventional, dual, quad or tilt rotor) can come with shrouded or un-shrouded rotors and is designed to best fit particular mission scenario requirements.

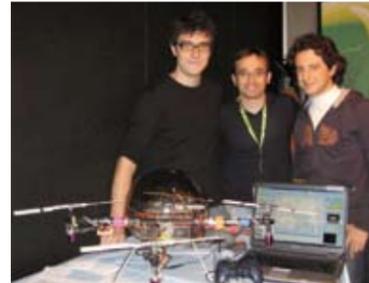
In order to identify a limited number of platforms, each scenario has been coupled with a rotary wing configuration, keeping in mind that the final aim is to develop a modular UAV that is capable of accomplishing different missions with only minor setting changes. As a matter of fact, market analysis has shown that a modular UAV is the most attractive solution. For this reason, a matrix based method (widely proved to be a useful and reliable



3 A particular of the quadrotor presented by Aermatica at SMAU 2008



4 The electronic box of the quadrotor presented by Aermatica at SMAU 2008



5 Luca Natale, Francesco Ricci and Alberto Torasso with the quadrotor presented by Aermatica at SMAU 2008



6 Testing the resistance of the quadrotor presented by Aermatica at SMAU 2008

tool for decision making analysis in a multi-objective optimization) was used to select the best configuration to perform a specific mission or application. Based on the selected optimal configuration and the mission requirements, four platforms have been proposed to cover almost all scenarios: a heavy helicopter with conventional configuration, a mid-sized or small coaxial shrouded rotor and a small quadrotor.

Among these four platform opportunities, the quadrotor was selected because of the innovative approach of using a toy-sized rotorcraft to perform complex tasks in urban environments. Some of these tasks are nowadays fulfilled by manned helicopters while new ones could start being performed according to the much lower acquisition and operative costs. Among these, the possibility of flying inside buildings will open a new wide range of uses. Quadrotors specifically have multiple advantages over other configurations; the most important include reduced mechanical complexity and higher safety.

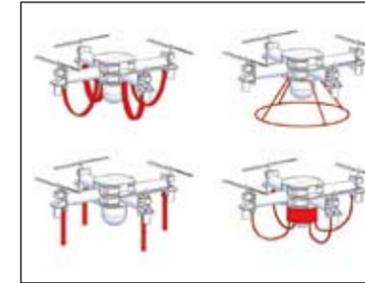
Due to the advantages of the configuration, quadrotors are becoming a new interesting area of research. A start up Italian firm, Aermatica, born to operate in this field, is developing a family of innovative quadrotors. Their product differs from toy quadrotors, easily available in the RC model market, for the payload that can reach 2kg and for the control system which allows fully autonomous takeoff, waypoint navigation and landing. Then, due to academic tutor involvement, a collaboration

started. Given that Aermatica is still in the design and development phase of the project, we have been requested to cooperate in order to complete the project, maximizing the mutual advantages of this agreement.

GENERATING A SOLUTION

The first phase of the cooperation with Aermatica was based on a general review of design and on the identification of a cooperation area through formal meetings. Interaction opportunities included the following: the study of a man machine interface (MMI), the development of an inertial measurement unit (IMU), the design of some lacking elements and a complete review of all the design aspects which impact on safety. Given the relevance of all the previous themes in the success of the design of such an high-technology platform, the competences of the group and Aermatica preferences, efforts were devoted to the realization of a safety and security package. This kind of activity, besides being a central issue in aerospace systems, requires a multidisciplinary approach given that it is based on the redesign of all functional systems. Safety in aerospace activities involves the protection of the flying system from the environment and vice versa.

The preliminary step consisted of understanding and reviewing general system requirements and their effects on safety issues. The initial focus was on actors which needed to be protected



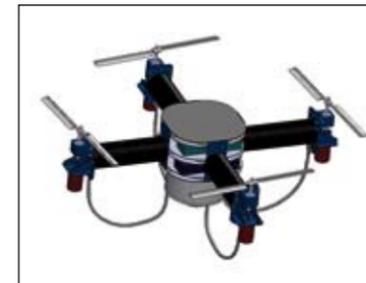
7 Different solutions for the quadrotor landing gear



8 A possible quadrotor configuration



9 A possible quadrotor configuration



10 A possible quadrotor configuration

(the flying platform, payload, human operators, environment) followed by the operative phases and threads related to particular activities (e.g. take off and landing, night flying, transportation). Matching phases with actors, a set of safety enhancing technologies and countermeasures have been identified. Each solution has been studied in detail by following an approach similar to the one used for operative scenarios. Through the use of the House of Quality technique, a relative ranking of importance and effectiveness of the solutions was proposed in order to help the selection of countermeasure systems.

Given the analysis results, an agreement was reached with Aermatica to work on the following activities: the complete design of a landing gear, the preliminary analysis of the effects of shrouded rotors on performances, and the design and analysis of safety procedures through flight simulation. In parallel a study on communication protocols has been conducted in order to assess safety and security on data transmission. For the

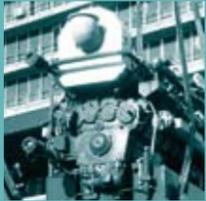
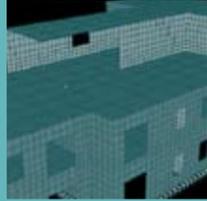


11 A rendering of the quadrotor in urban environment

design of 3D subsystem models, static and dynamic structural simulations have been used. A flight simulator has been adapted including quadrotor characteristics in order to compare aeromechanical performances and behavior of the platform in the case of failures.

MAIN BIBLIOGRAPHIC REFERENCES

- Proceedings of the *International Conference UAV World, Frankfurt October 24-25, 2007*.
- Saggiani G.M., Teodorani B., Rotary wing UAV potential applications: an analytical study through a matrix method, *Aircraft Engineering and Aerospace Technology*, Vol. 76 Issue: 1 pag 6 – 14, 2004
- Prouty R.W., *Helicopter performance stability and control*, Krieger, Malabar, 1990.



SensoBot

Sens**o**Bot

PROJECT 11

SENSORS AND CONTROL FOR SOCIETAL ROBOTS



SensoBot

Sensors and control for societal robots

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project 11

Integrated sensors and control electronic devices in smart and intelligent autonomous robots to be used in everyday life; interesting for the market

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PROJECT DESCRIPTION

In 2004, sales in non-industrial robots has surpassed sales in industrial robots, thus making evident the long-expected distribution of robots in the society. The successful market deployment of such devices often depends on the availability of low-cost, reliable, well-suited sensors and control devices, integrated with a market-effective robotic body. The aims of this project included the analysis of the needs and potential of the robot market in the society of the near future, together with the definition of case studies concerning possible products. Activity have focused on studying the possibility of integrating sensors and control devices in smart autonomous robots, thereby increasing the interest of the market. Here lies the interest in the project of the industrial partner, ST Microelectronics, which are exploring how of their products can find a role in this market.

The project has been developed by three multi-disciplinary groups that focused on three different applications.

The first group designed Helios, a robotic desk lamp aimed at creating a new way of interacting with light. The user can dim the light intensity, or change the enlightened area in position and dimension, just by moving hands in natural ways or snapping fingers and clapping hands. A camera, a set of microphones, and a set of infrared sensors provide information to a microcontroller integrated in the lamp that controls the engines moving the parts of the lamp body. It is also possible to set the lamp in a “fun mode”, thereby transforming it into an entertaining interactive experience: the lamp reacts unpredictably to events perceived by the sensors.

The second group focused on an autonomous robot capable of performing gardening activities: Aldaron. The key feature of the project is the modularity of the device: different modules can be easily plugged into a common robotic platform in order to perform different activities in a garden. The main platform has



the sensors and basic movement abilities needed by all the other modules; moreover it implements all the needed basic features: localization, mapping, navigation. The design of Aldaron has been focused on the casual gardener scenario, requiring modules for lawn mowing, leaves collection, and flower/plant care, but it can be, in principle, be extended to cover all gardening activities. The main interface is implemented on a PDA or mobile device.

The third group worked on the idea of a home robot: DoMa, the DOMestic MANipulator. An out of the box, DoMa is already able to perform typical tasks such as: Fetch Object, Collect Toys, Water Plants. DoMa is provided with a user-friendly interface through which the customer can interact with it. The user can show DoMa the objects to be known, and even instruct it to perform specific tasks by using a simple visual language. DoMa includes a robot platform, a vision system, a mechanical arm, and a graphical interface, and is intended to be an expandable companion for enhancing home living.



Helios

SENSOBOT_SENSORS AND CONTROL FOR SOCIETAL ROBOTS

TASKS & SKILLS

Italo Belmonte: helped to structure the flow of activities in addition to contributing to the concept generation phase, studying the market and aiding the group in always linking work development with fundamental concepts.

Matteo Bianchi: was the team leader and controller. Leveraging on his management background, he studied the target market and the marketing mix, thus providing high level information in the design phase.

Luca Carlone: was the coordinator of the technical sub-group, responsible of electro-mechanical design and promoter of the prototyping phase in addition to supervising component buying activities.

Davide Girlando: gathered information on artificial intelligence methods and took care of the software parts of the robot, particularly audio and computer vision tasks.

Andrea Mangone: was responsible for the Design, sense making and Lighting aspects and, in particular, contributed to the problem setting and concept generation phase.

ABSTRACT

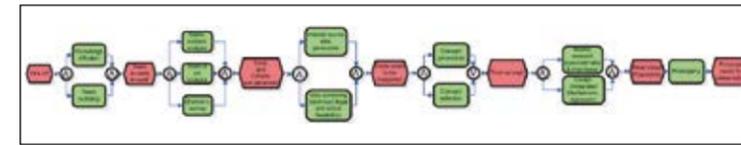
When we started this experience we knew it wouldn't have been easy; we needed to create a robot that was not only brand new but that would make sense to the people around it.

In the SenSoBot project, we were asked to design a killer application for a basically non-existing market and we believed that thinking about new functionalities or tasks to be accomplished was not the right approach to finding such a solution - what we needed was to get a deeper comprehension of what robots are, what they represent for people and which role they may have in the society of the future. We needed vision, more than technological know-how; we needed to think conceptually before going into details, and that's what we did with Helios.

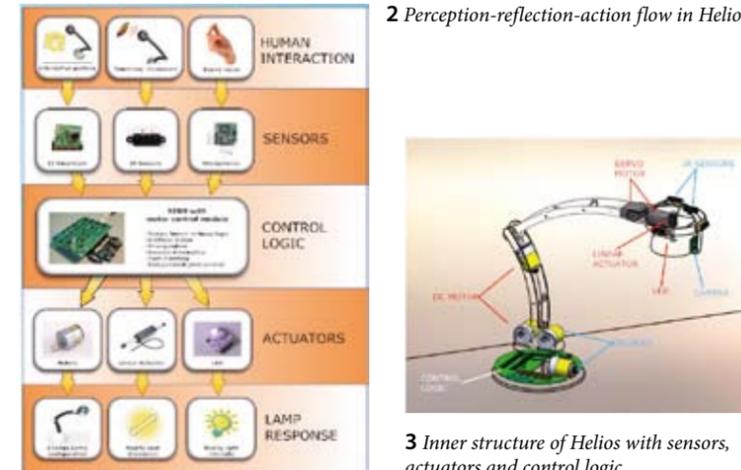
Helios is a robotic desk lamp that is going to create a new paradigm in the way humans interact with light.

It doesn't do anything more than a normal lamp: it just lights your desk. But it does it in a much more enjoyable, intuitive and natural fashion. You can dim or brighten the intensity of the light by just moving your hand up and down, enlarge or shrink the light spot with a simple movement of your hands, or you can call the attention of the lamp with a snap of your fingers and then move the lit area to lighten what you need. If the shadow bothers you, you only need to re-position the lamp's head through a touchless movement. In a sense, you can touch the light and mould it any way you like. All of this is possible due to gesture recognition, sound recall functionalities and a smart use of sensors and actuators.

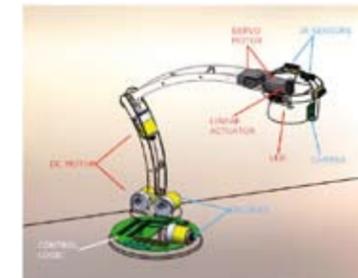
Robotics as a medium between humans and light, and more generally, humans and technology: this is our vision. Men and machines are seen as two opposite concepts: the organic vs. the artificial, emotions vs. rationality. In this project we defy this thought: by adding technology, complexity and a robust robotic soul to a simple and well known mass consumption product such as a lamp, we demonstrated that the result is not that the user and the lamp will be more distant, but rather that they will get closer, experiencing an all-around multi-sensorial interaction.



1 NPD event process chain



2 Perception-reflection-action flow in Helios



3 Inner structure of Helios with sensors, actuators and control logic

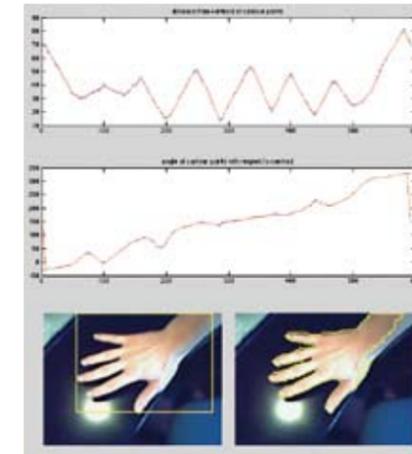
UNDERSTANDING THE PROBLEM

The work was organized in a concurrent engineering way by undertaking the following activities, presented in logical sequence in this section and in the following ones.

Team building was the starting point with a knowledge sharing phase. After that, starting from the definition of the stakeholders' objectives, we developed a criteria framework to evaluate product ideas.

In parallel we elaborated studies and research on the current scenario of domestic robots and we came up with some key factors that may prevent their mass adoption:

- Technological limits: in most cases, Artificial Intelligence does not yet allow a smart interaction, so robots are often perceived as unintelligent, since there is a gap between user expectations and actual performances. Other technical limitations are linked to the sensors and actuators;
- Cost barriers: current state-of-the-art robots express a trade-

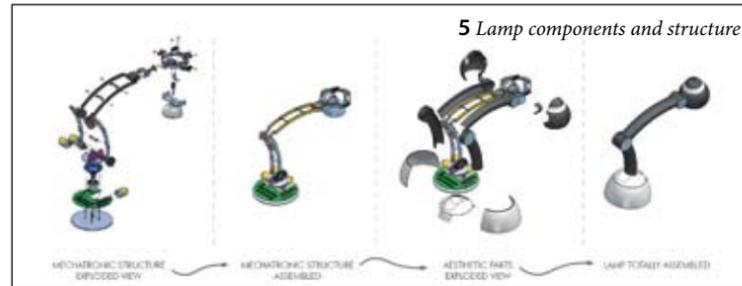


4 (above) Plot of the distance between the centroid and the contour points in pixels and relative angle (blue: rough plot, red: smoothed). (below) Rough recognition of the contour and centroid of an open hand

off between robotic contents and price, being either very expensive and only affordable for few people (e.g. Asimo), or cheap and very simple (e.g. Roomba). The aim of designing a killer application implies offering a high level of interaction at an adequate price;

- Social Barriers: in a futuristic view robots will substitute humans in many activities; in this sense they will not only become helpers but also competitors for human labor, creating social contrasts. Another issue may be the psychological reaction to human likeness as the 'uncanny valley' theory underlines;
- Sustainability issue: the growing attention to sustainable issues at a global level may prevent the diffusion of robots as they may be considered the symbol of pervasive materialism of a consumeristic society;
- Safety issues: interactive human-in-the-loop tasks in service or domestic robotics raise concerns about safety and dependability of autonomous systems. Probably due to industrial applications of robotics, the idea of robots is often associated with dangerous and overwhelming devices, unsuitable for home environments.

We believed that many of these threats could be turned into opportunities by adopting an approach which is focused more on



interaction than on technological content: this is also shown by the study of successful cases in the market (Keepon, Nabaztag).

EXPLORING THE OPPORTUNITIES

The ideas for our killer application were collected both from surveys with children and through brainstorming sessions. All proposals were filtered with objective-based criteria, integrated with our considerations and thence limited to three feasible solutions: a modular fighting toy robot, a rabbit-shaped wireless video-communication tool and a robotic lamp. We excluded the first one because of market considerations on competitors. The second one was focused too much on technical innovations being trapped in costs and technological barriers.

