ALTA SCUOLA
POLITECNICA
POLITECNICO DI MILANO | POLITECNICO DI TORINO

PROJECT / 10TH

Preface

This book marks the completion of the course of studies for the 10th cycle of students of the Alta Scuola Politecnica.

Created in 2004, the Alta Scuola Politecnica programme draws inspiration from the experience of the Politecnico di Milano and the Politecnico di Torino, two universities with different histories, contexts and methods, which both share the common goal to offer a highly-innovative academic curriculum to talented students with a high interest in multi-disciplinarity.

From the beginning, this ambitious project aimed to create a so-called “Learning route” between Torino and Milano. Thanks to the growing economic and social bonds between these two cities, two key realities of the Italian economy, we are even more certain that ten years ago we took the right decision, a decision that, during this time, has evolved and has been implemented.

The world is experiencing a very fast technological and social development, which is leading to the emergence of new paradigms. As a result, future technical professionals should not only be specialists in a given discipline, but they should be also able to build the most suitable and innovative solutions to be transferred to the products and services of the future. At the same time, considering particularly talented students, we believe that universities should do more than simply awarding degrees but they should also prepare students to become future leaders and meet the specific demands that prospective employers ascribe to this particular segment of graduates. In this regard, the Alta Scuola Politecnica provides an added value with respect to the traditional academic approach. ASP students are given the opportunity to continuously benefit and profit from one another, from the interdisciplinary and cross-cultural courses offered by the ASP programme, and from projects at the cutting edge of technology proposed by companies. Through this unique learning experience, they develop managerial skills and competences that employers are increasingly seeking from top graduates in technical disciplines. Students have the opportunity to work in teams, to manage complex projects, which require multi-disciplinary contributions (as illustrated in this book), and attend residential courses, as well as enjoying a stimulating learning experience. The significant presence of industrial sponsors in the twelve ASP cycles gives proof of the fact that the mix of specialized skills, coming from the Master programs, and interdisciplinary skills, coming from ASP, are really appreciated by those who operate in this sector.

This important achievement confirms that the path we chose to follow in 2004 proved to be appropriate and still promising, and encourages us to pursue this goal with the same enthusiasm shown by our ASP students.

Prof. Giovanni Azzone, Rector, Politecnico di Milano
Prof. Marco Gilli, Rector, Politecnico di Torino

Alta Scuola Politecnica (ASP) is a school for exceptionally talented students who wish to develop their capabilities for leading and promoting innovation in a multi-disciplinary environment.
Founded in 2004 by Politecnico di Milano and Politecnico di Torino, ASP is attended by students who at the same time pursue a Master of Science programme (Laurea Magistrale) in Engineering, Architecture and Design offered by the two Universities. Therefore, ASP is characterized by a multidisciplinary and multicultural community of students, and by an equally diverse Faculty.

The ASP cultural program complements the disciplinary knowledge achieved in the Master of Science programme with multidisciplinary knowledge that aims to provide methods and conceptual tools for designing solutions to complex problems and to enhance cognitive capacities, aptitude to learning, and talent for interpersonal relations.

This book presents the results of the multidisciplinary projects of the tenth ASP cycle. These projects are developed by teams of students coming from very different disciplinary backgrounds, in cooperation with professors and with external institutions such as companies and governmental bodies. The book provides a snapshot that illustrates the variety and creativity of ASP contributors, as well as an inside view of the work and life of this unique community.

The illustration of project results is preceded by a short presentation describing the ASP program at its twelfth birthday, complemented by testimonials from ASP Sponsors and Alumni.

ASP Sponsor

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

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 Research and Health, Art, Cultural Heritage and Activities, Cultural Innovation, Social Policies, and Philanthropy.

In 2015 the Compagnia awarded 957 grants in its areas of activity, amounting to 143,5 million euros. 31,2% of this amount was awarded in Research and Health.

The Compagnia pays great attention to advanced research and the development of scientific and technological centres of excellence, seen both as catalysts and multipliers of research and higher education initiatives. It supports the strengthening of Torino's university system, especially through the promotion of excellence at Torino University and Politecnico.

The commitment of the Compagnia in the field of Research is focused on university and postgraduate education, starting from the growth of human capital, internationalization and the provision of infrastructures, with special attention to the conditions that assure equal access for students. The Compagnia's relations with the universities in Piedmont (Università di Torino, Politecnico di Torino, Università del Piemonte orientale "Amedeo Avogadro") are regulated by strategic agreements covering infrastructure, research and postgraduate education.

In this context, the ASP's focus on excellence and innovation – besides characterizing it as a valuable initiative *per se* – allows this programme to enhance the global attractiveness of the Universities involved and promotes, within the leaders of the future, a specific attention to the interdisciplinary and international dimension of contemporary society. The programme, which has been supported by the Compagnia since 2007, also represents an interesting and successful example of cooperation between educational institutions based in the north-western region of Italy, such as the Torino and Milano Politecnici.

www.compagniadisanpaolo.it

UBS is committed to providing wealthy, institutional and corporate clients worldwide, as well as private clients in Switzerland, with superior financial advice and solutions while generating attractive and sustainable returns for shareholders.

Its strategy centers on its Wealth Management and Wealth Management Americas businesses and its leading universal bank in Switzerland, complemented by its Asset Management business and its Investment Bank.

These businesses share three key characteristics: they benefit from a strong competitive position in their targeted markets, are capital-efficient, and offer a superior structural growth and profitability outlook.

UBS's strategy builds on the strengths of all of its businesses and focuses its efforts on areas in which it excels, while seeking to capitalize on the compelling growth prospects in the businesses and regions in which it operates. Capital strength is the foundation of its success.

Headquartered in Zurich, Switzerland, UBS has offices in more than 50 countries, including all major financial centers, and approximately 60,000 employees.

UBS Group AG is the holding company of the UBS Group. Under Swiss company law, UBS Group AG is organized as an Aktiengesellschaft, a corporation that has issued shares of common stock to investors.

The operational structure of the Group comprises the Corporate Center and five business divisions: Wealth Management, Wealth Management Americas, Personal & Corporate Banking, Asset Management and the Investment Bank.

www.ubs.com/italia

Summary

ASP Alumni

Association - Overview

The ASP Alumni Association was founded on June 28th, 2007, the day of the 1st-cycle ASP students' graduation ceremony, with the aim of promoting opportunities for personal and professional growth and becoming a frame of reference for all future Alumni.
ASP Alumni operates with the purpose of growing the professional value of the Alumni and their network, acting in accordance with the common values of competence, innovation, and attention to sustainability and social responsibility.
The Association is a global network of highly qualified professionals who wish to share experiences and growth opportunities. Indeed, the association has grown rapidly during its first 9 years, and now boasts a community recognized both in the academic and business worlds, with a network of over 1000 members located across 20 countries and operating in the most widely recognized international companies and research organizations.
The Association, led by the passion of many young professionals alumni, offers a wide-ranging agenda of events. All of them - conferences, workshops, parties or outdoor events – contribute to strengthen the unique community spirit of ASP and foster the professional career of the associates.
A brand new official website has been released at the beginning of February 2015 and is going to be the main internal and external communication channel and organization platform of the Association, jointly with the groups and pages on the main social networks (LinkedIn discussion group, Twitter page and Facebook group, which at present hosts more than 800 members). ASP Alumni members, but also ASPers who have not completed their ASP path yet and followers of the Association can keep themselves updated about all the Association activities and events through the above mentioned social media. Moreover, interactions and sharing opportunities within the Alumni community are fostered by these communication media, as their users continuously post comments, pictures, articles, opinions and professional opportunities.
A brief review of the main recent activities organized by the Association is presented in the following paragraphs.

DISRUPTING ENERGY | Conference on energy business and innovation

On February 7th, 2015 the latest ASP Alumni conference took place at Politecnico di Milano. ASP Alumni hosted a panel discussion about the current situation of the energy market and the paradigm shift that renewables, energy efficiency and innovative technologies or new sources may cause in the next years. The guests – Loris Tealdi (Society of Petroleum Engineers, Italy), Francesco Profumo (Iren Group, Italy), Carlo Zorzoli (ENEL Green Power Spa, Italy), Luca Dal Fabbro (Domotecnica Spa, Italy), Alessandro Ortis (Economic and Social Committee of the Assembly of the Mediterranean) - analyzed the energy business from a wide-range point of view, from the technological trends and innovation in the Oil&Gas industry, as well as in the production from renewable and alternative energy sources, the advances in distribution and energy efficiency and the impact that different policies of Institutions and Companies have on the energy sector.

Disrupting Energy

SPACE HORIZONS | Conference on space exploration and research

Following the leading role of Politecnico di Milano in the Rosetta mission, the involvement of many Italian astronauts in international space expeditions, and the challenges that are currently driving space research and business, in occasion of the 8th edition of ASP Alumni traditional Fall Event, four high level guests were asked for a contribution to describe the current situation of space exploration and research, and to discuss its development horizons. Franco Bernelli (Politecnico di Milano, Italy), Luca Rossettini (founder of D-Orbit, Italy), Luisa Innocenti (ESA, Head of Clean Space project) and Paolo Nespoli (ESA Astronaut) drew an overview of hot topics in the space exploration field, including academic research and technological innovation, international projects on environmentally sustainabile missions, entrepreneurship related to the challenge of space debris, astronauts' preparation for a space mission, and Italian and international future perspectives, challenges and goals towards the field of space exploration and research.

Space Horizons

Sliding Session 2015 | Winter leisure event

Born in 2012 as a collaboration between students and Alumni, the fourth edition of ASP Alumni Sliding Session took place in March 2015, with a growing success among ASP Alumni members and ASP students. The event took place in Clavière, renowned alpine resort close to the French border and to the equally renowned ski area of Montgenèvre, hosting over 50 Alumni and students for a weekend and engaging them with a number of different activities including alpine skiing and relaxing hours at the thermal baths of Grands Bains du Monêtier. Accommodation for all participants was arranged in a chalet exclusively dedicated to ASP Alumni.

Sliding Session

Carton Rapid Race 2015 | Summer leisure event

As 2015 Summer Event, based on the success of the previous year, ASP Alumni joined for the second time the famous Carton Rapid Race in Cesana Torinese. The event, usually followed by more than 15000 people, engaged the participants in a crazy rafting race, for which all registered teams had to build their own boat only using some self-retrieved paperboard. All participants enjoyed a sunny weekend in the camping settled by ASP Alumni on the Dora River.

Carton Rapid Race

ASP Alumni Mentoring | Building the cooperation bridge

60 Mentors, 60 Mentees, the Education Team of our Alumni Association and the desire to create a project of excellence! These were the ingredients of the Mentoring Project launched by ASP Alumni in December 2012 and that is up and running for its fourth edition. Moreover, the Education Team is currently working at the fifth one. The aim is to build the cooperation bridge between ASP Alumni and Students to help them enter the job market, because talented students deserve promising opportunities.

The Project has started with two simple questions: “Have you completed your time at university without any idea of what comes next? Is it worth getting support from the network of ASP Alumni in the steps towards the first job?” After experiencing these needs as students some years ago, the ASP Alumni Association has decided to take care of current ASP Students. The key players are the Mentors, Alumni with several years of working experience in all areas, such as research, marketing, finance, consulting, design, etc. together with the Mentees, selected ASP Students. Mentors and Mentees are paired according to their background and the professional preferences stated by each Mentee.

The enrollment for the Project starts every year in the first ASP Summer School. After that, Mentees are entitled to a minimum of five meetings with their Mentor, both face-to-face or by videoconference, to address topics such as the choice of the sector or geographical area, how to write a CV and a cover letter, how to get ready for a job interview and much more. From the second meeting onwards the Mentee is able to meet additional Mentors who can offer experience in other job fields.

The Network of Mentors is truly global; widespread in five continents, they can give a live perspective about their own function, business segment and country. Along the way, the Education Team helps Mentors by means of a guideline, to be used as a reference in their encounters with the Mentees. Moreover, the Team created a Linked-in group to put together all the Mentors, so that they can help each other with some Mentee’s tough questions or special needs. All participants are enrolled in the project only after signing an Ethical Code. The Code seeks to ensure that Mentors will honor their commitment and provide the service free of charge, as a token of gratitude, with the idea that Mentors give back something they had received.

ASP Alumni Meets - Education

Coming Soon

The Open Innovation Way | 5 March 2016
Sliding Session 2016 | 19-20 March 2016 | Clavière
Carton Rapid Race 2016 | July 2016 | Cesana Torinese
Fall Event 2016 | October 2016

ASP Alumni in Internet

Website **www.aspalumni.com**
Mail **alumni@asp-poli.it**
Twitter **@AlumniASP**
LinkedIn **www.linkedin.com/groups/Alta-Scuola-Politecnica-4297244**
Facebook group **www.facebook.com/groups/AlumniASP/**
Facebook page **www.facebook.com/AlumniASP/**

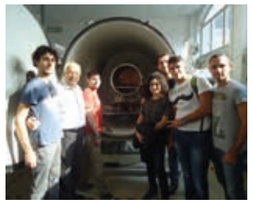
HyperSMS

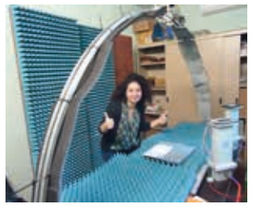
GOING HYPERSONIC: Spaceplane Multifunctional Structures

Project

HyperSMS

GOING HYPERSONIC: Spaceplane Multifunctional Structures





Principal Academic Tutor

Emma Angelini
Technology and Applied Science Department, Politecnico di Torino

Academic Tutors

Domenic D'ambrosio
Mechanical and Aerospace Engineering Department, Politecnico di Torino
Sabrina Grassini
Technology and Applied Science Department, Politecnico di Torino
Mario Marchetti
Aerospace Department, Università La Sapienza, SASLab
Marco Parvis
Telecommunication and Electronic Departement, Politecnico di Torino