The final choice was the third one and three main scenarios were considered: ceiling, floor and desk lamp.

Besides being able to illuminate a whole room and work in more situations, the ceiling lamp introduced a big issue: the adoption process seemed to be more affected by switching costs for substitution and installation, so the likely market was only for new-house holders. The floor lamp was also excluded because of safety issues related to its massive size.

The desk lamp was the further developed option. It presented the advantage of closer proximity to the person, higher possibility of appealing by design and was a much easier-to-acquire product, due to its price as well as advantages linked to potential sales channels, ease of installation and even its size (what we called «impulsive buying»). This last issue is crucial for the success of a killer application.

By this point a market analysis was carried out, particularly to define the features of the product according to feedback from surveys with consumers and interviews with experts. The outcome of the study highlighted the importance of aesthetics and preference for controlling the lamp by means of voice and gestures. Moreover, a Kano analysis was carried out, revealing the «*excitement*» classification of most of the main features.

GENERATING A SOLUTION

Traditional processes of electro-mechanical design are focused on competence division. We faced the challenge of the SenSo-Bot project in a different manner: the Integrated Mechatronic Approach (IMA). Instead of dividing fields of competences, the process was led as a whole, finalizing each part to a human-centered design. This point is particularly important for innovative robotic products where no market exists. In this case, product development is a balance between a Technology Push approach and market perceived needs.

The design phase was characterized by some primary keywords such as simplicity, natural interaction and common shape, which reflect lamp aesthetic and features. Helios performs four main functionalities:

- **Gesture interaction:** a camera, pointing to the light spot, recognizes special hand gestures. This makes it possible to set the intensity of the light, move the lit area and even to enlarge or shrink the light spot in an intuitive fashion. The Computer Vision module, placed in the smart-cam board, can distinguish three kinds of gestures from the shape of the hand and the movement detected from the camera;
- **Touchless movement:** after positioning the lit area through gesture interaction, the user can move the lamp body in a comfortable configuration using his hands. Infra-red sensors located in the lamp head detect the proximity so the user can push or pull its body without touching it. This communication channel is radically different from the previous one because, while gesture allows for changes in light conditions, the touchless interaction allows the position of the lamp to be modified

without moving the lit area, given that the intelligence in the lamp compensates for the relocation;

- **Sound recall:** four microphones, located in the lamp base, can detect the source position of an impulsive sound like hands clapping: the lamp head will then turn to light that point. The difference between the arrival times of the sound to the various microphones provides information about the source position: if the microphones are not coplanar, the point is univocally detected;
- **Fun mode:** the lamp reacts to external inputs in a creative unpredictable way. Helios can perform predefined demos or simply show sociable behaviour. By choosing this mode, the user transforms a lamp into an entertaining interactive experience.

These features were chosen among others by mostly taking into account user feedback through surveys. Each functionality represents a sensorial channel between humans and light, therefore users have more communicative ways to mould light. As a consequence, light becomes flexible and robotics becomes a medium between human beings and light.

Interaction is the key point of our robot, so the mixture of perception, reflection and action is the necessary condition for a smart experience between user and robot.

Our robotic lamp can be seen as an interactive agent that senses information from the environment, interprets them and obtains a desired output. Robot perception is performed through sensors, while action and tasks are accomplished by using electric actuators.

Helios includes infra-red sensors for proximity, a smart-cam from ST Microelectronics, encoders and microphones. Actuators present are electric motors, a linear actuator and LEDs.

The linear actuator allows modifying the lit area dimension by varying the position of the LEDs with respect to the focus of the parabolic reflector. Moreover the light intensity can be changed by dimming the LEDs. Sensors and actuators are coordinated by the control logic that represents the inner part of the machine using input information to elaborate the correct response.

FUTURE DEVELOPMENTS

Other scenarios open up for our lamp, as technology advances and the interaction between users and robots becomes easier and more intuitive.

The placement of an additional camera, pointing to the user's face, could make room for new exciting functionalities. The lamp could detect the presence of the user, and go on standby when he/she has been away for some time (thus saving energy), or even learn to recognize different users, and to take on different behaviours accordingly. Supported by some recent research (Keepon) it could even understand the direction of the user's glance and follow it with its light.

Besides, using RGB LEDs as the main light source, instead of regular ones, would allow for colour variations. The user could consciously decide to change the colour to create a brighter or dimmer atmosphere, or the lamp itself could detect his/her mood with visual or audio cues (facial expressions, vocal tone) and react to it.

An extra and easy to implement function could make the lamp turn to the wall in order to create diffuse light for the whole room.

Helios introduces an innovative way to interact that seems to be the natural evolution of recent concepts proposed by Nintendo (Wii), Microsoft (Windows table Top) and Apple (Iphone touch sensitive control) and, in a way, it goes beyond these examples by dematerializing the interface and even freeing the user remote controls or touch-screens. We believe this is a significant step forward and we envision that, in a futuristic view, this kind of interaction could be extended to other domestic appliances, thereby reaching new markets.

MAIN BIBLIOGRAPHIC REFERENCES

- [1] B. Siciliano and O. Khatib, *Springer Handbook of Robotics*, pp. 521-540, 921-936, 987-1005, 1127-1148, 1253-1280, Springer-Verlag, 2008.
- [2] Frederik L. Schodt, *Inside the Robot Kingdom (Japan, Mechatronics and the Coming Robotopia)*, Kodansha International, 1988
- [3] B. Moggridge, *Designing interactions*, the MIT Press, 2007



Aldaron

TASKS & SKILLS

Cambiagio Valentina worked on market research and scenarios definition. She interviewed gardeners and possible customers for an in-depth perspective. She also interacted with stakeholders.

Cambursano Francesco brought his practical experience in localization, navigation and mapping issues to the project. He conducted simulations and analyzed the interaction between robots and users.

Gotti Pamela designed the IT system exploring service opportunities and managed the mechanical issue of the platform. She organized and planned the group activities too.

Joe Anthony Keyrouz carried out an investigation on the state of art and trend analysis of domestic robots. He developed the marketing mix and objectives setting.

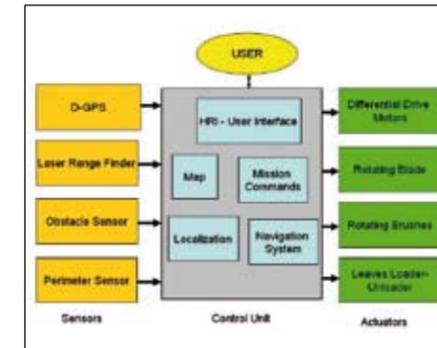
Pannunzio Giuseppe dealt with modularity and the electronics aspect for the developed solution. He worked in the technical design of the functionalities and managed the administrative issues.

ABSTRACT

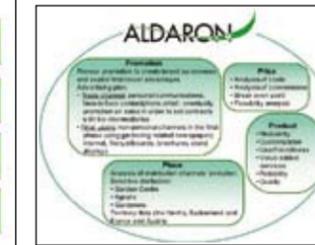
Departing from a rather unrestricted briefing in which the main aim was to develop a robot for the mass-market, the team had to firstly understand the robotics sector with a 360-degree perspective. That meant analysing current robotics and electronics, understanding the current limits of technology, the R&D in the sector and identifying the existing and latent needs of final users that could be satisfied by a robot. In parallel, many brainstorming sessions were held in order to look for concepts that would be appealing to all stakeholders. Having scrutinized the sector, on different levels, it was found that most applications are directed to indoor rather than outdoor environments; as a result, even though all ideas were analysed at the brainstorming, the final selection of the interacting stakeholders was the gardening robot. The concept was chosen since it was the most feasible and in line with the findings of the various analysis and researches that were conducted.

Having set the concept, thorough analysis was conducted in order to analyse the needs and relevant gardening activities. This analysis were carried from various perspectives in order to finally choose the functionalities to be implemented, using a weighted average to account for the different issues.

The main strong elements of the proposed solution, 'Aldaron', include the modularity, the provided services, and the user interface. The modularity allows users to purchase only the modules, which are easily plugged in, with the functionalities needed. However, a main common platform contains all the main features needed such as mapping, navigation, and so on. The proposed initial modules are lawn mowing, leaves collecting, and plant care. In addition to these, many value-adding services are proposed to enhance garden work. The developed concept, as a whole, should provide an adequate solution, as well as a foundation that could be further exploited to address other gardening activities.



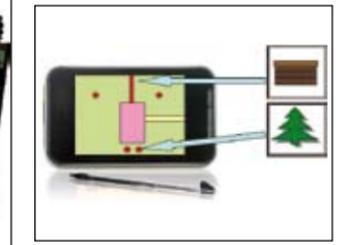
1 Robot system architecture



2 4P



3 Aldaron working in a reference garden



4 Interface between user and robot

UNDERSTANDING THE PROBLEM

Considering the widespread distribution and the long-expected diffusion of robots in our society, the main brief of our project was to develop a service robot targeting the mass market. Our aim involved analyzing the needs as well as the potential of the robot market in society in the near future and proposing possible solutions.

The first period has been dedicated to the understanding of the issue and the creation of a common know-how on the robotic field. Starting from such a brief, many brainstorming sessions were held with the aim of finding concepts that are appealing to all stakeholders. At the same time, extensive research was carried out to check the latest developments in the robotics field in order to assess the existing robots on the market as well as their market performance and acceptability, as well as to be updated to the latest developments in the field.

EXPLORING THE OPPORTUNITIES

Departing from the objective of creating a robotic application that could be mass-marketed, the sector of service robots has been investigated by partitioning it in two parts: indoor solutions and outdoor solutions. As a result, almost every aspect of day to day activities were scrutinized by taking into account the different demographic segments.

After extensive market research, it was found that there are already a lot of robotic products directed at indoor environments

however much fewer directed towards outdoor ones. However, when looking for a concept, all solutions - whether indoor or outdoor - were taken into consideration. Even though the indoor solutions already proposed on the market have not yet been perfected, the concepts proposed for the outdoor had more prospects considering the unaddressed needs and the higher feasibility of the development. In the end, the concept that was chosen and brought forward was the gardening robot. In fact, this choice was based on an analysis of social trends, such as increasing preferences to move to the suburbs around the main cities rather than downtown, to move to houses with a back and/or front gardens and not apartments, environmental awareness and the transformation of a garden in an actual living space of the house. Gardening has emerged as one of the most widespread hobbies in Italy and – when looking beyond the Italian territory - an analysis of the markets in both the U.S. and in the rest of Europe further backed the choice of the concept. In the first stages concepts screening, interviews, focus groups, as well as surveys were also conducted in order to have a wider and deeper understanding of the existing and latent needs related to the gardening market sector.

GENERATING A SOLUTION

Once the concept was chosen, each member of the team, according to one's competences, started developing the part related to



DoMa: Domestic Manipulator

TASKS & SKILLS

Alberto Puggelli defined the most suitable sensors to let DoMa interact with the outer world and proposed a possible implementation of the control board.

Salvatore Renda defined the software functionalities of the robot. He developed a simple visual programming language and specified the human-robot interaction.

Andrea D'Adamio realized the market research and defined DoMa's user requirements. He developed a basic economic analysis to determine the business feasibility of the project.

Roberto Migliorini defined the main architecture, contributed to the basic assumptions for the subsystems and coordinated the group.

Matteo Trascinelli defined DoMa's mechanical structure and conducted investigation on bases, robotic arms and end-effectors suitable for the project.

ABSTRACT

DoMa is a robot of innovative conception, since it belongs to a market in its early adoption stage, that of societal robots, and targets the segment of multi-task programmable robots.

Today the robot market is mainly industrial, but in the last years there has been an increasing number of sales of societal robots. As shown during ICRA2008, the International Conference on Robotics and Automation, many corporate venture capitalists are heavily investing in this field and several enterprises highly esteem the potential of robots that are capable of performing many tasks in the household. Robots such as "Roomba", produced by iRobot in the USA, characterize the present market: these products are mono-task since they are strictly oriented to accomplish just a single action. New market researches show that the business might swiftly move to the demand of more complex robots that are capable of reproducing several general tasks. DoMa tries to accomplish exactly this goal.

DoMa is designed to help people perform a wide variety of duties in the home environment. To accomplish this aim, the robot is endowed with a user-friendly interface which the customer can interact with. When sold to the customer, the robot already performs specific tasks oriented towards accomplishing everyday life chores (Fetch Object; Collect Toys; Water Plants). Moreover the user can program new tasks himself and the robot memorizes and repeats them whenever asked. The user calls the robot by vocal instructions; it comes over and performs the selected action.

DoMa is composed of a robot base, a vision system, a mechanical arm and a graphical interface. The robot base allows DoMa to move freely in the house. The robot can "see" and create a map to improve its interaction with the surrounding environment and is visually guided to perform its tasks. Eventually, the robot arm allows DoMa to perform them.

Initially the main intent was to identify a killer application through extensive research in literature, industry publications and university papers in conjunction with individual perception and creativity of the team members. However, as the analysis went through a whole universe of proposals and discussions, we went beyond the idea of a single killer application and we moved on to think of a product that does not use up exhaust itself in just one single action. It is not a single purpose machine, nor a robot meant to accomplish a single kind of mission, but a robot with some skills that can be exploited in different ways to carry out different actions. Our final aim was to break the psychological barrier of dealing with a machine in everyday life and convince people to have a robot inside their homes.

WE GOT DOMA.

DoMa is the acronym of Domestic Manipulator. It is meant to act in a domestic environment, with the ability of moving autonomously and handling objects. Due to such basic skills, and equipped by an advanced sensor system, with a smart artificial intelligence and a user-friendly interface, DoMa is conceived to become the home-robot. It can locate itself in the house, it moves from one room to another, it looks for an object and brings it to you; it waters your plants or tidies up your room collecting all the objects lying on the floor. DoMa has a set of pre-implemented functions and moreover it can be programmed to perform new ones. Being a programmable robot makes DoMa an extremely flexible system. Its user-friendly interface lets the user program it easily, in order to make the robot accomplish the user's desired actions. Every user can define new functions by customizing his own DoMa to his own needs. The project was ambitious and had to cope with several challenges. Above all, we had to define the Human Robot Interface in detail, which represents the innovative part of our project since it has to allow laypersons to easily interact with the robot and program new functionalities. Furthermore, we had both to provide DoMa with the required sensors to relate with the outer world and to give DoMa the possibility of physically and autonomously moving within the home environment.



DOMA'S INTERFACE AND PROGRAMMING FUNCTIONALITY

DoMa is provided with a user-friendly interface and a simple visual programming language.

The main interface is a touch-screen, through which the user can enter an *execution mode* or a *programming mode*. The first mode is meant to order the robot to execute a task already defined within DoMa, while the second mode allows the user to define new tasks for the robot.

In order to make the programming phase as simple as possible, a visual programming language was developed. The main principle of this language is modularity: the user can build up new tasks for the robot by combining appropriately tasks that were already defined. In this way, more and more complex actions can be programmed by starting from simpler tasks.

In DoMa's programming language tasks are represented as graphical boxes. A program is a graph where boxes are linked to one another to define the order of execution of tasks. Basic programs can be written by putting in sequence a number of tasks, thus obtaining a linear flow of execution.



More complex programs can be composed by using conditional statements, loops and exception handling procedures.

The user is not supposed to draw the graphical elements necessary to build up a program. DoMa's interface guides the user in writing the program and automatically builds the program graph. In particular, it provides a list of tasks available to be selected and it helps the user in defining the input parameters by asking simple questions and activating the proper input device (e.g. virtual keyboard, camera).

When out-of-the-box, DoMa is provided with a core library of *micro-tasks*, which are the basic tasks that are necessary for the use of the robot's hardware (sensors, actuators). User programs are also called *macro-tasks* in order to underline that they are complex tasks built on top of micro-tasks.

In addition to the core library, DoMa is also provided with three macro-tasks: "fetch object", "collect toys" and "water plants".

Since the programming phase may be still difficult for some people, users of DoMa are invited to join an *online community* where they can share their experiences and their programs. Expert users will tend to publish their programs and support other



users. Less expert users will download and use the published programs, provide feedback and raise open issues. This will guarantee that DoMa will evolve with new functionalities, thus gaining user satisfaction and success in the market.

DOMA'S SENSOR NETWORK

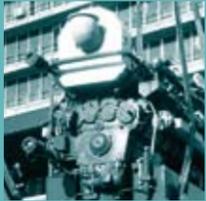
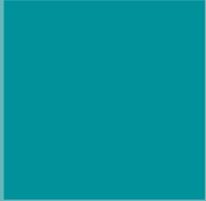
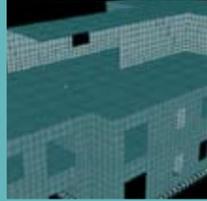
DoMa shares the same senses with humans that are used to acquire data from the outer world: sight and hearing. The robot, in fact, is provided with two video cameras and a microphone, all mounted on the top of the robot, in what represents its head. The cameras allow DoMa to identify objects, move towards them, possibly grasp them and finally go back to the user, exactly as eyes do; the microphone enables the user to deal with the robot just by speaking with it and to call it exactly as he would do with another person. Moreover DoMa is able to answer the user by means of a loud speaker and a vocal synthesizer. Besides representing the most efficient way of exchanging data from a technical point of view, the choice of creating such a human-like design also addresses the aim of providing a user-friendly appearance to the robot so that all users can get in touch with it



more easily and feel that DoMa is a part of the family from the very moment they buy it.

DOMA'S MECHANICAL ARCHITECTURE

DoMa's mechanical architecture has been obtained by a trade-off analysis of the severe constraints implied from its various functionalities. The physical overlook of DoMa is mainly composed of a base to move in the environment and a manipulator to operate with objects. DoMa's base has to be sufficiently compact to guarantee manoeuvrability in a domestic environment but, at the same time, it has to be steady enough to guarantee the dynamic stability of the whole system even when the arm is fully extended. For its motion, the base holds two train wheels and a pivot displaced on a triangular shaped frame that allows DoMa to move in all the directions. The manipulator is a 6 degree of freedom robotic arm whose joints are all revolutionary, thereby granting extreme flexibility to DoMa which can reach any point within the maximum extension of the arm. Moreover, DoMa presents an end-effector that is suitable for grabbing and interacting with objects of considerable size.



UP4tin



PROJECT 12



UP4tin

PRINCIPAL ACADEMIC TUTOR

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Energetics, Politecnico di Milano

ACADEMIC TUTORS

Emanuela Colombo

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Industrial Design, Arts, Communication and fashion, Politecnico di Milano

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Architectural Projects, Politecnico di Milano

Maurizio Tiepolo

Inter-university Territorial Studies and Planning, Politecnico di Torino

EXTERNAL INSTITUTIONS

UNIDO - United Nations Industrial Development Organization

EXTERNAL TUTOR

Emilio Vento

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[Project Communication Coordinator]

Architecture

Damien Lebonnois

Civil Engineering

Ion Iriarte

Environmentally friendly product Design

project 12

Engineering and Architectural support for upgrading “el barrio El Fortin” in Guayaquil through sustainable development. Project sponsored by UNIDO

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Francesco Madonna

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Federica Secondi

Nuclear Engineering

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Management, Economics and Industrial Engineering (full ENG)

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Space Engineering

PROJECT DESCRIPTION

The challenge The project was focused on the general benefits that a full engineering and architectural approach may provide when dealing with sustainable development and within the framework critical social realities. In these environments, such as the suburbs of a big town in one of the Least Developed Countries (LCD), many complexities need to be faced. The main purpose of the project was the identification, the planning and the partial implementation of a “sustainable way” towards local developments, empowering the local autonomy in the long run. A technical approach, inspired by social factors and coupled with the cultural local tradition, was one of the key elements to foster local capacity able to promote higher standard of life.

The “sustainable way” proposed in the project was applied to the case of Guayaquil within the barrio named “el Fortin” where the Mission of the “Consolata” has been successfully working since 1996 on primary education and is nowadays facing new challenges.

The project was split into three complementary areas: resources and infrastructures, social services and safety of the suburban area.

The Teams *Group A: Living in informal settlements (Resources and Infrastructural Managing)*

Civil development is strongly based on efficient management of resources (human and material) and on adequate infrastructure: urban and buildings rehabilitation of existing and sustaining settlements implementation safety and adequate standard level (water supply, sanitation, energy, waste, basic common services) and efficient utilization of informal settlements human resources. Group A identified the local stakeholders and developed a preliminary solution to the infrastructural management related to water supply, waste management and urban street network.

Group B: Planning for chance (Social Services for Sustainable Development)

Individual developments strongly based on basic and vocational education as well as training for preparing professional activities is a basic condition for granting human growth. Quality of life



also depends on the quality of the context in which individuals live. It is therefore fundamental to support a self and common consciousness on the role played by social services as schools, health education programs, green areas as basic factor to promote social cohesion. Group B focus its activities on a global assessment of the social services within the barrio, analyzed different scenarios and proposed a possible strategy to face the different issues.

Group C: Preserving daily life (Risk analysis and Mitigation)

Quality of daily life depends preliminarily on the quality of the settlements. In an environment of illegality, urban development is not regulated and can not therefore take into account any strategy of mitigation that can be useful in case of accident such as fire or earthquake. El Fortin is crossed by a oil pipeline exposing people to a risk in case of rupture. In order to prevent possible damage of the infrastructure or to prevent any considerable risk for the inhabitants an emergency plan would be required. Group C focus its research on a risk analysis of the barrio to find out proper mitigation strategies for the future urban development.

The results The final result is a project document of the future sustainable development of El Fortin barrio. This project will be presented to the local authorities, selected stakeholders and donors with the aim of fostering public and the private interest in the barrio in addition to looking for additional opportunities for funding needed to upgrade these informal settlements and the individuals living in it.



The informal settlements Resources and Infrastructural Managing

TASKS & SKILLS

Andrea Cilona analyzed waste water, the electrical power and the drainage systems at the city and at the El Fortin neighborhood levels. He identified appropriate sewerage components for the *barrio*.

Elena Holsztein Tarczewski analyzed the El Fortin road network and drainage system. She prepared all the thematic maps, and identified a progressively improved hierarchical road system.

Ion Iriarte analyzed the existing waste collection and disposal system at city and *barrio* level. He identified an improved collection and disposal system through trash bins.

Damien Lebonnois analyzed the water supply as well as the drainage systems of the *barrio*. He identified possible improvements in stormwater drainage, based on specific drainage channel section considerations.

ABSTRACT

Guayaquil (pop. 2.4 millions) is the economic capital city of Ecuador and a Latin America hot spot in urban renewal. Nevertheless, popular neighborhoods, where the bulk of city inhabitants lives, have still very little access to infrastructure.

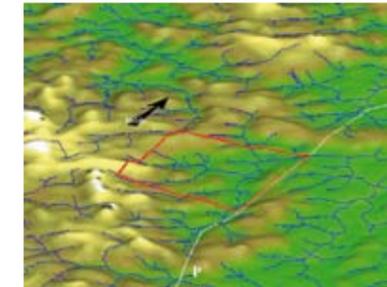
The El Fortin neighborhood (*barrio*) is a typical example of the huge western periphery. Created 30 years ago, the *barrio* is already densely populated (around 50,000 inh. in about 2 sq km). Drainage system is under-sized and poorly maintained, generating huge flooding during each raining season; sewerage is absent, water is brought by trucks, and the length of the road network is only 5% paved. Legal electrical power is not present, and street lighting system only exists along the main streets.

These conditions damage the built environment, create health risks, create an unsafe living environment, and keep the costs of basic infrastructure access at high levels.

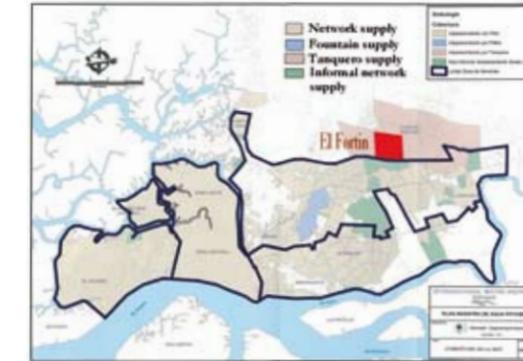
The Team's goal was twofold: first, to develop a multidisciplinary sector-based analysis to identify the main stakeholders and the problems; second, to identify possible solutions to increase the population access to infrastructure.

The team activity simulated the first phases of an Upgrading Program: situation assessment, stakeholder identification, and initial proposals to allow for an assessment of *barrio* upgrading costs.

Activities were organized in five steps. Firstly, a literature analysis was carried out. Secondly, an on-field snapshot identification of the stakeholders in infrastructure provision was developed during a short mission in Guayaquil in September 2007. Third, a mission report was prepared. Fourth, an assessment of El Fortin infrastructure was carried out in March 2008. Fifth, improvements of storm water drainage, human excreta water, street network, waste collection and disposal were proposed as well as ideas to implement and maintain these works through micro-enterprise creation. The capture through taxation of land value increments generated by infrastructure upgrading is finally proposed.



1 Guayaquil according to the Digital Elevation Model. The white line shows the Perimetral (ring road), while the red spot delineates the El Fortin neighborhood



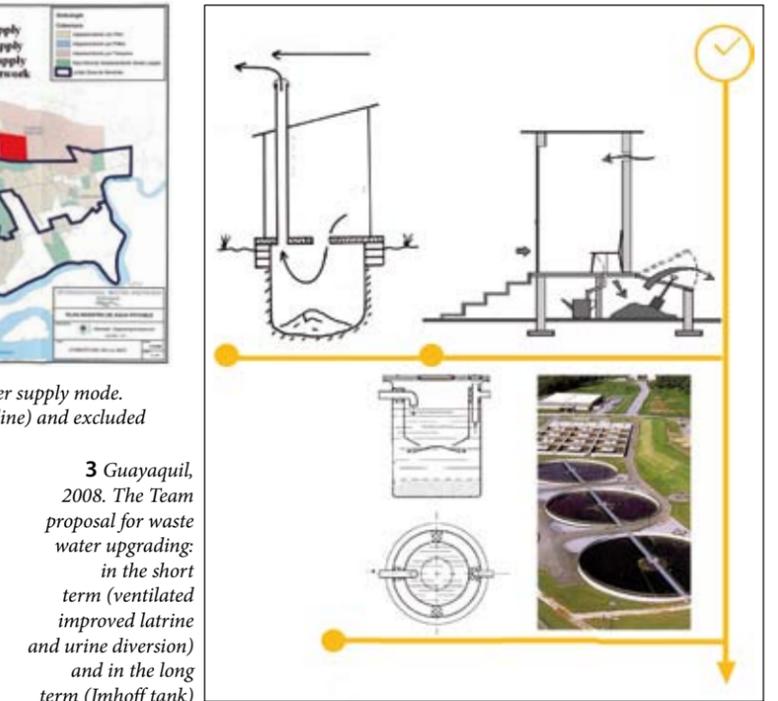
2 Guayaquil, 2007. Current Interagua water supply mode. Piped drinking water area (inside the blue line) and excluded neighborhoods like El Fortin (red)

UNDERSTANDING THE PROJECT

The first step was to understand what an informal settlement upgrading project is. To reach this objective the Team attended different meetings with Tutors and other experts, gathered literature on the Guayaquil case study and analyzed the latter.

A first mission in Guayaquil was carried out by four Students and Tutors to meet several public utilities, NGOs, and grassroots organizations stakeholders, and to visit upgraded and un-upgraded *barrio*. A second mission in Guayaquil of the Tutors and eight students was focused on conducting an El Fortin survey. These activities allowed the key elements for a *barrio* upgrading project to be understood:

- Public utilities in general. Mostly privatized (waste disposal and treatment, drinking water supply, stormwater drainage, and mass transport), they have not so far been implemented in the huge western *barrio*.
- Stormwater (surface) drainage. Surface water channels are almost inexistent. The pipe system to cross primary roads is obstructed. During the rain season, large parts of the *barrio* are flooded. The Team drew detailed situation maps of flooded areas during the rainy season.
- Water supply system. Aqueducts do not reach El Fortin yet. People buy drinking water to private sellers (*tanqueros*) who then bring it door to door by truck. The *tanqueros* supply of



3 Guayaquil, 2008. The Team proposal for waste water upgrading: in the short term (ventilated improved latrine and urine diversion) and in the long term (Imhoff tank)

water is more expensive than the Interagua water company which is piped.

- Waste water. Pit latrines are widespread in the El Fortin. When a pit is full, another is created aside. This practice increases health risk. During the rainy season in the flooded areas, the content of the pit latrine is usually brought up and dispersed in the *barrio*.
- Road network. Few paved roads with an under-sized and often obstructed drainage system, exist. The network is not hierarchically organized. In the rainy season, pedestrians and cars have difficult access to the *barrio* and inside it, due to puddles, mud, and garbage.
- Solid waste collection & disposal system. Formally in charge of Vachagon group it is not run properly in El Fortin, especially during rainy season. The garbage is just piled aside in the streets.



4 El Fortin, April 2008. Flooded streets (thick black) and stormwater drainage channel (thin lines) after a field survey



5 El Fortin, April 2008. A street after a short rain. A lamppost with illegal connections (corner, right)



6 El Fortin, 2008. Proposed street network hierarchy: 1. Ring road -yellow- 2. Feeder roads -blue- 3. Primary paved streets -thick red- 4. Secondary paved streets -thin red- 5. Other unpaved streets, with surface drainage and sidewalk

- **Electrical power.** People are illegally connected to the street lighting network. These connections are done without any precautions. House fires are common due also to the inflammable materials (wood and bamboo) employed to build up the most basic dwellings.

EXPLORING OPPORTUNITIES

El Fortin is better localized within Guayaquil metropolitan area than other *barrio* for two reasons: it is situated along the ring road (*Perimetral*), and it is in between the hilly western area and the neighborhoods along the Guaya River.

This allows the localization of general interest activities along the *Perimetral* and makes surface water drainage less costly in comparison with the flooded prone *barrio* along the River.

Moreover, El Fortin has relatively regular road network (straight streets cutting rectangular blocks).

Among the constraints the Team singled out: (i) a poorly organized population to lobby for an improvement of infrastructure, (ii) little interest of Public utilities to improve El Fortin infrastructure.

We decided to divide the project into six big areas which can be implemented separately: drainage, drinking water, waste water, road, waste collection and electrical power systems.

Before designing our proposal, we identified different alterna-

tives and we analyzed opportunities and constraints of each one in relation to the El Fortin situation. The Team decided to propose already tested solutions for some sections and to develop specific ones for other sections. Each section has a short term scenario (quick and low cost primary infrastructure upgrade) and a long term one (completion of the short-term solution).

GENERATING A SOLUTION

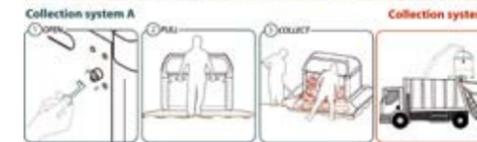
The Team

- designed a set of improvements to increase the population access to infrastructure and prioritize it.
- proposed a project implementation through existing corporations and new micro-enterprises, to offer job opportunities for the *barrio* residents (unemployment is one of the main *barrio* problems). For instance micro-enterprises can maintain surface drainage network, collect trash, etc. Taxation could recover land value increments generated by infrastructure implementation and fund micro enterprises creation.

Water drainage. The upgrading of the existing drainage channels (natural gully channel) into trapezoidal or rectangular consolidated ones is proposed. The bank sizing is based on GIS watershed evaluations and precipitation probabilities. An important issue is maintenance during the dry season, as the ab-



7 El Fortin, 2008. The Team proposal for a garbage/ trash bin placed on concrete platforms: A. for narrow streets and hand collection, B. for secondary streets to be mechanically collected by dump truck



sence of flow has to be compensated with real care in order to keep the channels clear.

Water supply system. Interagua intends to upgrade the *barrio* by connecting it to the formal network. *Barrio* dwellers are often reluctant to accept this option, because they would have to pay to make their habitation organization compatible with Interagua demands. The Team's short term proposal is to bring piped water to the *barrio* via fountains, locally managed and maintained by micro-enterprise. In a long-term scenario, all the private connections have to be achieved.

Sewerage. The proposal is to introduce gradual improvements: in the short period, the installation of a ventilation system or urine diversion systems could be easily realized by the population; in the long term, Imhoff tanks (for a primary treatment) associated to a classical black sewage network should be realized by Interagua. This network should be connected to a waste water treatment plant that is to be built, again by Interagua.