External Institution

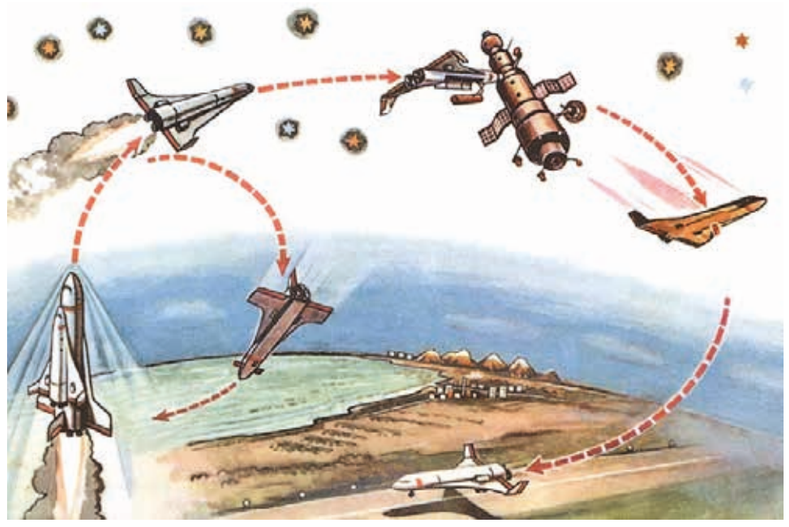
Agenzia spaziale italiana
ENEA

Team members

Chiara Corrà
Nuclear Engineering, Politecnico di Milano [Team Controller and Communication Coordinator]
Alessandro D'Ettorre
Materials Engineering, Politecnico di Milano
Paolo D'incalci
Aerospace Engineering, Politecnico di Torino
Edoardo Martino
Materials Engineering, Politecnico di Milano
Angela Giulia Ruberto
Telecommunications Engineering, Politecnico di Milano
Paolo Francesco Scaramuzzino
Aeronautical Engineering, Politecnico di Milano

Project description

The space industry plays a central role in our modern society, which would be unrecognizable without satellites. Meteorological forecast, Global Positioning System (GPS), Satellites communications and Earth observation are some of the most relevant activities related to space. Space will gain even more importance in the future, with a major number of satellites, which could be necessary for realize satellite internet, ultrabroad band communications or agriculture monitoring to improve crop yields. Manned activities are also emblematic of this field: fundamental research activities are now performed by astronauts onboard the International Space Station, feeding our hunger for knowledge and innate willingness to explore.
Sending astronauts and satellites into space requires considerable effort, accurate planning and resources. Space is a complex environment being demanding for all the components and structures of the spacecraft due to vacuum, extreme temperature change and ionizing radiations. The high cost and socio-economical impact of each satellite requires high reliability of every system, increasing overall expenses, because reparations and immediate substitution are not possible. What makes space activity so expensive and difficult is the fact that, due to technological limit, every space vehicle can be used only once becoming unusable at the end of its mission.
In the evolution of space research, and space systems design, it becomes clear that reusability is the fundamental approach able to revolutionize this field. Even though the objective is clear, its technological actuation is still not fully achievable. The stumbling block is the mission phase called re-entry, when the space vehicle impact with the Planetary atmosphere at enormous speed (up to 23'000 km/h) defined hypersonic velocity. In these conditions, the friction with air is so intense that the produced heat can vaporize materials and ionize the surrounding air, producing a plasma, which hinder any telecommunication.
The HyperSMS project is focused on the identification of innovative solutions able to sustain the re-entry phase in order to permit space systems reusability. This has been achieved through an integrated study of all the scientific/technological fields involved in this complex scenario: aerospace, telecommunications and materials science.



Schematic story of the taking off, the separation of the two stages and the safe landing.

Tasks and skills

Chiara Corrà: (Nuclear Engineering, Politecnico di Milano) [Team Controller] Involved in the investigation of re-entry plasma physics and study of mitigation methods to ensure telecommunications.
Alessandro D'Ettorre: (Materials Engineering and Nanotechnology, Politecnico di Milano) Responsible for bibliographic research, and combined knowledge management.
Paolo D'Incalci: (Aerospace Engineering, Politecnico di Torino) Identification of technological requirements during re-entry phase.
Edoardo Martino: (Materials Engineering and Nanotechnology, Politecnico di Milano) Coordination of bibliographic research and solutions identifi-

cation. Responsible for the Advanced Composite design proposal

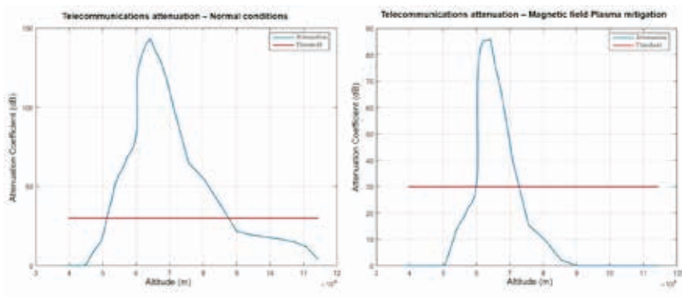
Angela Giulia Ruberto: (Telecommunication Engineering, Politecnico di Milano) Investigation of the telecommunication methods for space vehicles, involved in the computational analysis of the plasma mitigation system

Paolo Francesco Scaramuzzino: (Aerospace Engineering, Politecnico di Milano) Responsible for the development of the code for the computational analysis, combining Multiphysics necessary for trajectory, aerothermodynamics, telecommunications and materials analysis

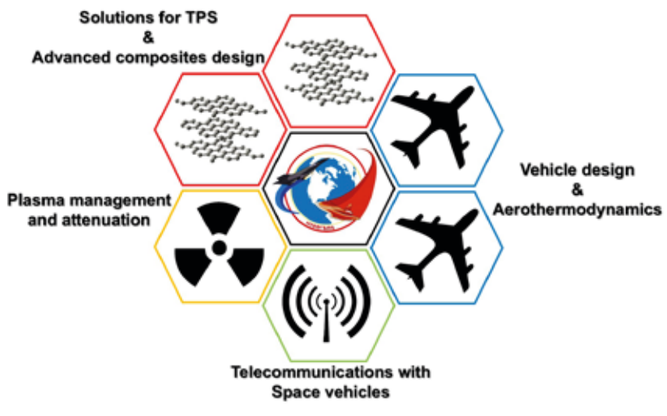
Abstract

The HyperSMS project is devoted to the identification of a solution for achieving reusability of space vehicles and thus increasing space access capability. What really is the obstacle for the realization of a truly reusable space vehicle is the flight phase called re-entry, when the space vehicle impacts with the Planetary atmosphere at hypersonic velocity. In these conditions, the friction with air is so intense that the produced heat can vaporize materials and ionize the surrounding air, producing a plasma, which cause the so called telecommunications blackout.

In the present scenario, the vast majority of space vehicles is not designed to sustain atmospheric re-entry, and is completely destroyed during it. Only few specifically designed vehicles, primary used for manned missions, are able to survive at the extreme environment of re-entry but losing any communication for few minutes. The current materials and structures used to shield the vehicle from the high temperature hypersonic gasses are not able to sustain re-entry with negligible degradation, impeding any immediate reuse of the vehicle.



Plots showing the effect of the magnetic field on telecommunications. When it's not applied, the radiofrequency blackout is experienced between 90 and 50 km of altitudes. If the mitigation approach with magnetic field is applied, the duration of the blackout is shortened between 75 and 60 km above the Earth.



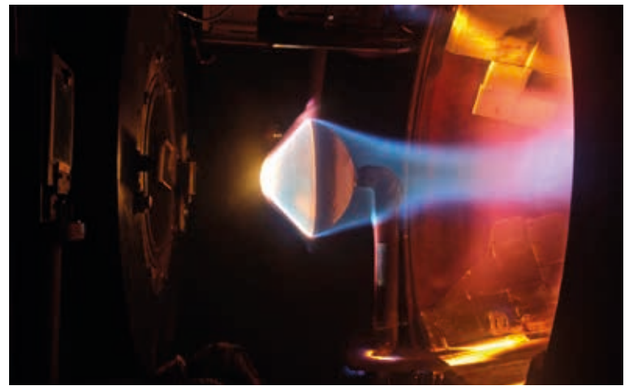
Engineering skills involved in the project and related tasks to be combined for the final solution.

Thanks to the knowledge acquired on re-entry environment and the state of the art regarding space vehicle, materials for extreme temperature and mitigation of plasma effects that induce telecommunications blackout, the team has been able to propose and combine suitable solutions. The full integration of all the technical knowledge associated to the project has been accomplished in the creation of simulation toolbox. The computational instruments determine the vehicle trajectory, heat fluxes and plasma characteristics during the re-entry. From these results the thermal loads to the heat shields and the effectiveness of the plasma mitigation to enhance telecommunications are quantitatively computed.

Understanding the problem

Since the 50's, when the first manmade object reached hypersonic speeds, a new engineering problem, far more complex than that necessary to reach those speeds appeared: aerothermal heating. This enigmatic term state one of the most relevant issue in the aerospace industry, limiting the development of space vehicles, and increasing projects complexity. When a vehicle moves into a gas at hypersonic speed many complex phenomena occur regarding fluid dynamics. This conditions are typically encountered in the re-entry phase of a space vehicle flight, when the object heads back to land and travels through the atmosphere. The most relevant heating effect can be understood in an over simplified manner as produced by the friction with the atmosphere when the vehicle travels at speed of few km per second. The heat generated is so intense that the gas temperature reached in front of the hypersonic vehicle, can be more than 10'000°C. In this conditions the gas atoms become dissociated and ionized, creating a very aggressive environment from the chemical and electromagnetic point of view. Knowledge of this key engineering aspect has been gathered trough intense bibliographic study [1]

Because the objective was to identify solutions that makes the design of a truly reusable space system possible, the interaction of the high temperature hypersonic plasma with materials and telecommunications systems has been analyzed by each team member according to his own background.

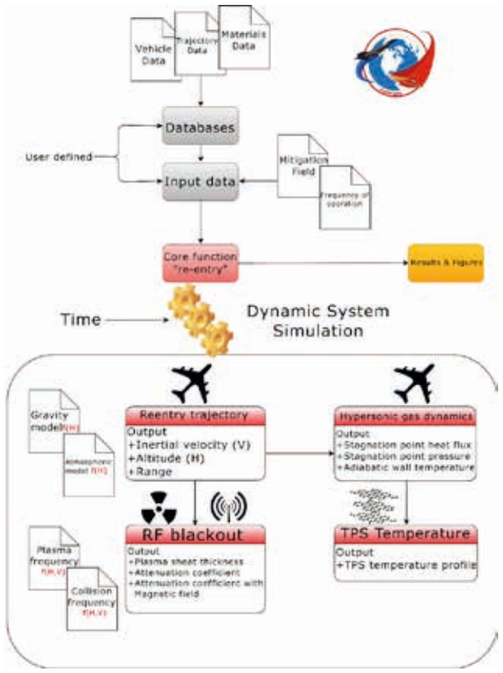


Experimental test in hypersonic plasma jet to verify materials behavior under reentry conditions.

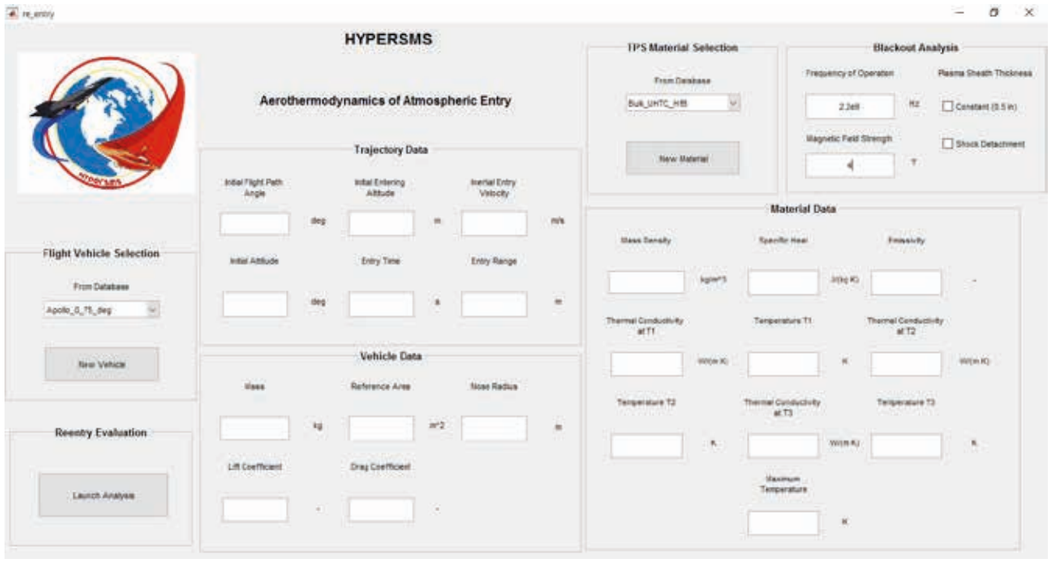
The primary concern of the project regards the materials behavior during re-entry due to extreme high temperature and chemically aggressive environment, in particular regarding atomic oxygen which easily reacts with many known materials. A first screening of all the suitable known materials has been carried out, revealing that only a really small number can sustain the high temperature typical of re-entry, and for all of them chemical reaction with oxygen is unavoidable in the studied conditions. For this reason design of novel materials for heat shields capable of sustaining this conditions with negligible degradation is a challenging task. Moreover, this activity requires an analysis of the production methods, which in the end defines the material performances, asking for further investigations and more intense analysis.

Artistic representation of the reentry of a space capsule, with the friction with air and plasma formation.

The presence of ionized gas, composing the plasma, negatively affects the telecommunications to and from the space vehicle during re-entry. This can produce a complete telecommunications blackout, insulating the vehicle from ground station and control. For a space vehicle, in particular during re-entry phase of manned missions or reusable systems, telecommunications have a fundamental role to guarantee safety and system functioning. The parameters that determine requirements for heat shields materials



Logic scheme of the simulation toolbox developed by the team.



Code interface from which the user can select a vehicle and a material for the TPS, performing the analysis of several parameters during reentry, together with the blackout mitigation.

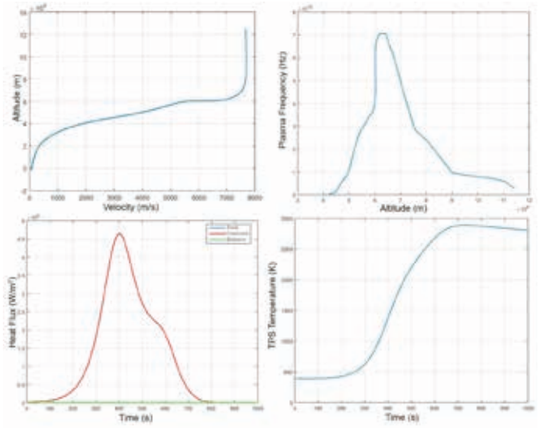
and telecommunications are affected by the space vehicle design and its flight profile. This connection between the different technological problems considerably increases system complexity, making the definition of the final solution a harder task.

Exploring the opportunities

Dealing with atmospheric re-entry of a space vehicle is a tough job, requiring: knowledge, intuition and a hard work. In order to propose a competitive solution in this difficult context the team activity has been divided in subgroups, each one focusing on a specific engineering aspect. The team management and coordination was always of central importance to ensure effective integration of all the concepts proposed by each subgroup into the final solution.
The principal tasks that the team faced to come to a final solution have been:

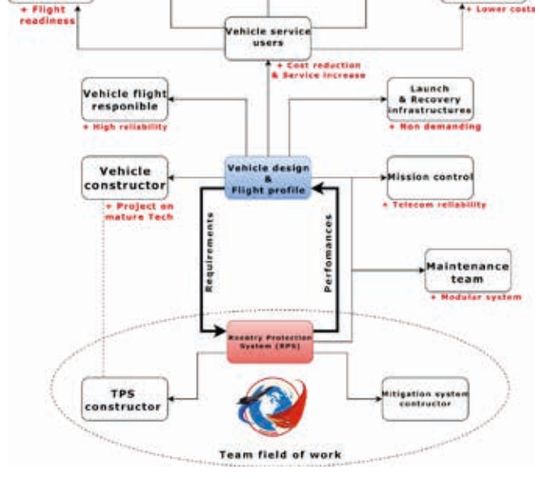
- Evaluate the optimal space vehicle design and its flight profile
- Design the advanced materials for the vehicle heat shields
- Methods to reduced degradation of telecommunications to re-entry plasma
- Acquire the necessary knowledge for the development of a simulation code with which is possible to investigate and evaluate all the proposed concepts.

It is worth to mention once again that all this different aspects are strongly related to each other, and the solution decided for one task strongly affect all the others.
When evaluating the possible design for space vehicles able to sustain re-entry, the set of those that have been already realized is pretty small with a few variations. Looking in the scientific literature is instead possible to discover a huge world of proposed and partially tested new vehicles, which have not come to success due to budget constraints or unsolved technical problems. Intense study of all the relevant parameters characterizing each type of space vehicle has been carried out, to better understand and evaluate the enormous design possibilities [2].
Wider and less clearly organized is the state of the art regarding refractory materials and advanced composites that can be suitable for the construction of a reusable heat shield. Considerable amount of scientific paper has been analyzed to gather information regarding the best performing materials in the analyzed conditions and how to produce them.



Plots of some of the outputs from the code. The Velocity, the Plasma Frequency, the Heat Flux and the TPS temperature are represented during the reentry phase conditions.

Production phase is not only fundamental to define costs, but also with respect performances, in particular for the case of complex composite materials. The materials analysis is therefore evolved from a materials selection, to an actual design activity of the final advanced composite.
The electromagnetic interactions between telecommunication wave and the plasma around the vehicle are those responsible for the complete impossibility for communications during re-entry. Using the knowledge regarding plasma physics and telecommunications, the evaluation of few proposed methods has been possible in order to ensure communications during in every part of the flight [3].
The need for special equipment, and the excessive costs made impossible any experimental activity to verify the effectiveness of the proposed concepts. To compensate for this lack, the development of a simulation toolbox has been of central relevance, enabling us to investigate the effects of the relevant parameters regarding: vehicle design, flight profile, materials properties for the heat shield and plasma mitigation method.



Stakeholder diagram. The primary requirements for each stakeholder are reported in red.

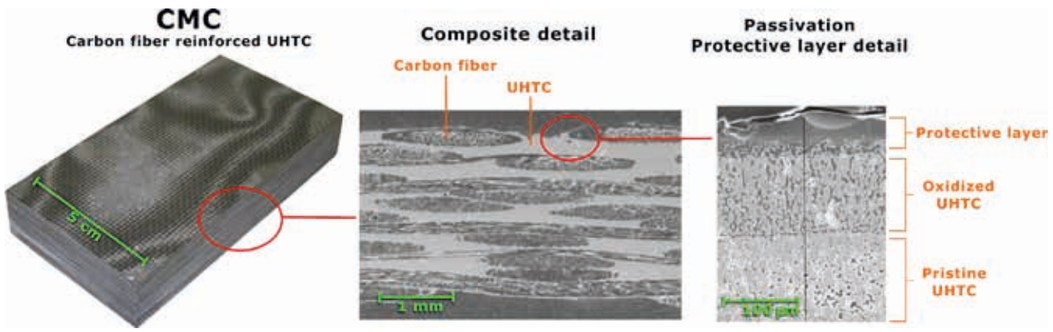
Generating a solution

With the clear goal in mind of propose a concept able to enhance space access capabilities, different partial solutions have been designed for each of the aforementioned team tasks. Once again the solutions integration has been a primary concern of the team, strengthen by the joint development of a simulation toolbox.
Even though space vehicle immediate reusability is a clear goal of space industry since the 60's, no effective solution has ever been obtained. The American Space Shuttle has been the only operative reusable space vehicle, but its intense need of maintenance after every flight, in particular regarding the heat shields, make it not able to reach the goal of reusability. In our solution we tried to analyze all the possible concepts, in order to acquire the sufficient knowledge and experience to propose innovative solutions, without adopting predefined concepts. A leading idea of the group was to evaluate the vehicle design called "flyback booster". This space

Example of the proposed solution for the reentry vehicle.

vehicle has a general design typical of the common space rockets, but it is able to land safely, moreover this design is the one able to better satisfy all the requirements from all the stakeholders. In our opinion, this will be the design of the future space vehicles, and not that of winged vehicle, that look like an airplane, as the Space Shuttle was.

To design a new materials which is capable to sustain the re-entry high temperatures was the primary challenge. The proposed advanced composite material is able to create by itself a protective layer that prevent intense degradation by chemical reaction with the dissociated gas at high temperature. In this way the material have something similar to a “self healing” capability, because when unavoidable removal of the protective layer happens, immediate formation of a new layer occurs. This behavior, called passivation, has never been truly applied on components designed to work at temperature higher than 1500°C. To obtain desired performance, a synthesis procedure based on the use of nanomaterials has also been proposed.



Proposed material design for the heat shields. Picture of different scale, showing composite structure and protective layer produced by the material when exposed to high temperatures.

To ensure telecommunication during re-entry, we decided to investigate at the same time different possible approaches, all capable to change the plasma nature and open a window in front of the antennas. Particular interest has been addressed to system based on the use of magnets and electrodes, capable of strongly interact with the plasma.

The simulation tool proposed and developed by the team was the creative work produced in this project. The capability of analyzing at the same time all the relevant parameters regarding the vehicle, the materials and telecommunications has never been reported elsewhere in the literature. To cope with the high complexity, and create a code that can work on limited computational power, some assumptions and simplifications have been performed. Even though the obtained results are sufficient to have a rough evaluation of all the proposed partial solutions.

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- (1) Anderson, J. D. (2000). Hypersonic and high temperature gas dynamics. AIAA.
- (2) Kuczera, H., & Sacher, P. W. (2011). Reusable Space Transportation Systems. *Reusable Space Transportation Systems by Heribert Kuczera and Peter W. Sacher. Berlin: Springer, 2011. UK: Praxis Publishing, 2011. ISBN: 978-3-540-89180-2*, *1*.
- (3) Starkey, R. P., Santos, W., Hoult, D., & Lewis, M. J. (2003). Plasma Field Telemetry for Hypersonic Flight. MARYLAND UNIV COLLEGE PARK DEPT OF AEROSPACE ENGINEERING.

MEM-BRAIN

MEMristor synapses
for BRAIN computing

Project

2

MEM-BRAIN

MEMristor synapses for BRAIN computing

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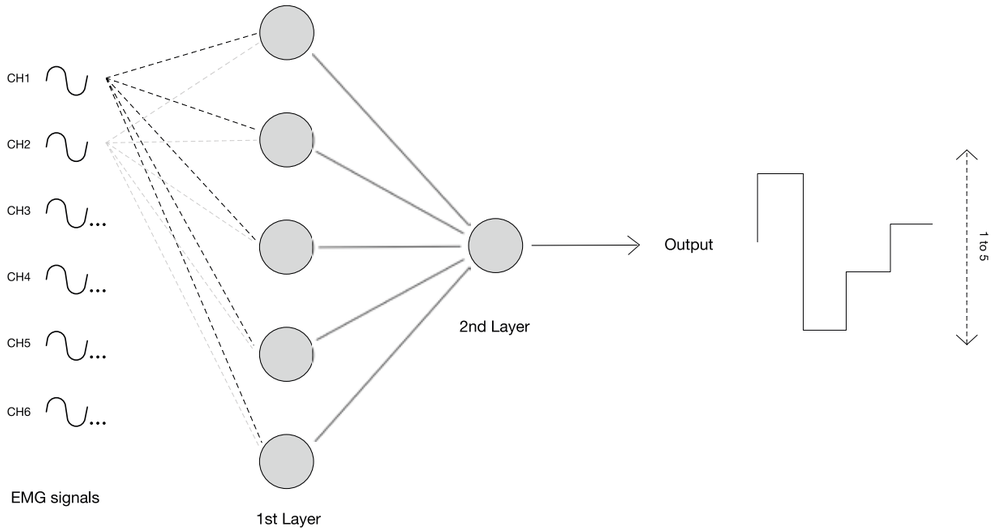
Electronic Engineering, Politecnico di Torino

Tasks and skills
Riccardo Pisoni: (Physical Engineering) implemented the process of memristor production through anodization.
Federico Badini: (Computer Engineering)
Stefano Bodini: (Computer Engineering) and **Alessandro Morelli:** (Automation Engineering) focused on the study of learning algorithms. The performance of state of the art algorithms were replicated through code developed in C, Matlab and Python.
Enzo Tartaglione: (Electronical Engineering) simulated the implementation of a neural network with memristive components in Spice.
Alessandro Costanzo: (Electronical Engineering) joined Enzo Tartaglione and analyzed the economical feasibility of the project.
Mario Lavanga: (Biomedical Engineering) and **Luca Della Vedova** (Biomedical Engineering) developed a virtual instrumentation prototype (using the BITalino board) to acquire and analyze EMG data.

Abstract
In the context of this project, we applied the principles of neuromorphic computing to the classification of EMG signals, proposing an innovative approach to prostheses control.
Although the market already provides high-tech solutions in fact, the process of adapting industry-standard prostheses to patients is nowadays complex and lengthy. For some aspects, it can be said that it is the patient the one demanded to learn how to use the prosthesis in an appropriate manner, rather than simply having a prosthesis capable of responding naturally to the patient.
In this context, our solution tries to shift the paradigm: exploiting the learning capabilities of a neural network, we propose an adaptive prosthesis control, capable of responding to the patient after a preliminary training phase lasting only 15 minutes.
In this summary, we briefly review the process we followed during the design of the solution, describing our work in relation to both the growing interest in neuromorphic computing and the requirements we received from partner institutions. Moving from a study of state of the art approaches to neural networks, we studied the efficiency and the feasibility of implementations using memristors as circuital components. We also proposed a new process of memristor production using inorganic (TiO2) and nanocomposite polymer matrix-based materials.
Our research on the topic of memristors production has been published and presented at the Nanotech World Techconnect conference in the cities of Washington D.C. and Birmingham. As far as the research on neuromorphic computing and learning algorithms is concerned, our work has been presented at Nonlinear Dynamics in Computational Neuroscience: from Physics and Biology to ICT conference in Turin, and we also succeeded in the implementation of a working prototype of the proposed solution.

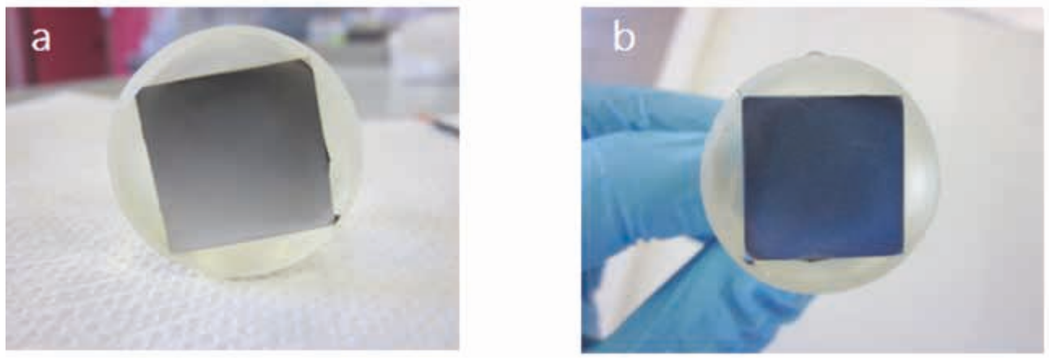
Testing of the prototype

Understanding the problem
One of the most fascinating areas of research is the strive for designing a neuromorphic or brain-simulating system, where specialized algorithms run on a brain-inspired microprocessor may replicate the dynamical behavior of the vast network of synapse-coupled neurons.



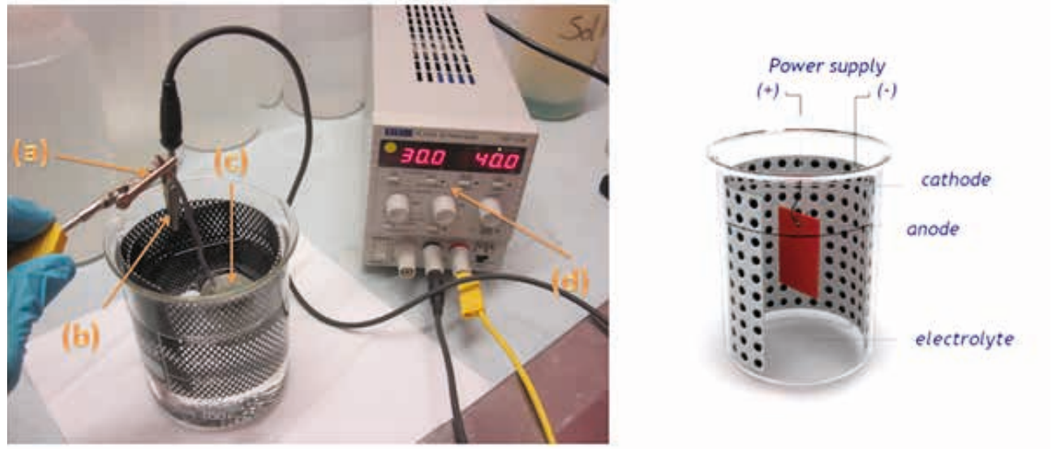
Logical scheme of a neural network

Current digital supercomputers are able to reproduce some of the brain functionalities, but, as more and more intelligent operations are emulated, the consequent increases in power consumption and integrated circuit area are somewhat unacceptable. These increases are due to the inefficient classical Von-Neumann architecture, which is at the basis of the machine design and is characterized by a rigid adherence to Boolean logic and, above all, by the separation between the physical location where data are stored, i.e. the memory, and the physical location where data processing takes place, i.e. the Computing Power Unit (CPU).