Road network. A primary road system improvement and a system of secondary "all weather" streets (at the present inexistent) are proposed. This should increase communication from the internal parts of the *barrio* with the feeder roads where all the main community services are, and facilitate the work of the dump trucks. The secondary street network was designed according to three criteria: (i) avoiding building plots expo-

priation; (ii) straightness and width of the existing streets, (iii) linking to existing commerce. Different routes, sections, thus different costs have been designed to discuss with stakeholders the best solution.

Solid waste. Two specific garbage bins to be placed on concrete platforms are foreseen: one to be emptied manually, where streets are too narrow for the Vachagon garbage trucks, the other one to be mechanically shifted and emptied by the truck itself.

Electrical power. An educational project is proposed. Illustrated manuals to distribute to each household would show how to adopt easy actions to prevent fire and electrical shock risks.

Implementation options. Due to the size and complexity of works, a formal sector implementation is needed. However, once the basic infrastructure is placed, completion and maintain should be assured by new micro-enterprises. The Upgrading Program should include a component to start up *barrio* based micro enterprises in order to sustain local economy. This could generate both social conscience and economic development. A land value increase taxation of industrial and commercial activities benefiting from the infrastructure upgrade needs to be discussed with local government in order to fund maintenance of *barrio* clusters.

MAIN BIBLIOGRAPHIC REFERENCES

[1] Godin L. (1987), *Preparation des projets urbains d'aménagement*, Washington, The World Bank
 [2] Tiepolo M. (2007), "The *Barrio* marginado regularization in Guayaquil, Ecuador", *Working Paper del Centro Città del Terzo Mondo, Politecnico di Torino*, n. 27
 [3] World Bank (1999-01), *Upgrading urban communities. A resource framework*, MIT
 [4] World Health Organization, United Nations Environment Programme (1991), *Surface water drainage for low income communities*, WHO



UP4TIN

Planning for change

ABSTRACT

Upgrading in low-income urban communities, at its simplest, has come to mean a package of basic services such as water supply or sewage disposals. Physical implementation, even if basic, is however not enough: to catalyze a true upgrading, culture is a fundamental factor, and that's what we based our project on. Of course, culture cannot be "exported" and needs a lot of time to grow in the community, involving every part of daily life; without claiming to solve the problem with an external project, we focused on some main issues, trying to suggest long-term solutions capable of building networks and diffusing a certain degree of self and community consciousness (school facilities to attack the lack of basic education; health issues to be addressed by providing clinics and health education programs; environmental quality, with the design of green areas, a basic factor for social cohesion). Our team focuses precisely on the social services issue in the upgrading of the barrio El Fortin in Guayaquil, Ecuador. In the first stage of the work, together with the two other teams, we tried to identify the people's needs, mainly through our two ten-days trips in El Fortin and in Guayaquil; we had there the irreplaceable opportunity to see what the actual situation is and to meet authorities, representatives of various organizations and local people who made us understand their needs.

Once at home, we identified the most important issues relating to "social" upgrading (education, health, and the problem of green and equipped areas) and we started working on potential alternative visions, always considering their feasibility and referring to recognizable standards (reduced Italian ones, when local ones were not available). Finally, we do not propose unique, sure solutions, as we recognize they're meaningless without a real dialogue and cooperation with the interested actors (commune, ONGs, local actors); our aim is to provide a decision supporting tool, capable of suggesting the most problematic and urgent issues in the barrio and to give an idea of potentially related solutions, with a range of possibilities to choose between (or to start from).

TASKS & SKILLS

Francesca Bariviera and **Silvia Botto** focused on the theme of health care. In addition, Francesca worked on green areas and Silvia designed possible scenarios for kindergartens.

Francesco Madonna and **Serena Pollastri** took care of the educational issues. Serena designed the first aid kit as well, and Francesco studied the economic impact.

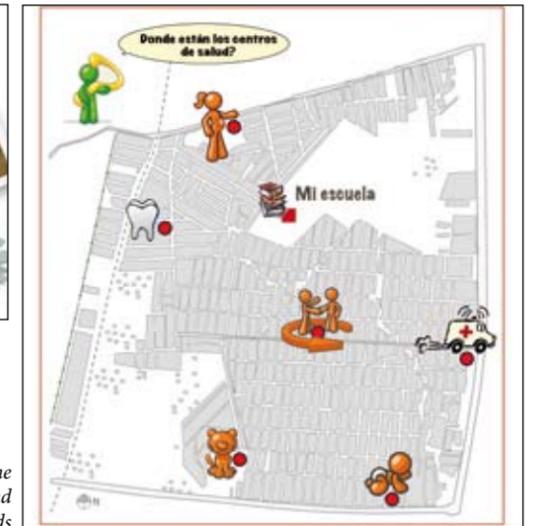
Sophie Tison dealt with preliminary analysis and cooperated in coordinating the different parts of the work.



1 Scheme of new schools: in the map are located new schools that will be built in the Barrio. Some schools will be equipped with some services open to the community, such as Sport courts, library or great hall



2 Moodboard: an evocative image to express the spirit of the project



3 Kids map: map of the dislocation of health and educational services for kids

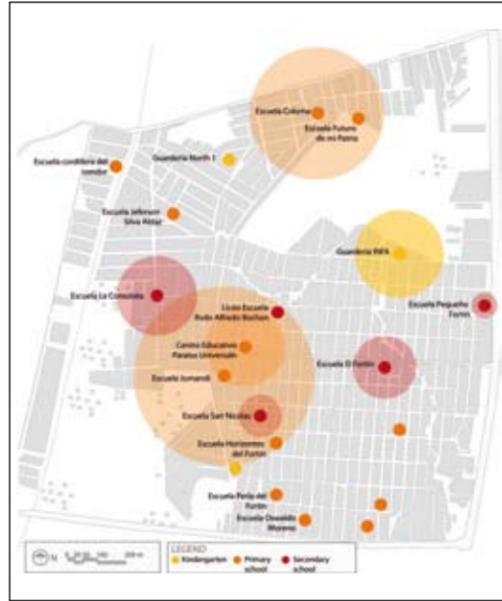
UNDERSTANDING THE PROBLEM

The first step of our work has been to understand the concept of "upgrading". We started with a reading of relevant documentation on the subject and with the presentation of a work about a similar case study in Esmeraldas. We also attended some technical lectures on underdevelopment and the economical and demographical issues related to it in Latin America and other topics regarding participated planning and strategy in upgrading projects. After this initial approach to the problem, we had the opportunity to work in the field. We organized a first trip to the barrio El Fortin in Guayaquil, Ecuador in September 2007 and a second one in April 2008: indeed, the reality of the barrio can only be understood on site. During the two ten-days trips, apart from seeing with our own eyes how people live in the barrio, we met many parties which could be interested in the project. In particular, we met teachers, school directors, doctors, politicians, workers, priests, social assistants, members of NGO related to the quarter, people responsible of utility company and people having a role in relation with the urban planning of the city. Then we made a complete survey of the quarter situation: we could thus notice that the sanitary conditions as well as the educational situation are very poor; medical assistance is insufficient and inadequate and the number of schools, their location and their state do not meet the needs of the slum dwellers. Fur-

thermore, in the barrio there's a complete lack of both social and physical support structures: not only schools and medical centers, but meeting or reference points are also absent and people, at least for the moment, seem to be resigned to this situation, with no ambitions and, consequently, almost no initiative.

EXPLORING THE OPPORTUNITIES

Following our return to Italy, we started updating the maps of the barrio – with aid of the documents we collected – in order to have a reliable basis to work on, and we thought about possible references related to the dimensional standards we could apply in the project. As there are no specific service standards for the barrio (just planning ones, which were just a reference but useless for services design), we referred to Italian ones which we tried to adapt by taking into account the local situation. For all the different services, we based our proposals on our estimation of the population, i.e. circa 60,000 inhabitants in the barrio El Fortin (prevision in 2028, with a 20% growth). For each issue we made some hypothesis about the main needs, their urgency and their interrelations in order to think about all possible solutions. Concerning sanitary services, we were starting from a situation



4 Rays of existing schools: map of the existing schools with their hypothetical ray of influence



5 First aid kit: picture of the first aid kit for commercial activities and schools. It is designed to ease the use and the comprehension in emergency situations



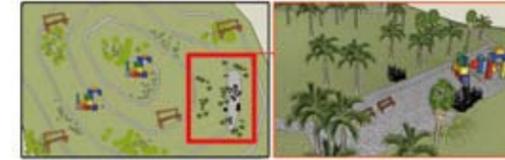
6 Family kit: picture of the bopoklet given to children to improve medical education

of complete lack in the barrio, and the idea was to provide a complete supply at least of basic medical assistance, which has to also include social assistance and health education (about hygienic and sexual behaviors, food, children breeding). We started evaluating the basic fields of health assistance, and thinking about how they could be distributed around the barrio; our analysis included localization, accessibility, specialization, required investments and managing costs, in order to build a clear vision of many possible alternatives also to be built starting from our data framework.

The same was applied to schools: the idea here was that schools have to be the basic point for a true upgrading as well as the build-up of a cultural background and a sense of community in addition to spreading healthy behaviors both in children and in parents. That's why our hypothetical, ambitious goal is of 100% of schooling for compulsory schools and kindergartens, and of 50% for professional schools. We analyzed the required school sizes and evaluated their dimensions and possible locations in the barrio, also considering the need to displace some people to provide

the needed space (total schooling means thousands of children and lots of space). Of course, our visions take into account dimensions, access, investments and managing costs, always providing a data framework that can be used for building lots of visions (and to provide a list of the issues to be taken into account facing the education problem). The same happened for kindergartens, whose coverage had to be reduced (even in Italy it's not total); they were designed in a different way, since their goal is to sustain both children and mothers in the process of becoming an active part of the social community. We imagined two possible organizations: institutional kindergartens with a structure similar to schools, or informal ones organized in a communitarian way. In both cases, we calculated the dimensions, planned the management of the kindergartens, and estimated the costs. We also proposed some scenarios for the professional schools, whose aim is to introduce young people to work and to create favorable conditions for the future development of El Fortin.

Finally, we began analyzing the physical aspect of the barrio and to its equipments relating to free time as well as green areas and open-air services. This issue is fundamental, as it allows people to recognize in their barrio some reference points to meet or to spend free time, potentially using public spaces for community building. The reference standard here was a Guayaquil law, and the basic idea was to provide green and equipped areas in



7 Park design: Hypothesis of a structure for the kids' park

non-buildable zones in order to avoid people displacements. We studied the morphological configuration of the barrio and identified some suggested zones available for parks, providing some visions (and of course the related investments); furthermore, we imagined using some of the secondary streets and residual spaces to locate equipment and services in order to distribute them in the whole barrio without moving houses and people. Self-construction here can be a good hypothesis, especially once a real active community starts growing in the barrio; for the first steps, and for every issue, we tried maintaining dimensions and technologies as easy as they can be in order to allow local workers to be employed and start feeling a greater sense of belonging to their barrio and their community.

GENERATING A SOLUTION

Given the wide range of potential solutions (always starting from our hypothetical goals), we decided to suggest a "preferred" scenario for each of the considered issues, presenting a configuration which we identified as the most feasible. However, the idea was not to provide a single optimal solution, which probably does not exist, or suggest changes following the needs and the aims of the involved stakeholders. What was decided - and here's the most innovative point - was to suggest possible scenarios while always providing affected parties with the possibility of creating their own scenario, allowing a positive interaction between inhabitants, institutions and donors. The starting points are the data and the analytical framework we built, where we underlined most of the problems and interests they have to take into account, and the costs and benefit engender by each choice. As a result, we proposed a vision based on cooperation between schools and medical centers, located in the same complexes but of course carefully separate in functions, in order to

increase the consciousness about healthy behaviors and involve families through children; we designed a specific strategy about this problem, with a kit for children to bring parents to medical centers (with the double objective to allow centers to know their users and to make people know about the existence and the use of the centers). Our suggestions also consider the huge investment required for the whole system building; that's why structures are thought to be buildable step-by step, diluting the need for money and also suggesting temporary solutions for the intermediate period, such as temporary medical units (with a wide analysis) supplying basic health care while the whole system is being prepared.

In parallel, we designed some suggested configurations for collective, open-air services and green areas, providing replicable solutions while also supporting self-construction; once people realize the usefulness of these structures, the hope is that they start taking care of them and use them as community goods, possibly implementing (starting from schools, kindergartens, community work) some sort of self-organization, which is the real foundation for effective, long term upgrading.

MAIN BIBLIOGRAPHIC REFERENCES

[1] European Commission, Aid Delivery Methods, Volume I – Project Cycle Management Guidelines, March 2004 (<http://europa.eu.int/comm/europeaid>)
 [2] Gilbert (edited by), Urbanization in Contemporary Latin America – Critical Approaches to the Analysis of Urban Issues, John Wiley and Sons, Chichester 1982
 [3] J. E. Hardoy, D. Satterthwaite, La ciudad legal y la ciudad ilegal, Grupo Editor Lainoamericano, Buenos Aires 1987
 [4] M. Tiepolo (a cura di), La regolarizzazione degli insediamenti informali in America latina: Messico, Brasile, Uruguay, Argentina, Cile, Perù, numro monografico di Storia Urbana, n. 88-89/1999
 [5] M. Sole, Manuale di edilizia scolastica, Carrocci, Roma 1995
 [6] P. Verde, Manuale di edilizia sanitaria. Progettazione di strutture di base, poliambulatori, ospedali, Carrocci, Roma 1984



UP4TIN

Preserving daily life Risk analysis and Mitigation

ABSTRACT

The work of Team C deals with the risk analysis in the area of El Fortin to find out proper mitigation strategies for the future development of the barrio. In order to perform the analysis it was necessary to collect all information about natural risks and risks due to dangerous human behavior. A detailed literature research on the type, frequency and possible levels of gravity at local and regional level was therefore carried out. Moreover, there was the possibility of directly observing the area during the travel to Ecuador. The analysis has pointed out the presence of two main risks. The first one is related to the presence of a pipeline running underground from South to North along the border of the area. The risk is linked to the possible rupture of the pipe due to natural events, as an earthquake, and the consequent development of a fire. A study was then realized on the possible consequences of pipe rupture or leakage (in particular with respect to buildings). This allowed for the evaluation of the number of people exposed to risk that should be dislocated. On the other hand, various methods to control erosion were analyzed and the most suitable to El Fortin has been identified. Indeed, soil erosion due to intense precipitations is quite common in the whole barrio and this represents a further source of risk for the pipe because it could lead to exposure of the pipe itself. As a result, erosion control represents an alternative to the transfer of people. The second risk that affects the barrio is the seismic one. The suggestion was therefore to realize an emergency plan on the basis of an earthquake scenario. A detailed calculation of the possible impacts of a seismic event in the area of the barrio is presented: the different effects on the different type of houses were taken into account. The output of the emergency plan definition is a proposal of an alarm system, an evacuation plan and an informative campaign for the inhabitants.

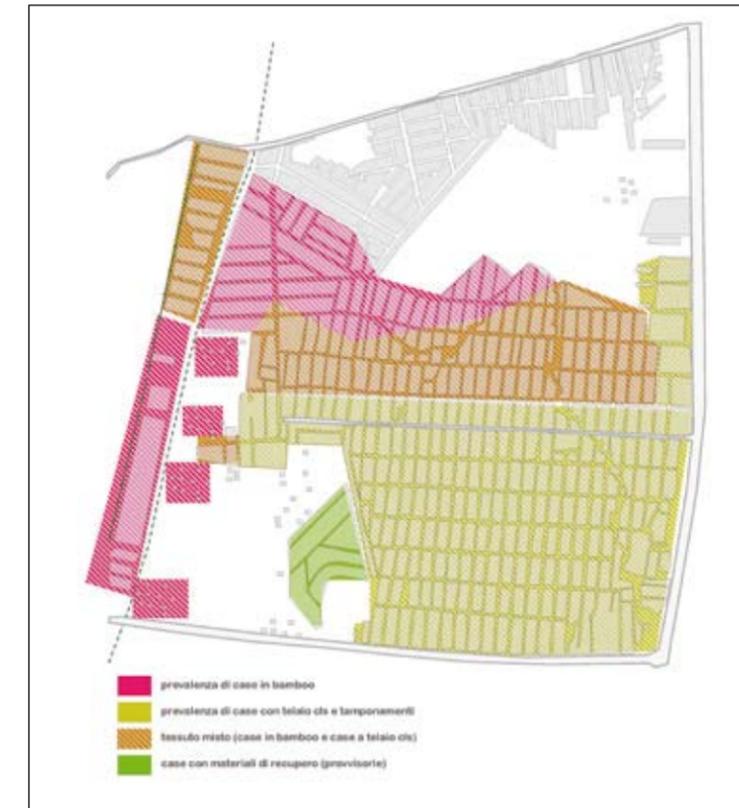
TASKS & SKILLS

Andrea Ferrario led extensive field work in updating maps, explored the basics of risk analysis and collaborated in the risk evaluation phase.