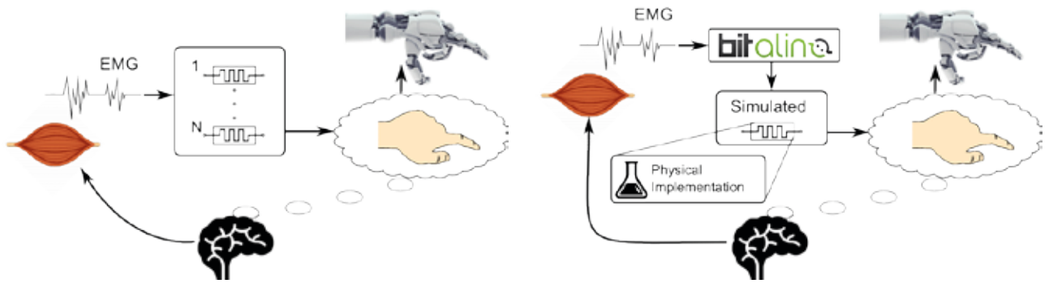


Sample of the producted memristor

In addition to that, complex integration of information performed by biological neural systems is based on several dynamical mechanisms. Despite remarkable progress has been made in the field of Neurophysiology and Nonlinear Dynamics needed to understand neural structures and interactions, current brain-simulating systems require high-computational capabilities to reproduce only a few brain functionalities.
Completely new neuromorphic computing systems, to bridge the main divide between biological brain-computation and current brain-simulating computation, require the combination of efficient synapse circuitry (efficient in terms of power consumption and size) with conventional neural networks, i.e. arrays of a large amount of interconnected units performing nonlinear transformations in parallel.
The neural computation is not only distributed among different elements that work in parallel, but it presents the property of emergence. This type of networking between nodes could enable processing abilities that are not present in the single neuron and could perform better than any other standard computer CPUs, in particular if the pattern recognition is considered as task.
Istituto Italiano di Tecnologia (IIT), which was founded in 2003 to promote Italy's technological development and advanced education, fosters the spread and implementation of neuromorphic solutions.Most of the project work was carried out in joint collaboration with the Center for Space Human Robotics (CSHR), a branch of IIT located in Turin, that is interested in a deeper understanding of advanced devices, like memristors networks, and how to integrate them in electronic systems architectures, based on engineering problems, mainly related to robotics. Furthermore, it deals with human-machine interfaces, exploiting the EMG signal with different measurement methods with a variety of applications in the fields of prosthetics, neuro-muscular rehabilitation and fitness.



Setup of the anodization



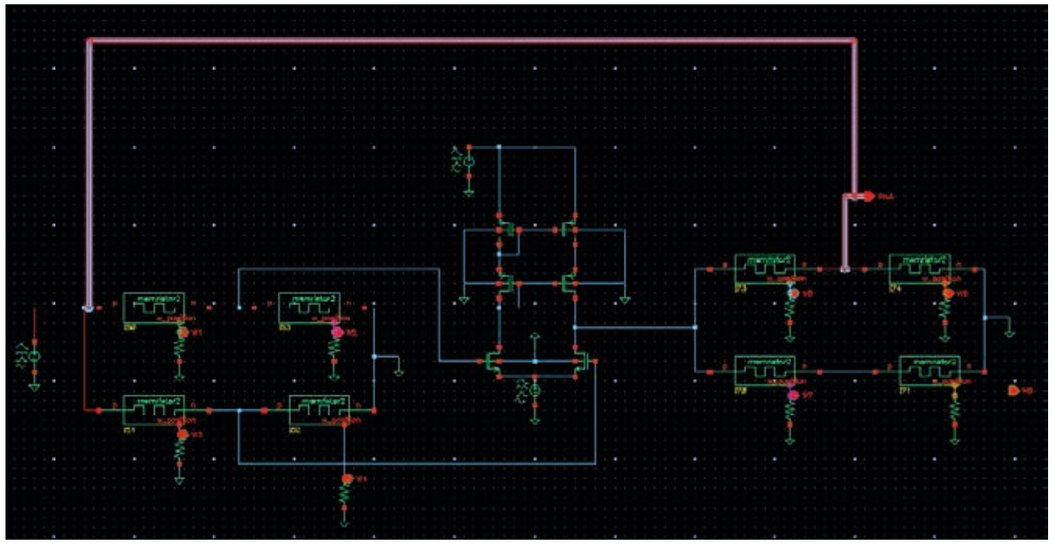
On this perspective, IIT outlined the main features of the project with ASP members, requiring the development of a device which involves memristors in a real-life application with EMG signal.

Ideal scheme of the project

Scheme of the implemented prototype

Generating a solution

After a long discussion between IIT and the project main tutor, professor Corinto, before the start of the ASP project and among IIT and project students then, Mem-brain group defined the following objectives.



Simulation of a circuit with memrisive components in Cadence

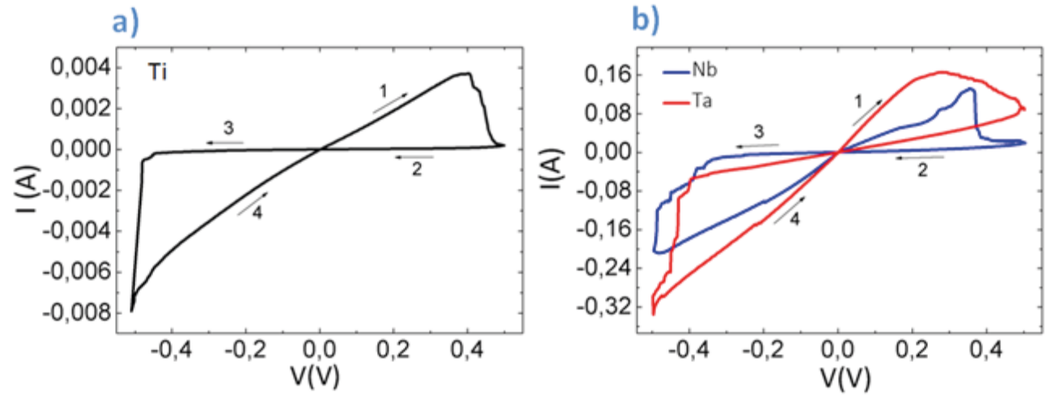
First of all, we were asked to investigate and formalize the process of memristor fabrication, using inorganic (TiO2) and nanocomposite polymer matrix-based materials with a new production process. The features of a memristive device have been studied in detail, aiming at defining the specifications of an innovative process of memristor production. We succeed in developing anodic oxidation processes aimed at producing oxides with memristive behavior on valve metals (in our case: Ti, Ta and Nb). Thanks to the employment of the electrochemical anodization process, those resistive devices are approaching the realistic levels for mass production [2] . After that, we were required to study the characterization of memristors and the design of a small platform exploiting memristors arrays, at least on a computer simulation.

At last, IIT asked for the prototyping of a real life application using EMG signal. More in detail, IIT was interested in a future application for prosthetic engineering, implementing a bio-inspired algorithm that can be run on neuromorphic circuits. Due to the limited time horizon of the project, the actual implementation of a circuit based on memristive components was not a requirement.

In order to fulfill the last requirement, we proposed the implementation of a chip capable of processing muscular signals to recognize hand gestures and pilot a robotic hand prosthesis. For the purposes of prototyping, three main issues had to be addressed.

First of all, we had to define a set of gestures that the patient should visualize, memorize or imagine to generate a well-precise EMG patterns. Secondly, we had to build a device capable of measuring the EMG signals generated by the patients, providing the input data to our data classifier. At last, we had to implement on chip a classifier algorithm capable of recognising different EMG patterns, even when performed by different patients. Different algorithms based on the neural network paradigm were compared, in order to find the one that best suited our needs.

In order to reduce the complexity of the prototyping, a microcontroller will be chosen as interface to the EMG sensors, allowing to abstract from the issues implied by an implementation in hardware. This solution will leave to future developments the implementation of a circuit based on memristors [1], while still satisfying the specific requirements of the project in terms of research and deliverables. A low-cost programmable board was exploited



Comparison between literature and our memristor production process

to implement system according to the virtual instrumentation paradigma. According to what discussed above, we implemented a chip to recognize hand gestures using EMG as a future piloting system for robotic prosthesis, basing on the paper written by Riilo et al. [3].

The decision of implementing a prototype exploiting a Bitalino board as interconnection device between the EMG sensors and a traditional microcontroller was mainly motivated by the requirement of containing the project in a two-year time horizon, presenting a fully functional prototype within the final deadline. In a medium-long term, the implementation of the learning algorithm on a circuit processing EMG signals with physical memristors will lead to smaller and lighter circuits and also to an improved energy efficiency (thus improving the battery life of the final product).

As a future development, the solution proposed for hands prostheses may be extended to other types of prostheses. For instance, the same device developed so far could be used also to control prosthetic arms or legs. In this scenario, the approach described will only need the re-tuning of the classifier parameters in order to fit to the new applications.

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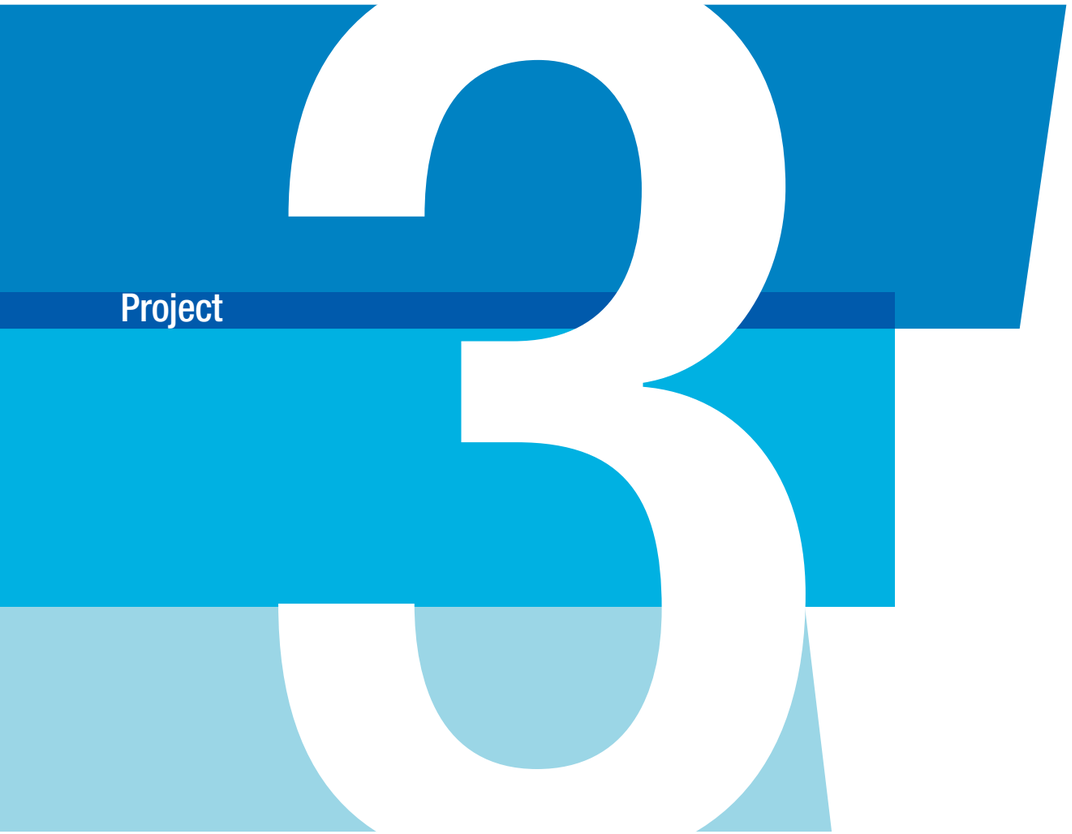
- [2] M.V. Diamanti, R. Pisoni, A. Cologni, F. Corinto, M.P. Pedeferri: *Memristor fabrication and characterization based on TiO2*, Advanced Manufacturing, Electronics and Microsystems, TechConnect Briefs 2015, Chapter 6, pp. 196-199, 2015.
- [3] F. Riillo, L.R. Quitadamo, F. Cavrini, E. Gruppioni, C.A. Pinto, N. Cosimo Pasto, L. Sbernini, L. Albero, and G. Saggio. Optimization of EMG-based hand gesture recognition: *Supervised vs. unsupervised data preprocessing on healthy subjects and transradial amputees*. Biomedical Signal Processing and Control, 2014.

ESTIA

Collaborative platform for
emergencies in aree sparse

Project



E S T I A

collaborative platform for emergencies in *aree sparse* ////////////

E S T I A
collaborative platform for emergencies in *aree sparse* ////////////////

ESTIA

Collaborative platform for emergencies in aree sparse

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Project description
The ESTIA project is an innovative product-service solution for earthquake-related housing emergency in '*aree sparse',* meaning all those areas far from the main urban centres, where housing emergencies cannot be tackled through standard procedures (i.e. large makeshift camps). The groundwork of the project was the collaboration with two external partners: **AcellTec Ltd** and ***Protezione Civile Regione Lombardia***. AcellTec is a firm producing a patented, special material, the **Acell foam**. The firm wishes to exploit its innovative material's properties in the field of emergency and temporary housing. *Protezione Civile Regione Lombardia* is a regional branch of the *Servizio Nazionale di Protezione Civile*. They have drawn the team's attention on the existing design gaps in the current 'aree sparse' management and on other issues within the *Protezione Civile* system.
The collaboration the stakeholders and the academic tutors, allowed to the team to identify the following research questions:

- Is it possible to use the ACELL foam to produce emergency housing solutions?
- Is it possible to design a housing solution that takes into account the psychological wellness of displaced people in *aree sparse*?
- How can web 2.0 technologies be exploited to increase the knowledge and the intervention effectiveness in emergencies?

To answer these questions, the team has explored the Italian emergency scenario through interviews to evacuees, market analysis and desk researches. The outcome was a product-service system that includes a web platform and a housing unit. These two parts reciprocally informed each other to reach a final, **coherent solution**. The web platform is a collaborative tool that facilitates interactions between *Protezione Civile* and problem solvers around design gaps. '*Aree sparse'* are its current focus. Yet, the platform's structure can accommodate other sections for future design unknowns. In this way the platform can become a vector of constant adaptation to change for *Protezione Civile*. The **housing unit** is a foldable shelter, easily stockable and transportable with *Protezione Civile* means. The house answers the needs of '*aree sparse'* in a tailored way. Alongside with the housing unit, the team has devised a distribution and use scheme, that integrates many bureaucratic and logistics aspects. The housing unit is the first outcome of the ESTIA platform, through an offline interaction between the ESTIA team and *Protezione Civile*.