Federica Secondi took part in the risk analyses by collecting information and realizing the emergency plan for El Fortin in the scenario of a seismic event.

Thai Thi Thanh Binh analyzed and evaluated the different methods for controlling erosion around the pipeline and the implementation of a suitable one.

Federico Zuiani was particularly involved in “in situ” surveys, maps updating and in pipeline risk scenarios analysis. He also contributed to the risk evaluation phase.



1 El Fortin, subdivided in macro-areas according to the most common building type in each one

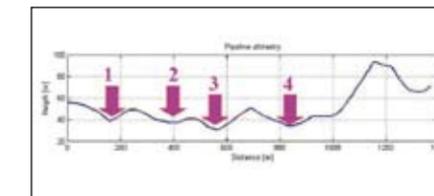
UNDERSTANDING THE PROBLEM

According to the decision adopted by United Nation on sustainable development, the integrated planning and management of human settlements has to include natural disaster risks mitigation in order to implement the Millennium Declaration in urban poor. As a consequence, for the specific case of upgrading the informal settlement of El Fortin in a sustainable development perspective, it is necessary to assess first whether the area is exposed to any considerable risks.

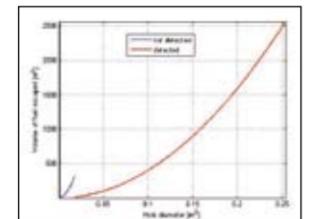
As a result of our research, the area is prone to a high risk of earthquakes and floods. In fact, these phenomena actually happened in the past in the adjacent area with disastrous results.



2 Pipeline control tower



3 Pipeline height profile, as reconstructed by the team

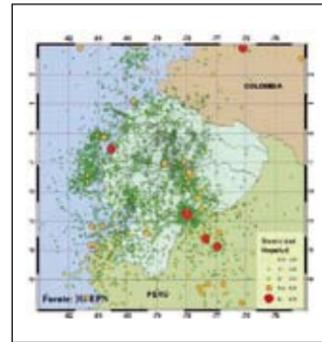


4 Volume escape from the pipeline with respect to leak dimension in two cases: big leakage but with early detection (red), small leakage with late detection (blue)

Beside those natural hazards, we also recognized the presence of a pipeline and power lines inside the barrio. All these combined conditions can create a significant risk for the population of the barrio that is already subjected to an high level of exposure and vulnerability due to the low economical conditions. Hence, it is necessary to set up a comprehensive analysis and evaluation of risks, taking into account the effect of each hazard, rather than exposure and vulnerability according to different possible scenarios. Once the main risks are characterized, we can propose some solutions to control and reduce potential damages.



5 El Fortín, Areas exposed to effects of fuel loss from the pipeline



6 Earthquakes statistics in Guayaquil area



7 Emergency services in Guayaquil area

EXPLORING THE OPPORTUNITIES

By enlarging our knowledge on risk analysis and risk mitigation measures, we discovered that the possible interventions to reduce risks are manifold. As a consequence, the real hot point of our work was the identification of the drivers and their relative importance in making the most suitable choice. We had to consider, first of all, the situation of the area we were working on: an approach that only took into account the technical and legal constraints would have failed from the beginning in the attempt to provide feasible solutions. In fact, the situation of the barrio is rather complicated, both from a social and an economical point of view, and only a 360° overview of the problem would have brought to possible and effective proposals. For this reason, we took part in several seminars in order to deepen our knowledge of the historical, social and economical factors that had led to the critical situation under analysis. Moreover, we examined the meaning of sustainable development, its importance and even its fundamental role in developing countries in relation to the need to mitigate and avoid risks for the population.

After the visit in Ecuador - which provided us with a clearer understanding of the main problems - we assigned a different priority to the identified risks. As a result, we decided to concentrate our attention on the pipeline, with the consequent risk of a fire in the area, as well as on the seismic risk and the presence

of the electricity line, since another team was already dealing with the flooding problem through the study of the main service networks.

The basics of the risk analysis split the potential actions into short-term and long-term measures. Another possible prospective is the division between actions aimed at the mitigation of the hazard (the intrinsic dangerous characteristics of a phenomenon) or of the exposure and vulnerability; these represent, respectively, the areas and number of people potentially affected by the events and their intrinsic predisposition to be damaged. With regards to the problem of the pipeline, the possible interventions that turned out to be feasible and effective were the reduction of its hazard or the evacuation of people potentially involved in the disaster. The hazard mitigation would have been made possible, according to the opinions of different experts, by a reduction of significant soil erosion. This can result in the adoption of various solutions that we analyzed from both a practical and economic point of view. The evacuation of people would have had, on the other side, a relevant economical and social backlash on the whole Barrio. For this reason it was necessary to only identify the areas exposed to high risk level, in order to limit delocalization.

With regards to the seismic hazard, short-term oriented solutions were proposed. The preparation of an emergency plan

alongside with the creation and implementation of new and strict rules for the construction of buildings are only examples of the wide range of alternatives we searched for.

With regards to the power line, the two electricity towers present in the Barrio represent a pointed risk that involve a very small and localized group of people. On the other hand, the wrong use the inhabitants make of the public system for electricity distribution represent a serious fire hazard. In addition, solutions in this case can be more technical or more oriented to the short term, such as the creation and distribution of a small manual with simple but effective suggestions to reduce this hazard.

GENERATING A SOLUTION

With respect to risk analysis, the two main hazards, pipeline rupture and earthquakes, were carefully examined. A detailed assessment of the current situation of the plant which uses the pipeline was carried out and the most probable rupture scenarios were simulated in order to identify the area exposed to potential leakage. With regards to earthquakes, the data collected for the geographical area were distributed in a wide scale of intensity and frequency. Therefore we decided to base our analysis on the worst seismic event in the last century. Moreover our work was focused on the evaluation of vulnerability with respect to the various types of buildings. The area was first split in macro-zones on the basis of the most common building types. As a result, a vulnerability index was calculated for each type of house and finally it was possible to define an index of risk for the populations in the various zones. It is important to note that this analysis was performed through a method that is specific for developing countries: even if some input data were not completely reliable because of lack of information, the methodology adopted in our work is absolutely valid and is meant to be a tool easily applicable to other similar realities.

The second part of our project dealt with the possible mitigation strategies. The idea was to propose feasible and low cost measures of intervention. For pipeline risk, two possible actions were envisioned: in the most exposed areas, the cost of a precautionary



8 The team members temporarily at rest

relocation of the inhabitants was estimated. At the same time, in order to reduce the general hazard, naturalistic engineering interventions were proposed along the pipeline track. The strategies to counter the seismic risk were instead articulated in two different time frames. In the long period, it was obviously desirable to radically reorganize the Barrios; this however was somewhat difficult to realize because of the lack of economic funds and of the legal acknowledgment of the existence of the Barrio. A more feasible solution, in a short term perspective, is the development of an emergency plan. This would be drafted on the basis of a comparative analysis of the state of the art emergency plans both in Europe and in Latin America.

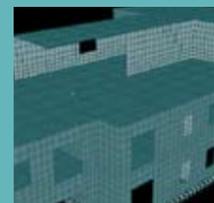
MAIN BIBLIOGRAPHIC REFERENCES

- [1] Vito Ferro, Opere di sistemazione idraulico-forestale a basso impatto ambientale, McGraw-Hill Milano, 2004.
- [2] Scira Menoni, Costruire la Prevenzione, Strategie di Riduzione e Mitigazione dei rischi territoriali, Pitagora Editrice Bologna, 2005.
- [3] AA.VV., Estudio de microzonificación sísmica, vulnerabilidad y riesgo sísmico de la ciudad de Salcedo, Salcedo, República Dominicana, 2004.
- [4] AA.VV. Transporte de derivados (Technical writing on the pipeline), Petroecuador, 2005.

Home textile for tomorrow



PROJECT 13





Home textile for tomorrow

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project 13

HTT is focused on scenarios related to the future home, validating strategies and actions in accordance with textile industry needs in cooperation with Zucchi Group

PROJECT DESCRIPTION

Home Textile for Tomorrow is a project whose objective is the development of potential scenarios in terms of products, markets, features desired and technologies which are related to the home of tomorrow as well their validation through strategies and actions linked to textile industry needs; these products and technologies would be developed in cooperation with Zucchi Group. The Team (composed of five engineers and one designer) was initially asked to define basic the concepts of comfort and wellness, both in relation to the textile field and the concept of home as structural and emotional entity as well as the idea of a person as an individual and in relation with society, also by identifying possible trends of evolution. The main stakeholder of the project also underlined the need for developing a coherent communication strategy to create a Zucchi culture, that is to say a strong identification of the customer with firm, products and brand, exploiting business' potentials.

The Team conducted a wide range of research on the state of the art about the main concepts of comfort, wellness, home and person, that were proposed as a guideline for the project, and on perspectives of their evolution within five to ten years. This study has made it possible to point out the potential of the textile field, as well as its weaknesses, thus allowing the identification of some spaces for innovation.

This huge analytical work, carried out in order to get into the domain of textile items and market, led to the creation of a synthetic view in order to reach the proposal of a solution. The means for this synthesis has been considered the most effective for preserving creativity and also for retaining a constant reference to the background of preliminary studies. This approach involved identifying all the keywords related to the major fields of research – person, wellness and house – and associate them, creatively and without constraints, in order to create a network of relationships that could lead to figure out a targeted proposition of Home Textile for Tomorrow; the rationalization of this step has been implemented by using a powerful and versatile model, the **Tree of choices**.



Three main scenarios have therefore been identified in terms of situations, represented by a target, with its correlated needs and expectations, located in a particular type of house, depicted in the background. The type of developed scenarios does not go into details of the so-called feasibility analysis and do not include a factual project for the proposed products; no in-depth analysis of either economic, or specific technological issues was considered, in accordance with the specific decision to focus on the element of creativity and innovation in the home textile sector, as required by the external institution. The completion of the scenarios is carried out with the definition of a coherent representative product, proposed in terms of allocation in the house, functional and aesthetic features, the selection of a consistent technology in order to realize the planned product and the development of a communication strategy to be adopted by the firm in order to conquer the targeted customer; this was implemented in conjunction with suggestions in terms of retail design, sensory shop experience and message to be conveyed during the purchase.



Home Textile for Tomorrow

TASKS & SKILLS

Federica Balconi performed a psychological analysis on the values in society and on the new notion of “family”, as well as an analysis about the distribution of wealth.

Emma Barker-Hemings examined the evolution of the house under the perspective of the building market, investigating the rooms in which new textile items could most effectively be allocated.

Roberto Cicellini analysed the evolutive trends of the textile market and potential strategic solutions to the deduced problems.

Eloisa Fontana studied the relationship between the five human senses and the perception of wellness, analysing the opportunity of sinaesthetic experiences and of a new retail design.

Diego Gallo examined the concept of wellness, as it is conveyed by the media and as it is tackled in the contribution of important sociologists.

Andrea Lussana analysed some major trends in the expected evolution of the Italian population, paying particular attention to the phenomenon of immigration.

ABSTRACT

The project has been carried out by a single team, thereby working on the general theme of Home Textile for Tomorrow.

A preliminary discussion was initiated with the main stakeholder, i.e. Zucchi Group, in order to formalise and specify its request. A creative and innovative effort was considered central, thereby giving value to the unconventional and multidisciplinary backgrounds of the team members. Technological and economical issues were to be addressed in general terms, and not in depth, since the firm already had enormous experience in the field.

The first part of the project was dedicated to a preliminary analysis, in which the problem was investigated starting from the very title “Home Textile for Tomorrow”. The title was decomposed into its three terms, thereby defining equivalent areas of research. The outcome of the analysis was the listing of some major keywords which were meant to resume the general trends of evolution in the fields of person, house and wellness. A comprehensive frame of the contemporary society in its relationship with the textile products meant for domestic use was depicted and constituted a stable reference for the development of the project.

The second phase was devoted to the identification of potential paths of evolution in the above mentioned areas and the consequent definition of possible scenarios. A synthetic effort was necessary, in order to sum up all the contents and to organise them in a solid structure. This was achieved with the help of a comprehensive and highly organised tool such as the so called “tree of choices”, that is to say a hierarchical network of consequential choices that lead from the definition of a specific product, back to the general ideas that underlie its conception. It was therefore possible to identify some coherent paths of evolution which were put into practice in the proposal of three different scenarios. Each scenario includes the previous analysis, and contains an addition of originality in the terms of the proposal of a specific product.

UNDERSTANDING THE PROBLEM

In every period of human history, the home represents a central element of man’s life, even if it changes during centuries. Nowadays, it is the place in which we can find opportunities to relax, meet our friends, take care of our relatives and free our personality. Within this vision, textile products are important since they become instruments to satisfy new wishes and needs, with new functional performances and higher levels of comfort.

In order to create future scenarios for home textile, Zucchi Group asks to explore the evolution of three keywords: person, house and wellness.

Analysing the notion of **person**, a psychological trend is deduced: traditional values are going through a crisis and, in the arising sense of uncertainty, people tend to invest their feelings in consumer goods. The traditional family is evolving towards more insecure structures and a similar trend of instability can be generally seen in affective relationships. Another major trend in the evolution of the Italian population is the phenomenon of immigration and the resulting lifestyles.

The evolution of the **house** is analysed from the perspective of the building market while considering a psychological focus: the house is regarded according to the notion of “home” and of dwelling in the space.

With regards **wellness**, sociological researches highlighted some features: a strong emotional connotation of objects and a tight association between material items and immaterial wishes. The promotion of sinaesthetic experiences is used to gain the customers’ fidelity, through a psychological process of valorisation of individuality. The strategies that have to be adopted are experiential marketing and the brand experience, with a fundamental role played by the retail design, where customers can have a polisensory experience. Obviously, touch is explored as the most important sense in the textile field.

In addition to the analysis of these keywords, some drivers for the evolution of the textile market are identified, e.g. threats and opportunities of the outsourcing. A reflection is made on the meaning of the “Made in Italy” and its possible exploitation. A



1 Image taken during the team’s visit to the production site of Mascioni, in Cuvio

final opportunity is identified in the building of niche markets as an answer to the strong competition from low cost products created in the Far East.

EXPLORING OPPORTUNITIES

Potential areas of interest for innovation in the field of home textile emerged.

Starting from the general framework of society - which is responsible for creating needs and desires whose fulfillment is linked to psychological wellness - the upsetting rhythm of changes will drive fast changes in consumer desires. In such a context, the main concern will be in present and instant gratification. This situation will have the consequence of creating a growing psychological need of stability, safety, protection; a net tendency in the care of the self, both in terms of health and time is expected. The issue of ageing population is addressed: needs linked to home textile will change in relation to a consequent increasing demand for health and well-being.

Focusing on the house as the physical domain which we intend to enter with our work, trends of evolution involve the formula-



2 Image taken during the team's visit to the production site of Mascioni, in Cuvio

tion of new standards for comfort as well as the importance of health and focus on the use of space. A keyword will be rationalization in connection with a strong functional and emotional characterization of the room.

A trend of individualization is expected again by taking into account the person. A lack of codified structures in relationships, a feeling of uncertainty and instability go with a continuously changing society.

To meet these needs the textile sector has to innovate, both in terms of technologies and in terms of strategy of the firm. Production recently oriented towards high quality products and the focus on innovation is increasing. The communication strategy of the firm has a central role; in particular, human senses can be stimulated in order to promote experiences and reach the irrational side of consumers.

All these features merge during the definition of potential scenarios.

The path of formulation of each scenario, starting from identified needs and keywords and ending with a product, is built using the "Tree of choices". Consequential questions, in each of which



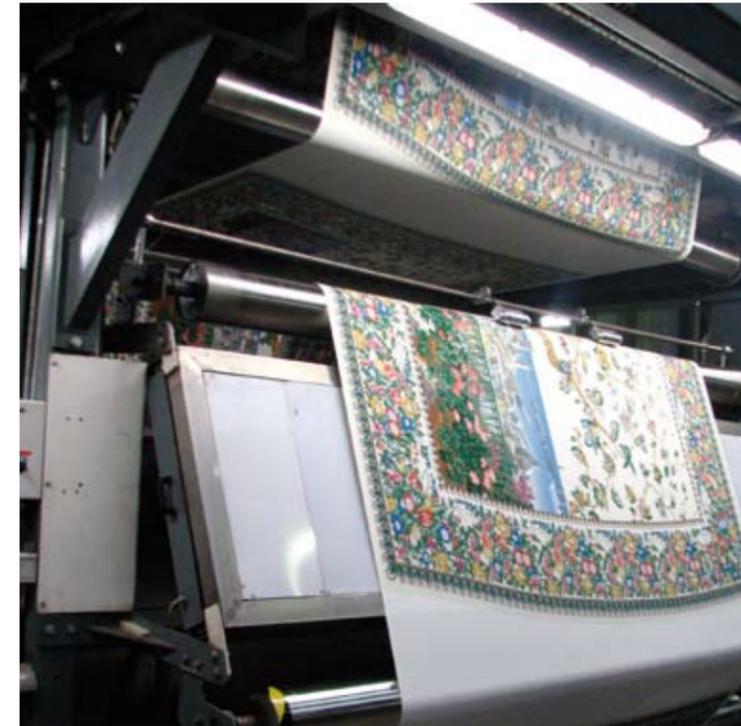
3 Image taken during the team's visit to the production site of Mascioni, in Cuvio

an irreconcilable dichotomy is proposed, are asked. The tree begins with the choice of one of the three major needs ("Why?"); this is followed by questions on the person ("Who?"), the house ("Where?"), and finally the product is defined ("What?"). It is possible in this manner to easily define the main features and requirements which a product of every scenario should have.

DEVELOPING A SOLUTION

The confluence of the analytical work is represented by the proposal of three scenarios, in which a common framework can be traced. The scenario has a protagonist and is built around a specific person, identified by age, sex, nationality, occupation, social status and economic assets. The targeted person has needs, both emotional and material, that contribute to the definition of an idea of wellness. The type of house in which the selected customer lives complete the demand to which we are asked to answer. A proposal for innovation is thus formulated, in terms of a type of product, a retail experience and a supporting brand strategy.

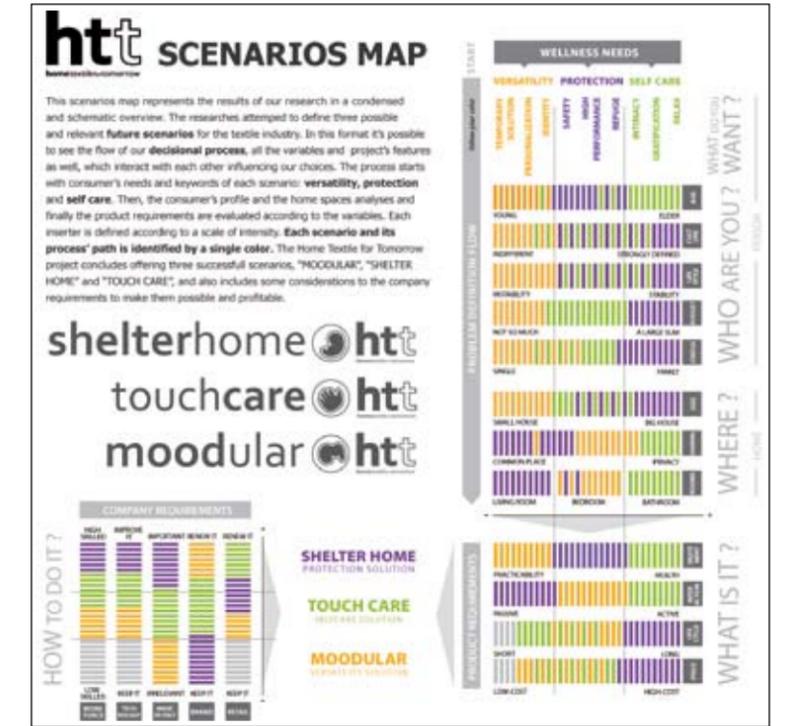
The first scenario is based on versatility. Relationships among people are fluid and not codified, and this is reflected in their



4 Image taken during the team's visit to the production site of Mascioni, in Cuvio

houses which are frequently non-finite spaces that are continuously adapting to the corresponding variations in people's needs. Even the very building is frequently changed. A new paradigm arises: adaptive and modular products, conceived for a type of home which is often changed and changing. Focusing on home textiles, a possibility could be a kit of modular bed linen, capable of adapting to beds of different sizes.

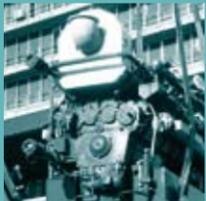
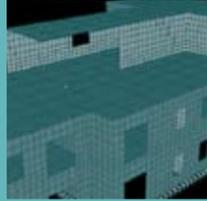
The second scenario is centered on protection. In a world of fast and continuous change, people do not recognize the environment in which they were born and grown. Loneliness and estrangement are the causes of a disease, to which the house can offer a remedy. A new idea of nest, in which people experience family, safety and shelter is associated with the home. A textile product combining the functionality of material protection, and the ideal of a safe "womb" is represented by internal, high-



5 HTT scenarios map

quality curtains, in combination with lighting effects, thermal or acoustical insulations, anti-UV filter, smell absorption and retention of pollutants.

The third scenario is built upon self-care and relax. The external world is fast and stressing, thus compromising the healthy balance of physical and psychological harmony. In response to the attack, people tend to intensify the care of the self, re-evaluating the importance of the body and the sensory experience of wellness that goes with it. In this context, a line of products is envisioned as entering the domain of the bathroom. Mainly, fragrant bathrobes with the incorporation of soft medical and cosmetic principles may represent an opportunity to experience moments of care as well as mind and body relaxation.



Expo 2015



PROJECT **14**

TOWARDS A POLYCENTRIC MILAN



Expo 2015 towards a polycentric Milan

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project 14

Expo 2015 can be a catalyst for large and local scale projects and may enhance the quality of cities and the international role of the Milan-Turin macroregion

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PROJECT DESCRIPTION

We could define the process of development of this ASP project “from EXPO to EX.POint(s)”.

The starting point of the project is related to the fact that the nomination of Milan for the event of Expo 2015 is going to result in important innovations in the strategies and policies of the main players at different decision levels: local, regional and national. The opportunity should be exploited in order to re-orientate programs and projects so as to enhance the competitiveness of the Milan urban region as a polycentric territory.

Following this challenge, two main objectives have characterized the project:

- on one hand, the attempt to understand the impact of similar events which have taken place in European cities (Lisboa, Hannover, Saragoza, Turin) or which will occur in the next years (Shanghai) in order to determine the effects of success or failure in the process of enhancing the performance of the cities and metropolitan areas where they have been realized. Effects have been studied, and organized for their understanding, following five main streams: quantitative data (surface, flows of visitors, participating countries etc.), governance, costs, transport, and masterplan concept. The students have visited the sites of the events, realizing interviews with important actors and establishing a network of international contacts;

- on the other hand, a specific topic has been chosen to test, in practice, the goal of polycentric development: an innovative model for a budget host system named EX.POint. EX.POint is a multifunctional and flexible micro polarity integrated within the urban contest and linked to the net of accessibility through sustainable mobility systems. It would promote social interactive dynamics within the neighborhood and improve the environmental livability through a urban renewal. EX.POint would give an innovative answer to the high level of temporary living demand in the Milan urban region - which will be extremely relevant at the time of the Expo event - but represents a common issue for Milan policies on account of the demand of students, research-

ers, and other low budget city users. This part of the project has allowed us to appreciate the importance of the multidisciplinary approach which characterizes the ASP training activity: the topic has been explored in a very innovative way, taking into account the physical aspects of the budget hotel and of its relationship with the urban or territorial environment as well as factors related to private-public sector negotiations and the funding and management issues which are required to realize the structures.

Both large scale and local scale approaches are relevant for incorporating the complex character of the transformation process foreseen within a polycentric re-organization of the Milan urban region and for matching the actions of the multiplicity of involved players. This has suggested a different, specific topic central for each team.

Team A has worked with a microscale approach which has led to develop a morpho-typological model of the EX.Point and which integrates different functions in order to allow for the introduction attractive public facilities spread in the urban region nodes. Another important task of the team has been to simulate a public bid to grant to private developers the areas where the budget hotels can be localized, according to project contents and guidelines and the public-private sector negotiation process.

Team B has followed a macroscale approach, aimed at defining, by means of a pre-requisites matrix, the territorial “nodes” for the localization of the EX.POint(s). Data concerning the existing regional transport network and the new projects have been taken in account in order to implement a model that is useful to help the decision.

The projects in the different phases of development have been presented to public and private players in order to get a feedback of the proposal from different points of view, and has generated great interest: the representative of the Settore Attività Produttive of the Municipality of Milan – one of the external tutors - asked to prepare a public presentation of EX.POint(s) in the context of the development of the Expo program. Some private players which were contacted are interested in being partners in the experimentation of the bid simulation.



From EXPO to EXPOints A microscale approach

TASKS & SKILLS

Alessandro Frigerio: developed accurate problem formulations while conducting the main case study analysis and its interaction with the proposal. A specific attention has been addressed to the representation of different settlement models with their urban effects.

Camilla Guerritore: contributed in performing the analysis of this complex issue and developing some important project guidelines. Her contribution also concerned the graphic rendition of the main concepts.

Fabio Lepratto: contributed in pointing out the purposes of the project and linking its multiple aspects in view of a profitable proposal to different stakeholders. The primary focus was on the urban role of the project. He created the logo design and contributed to the graphic presentation.

Elena Perego: She contributed to the success of this project by coordinating people involved and different stakeholders in all phases. Moreover, she analyzed the management aspects of the proposal in order to develop a complete and feasible solution and, finally, worked to define the main characteristics of the web site concept.

ABSTRACT

EX.POint, exploits the opportunity of a great event in order to suggest a potential path for the overall renewal and re-launching of the urban region of Milan in terms of attractiveness and hospitality for the purposes of enhancing livability at a metropolitan scale.

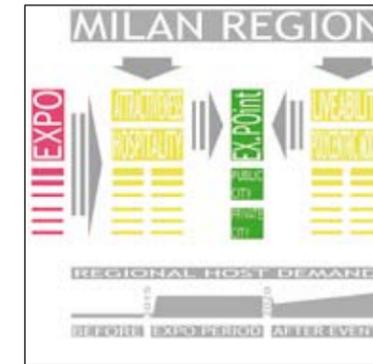
A great event is simultaneously both an opportunity and a challenge. The opportunity is in terms of image, creating widespread visibility for the city even if for a limited time; the challenge is to succeed both in the organization and in the realization of the event itself so as to face the ex-post consequences in an optimal manner. As all the previous great-event experiences teach, in fact, the task of the hosting city is to capitalize the complex material and immaterial legacy of the event.

The great affluence of people and competences that the Expo is able to polarize creates a net that should also be kept alive after the event; this requires, however, an adequate offer of hospitality able to enhance that spirit of sharing and cooperation.

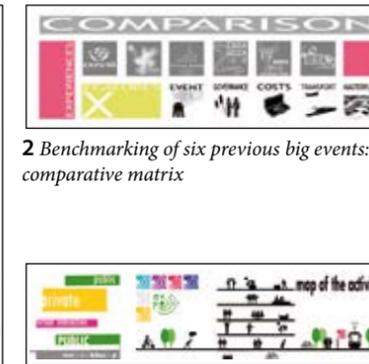
Social networks, infrastructures, new facilities, governance competences, sustainable mobility, cultural background, new high quality public spaces, hospitality system, open-mind view towards different cultures, new professional skills: all these ingredients constitute part of the multifaceted legacy that an Expo can leave to the city.

The EX.POint project therefore focused its interest on the issue of hospitality due to the great amount of people that the event conveys, creating a net of micro-polarities of excellence. The benefit for the city and the territory will be an enlarged capacity in providing better environmental quality, increasing liveability both for stable and temporary inhabitants.

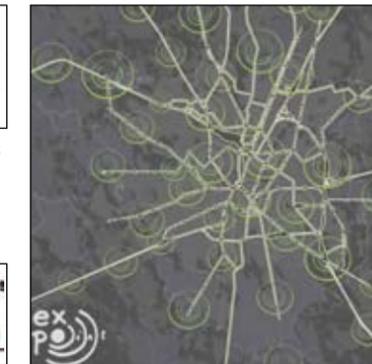
The output of the project will first identify a solution capable of granting a shared VISION in which the different inputs and answers find a way of working together. Secondly, the proposed tools will be explained, underlining the relevance of the marketing of the proposal, fundamental both to promote the initiative to the investors and to the potential users and to create a virtual community of interchange.



1 From Expo to Expoint: a solution for many issues



2 Benchmarking of six previous big events: a comparative matrix



4 Expoint as polycentric vision for the Milan region



5 Expoint: a concept rich of meanings

UNDERSTANDING THE PROBLEM

WHAT IS AN EXPO?

The Expo event is a temporary venue for effective education through experimentation, for cooperation between nations through participation and for international development through innovation. As a result, its aims include the sharing of culture and education, the promotion of development, activities in favor of the environment, and the renewal of the hosting cities.

CASE STUDIES

In order to have a better understanding of the concept and the impact that a great event has on the urban-region that hosts it, a comparative analysis has been carried out among six different big events (Lisboa 98, Hannover 2000, Turin 2006, Zaragoza 2008, Shanghai 2010, Milano 2015), taking into consideration five different variables:

- **event**, showing the peculiar characteristics of each single demonstration;
- **governance**, as the organizational structure of the actors involved and the network of their responsibilities;
- **economic management**, in terms of revenues, costs, funding, involvement of the different stakeholders and the UE;
- **transport network**, related to the improvement of the accessibility for visitors and operators;
- **masterplan**, considering the urban intervention at the great

scale in the perspective of a long-term strategy and a feasible re-use programme.

EXPO AND MILAN

“World Exposition Milano 2015” offers Milan “a unique opportunity for a city to reinvent or modify its international image by profoundly renewing its urban planning, thereby accelerating and anticipating a considerable flow of investments on the territory.”

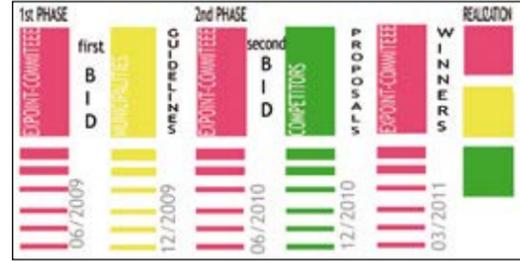
Considering the actual situation of the Milanese environment, receptivity is an important sector to strengthen in order to host the event in the best manner; the event is undersized for present needs both in terms of quality and quantity of the system of the supply and demand. The most penalized segments are: the temporary-stay target group and the non business target group. On the basis of these conclusions, the project aims to enhance the hospitality system and its impact on the different temporal-windows, covering the requests produced by the great event and the already urgent permanent requests through an innovative, high-quality response.

EXPLORING THE OPPORTUNITIES

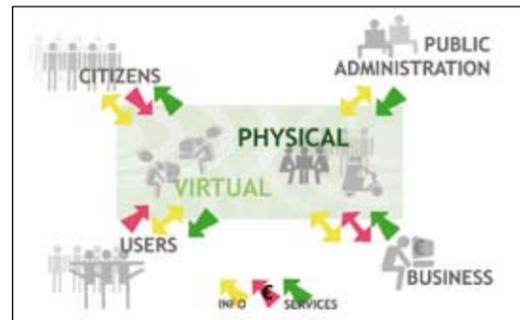
The aim of the project is the realization of a system of excellence with micropolarities spread in the Milanese region in order to develop a sustainable liveability model for overcoming the monocentric view of the city. These are intended to work



6 Vision representing a possible EXPOINT scenario



7 Conceptual phasing of the competition bid



8 The virtual and the physical spaces: possible interactions between the actors



9 A frame of the web site home page

as junctions between local and global networks. The constitution of a solid web between all the single poles will enhance the formation of a sort of “virtual proximity”, thereby favouring exchanges between people and ethnicities, foreigners and residential population and creating a dense environment where innovation and knowledge dynamics can develop.