ESTIA team before the final presentation

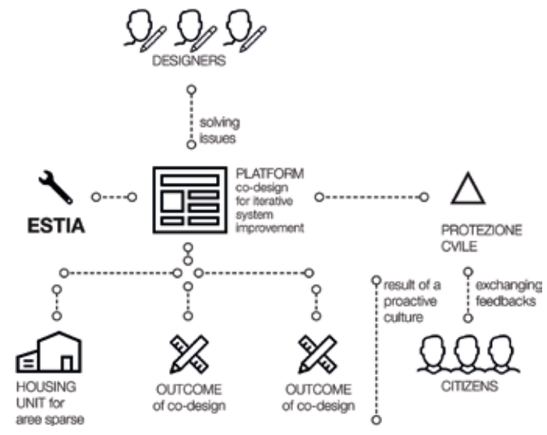
ESTIA team after the final presentation

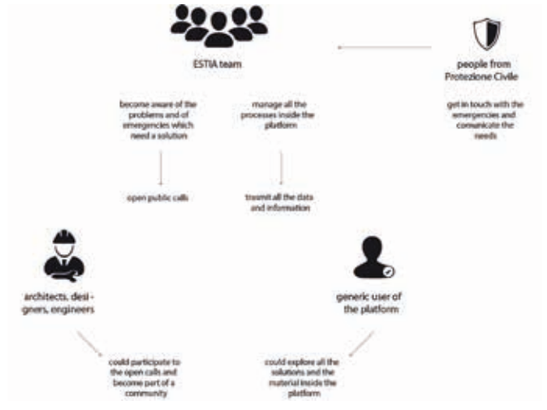
Tasks and skills
Geroldi Alberto: housing unit design and research, graphics, system concept development, problem framing.
Libera Francesco Angelo: economical and technical assessment of the housing unit, strategic design, market analysis, system concept development, problem framing.

Mantovan Mirko: housing unit design and meta-project, graphics, system concept development, problem framing.
Riccioni Eleonora: interviews to displaced people, graphics, system concept development, problem framing.
Santucci Eleonora: platform design and research, graphics, system concept development, problem framing.
Silenzi Anna: housing unit design and research, graphics, system concept development, problem framing.
Zampella Claudia: platform design and research, research on emergencies, graphics, system concept development, problem framing.

Understanding the problem

ESTIA's project brief was the result of the combination of different stakeholders' interests. In particular, AcellTec ltd wanted to explore the possibility to effectively exploit its patented material to the emergency context. The *Protezione Civile* was interested in innovative earthquake emergency solutions, which take into account the psychophysics wellness of displaced people. The Academic Tutor wanted also to exploit web 2.0 technologies in the emergency context.
To combine these three briefs in an organic project, the team carried out two kinds of analyses. In a first phase, a research over the state of the art of earthquake housing solutions was made, in order to have a clear idea about the as-is process of intervention and the main housing solutions adopted. In a second phase, direct interviews with *Protezione Civile Lombardia* and displaced people were carried out. This phase allowed an understanding the main area of improvement to be covered and the main psychophysical needs of displaced people. During this phase, '*aree sparse'* were identified as the main problem to be tackled. Simultaneously, a research over the web platform was conducted, in order to have sources of inspirations for the platform design.
At the end of this phase, the project was thus well framed and its goal defined: to exploit the Acell foam and the web 2.0 solution potentials to realize an efficient and effective housing solution for '*aree sparse'*.
The advantages of the solutions are twofold: it is specifically tailored to effectively solve an emerging problem. It also enables a **proactive** approach by directly involving experts in the design of solutions for unanswered problems. Both aspects enlarge and strengthen the *Protezione Civile* system on the long run, reducing vertical distance and allowing for adaptation to constant change.





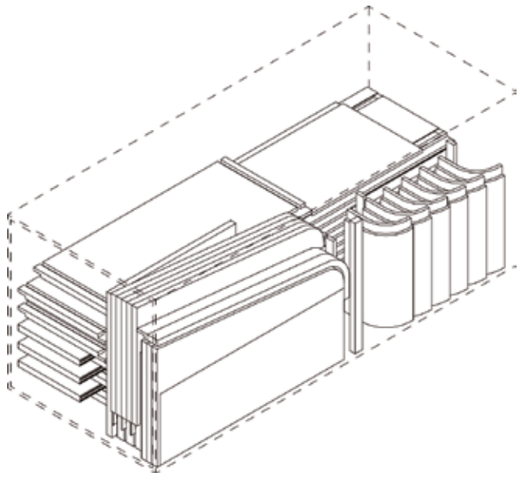
ESTIA system concept.

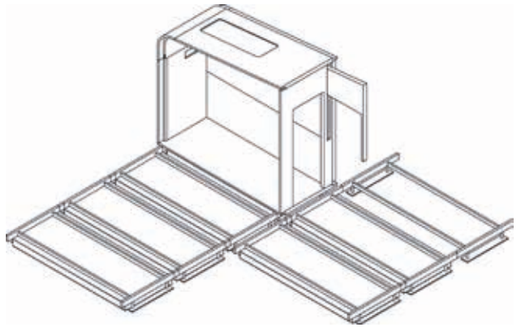
ESTIA platform. Functioning scheme.

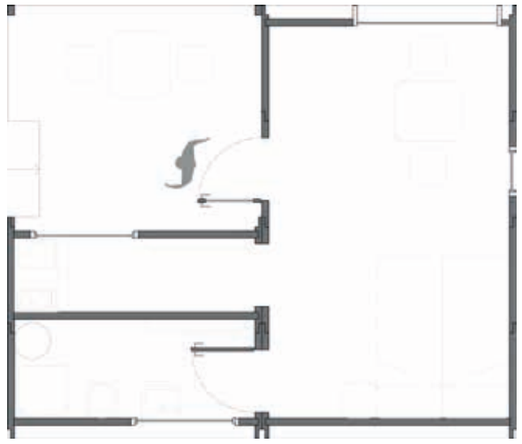
Exploring the opportunities

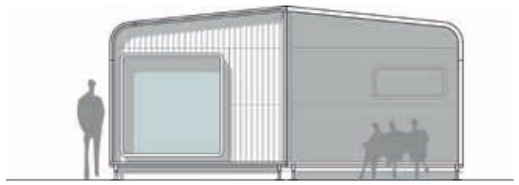
The analysis of the state of the art of emergency pinpointed that typically the emergency intervention consists of two main phases: the immediate phase and the long term one.
The immediate response is characterized by the setting up of a makeshift tent. During the immediate emergency, the speed is a fundamental factor that drives the effectiveness of the intervention. Therefore, since they are fast to be mounted, the tents are used during this phase. However, they generally have spaces with low quality living standards. Instead, the long-term phase is characterized by the use of housing modules (MAP), which are generally slower to mount due to the urbanization works they need. The housing modules grant higher living comforts than the tents.
However, this two-phased model of intervention is unfeasible for the '*aree sparse'*. Indeed, these areas are difficult to reach; trying to reach them two times with two diversified interventions would be too costly for the Civil Protection. Moreover, the housing modules are typically designed to be built in a context where more than one family resides.
Therefore, the opportunity that the present project wanted to exploit was the possibility to overcome the model of the two-phased intervention by creating an '*aree sparse'*-tailored solution that grants both rapid assembly and psychophysical wellness. In particular, in order to understand which are the drivers of living wellness, many interviews were carried out. The following results were obtained:

- Privacy is an important element. In particular, a private bathroom is a fundamental prerequisite for a solution wishing to grant good living quality
- The luminosity of the housing unit is a factor that highly increases the psychological wellness









Housing Unit for two people stocked.

One of the Housing Unit assembled phases.

Housing Unit - Floor plan.

Housing Unit - Front Elevetion.

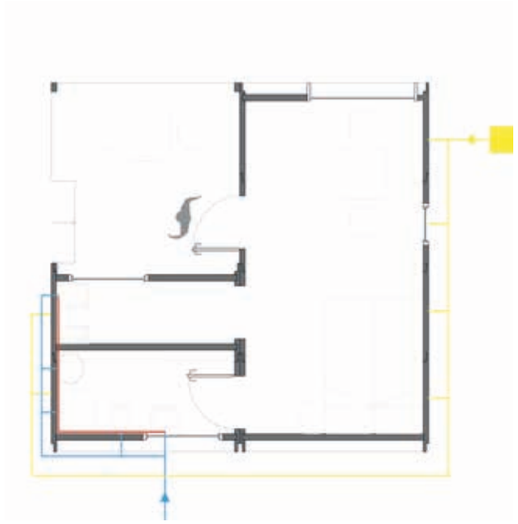
Housing Unit - Right Elevetion.

- Staying close to home reduces the eradication perceptions

The results of the interviews were considered as fundamental inputs to the housing unit design process, since they define some quality parameters to be taken into consideration.

Generating a solution

The proposed solution is a system composed by a **product** and a **service**, two elements that devise a whole **living and design situation** for *aree sparse*. These two coherent parts endeavour to look beyond the framework of '*aree sparse'*, by favouring and putting into practice a 'proactive civil protection culture'. This long-term process involves the institutionalised side of Protezione Civile as well as common citizens and professional designers. Essentially, the system builds upon the ground of a widespread and collective idea of civil protection, still identifying clear roles and duties.



Housing Unit - Fixtures scheme.

ESTIA in context - Productive activities scenario.

ESTIA in context - Agropastoral activities.

The housing unit is a modular, foldable kit that can fit into an ISO 20' box container while stocked. It fits the needs of groups from 2 to 5 people since the first days of housing emergencies. In case of longer emergency periods, it can be expanded into a larger house. In both cases, it guarantees high living standards in terms of services, comfort and space quality. It fosters people and system's proactivity in three ways: by keeping a **strong bond** with the living place, by i**nvolving people** in assembling (a process that takes few hours) and by **exposing** them to a civil protection culture during the pre-service phase. ACELL foam is the main structural material. The panels already incorporate fixtures and ducts to guarantee complete autonomy immediately after assembling. Co-design with *Protezione Civile* guaranteed a good integration of the product within the already established logistics system.

The platform is a tool that facilitates co-design processes between the *Protezione Civile* and professional designers. Through a mutual exchange of knowledge and competences, it aims at creating design knowledge about new or emerging aspects of emergencies. In the short term, it focuses on '*aree sparse'* and their unknowns. In addition to this, since new unknowns about emergencies will emerge in future years, the platform's structure will be scalable, with sections dedicated to other emergency situations. *Protezione Civile* will be able to ask questions about the unknowns through

ESTIA team during a meeting with the Protezione Civile Lombardia.

ESTIA team during a workshop.

ESTIA team during a meeting with the Association ViviamoLaq.

STIA team during a cultural visit.

ESTIA team

competitions, calls for ideas and editable open-source projects. In doing so, the platform allows and embodies the transformation of the *Protezione Civile* system on the long run, by keeping up with the pace of change.

The main innovative elements of the proposed solution are 4:

- The focus on '*aree sparse'*. This project is the first to tackle a problem that is still neglect by designers.
- The design of a housing solution employing an innovative material, the Acell foam. This could push the performance thresholds in the emergency housing field further.
- The implementation of the web 2.0 technologies into the emergency field within the Italian scenario. These tools should simplify, enlarge and open the *Protezione Civile* interaction.
- A cultural innovation, through the fostering of a **proactive and diffused 'civil protection culture'**.

One relevant problem in the future project development could be due to the long time it takes for a public administration to adapt to novelties. Flexibility in terms of the adoption of new solutions is often limited by bureaucratic and legal constraints. In addition to this, the system needs a clear structure and an *a priori* organisation process, in order to be effective. Given the very fragmented Italian territorial situation and the analysis of past examples, these conditions will not be equally guaranteed everywhere. Nonetheless, the ongoing co-design process with various branches of *Protezione Civile* could limit these effects and guarantee effective implementation. So far, the public actors interviewed have deemed the proposed solution interesting and feasible. Further and wider dialogue should strengthen it, tailoring it to the particular territorial contexts.

ORIENTOMA

A wearable orientation system for
blind and visually impaired people

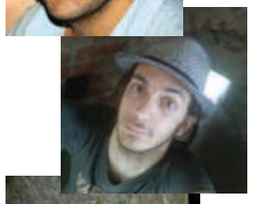
Project

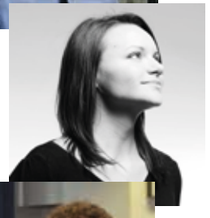
4

ORIENTOMA

A wearable orientation system for blind and visually impaired people





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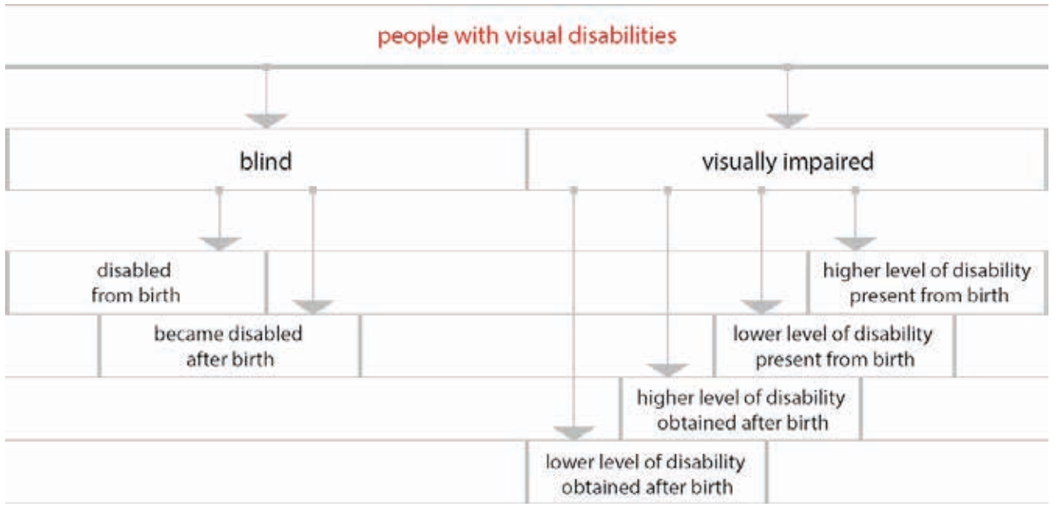
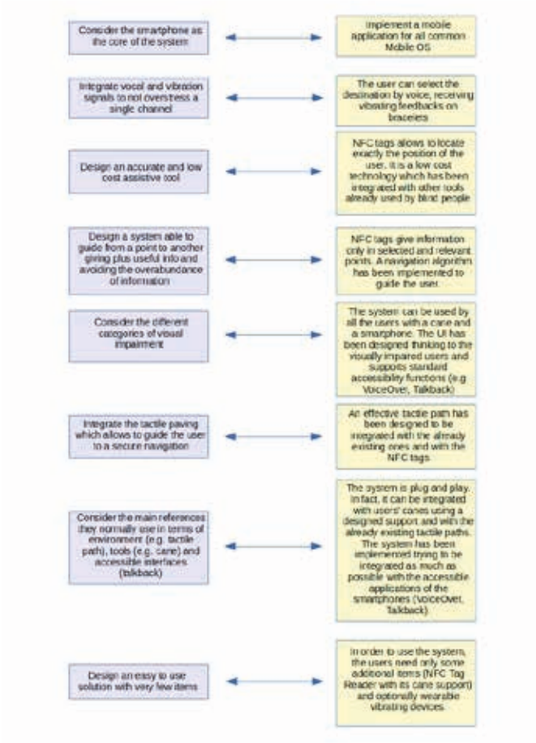
Project description

Globally, about 39 millions of people are totally blind and 246 millions of people experiment visual impairment. By the year 2020, these numbers will double. These people are affected by the inability for autonomous walking and orientation in open environments. Hence, they are not able to perform activities that sighted people can, such as walking alone to the nearest supermarket. Recent advances in technology and better knowledge of human perception permit the design of new assistive interfaces. Anyway, every research on this field should involve a strict and direct contact with associations and people who could benefit from the results of the research itself. Studies on supportive systems have traditionally focused on two main areas: information transmission and mobility assistance. Today, cities are equipped with audible traffic lights and pavements with embossed tracks to allow blind people to perform simple actions (e.g., crossing streets). However, only few cities offer these services which are static and cannot be easily updated or extended. Moreover, acting like this, it is impossible to provide real-time information (e.g., obstacles to avoid) nor person-centered services (e.g., where to go to buy one's favorite ice-cream).



Categories of visual disabilities

In this context takes place the development of ORIENTOMA, a wearable orientation system for blind and visually impaired people. This project stems from the realistic assumption that blind people can afford to buy a cheap smartphone and/or a low-cost wearable device equipped with GPS, Internet and other sensors and able to communicate using audible and/or tactile signals. Main goal is to create a system able to smartly, and safely, drive the person wearing the equipment to a pre-set destination or to points of interest in its surroundings. The system should try to avoid the problem of sensory overload (too many stimuli cannot be processed by the user) and should not interfere with the user's ability to pick up environmental cues. The detection of obstacles can be implemented using miniaturized and low-cost image acquisition devices, and well known navigation tech-



From users' requirements to system specifications

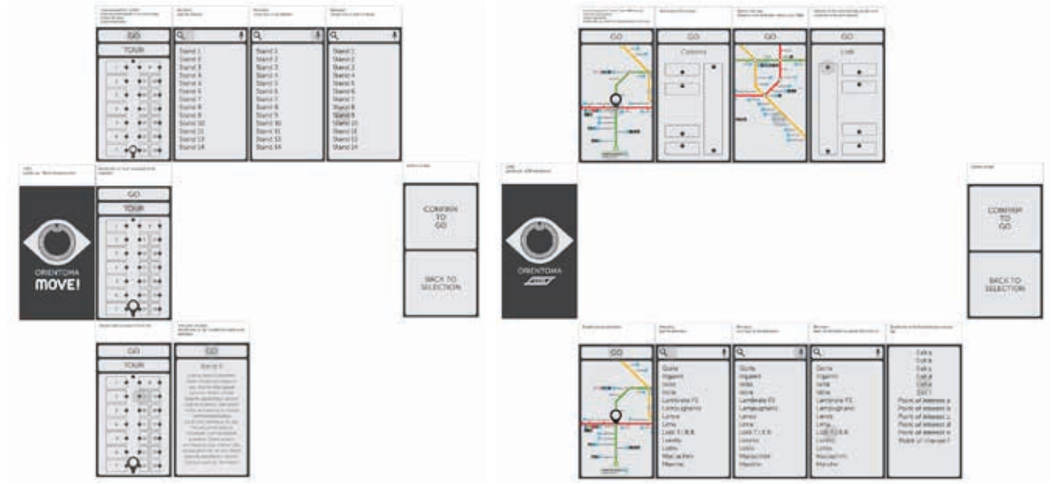
niques; the same devices presently used may send information to the visually impaired person, reducing the total system cost for the end user. It also could be integrated with already existing navigation services (fixed infrastructures or mobile apps), and may also encourage municipalities to install new access points, improving, at a reduced additional cost, the services offered and paving the way to a new kind of tourism targeted to blind users. Anyway up to now the systems developed cannot perfectly respond to the multiple challenges due to the realization of an assistive device for people with visual disabilities. In fact, there exist researchers working to satisfy a single need and most of the complete solutions proposed are not designed to be wearable, resulting uncomfortable.

Tasks and skills

Fabrizio Callari: was the team controller and communication coordinator. His work focused on the analysis of state-of-the-art systems and on the hardware choice, together with the testing phase and the definition of the application scenarios.
Sebastiano Castello: participated to the preliminary selection of the technologies and system hardware. He also took part in the definition of the technical solution, in the development of the software of the smartwatch, in the testing phase.
Filippo Garolla: focused on the specification of the technical aspects of the solution. He was also involved in the design of the App logical architecture and in the development of the solution's software.
Dario Passi: managed the process of gathering and defining the user requirements and application scenarios. He was also involved in the development of hardware components and of the App interface, participating to the system testing.
Milica Pavlović: managed the process of gathering and defining the user requirements. She was involved in the development of hardware components of the system, as well as the system testing with the end user.
Enrico Scopelliti: took part to the technical analysis of the main technologies and components exploited. He also was involved in design, development and testing of the entire sw/hw solution.

Abstract

Visual impairment is a global health issue which impacts the life of about 285 millions of people, interfering with their daily activities and routine. Among the major obstacles faced everyday by blind and visually impaired people, orientation and mobility are of utmost relevance, preventing a fully autonomous life. The design of a wearable user-centered device aimed at helping the blind and visually impaired people orientating and navigating in unknown context is at the center of this work. An intensive interviews phase focused on gathering information about end users' needs, to be then transformed into system functionalities, was carried out together with an accurate analysis on the state of the art systems, whose strengthen and weaknesses were defined. Once this preliminary phase of *problem analysis* has been completed, the team focused on the *concept generation and screening*, defining the most appropriate technologies and the hardware components, capable of ensuring accessibility, usability and low price of the system to be developed. Since the core of the entire system is a common smartphone, the software integration and optimization took place and an application based on an *ad-hoc* navigation algorithm was developed. To facilitate and effectively manage the application development, a variation of the waterfall design methodology was used.
Contemporaneously, the physical development of the necessary hardware supports was carried out, exploiting the 3D printing technology and testing the material produced in order to define and implement the possible improvements. Moreover, to make the system less invasive as possible, the tools already exploited by the blind and visually impaired community were integrated. An extensive usability testing phase with a visually impaired user was then realized in a metro station in Milan, so taking into account a realistic scenario of possible use of our application. The overall result of the testing phase was positive and the feedbacks about the system feasibility were gathered in order to fix the future improvements.

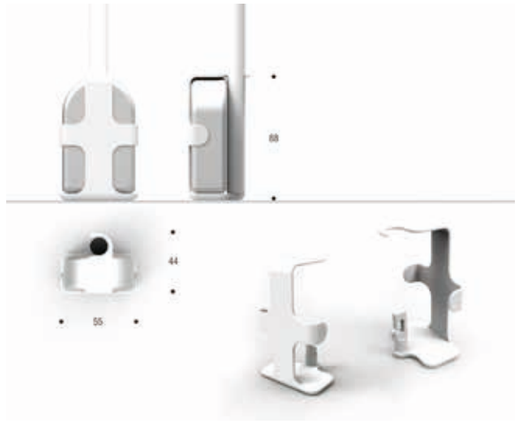


ORIENTOMA App Mockup for temporary events

ORIENTOMA App Mockup for Public Transport

Understanding the problem

The design of a wearable orientation system for blind and visually impaired people is a challenging task which belongs to the complex and wider world of the assistive technologies, aimed at improving the life quality of people with disabilities. While developing the concept, the end user's needs have always been the team main focus. The *direct semi-structured interview* with potential users of the blind and visually impaired community was selected, in a first phase, as the proper tool to collect information and input regarding their needs and to understand how a new device could be accepted. We have interviewed five subjects, targeting them with criteria such as their age, confidence with technology and degree of the visual impairment. At a later stage of the project, another session of interviews with potential users was carried out to figure out blind and visually impaired people feedbacks about the tactile paving assistive tool and to collect other requirements. In addition to the end users, other actors, directly and indirectly involved in the prototype realization, were considered.
Thanks to its social impact, in fact, ORIENTOMA boasts the participation and the interest of several external institutions such as U.I.C.I (Unione Italiana Ciechi e Ipovedenti), the Scuola Superiore Sant'Anna and the C.N.R.



Render of the elastic tag reader holder

Render of the unique rigid body tag reader holder

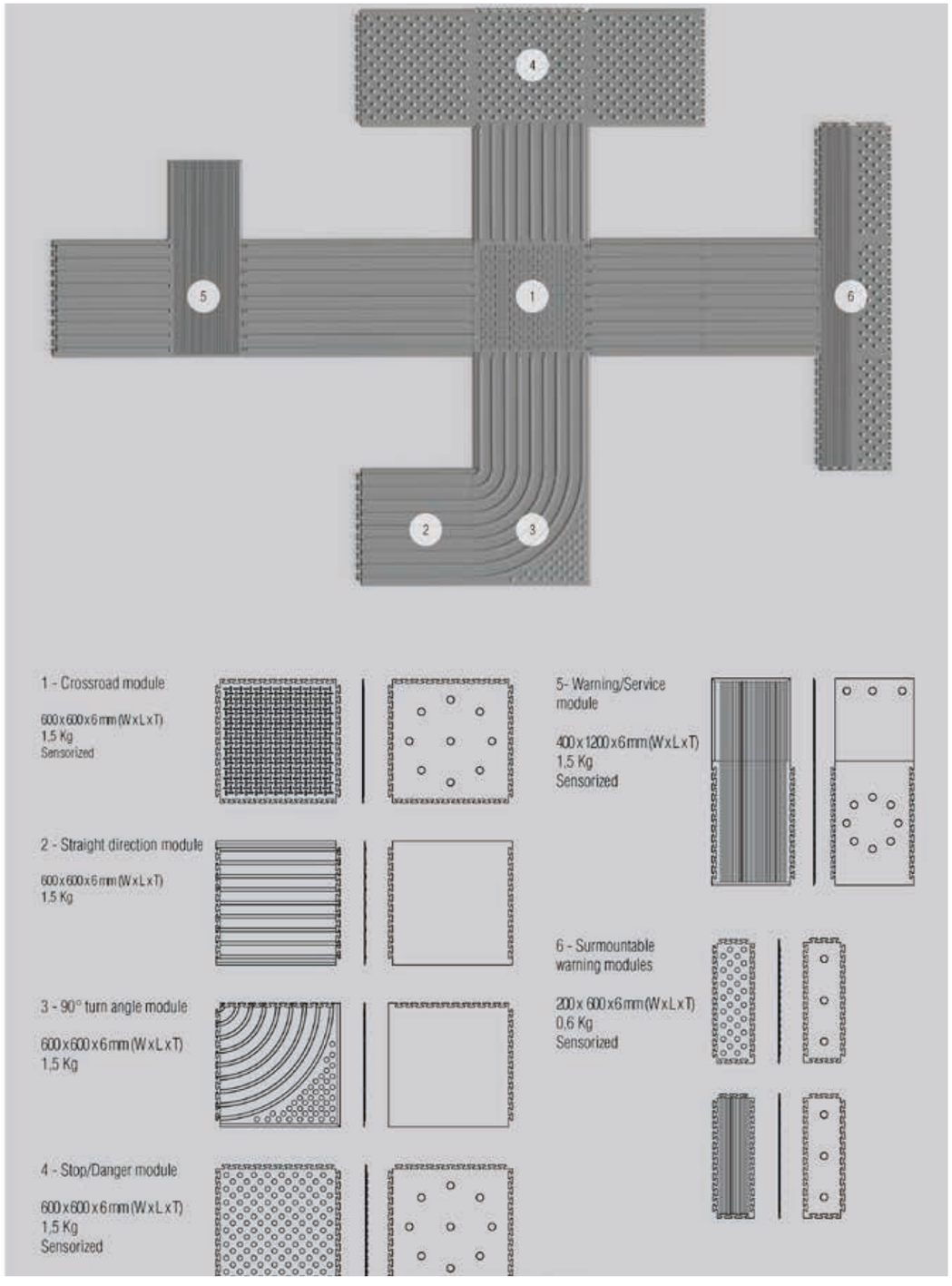
Prototype of the elastic tag reader holder

Prototype of the unique rigid body tag reader holder

(Consiglio Nazionale delle Ricerche) that we had the possibility to meet at U.I.C.I Toscana headquarter. Furthermore, other stakeholders were identified such as possible customs interested in our system to be developed for indoor contexts: museums, temporary events, universities etc. The analysis of the roles and needs of the various actors of the system has led to the definition of the basic requirements of the concept, mainly derived by end users.
Through the interviews sessions, it emerged that the blind and visually impaired community needed a service more than a product, based on very few items, integrating the tools the community already uses such as the cane and the tactile paving and avoiding the overabundance of information. Moreover, one of their main requirement was to use the smartphone as the core of the system, with an accessible interface and integrating vibration signals.
From the requirements analysis, the team transformed each of those into a specification to be implemented in the system prototype.