The project should work as potential engine of development, stimulating the attractiveness of the territory and improving social network opportunities. In this manner, the proposal aims at promoting a new field of experimentation for policies of liveability based on specific governance and management tools and public spaces, renewed urban conditions and interaction networks as well as an innovative system of hospitality and temporary living.

GENERATING A SOLUTION

EX.POint

EX.POint as a response to attractiveness: the importance of a hosting system associated with an environmentally oriented quality of life

The Milanese region, as all the urban regions that have the aspiration to identify their economy as a knowledge based one, needs to attract intellectual assets from all over the world. The EX.Point project focuses its interest on liveability: the capacity of the city to host visitors offering good high-quality and appro-

riated priced accommodations while at the same time producing better habitability for the specific local contexts.

The EX.POint is a multifunctional and flexible micro-polarity integrated within an urban environment and linked to the accessibility net through sustainable mobility. EX.Point promotes a sustainable model of city regeneration and growth. It supplies an innovative solution to the temporary living demand, promotes social interactive dynamics within the neighbourhood and improves liveability through urban renewal interventions. Moreover, its sharing dynamics act at a regional scale by contributing to the polycentric vision and by-passing the administrative limits surfing the Expo wave.

The EX.Point includes two interdependent parts: the *public core* and the *private structure*. Public spaces and ground floors of the Expoints set the relations with the surroundings, thereby responding to local needs through the localization of specific facilities and improving the attractiveness of the urban region

by acting on environmental quality. As for the private structure, it implements the hosting system both for the Expo and the post Expo periods; it follows the expressed will of investors to enter a new business, creating an incentive for them to contribute to the public city under the direction of the local administration. The benefits will be generated for both the stable inhabitants and temporary visitors.

TOOL

The Competition Bid

The complexity of the theme requires the formulation of a specific governance strategy.

By proposing a public cooperative competition, the “coopetition” bid aims to be a tool for promoting synergy between the various players, making them interact. This bid represents an important instrument of communication and collaboration between political institution, public administration, business sector and civil society: the innovation of a model of public intervention finds its form in a shared, common VISION.

The bid comprises two documents. The first consists in general guidelines elaborated by a dedicated EXPOINT(s) committee in order to formulate a coordinated macro-scale scenario, endowed with specific recognisability and quality features; the second, elaborated by the different municipalities, is constituted by panels defining characteristics and micro-scale guidelines to be applied to the specific public available areas selected for the bid.

In this manner, it not only identifies local areas of potential as well as needs but also introduces new opportunities which are proposed by the single projects presented by the competitors. Combining the top-down strategy with the bottom-up proposals, it is therefore possible to identify spaces for private investors as well as spaces for the creation of public areas and services for citizens. This synthesis of local offer and global answer should lead to the creation of points of *glocal* identity.

MARKETING AND COMMUNICATION

EX.POint is meant to be a collective space where different people could rest, meet and share experiences. Its success strictly depends on the ability to incentivize clients to visit the struc-

tures and encourage citizens to join in the promoted activities. In this manner, everyone would be aware of the mission and the values of the initiative and informed about numerous events with the possibility of finding contacts and information about services and organizations involved. The EX.POint marketing plan accomplishes all these complex goals.

A general investigation of the target group would be useful to customize the promotion initiatives and the EX.POint image itself. Two different types of target groups on the demand side can be identified: the citizens who live in the EX.POint neighbourhood and are interested in its public spaces and facilities, and the clients of the accommodation structure. The supply side is also composed of two clusters of players: the public and associative networks and private companies.

EX.POint is not only a physical structure: there will also be a virtual location on the web where people can meet and share their ideas, leaving their feedbacks and finding information. This web site is intended as a virtual meeting point: the web platform wants to foster social network dynamics as it has the aim to enforce real relationship made in the physical spaces. The web-site has to be a Web 2.0 platform: a modern technical architecture which allows users to participate, share ideas, and collaborate through interactive 2.0 tools like blog wiki and forum.

MAIN BIBLIOGRAPHIC REFERENCES

[1] Comitato Giorgio Rota, *Senza Rete. Ottavo Rapporto Annuale su Torino*, Guarini, Torino 2007
 [2] Guala Chito, *MEGA EVENTI. Modelli e storie di rigenerazione urbana*, Carocci, Roma 2007
 [3] Gennari Antonio, Nurra Maria Grazia, *Budget hotel. Evoluzione delle tipologie di prodotto nel mercato dell’hospitality*, Il Sole 24 Ore, Milano 2002
 [4] Paddison/Miles, *Culture-Led Urban Regeneration*, Routledge 2006
 [5] Roche Maurice, *Megaevents and Modernity: Olympics, Expos and the Growth of Global Culture*, Routledge 2000
Impresa e Stato-Rivista della Camera di Commercio di Milano, n.81, Anno XX, 2007



From EXPO to EXPOint(s) A macroscale approach

TASKS & SKILLS

Martina Balconi: managed the entire group activities and served as the reference for institutional and administrative analysis, policy screening and modeling as well as support on economic and feasibility factors.

Antonio Mannino: contributed analyzing architectural, urban and planning issues and their subsequent development, managing the link between existing settlements and future scenarios.

Stefano Minini: contributed to territorial and infrastructural analysis, focusing on development related to public transports while sharing his know-how for the implementation of the model.

Mario Pan: contributed by analyzing insediative and the urban impact of big-events related structures, creating new territorial scenarios of development and implementing the GIS model.

Xiang Wang: developed a financial evaluation model for the settlement of new hospitality facilities, based on the analysis of big-event related case-studies and investments market in this field.

ABSTRACT

The north-western part of the Milan region is going to be the site of relevant territorial and economic transformations on account of the presence of the Fiera District and of the new infrastructural network, which will improve regional and international accessibility.

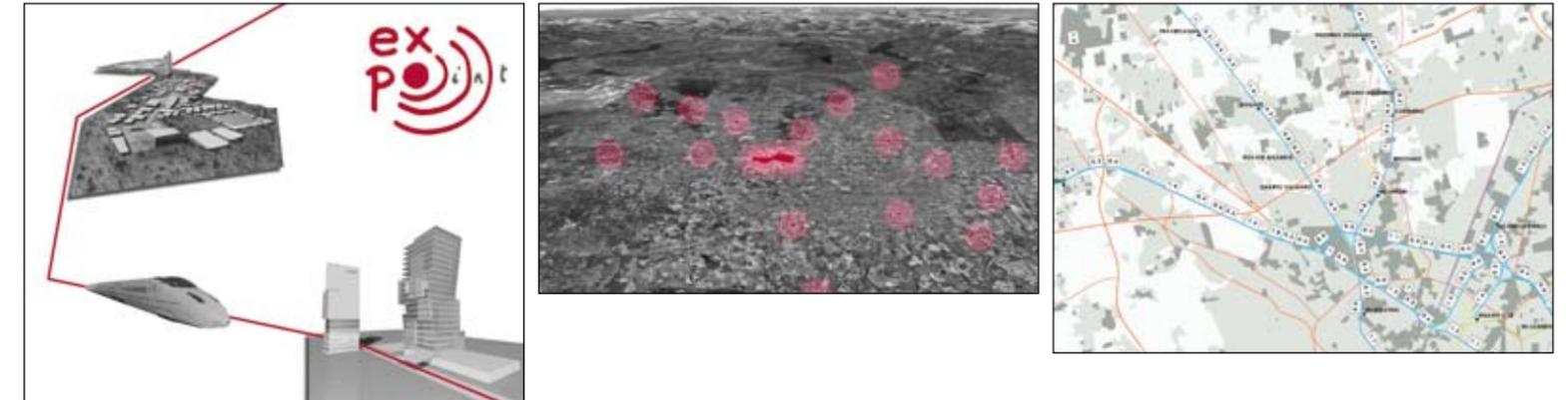
The main event of Expo 2015 can be considered a catalyst for the implementation of projects capable of enhancing the performance of the two metropolitan areas of Milano and Torino and their international role.

The main aims of the project were to start-up important innovations in strategies and policies in addition to establishing programs and projects capable of enhancing the competitiveness of the Milan urban region as a polycentric territory and its role in the international scenery.

The Expo project - by means of a strategic and shared vision of the transformations occurring in the next years - represents an opportunity of local development, urban regeneration, improvement of the quality of the environment for a large area, as well as a challenge for a polycentric re-organization of the Milan urban region.

The first steps of the work included the analysis of the decision process, acknowledgment of the multiplicity of actors involved and of the procedures of implementation of the EXPO project, as well as the build-up of different scenarios in order to compare and assess the latter on the basis of the goal of improving the quality of transformations of these areas. The analysis first involved an evaluation of factors of success or failure of Expo events realized in the past in other countries in order to highlight the minimum requirements for the program start-up and project feasibility (procedures for the coordination of the involved players and models of management).

The result was to build various “scenarios” which were useful in defining criteria of intervention and guide lines for the future development of the city of Milan, the Fair and EXPO Area as a strategic pole in the north western macro region.



UNDERSTANDING THE PROBLEM

Expo 2015, and its interaction with the Milanese region, is a complex issue that involves a high number of inter-related themes: connections between a so-called big event and the territorial and social development are to be considered. A universal exposition, like any event that attracts visitors and investments, has often been used as an opportunity to develop a strategy from both an economic and political point of view. As a consequence of an Expo, the interested cities are deeply re-modeled in their physical aspect and re-launched from both an economic point of view and in terms of the political and touristic re-affirmation in the international scene. Besides, cutting edge infrastructures, retrained zones, expanded tourism and new job places are an important heritage to the inhabitants.

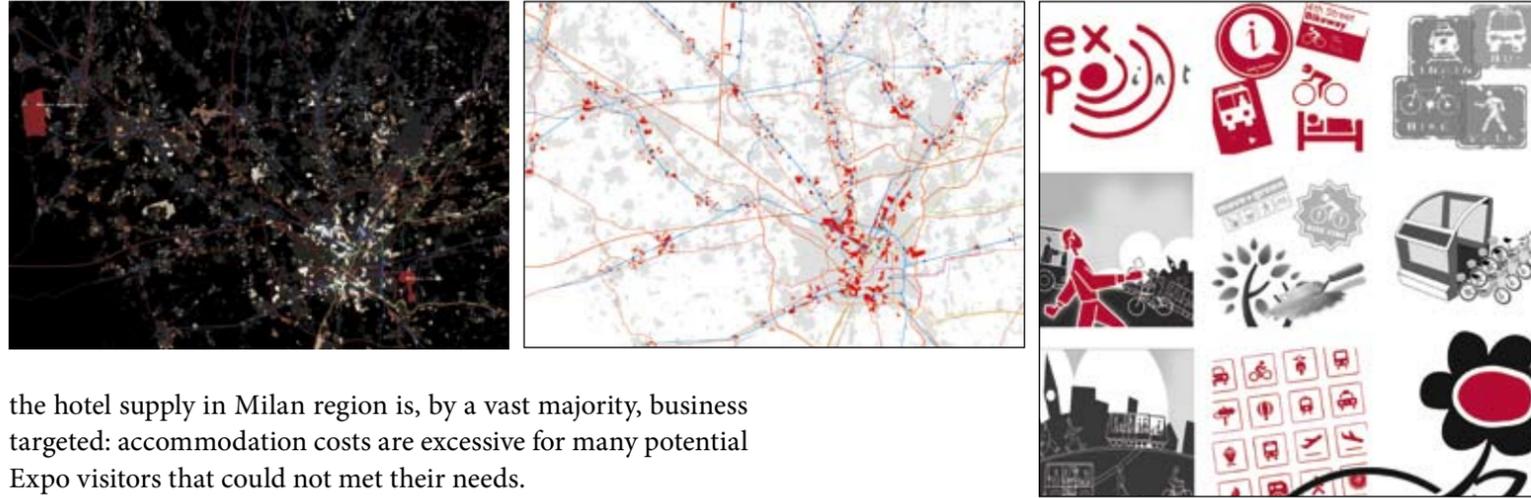
In order to understand these elements, a thorough analysis of big event best practices has been recognized as fundamental; this preliminary study pointed out necessities and innovative solutions for territorial and event management: in cases like Lisbon Expo 1998 or Sevilla 1992 the objectives are clear and declared (city renewal, citymarketing,..), while in other cases as Hannover Expo 2000 they are less tangible.

An important element emerged throughout the analysis: the necessity to comprehend the involved players' demands and roles, particularly in the phase of planning. In the specific case of the Milan metropolitan area, this topic has particular relevance: the

region is rich of excellences but lacks governance schemes that can solve the fragmentation of administrative management. The representatives from the principal economic delegations - as Milan Chamber of Commerce, or from the administrative part - as municipalities, provinces, regions, are a good base on which the know-how can be built, enriching it with the numerous publications and critical reviews on big events.

EXPLORING THE OPPORTUNITIES

The general research focused on the case of the Milanese region, enlightening strength and weaknesses in the administrative, territorial and economical asset. Milan is, today, a metropolitan region, that overcomes its administrative confinements. Like most postmodern cities, it is a network, more or less efficient, of relationships; it is a productive region, a fertile territory for technological research and knowledge development and diffusion. Nevertheless, the regional network is strongly centralized and the heart of the chief-town attracts deals, capital and decisions, neglecting an integrated strategic vision throughout the metropolitan area: this results in limits to territorial development. Secondly, Milan has the heavy inheritance of the stereotypes: it is represented as the city of business, fashion, and design while its metropolitan region doesn't exalt the specificities of its territory. Besides the complex issue of territorial valorization, the analysis pointed out a dramatic lack in the market of budget hotelierie:



the hotel supply in Milan region is, by a vast majority, business targeted: accommodation costs are excessive for many potential Expo visitors that could not met their needs.

As a consequence, *innovative solutions for appropriate cost accommodation* have been defined, identifying them as qualitative, long-term valuable structures, offered at a relatively economic price and refurbished with a complete range services to customers (residence, canteen, laundry service, etc.): this new structure typology, that will constitute a multifunctional and flexible micro polarity, has been called “EX.POint” in order to remind of the strong connection with the event.

Milan could benefit from the development of such a system which will renew the image of host city, extending the potential visitor parterre. Furthermore, the integration of EX.POint in the urban context and their connection by sustainable mobility system, may foster the latent polycentric lean of the Milanese region. After the event, these structures may fulfill the needs of not only Milan visitors but also of thousands of workers, students and other subjects interested in economical accommodation with easy access to the city and its peculiarities (universities, hospitals, etc.).

GENERATING A SOLUTION

At this stage, the research has branched out, with team 14-A devoting attention to the detailed aspects (Expoint design and management); team 14-B, on the other hand, analyzed the local-

ization problem from a polycentric perspective. The outcome of the latter group has been a model whose aim is to define, through a multi-criteria analysis, a potentially optimal site for locating EX.POints. This model, in addition, will be the necessary tool for the subsequent promotion of an open notice, addressed to municipalities and finalized to find those areas which, by satisfying criteria defined by the model, will be used for the edification of EX.POints.

Two different development levels have been proposed in this work:

1. Firstly, the optimal legal instrument for choosing areas was researched and has been identified as an open notice for the municipalities. The competition bid should be proposed by the Executive Expo 2015 committee, a public body that is supposed to be set in order to manage the event and is involved in the quest for residential areas and to their subsequent selection for the construction of EX.POints;
2. Secondly, the necessary technical tool for the areas assessment: the model, based on the definition of three main variables and highlighted through a multi-criteria analysis. The three variables have been identified as follows:
 - a. The *generalized transport cost*, designed to generally measure accessibility to the accommodation structure: it has



been identified as a necessary requirement, from the perspective of providing a sustainable and budget-oriented mobility through access by public transport, such as the railway network.

- b. The *qualitative and morphological features of the area*: this second variable, that includes a series of sub-components contributing to the evaluation, aims at identifying the specific characteristics of EX.POints location. Examples of evaluation parameters are environment quality or the proximity to non-Expo-related locations of interest; this is particularly important with regards to functional upgrading, or re-qualification, to which EX.POints are devoted.
- c. The *internal rate of return (IRR)* expected for an EX.POint within a given location: IRR is a capital budgeting metric often used by companies to decide whether they should make investments. Techniques, expected ranges and principal cost invoices (labor, land concession fee, building expenditures, etc.) have been outlined during meetings with Accor Hotel, a leading European company in budget hotels.