Exploring the opportunities

Contemporaneously to the interview phase, we started the research about the user experience focusing on the existing similar devices on the market nowadays, in order to understand their lacks and necessary improvements. There is a dedicated branch of the assistive technology that is currently under development to provide assistive, adaptive and rehabilitative devices to people with visual disabilities. Anyway state-of-the-art systems cannot perfectly respond to the multiple challenges that the realization of a

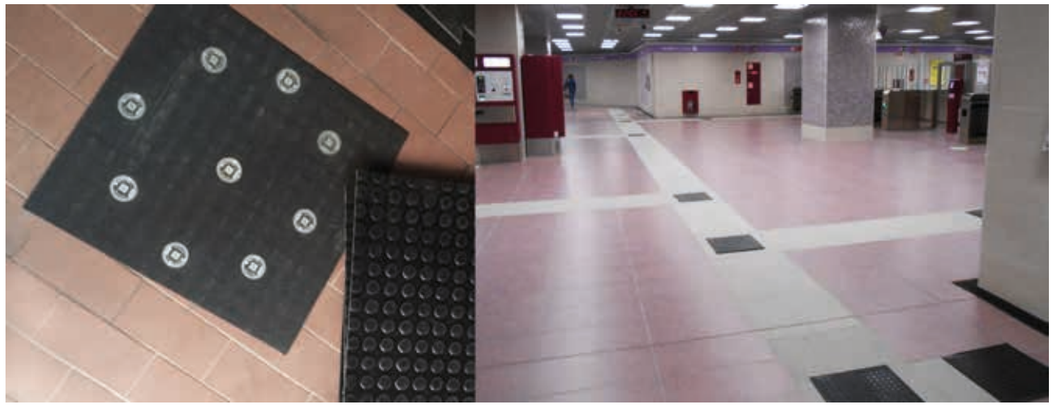


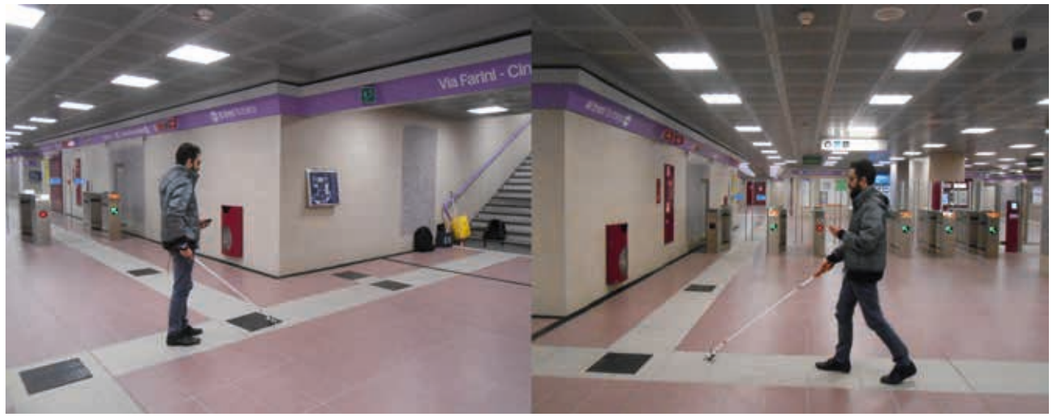
Tactile Paving

user-centered assistive device for blind and visually impaired users poses, such as accessibility, usability and price and they fail to exit the research stage. These are the same challenges ORIENTOMA had to face. To ensure an accessible user interface of the application developed, several solutions were investigated and focused on exploiting the accessibility

functionalities (TalkBack - Android / Voice Over - IOS), guaranteeing the maximum possible visual contrast (not *hue* but *brightness* contrast), using big text characters and icons, avoiding the use of complex backgrounds and the reciprocal disconnected movement of backgrounds and texts. With respect to the user-machine interface, the way of correctly sending output to users was challenging as well. The majority of navigation systems analyzed relies on the audio feedbacks to provide the directional information to the users, but, as emerged from the interviews, the hearing canal should not be overloaded. For this reason, the vibration signals were taken into consideration.

In order to develop a system easy to use, we have chosen to exploit the tools that commonly helps the mobility of blind and visually impaired users, making the all system less invasive. In this way, the usability is granted because the system designed complies with the mobility habits of the user, not requiring a radical change or a dedicated training. For what concerns the price, the use of the smartphone as the main computational structure and an appropriate hardware choice makes the all system relatively cheap. Furthermore, providing the precise location to be computed by the navigation algorithm, was another relevant issue to cope with, since the main





Tags temporary installation in an urban context

Prototype testing session with a visually impaired user

functionality of the system is to guide the user to a pre-set destination. An accurate analysis on the state of the art of indoor and outdoor localization technologies was conducted. The Global Positioning System, commonly known as GPS, turned out to be not accurate, so other solutions such as Ultra-Wideband, Bluetooth or Radio Frequency Identification (RFID) were investigated. The best way of correctly distributing positioning sensors in the environment was then discussed and taken into analysis in order to avoid unnecessary sensorization of the environment and to reduce the whole price.

Generating a solution

The solution developed successfully integrates the common tools already exploited by visually impaired users, in particular the tactile paving and the white cane, with Near Field Communication (NFC) and Bluetooth technology. These technologies have been selected because of their intrinsic properties: low energy consumption, low cost and wearability. NFCs tags are positioned at the crossings or nodes of the tactile paving. As soon as a user walking with a cane reaches a crossing, the NFC unique identifier (UI) is read by a tag reader, placed on the tip of the cane, and transmitted by Bluetooth to the user's smartphone, which is the core of the entire system. By acquiring the tags UI of the node, an ad-hoc application on the smartphone informs the users about its surrounding area and calculates the next node to be reached in the path according to a shortest-path policy selection. To provide the users with the directions to follow, vibrating feedbacks through a wearable smartwatch are used. For what concerns the way user sets his destination, the so called speech-to-text is used, meaning that the user communicates vocally his arrival point, that could be a rail in a train station, a gate in an airport, or a work of art in a museum. The solution proposed is adaptable to existing tactile paving, but, for new installations or temporary uses, ad hoc modules have been designed.

During the last phase of the project different prototypes were developed. In particular tag-reader holders were realized using 3D printing technologies, while temporary tactile paving and the mobile App were tested and improved several times in order to better fulfil users' requirement. Extensive

Museum scenario

Metro station scenario

testing sessions with end-users in a realistic scenario were carried out to evaluate the feasibility of the solution and to provide important indication about future development. Two scenarios of possible future application of the solution proposed were presented.

The prototype designed can participate to the ambitious but necessary task of making our cities smarter, so accessible, usable and above all enjoyable for everyone.

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Big Diamond

Big Data for Internet Monitoring

Project

5

Big Diamond

Big Diamond

Big Data for Internet Monitoring

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Project description

The number of Internet connections is growing at impressive rate and today billions of people browse the web, update their social network profiles and send out emails from both their mobile phones and their personal computers. Within few years, trillions of devices will be connected to the network and they will massively contribute to increase the Internet traffic and the network congestion as well.
With this scenario in mind, analysing the data that the Internet exposes is one of the major challenges that needs to be faced soon. This includes the information generated both by the network *per se*, and by the users accessing Internet services. Algorithms must be devised to extract valuable information out of the raw data. Similarly, proper visualization tools must be investigated in order to better comprehend these complex datasets.
Recently, the so-called Cloud and Big Data technologies have been proposed as a possible joint solution to process very large datasets. The idea is to partition the dataset into chunks, each stored on a separate server belonging to large clusters. Each server processes then its subset and later results are combined.
However, several research problems are still open, ranging from algorithmic problems and technological solutions to business models that must be defined and properly investigated as well as visualization tools to let analysts efficiently explore the dataset. The Big-Diamond project focuses on how to use and apply Big Data technologies and techniques for processing raw datasets collected from the Internet network in order to create and extract valuable data for companies. More in details, the Big-Diamond project focuses its attention on helping Internet provider companies to better comprehend the people behaviour within a highly complex network. In fact, the continuously growing price-based competition in their traditional core services, is pushing the ISPs to look for alternative revenue streams. In particular, in this project we propose as a possible tool to extract information the so called *Webgraph*, i.e., a graph whose nodes represent the websites that users visit, while the edges connecting these nodes record the frequency of transitions made by users when surfing from one website to another. In simple words, when a user clicks on a link hosted in website 1 to reach website 2, a directed edge is created from website 1 to website 2 with weight 1. By creating *Webgraphs*, and by analysing the information they carry, it is thus possible to observe and study how people arrived to a content, or which are the nodes that support the user to discover content in the web.

Tasks and skills

Giorgio Conte: (Computer Engineer) He developed the algorithm to create the *Webgraph* and implemented the dynamic visualization to better inspect the results. He acted as Communication Coordinator of the team.
Davide Dipinto: (Management Engineer) He worked on the generation of the commercial solution and as team controller, organizing and coordinating the work on the three analyses conducted.
Umberto Fugiglando: (Mathematical Engineer**)** He focused on the computational implementation of the statistical analyses carried out on the pre-processed data.

Alessandro Antonio Grande: (Mathematical Engineer) He conceived the *Webgraph* and proposed the statistical analyses to be run on it, which he further implemented together with Umberto.
Abubakar Siddique Muqaddas: (Telecommunication Engineer) He developed the script to extract and transform raw data into a dataset with an higher level of aggregation.
Elisa Piscitelli: (Management Engineer) She conducted strategic analyses to compare opportunities and to identify the market in which Fastweb S.p.A. could gain the highest competitive advantage exploiting its resources.

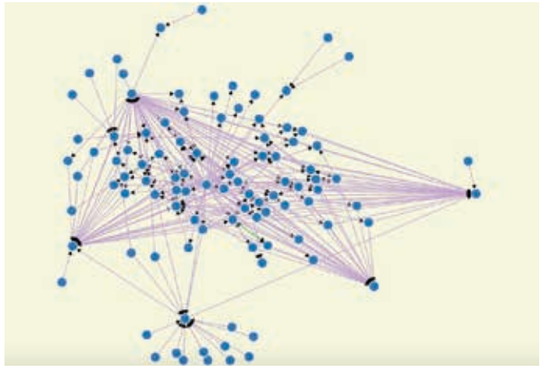
Abstract
In recent years the data companies collect from their business have increased exponentially and new frontiers of information extraction has started the so called *Big Data* techniques. In fact the real value that companies can obtain from data measured not only upon the quantity of collected data but also upon the process they implement to exploit them.
In Big Diamond project, data are provided by Fastweb S.p.A., a major Italian Internet Service Provider, and contain information about users Internet navigations in an anonymous form to preserve users' privacy.
The first part of the project consisted in an analysis of Big Data related business model, identifying the driver for creating value, the future trends, the type of business in which Fastweb S.p.A. should operate and a strategic analysis. The *web usage mining* field turned out to be the best market Fastweb S.p.A. could enter in order to keep a competitive advantage.
After having inspected the raw data, a pre-processing has been performed in order to generate and visualize a graph which represents the paths users follow from one website to another. This abstraction model, referred to as a *Webgraph*, allows us to perform useful analyses.
To better understand and inspect the Webgraph created, a dynamic visualization has been developed. In particular, a force-directed layout is at the base of the visualization in order to avoid and reduce overlapping effects, which may create a visual clutter phenomenon.
To prove the potentialities of this analysis, a case study on a web usage dataset from a Bologna sample in April 2015 has been conducted: statistics on incoming and outgoing traffic have been compared among different websites, in order to identify common trends and differences. This information has been analysed, allowing us to create a description of both users' habits and websites' marketing strategies with particular reference to their competitors' market positions.

Understanding the problem
In the last years companies have hugely invested in building new data centres understanding the important current trend dictated by the Big Data phenomenon. For companies, processing and analysing the data collected from customers, or in general from the market, can have a big positive impact for their overall business.
The purpose of the project is to create value from the data collected by Fastweb S.p.A, focusing on the so-called "traffic data". Traffic data is data gathered throughout the network and generated by users moving from one website to another.
Fastweb S.p.A. was already aware of some opportunities in exploiting these data. For this reason the project aims to provide an innovative solution as output of the work.
In order to reach the desired goal, three type of analysis were carried out:

1. An analysis of Big Data related business model, identifying the driver for creating value, the future trends, the type of business in which Fastweb S.p.A. could operate with a strategic analysis.
2. Raw data analysis in order to understand how to pre-process and clean the available datasets, as well as to develop an algorithm to create the web graph and finally visualize it.
3. Statistical analysis to provide customers with valuable insights.

Exploring the opportunities
With the advent of Big Data era, managing and analysing large datasets have become a main concern and priority among IT companies. In fact, this phenomenon has opened a wide variety of opportunities. Among them, Fastweb S.p.A. may be interested in deepening how its data could provide added value.
The two markets in which the data about web users are a resource that enables a competitive advantage are web usage mining (i.e. a set of data mining techniques that allows companies to understand web users' behaviours) and web advertising. The big players of the second market, such as Google and Facebook, have platforms that enable them to support companies to sell/buy spaces on websites. It is a capital intensive market, entry barriers are high, and Fastweb S.p.A. does not have resources that can make the difference with respect to the other competitors.
On the contrary, considering the second market, Fastweb S.p.A. has "valuable", "rare", "inimitable", and "non-substitutable" resources that guarantee the company a sustainable competitive advantage. In particular, Fastweb S.p.A. has data from multiple users and multiple websites, while traditional players in the web usage mining market have data from multiple users and one website. As a result, the other players can offer a service to a company by analysing the behaviour of the users of its website, while Fastweb S.p.A. can extract more information by comparing the behaviour of users from the entire Internet network.
Additionally, the web usage mining market is always growing. Potential customers are always more aware of the importance of Big Data and web mining analysis in running their businesses. They need to better know their customers to target marketing campaigns and customize services.
However, reaching this goal presents challenges and obstacles. The project perfectly matches the context defined by the concept of Big Data and within this area it shares most of the well-known challenges. Especially in this context, the amount of noisy data is quite relevant when compared to the useful parts. Houidi et al. (2014) estimated that only 1.6% of the requests captured on Internet links are caused directly by a user click. All the rest parts of Internet traffic data are browser-generated requests with the aim to improve performances of the navigation as well as the user experience. Thus, being able to exactly identify this small part of data constitutes a challenging problem.
At the same time, being able to predict and forecast the ways in which users move across the Internet may represent an important added value for spread variety of commercial activities and businesses.
This in-the-making and novel context pushed the team to find innovative solutions.

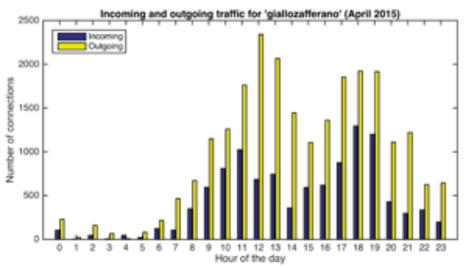
Generating a solution
During the solution-generation phase of the project, the team focused on producing a solution that could greatly value the fact that Fastweb S.p.A. can anonymously collect the *full* web-surfing path of its customers. The solution the team has developed is then the so-called *Webgraph*, a graph representing the aggregate behaviour of users on the web. The nodes



a sub-area of the Webgraph

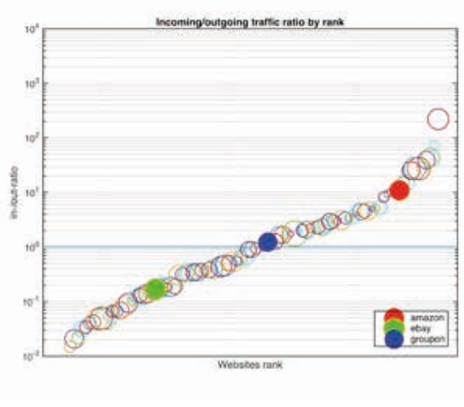
of the *Webgraph* are formed by websites (or classes of websites), while the edges connecting these nodes record the frequency of transitions made by users when surfing from one node to another. Hence, in the *Webgraph* two websites are connected by an edge if and only if there exists a link between them and that link has been clicked by at least one user.