The output of this stage is intended to be a triad of values associated with each area (representing the three outlined variables). On the basis of the calculated parameters, an overall assessment of any bid area is obtained by conducting an investigation based on MCA. This model allows the user to separately consider supply costs, accessibility and urban quality, assessed to a good degree of refinement and a low degree of vagueness. Only in a second step are they matched together to form a unique index called the Localization Index (LI) expressed in a zero-to-one scale: the advantage of this representation lies in its conciseness and in the possibility of developing numerical rankings of areas, in order to evaluate them within the framework of a competition bid.

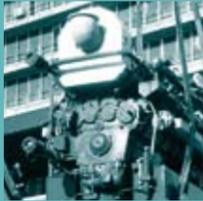
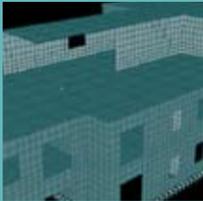
In conclusion, the future goal of this project is to create an efficient tool which allows for the evaluation of territorial areas which have to be chosen for different purposes, and, thus, to define a flexible model, that is adjustable to other environments.

B²M



PROJECT **15**

THE BROADCASTING REVOLUTION: SOCIAL IMPACTS AND OPPORTUNITIES



**B²M****The broadcasting revolution: social impacts and opportunities**

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project **15**

The project aims to analyze the evolution of the “broadcasting to mobile” market from a technological and competitive viewpoint in the next 3-5 years

PROJECT DESCRIPTION

Almost everyone watches television, nowadays. And we all have a mobile phone in our pockets! Could you imagine, then, an unsuccessful future for TV over a mobile phone? Before launching of the service, just few years ago, not even the most visionary individuals would have imagined such large problems in penetrating the market. But the first standard used to deliver such a service, UMTS, has not been up to expectations. Now DVB-h, a specifically created broadcasting standard to deliver high quality TV over mobiles, is being developed. Will it turn again into a big flop? Or will it be able to meet user expectations?

The work provides an answer to the questions above, provided that all the involved players in the value chain of the segment jointly cooperate. The project has been carried on in collaboration with Motorola, the External reference institution and sponsor, and with *Politecnico di Torino* and *Politecnico di Milano (Polytechnic institutes of Turin and Milan, respectively)*. The main stakeholders of the work are the manufacturers of mobile phones (in our case Motorola), DVB-h service providers (Tim, Vodafone, ...) and the end users, who can derive great benefits from DVB-h future success in terms of improved user-experience.

Research activity in the DVB-h market has made it possible to highlight the low quality of current offers in terms of mobile terminals, services other than mobile TV and adequate business models. DVB-h enabled phones present on the market are in fact majorly of minor brands: this is a initial significant problem in a sector where brands plays a major role in the purchase of a new phone. Mobile TV offers are not even close to users expectations and no additional services are present. Finally, since DVB-h is not perceived as a real breakthrough service, users are not willing to pay for it: all these factors finally result large-scale adoption and distribution problems.

Given the above assumptions, the solution to the adoption issue has been created by combining the technical and managerial backgrounds of the members of the group. Firstly, the team has designed and modeled an innovative mobile phone that should



meet users' needs, enriching it with some very original features. Secondly, two original personalized service have been modeled, *InfoMobility* and *InfoUniversity*, so to enrich actual offer. Subsequently, a free-to air business model for generalist mobile TV has been proposed, providing a detailed and sustainable timetable for its introduction, and formalizing a less rigid structure for the value chain of the segment.

Finally, the team has estimated adoption curves for DVB-h and demand curves for mobile TV: both the topics are still not present in literature, providing an innovative sight to this section. To conclude, the team proposes an innovation curve, presenting the schedule of introduction of all the factors presented in the work that enables real adoption curves to meet our estimates.

The presented solution has been built above solid foundations: apart from the deep base-research, the team has had many interviews with Tim (Telecom Italia Mobile), in quality of DVB-h service provider, and with *Istituto Mario Boella*, a research institute which is developing DVB-h services. In addition, a statistical survey aimed to poll user opinions has been conducted among the Politecnico's students. Finally, for the whole duration of the work, both Motorola and *Politecnico di Torino* practically supported the team in reaching the solution by making available all their know-how.



TASKS & SKILLS

Riccardo Ocleppo organized and planned the activity of the team; his electronic engineering background has been fundamental in the development of new services and of the CAD model.

Sergio Doriguzzi brought his experience as Management Engineer to the study of a new business model and was also useful for the organization of the work.

Spinnato Davide, as Telecommunication Engineer, developed the features integrated in the CAD model, also contributing his experience to the creation of new services.

Stefano Tomasino has been fundamental in the evaluation of adoption and innovation curves due to his Managerial engineering background.

Ricardo Cordeiro Scherrer completed the competences of the team and was also helpful in clarifying the fragmentation of broadcasting standards.

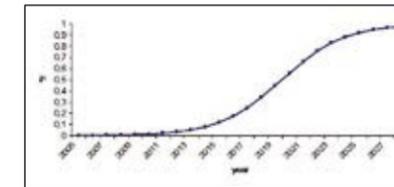
ABSTRACT

The team developed a strategic manner to counteract the problems of distribution for DVB-h standard, the target of many investments in the last few years. How can we make television over mobile phones more attractive? The work answers this difficult question proposing an original and innovative solution to the problem. This solution has been reached by working with passion on the topic by means of in-depth research activity, multiple interviews with significant players within the value chain and a very important statistical survey. We first defined the three fundamental bricks of the offer that slow down the adoption process: mobile phones, services and business model adopted for mobile TV. Then, one by one, we analyzed how they can be turned into a stimulus for users' adoption.

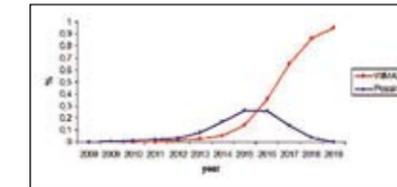
To begin, we had to find a way to improve the user experience of customers: we did so by designing and modeling a totally new phone that was specifically designed for more effectively enjoying DVB-h contents, particularly mobile TV, the leading service. We also pointed out all the features it must have, modeling a new original feature: the integrated PVR. We then had to improve perceived added value of DVB-h: we practically implemented an InfoMobility service, based on a video processing software capable of detecting relevant statistical parameters, and an original InfoUniversity service aimed at university students. These services have a strategic role and serve to accelerate adoption.

Finally we proposed a way to stimulate the demand, by means of a free-to-air business model for mobile TV: it is a complete change of paradigm which relies on the forecasted future importance of mobile advertising. We also propose the time schedule to be followed for the introduction of such a business model in a sustainable way. We finally formalize a new structure of the value chain apt to sustain such a model.

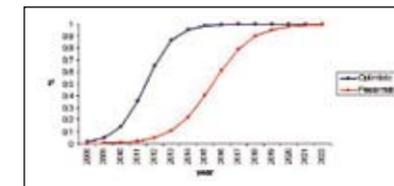
The work was concluded by our forecast of DVB-h curves: we first estimated potential adoption in a closed and in an open environment. We proposed an estimation of the adoption curve for DVB-h services and then an assumed demand curve for mobile TV, independently from underlying technology.



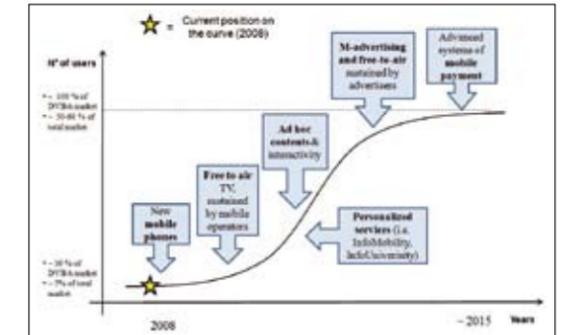
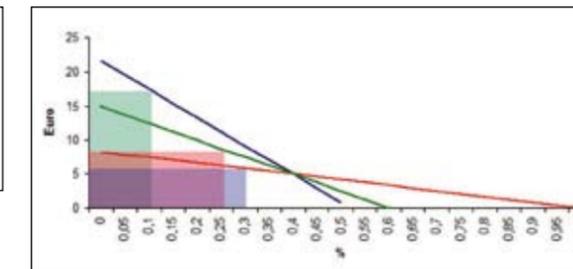
1 Estimated adoption curve for mobile TV



2 Estimated adoption curve for DVB-h technology with competing technology cannibalizing its market share



4 Estimated pessimistic and optimistic adoption forecasts for DVB-h



3 Proposed time schedule for the deployment of our solution

5 Estimated demand curve for mobile TV service

UNDERSTANDING THE PROBLEM

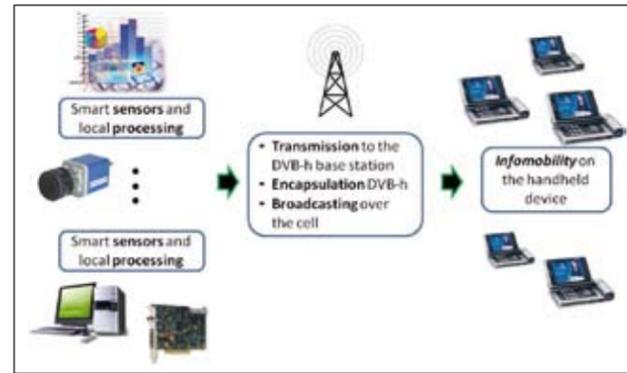
The purpose of the work is to define the evolutionary framework for DVB-h technology, highlighting the factors that will determine the future growth or decline of the technology. The first part of the project activity, that lasted for the whole first year, has been dedicated to understanding how to approach this issue and creating know-how on the matter. The initial objective was very broad and focused on mobile market in general: we then had to make a big effort, together with the academic tutor and Motorola, to find one that was focused on a specific issue and which was stimulating and appropriate for our capabilities. While we were clarifying the objective, we simultaneously conducted in-depth research activity: we first analyzed the mobile market in general and then, once the objective was getting more and more defined, we slowly oriented to the selected topic (DVB-h market). This research activity allowed us to initiate the second part of the project with a high level of preparation, thereby allowing us to obtain a really outstanding and innovative solution.

GENERATING THE SOLUTION

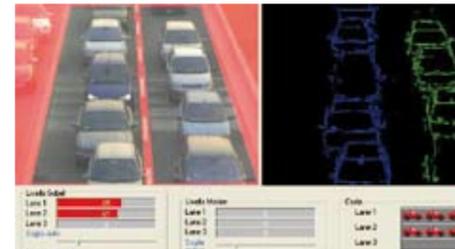
The main problem involved within this kind of work is that it is very easy to fall within the “easy-to-say” but “difficult-to-implement” solutions. Moreover, the solutions presented in many reports or researches often appear very intuitive and not particularly revolutionary, providing a sense of “already created” to these works. Since these two issues were exactly what we wanted to avoid, we made big efforts in achieving this goal. We found that the best way to avoid doing so involved building a very complete and complex work, brick by brick, basing conclusions on very solid foundations. Foundations are represented by the many interviews we have had with important players in the DVB-h value chain (Tim, Motorola, researches institutes), and by an important statistical survey conducted among Politecnico's students. This survey has been fundamental in sustaining our thesis, making the whole work very authoritative and self-standing. In order to get the biggest number of data from this survey, we waited to submit it until our work ideas were totally



6 Practical deployment of the InfoMobility service over Turin's municipality



7 Basic block of the implemented InfoMobility service



8 An operating sequence of the queue evaluation algorithm



9 The tracking algorithm to count vehicle and determine their speed

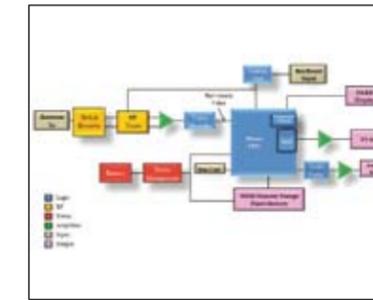
New services. Even though mobile TV, especially for DVB-h operators, remains the most added value service, our statistical survey clearly expresses that some more personalized services still have to be developed to fully meet user requests. We practically implemented an *InfoMobility* service, based on a local and low cost processing platform, which - through the execution of video processing algorithms - retrieves statistical parameters (queues, average speed,...) on vehicles. Data are then aggregated and sent over DVB-h and finally selected and displayed by an application on the mobile phone according to GPS position. Moreover an *InfoUniversity* service has been modeled: it delivers useful information to Politecnico's students on Turin area.

New business model. We finally proposed a sustainable free-to-air business model for mobile TV for stimulating market adoption. We based this business model on mobile advertising as the upcoming advertising medium that will become one of the most effective future means of advertising. In our proposal we took into account the lack of some enablers (means to estimate usage figures and poor user base) and, based on these facts, we split up the introduction of such a business model into two phases. We also took into account the areas of inflexibility within the

defined: by doing so we generated really specific questions, instead of general ones, which provided a lot of relevant information. As previously stated, the solution that was proposed to overcome adoption issues concerning DVB-h is complex: it relies on the introduction of different factors by multiple players in the value chain. It then requires joint cooperation and a common willingness to overcome existing problems. Our work strongly relies on this assumption.

According to the DVB-h market gaps identified in the first part of the work, our solution relies on the introduction of the following three factors in order to exploit all areas of potential in the DVB-h sector.

New mobile phones. We CAD modeled a "next generation" mobile phone to more effectively meet user needs. The basic hypothesis in this case was that its size should equal *i-Phone*'s and its cost should not be excessive. In particular, we equipped it with a 640 x 480 OLED screen that can be specifically pulled out to watch mobile TV on it as well as a long lifetime polymeric battery and an integrated PVR to record broadcasted content so to watch it whenever possible. Since the mobile PVR is still not a major research topic in literature, we designed and modeled our own. Adoption of DVB-h terminals directly relates to an increase in market size: as a result, this first point is of relevant strategic importance.



10 Modeling of the integrated PVR for the CAD model



11 Battery slot within B²m-Phone



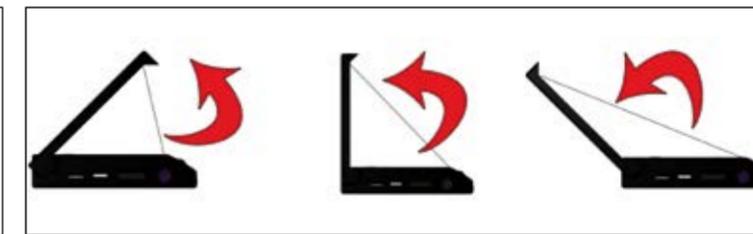
12 The B²m-phone can be opened and a 640x480 OLED display comes out to watch mobile TV



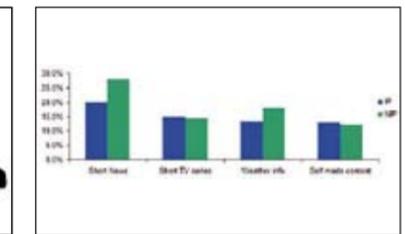
13 The B²m-Phone, when closed, has an innovative design and *i-Phone* dimensions



14 Keyboard within CAD model for PVR control



15 B²m-Phone: opening sequence control



16 Appreciation different mobile TV contents by survey's respondents

current value chain for the introduction of such a model, and formalized a different value chain that could enhance its introduction.

The above three factors have been developed by assuming that the market for DVB-h exists, the DVB-h has no coverage problems and that, with introduction of certain factors, people could be interested in DVB-h contents. To conclude, however, we analyzed if this hypothesis could be correct by estimating **adoption curves**. We found that adoption of DVB-h (in terms of percentage of people who have enabled terminals) will reach significant levels ($\approx 60\%$) in 7-10 years in the pessimistic scenario and that, even within four years, competing technologies such as WiMAX, may start cannibalizing its market share; we then estimated an adoption curve for mobile TV and, also according to the previous datum, we found that the DVB-h lifecycle will be located among the 20-50% range of mobile TV service adoption.

Finally, we carried on a study on demand curves for mobile TV independent from the technology used to vehicle the service.

CONCLUSIONS

This works clearly outlines opportunities and limits within DVB-h technology. This technology certainly represents a low-cost and simple way to deliver common services to a wide variety of people; our work proposes an approach to maximize the user base and thus the profit connected to this base on the basis of a certain hypothesis. On the other hand, in a time where interaction and personalization of services plays a more and more important role, DVB-h, as a broadcasting technology, seems to suffer from a lack of potential. The fact that new upcoming technologies, such as WiMAX, could more effectively meet these needs could result into a potentially reduced lifecycle for DVB-h.