The main innovation that the *Webgraph* introduces is that it allows to investigate users' surfing behaviours around all the websites that appear in the logs, completely exploiting the competitive advantage of Fastweb S.p.A. over traditional companies in the web usage mining sector. Hence, a potential customer could use the *Webgraph* as a tool to extract meaningful information on its competitors. For instance, a company could compare the information gathered on the traffic trends of its own website with that of its competitors, so to have a feedback on how its e-commerce business is performing with respect to its sector of reference.



incoming vs. outgoing traffic of 'giallozafferano.it' by hour over April 2015

In addition to such particularly innovative feature, the *Webgraph* has a series of advantages that made the team opt for this solution. First, as a more aggregate representation of the data, the *Webgraph* allows for uncountable analyses that can be designed ad hoc by the researcher depending on his/her needs, providing a vast set of problems to be explored. Also, no additional information but the users' web logs is needed to build the *Webgraph* and this makes it the best fit with the data the team was provided with. Indeed, other alternatives that the team explored focused solely on studying the relationship between users' interests derived from online behaviour and their geographical location, and required additional dimensions of data (e.g. users' Internet Protocol addresses).



a comparison between e-commerce competitors based on ISP data analysis

As an experimental application of the potentialities discussed so far, it has been built a *Webgraph* using the data provided by Fastweb S.p.A. gathered from about 5000 people in Bologna (Italy), from April 10th to April 23rd 2015. After deleting the IP addresses for privacy reasons, the data has been preprocessed by truncating the http traces at the domain level (i.e. not considering the pages within the same domain) and filtering about 600 websites of interest, leaving out all the domains visited automatically by analytics *sniffers*.

The traces have then been aggregated with an hourly granularity and some statistics of interest have been calculated at higher aggregation levels. As an example, Figure 2 presents hourly incoming and outgoing traffic for *giallozafferano.it*, which shows the different traffic volumes the site experiences during the day.

Moreover, the different roles played by different actors of the network have been studied by classifying them into *promoters* and *attractors*, i.e. those nodes whose incoming-vs-outgoing-traffic degree ratio is respectively less or greater than one. For instance, as shown in Figure 3, *facebook.com* appears as an attractor - which does reflect the policy of this company to keep users' surfing inside its pages; *ebay.com*, on the other hand, turned out to be a promoter, with most of its out connections towards *kijiji.com*, another domain of the group eBay.

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TEC

Turin Energy Centre

Project

6

TEC

Turin Energy Centre

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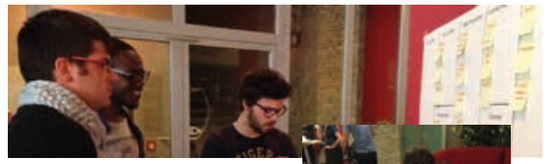
Project description

Comune di Torino together with Politecnico di Torino, Regione Piemonte, Compagnia di San Paolo and Fondazione CRT, are handling the construction of the Energy Centre, which is now standing into the assignment phase of the integrated agreement.
Architectural aspects as well as structural and plant systems of the Energy Centre's project have been already defined in the design phases. However, investigations regarding the functions to allocate and the connections between the different potential stakeholders needs still to be analysed and highlighted.
Accordingly to an early stage configuration, the Energy Centre should allocate spaces for companies and research bodies, develop technological transfer, and provide areas for communication and dissemination to public and private costumers of topics related to energy issues.
The analysis of the most significant experiences in the European and international context will help in understanding how to maximize specific skills and potential competences offered by this building. The results of this study will represent an indispensable basis for more concrete vision of the future activities of the Energy Centre. Energy Centre will start its operational phase by the end 2016, therefore this study perfectly fits the timing related to further uses of the Centre.



TEC team at ASP Summer School

Team description

Temitope Akintola: was involved in the energy simulation activity providing general advices.
Matteo Arietti: took part in the architectural co-working project. He designed the logo and focused on the data visualization platform and the representation of big data.
Salvatore Cicero: took part in the functional and architectural co-working project. His task was that of defining the organization of interior spaces, and the production of graphic material. In particular he focused on the description and representation of data visualization tools and the graphic organization of the whole report.
Antonio Mangogna: developed the energy model, performed the calculations and elaborated the results; he was directly involved in the redaction of the scientific paper that was presented in Riga at REHVA annual conference on the 8th and 9th of May. He provided general advices about the kind of data that may be presented in the Data Visualization platform.
Federica Mordillo: analysed the energy centres and data visualization. She worked on the user requirements, provided supports in 3D modelling for the energy model and worked on the design of the scenarios.

Team working

Anna Pagani: as team controller, coordinated the group, meetings, schedules and presentations; she worked on the State of the Art and researches for the Energy Centres and Data visualization; besides, she designed the scenarios for the project. In May, she visited the EC2 Europe China Energy Center in Beijing.
Rachele Sipione: took part in the functional and architectural co-working project. Her task was that of defining the organization of interior spaces and collaborating in the production of graphic material. In particular, she focused on the definition of the final scenario, the description and representation of the old ones and the design of exhibition spaces and furniture.

Daniela Valagussa: co-developed the energy model, providing the inputs and commenting the results; he was directly involved in the redaction of the scientific paper that was presented in Riga at REHVA annual conference on the 8th and 9th of May. She dealt with the exposition of energy aspects in the report.

Team Group

Abstract

The Turin Energy Centre multidisciplinary project is a work aimed at designing the functions and assessing the energy performance of a 20.000 m^2 under-construction building. The paradox of having to fill an “about-to-be-completed” empty box embodies both an opportunity and a challenge: on one hand, the need to outline innovative functions is a great chance for architects and engineers to collaborate and design with a relatively high degree of freedom, on the other shaping the energy centre’s role and meaning according to a fast changing society means being able to play with very fine boundaries. To be won, the game requires a flexible strategy and visionary mind-set, ready to face the actors’ continuing shift in opinions about the building intended use, the fast pace of innovation that constantly calls into question both its energy performance and its essence, the new approaches in terms of bottom-up interaction, and, lastly, the role of our cities as incubators. Indeed, Torino is becoming a place where research, university and citizens can meet and blend, fostering innovation; the ASP work aims at taking advantage of both the city’s and its stakeholders’ needs, transforming TEC in a new platform for exchange where users, decision-makers, research bodies and companies can dialogue on a common ground.

Understanding the problem

The project started with a careful analysis of the concept of Energy Centre through the design phases. Different needs require different functions and of course also different spaces. This was, mainly, the first problem we had to face. In this sense, deciding the functions means also to define the role of our centre. In short, we had to decide the meaning we wanted TEC to have, its role in the city, its mission and the message it should pass on.

Like an “empty box”, the Turin Energy Centre was waiting to be filled with real functions and activities. The second great objective was to make TEC as close as possible to a Nearly Zero Energy Building (nZEB), an icon of energy high performance, so that it could become the best example and landmark in terms of new energy-efficient technologies and environmental sustainability.
In order to reach these aims, the three words Turin, Energy and Centre were used to categorize and structure the design and energy evaluation process; conversely, the team had to design their meaning: a prototype for the Logo was also proposed, trying to reflect the main characteristics that the building would have in the future.

Exploring the opportunities

Accordingly to the early stage configuration, the Centre was designed in order to contain heavy laboratories for the test of new energy technologies; these activities, though, didn’t reflect the users’ and stakeholders’ final real needs and requirements. Indeed, the main problem was to find the right activities to allocate inside the Centre and, consequently, to design again the interior space. This first phase was carried out by exploring the state of the art of the Energy Centres around the world, analysing their characteristics from an architectural and management point of view. In addition, the research about users and their requirements has been part of our initial work. On one hand, we tried to get in touch with several companies in Piedmont and Lombardy that were somehow connected to the energy topic: producing or consuming energy. We proceeded sending a set of close-ended questions in order to better understand their level of interest in being part of TEC, their expectations from TEC (such as advertisement, quality certifications etc) but also their needs and requirements in terms of spaces and functions (such as offices, laboratories, conferences and

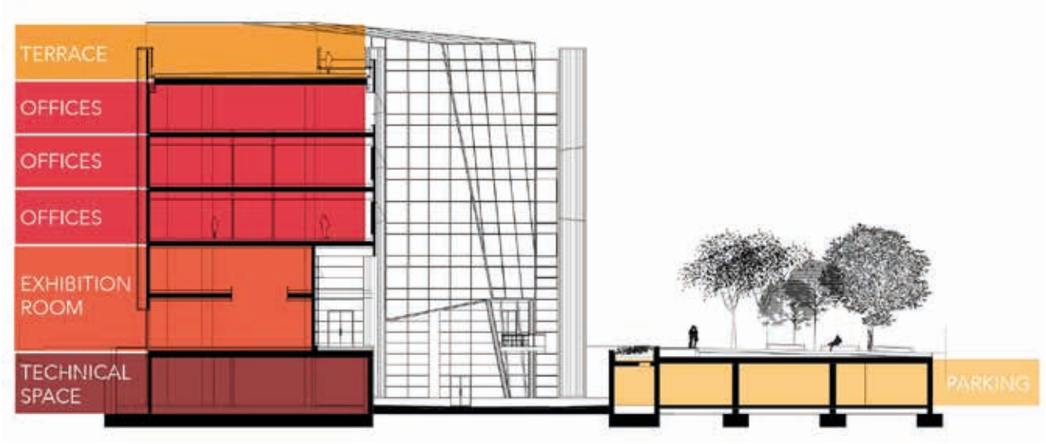
TEC visualization, front side

TEC visualization, back side

TEC visualization by night

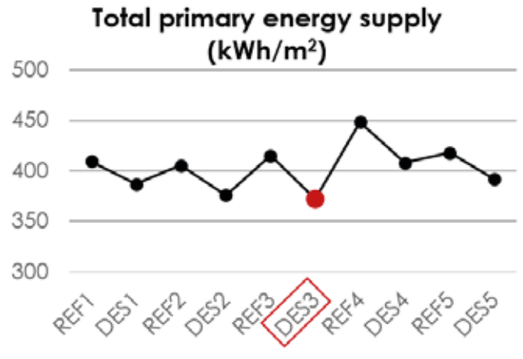
TEC under construction

exhibitions rooms etc); on the other hand, we got in touch with the Energy Centre “Technical-Executive Board”.
The analysis we carried out, from both the architectural and engineering point of view, allowed the team to explore several opportunities.



TEC activities

In particular, our method of work consisted in proposing four different scenarios so that, thanks to the energy analysis (developed with a dynamic energy model) and the stakeholders’ will, we could later be able to choose the best solution. The four scenarios we took into account were based on the different orientation that TEC could assume -educational or business and social- further fractioned into high- or low-tech, according to the areas devoted to the laboratories.



Scenarios’ energy analysis

The dynamic energy model developed served us even for testing different technological system configurations, aiming at making the Energy Centre a Nearly Zero Energy Building (nZEB). All these analysis were reported in a scientific paper that was presented at REHVA Annual Meeting and Conference (6th-9th May 2015 - Riga, Latvia) and published as a proceeding (https://journals.rtu.lv/index.php/AHNGT/article/view/rehvaconf.2015.001).
The challenge of finding the nature and meaning of the Energy Center could be, then, faced. But choosing the best scenario was not enough: innovation had to be brought in.
Indeed, the identification of the range of scenarios was a critical phase that provided precious and pivotal considerations on what kind of role TEC should play for local communities, but none of them was actually taking into account the peculiarities of the local context in which TEC will rise up. TEC should represent the early, bold cornerstone for the introduction of a completely different way of thinking about local development, centered on sustainable policies and innovative renewable energy systems. It should provide a space for communication, confront, collaboration and decision making. It should work as an incubator and promoter of innovative solutions and initiatives, by involving the most influential and powerful local companies and institutions and fostering their collaboration with the University and the research sector. It should also promote a campaign which might raise citizens’ awareness about sustainable, resilient and eco-friendly approaches.

To sum up, indeed, TEC should be provided with a very strong identity, by being turned into a critical melting-pot and essential policy making tool.
The challenge was clear: to reach the goal we, as a multidisciplinary group, had to build a room where the development of energy scenarios could be conveyed in the most talkative way, while trying to satisfy the external institutions and their expectations. After analysing several methods such as virtual and augmented reality, the aim was to define a platform able to collect all the energy data and transform them into a new extraordinary result.

Generating a solution

After evaluating the feasible scenarios from both the functional and energy consumption point of view, the definitive choice in terms of architectural organization of interior spaces had to be addressed. In this context, one critical aspect of TEC’s new identity was crucial: the focus on the big data. By turning the center into a huge system of data collection (Data Lake) and visualization, in fact, it would be possible to reach the main objective resulted from the study. These concepts are expressed by the main exhibition room that links users, data and policy makers.
What about the energy choices? At the beginning the dynamic model was born as a tool aiming to choose the most advantageous scenario. Afterwards this tool reveals itself as the outcome; this instrument became a prototype with a double relevance. The first one is the model as a software able to provide information about the energy performance of the building depending on the variable functions, schedules and users during the life of the building. The second one is the model as a testing workbench of energy data lake, obtained by trying to rescale the smart city problem to the single building. Big data collection and visualization will provide not only fundamental knowledge of the whole region’s consumption and GHG emissions, but also a wide range of renewable and alternative energy scenarios that could be depicted, besides showing a day by day updating of the TEC nZEB building energy life.
To sum up, then, rather than defining these considerations as the “main findings” of this research, they may be seen as a way to connect the dots: our group draw the lines to rejoin the need for the Turin Energy Centre to embody a change and a standard without losing its connection to energy, together with the need for the city and its stakeholders to build a dialogue on tangible, understandable and shared information.

Main bibliographic references

- Websites of Energy Centres around the world
- Websites about Data Visualization experiences
- Comune di Torino, procedura aperta 83/2013. Final project documentation.

Data visualization platform
Data visualization platform

Exhibiting platform
Exhibiting platform

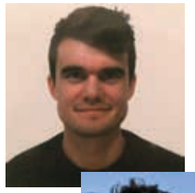
PTHELI

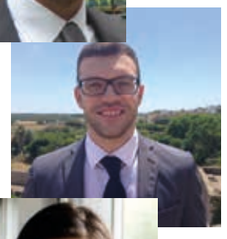
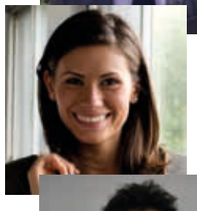
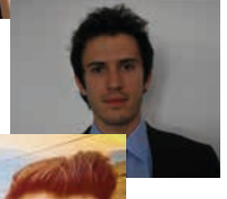
Piston twin helicopters for territorial
and environmental safeguarding

Project

PTHELI

Piston twin helicopters for territorial and environmental safeguarding

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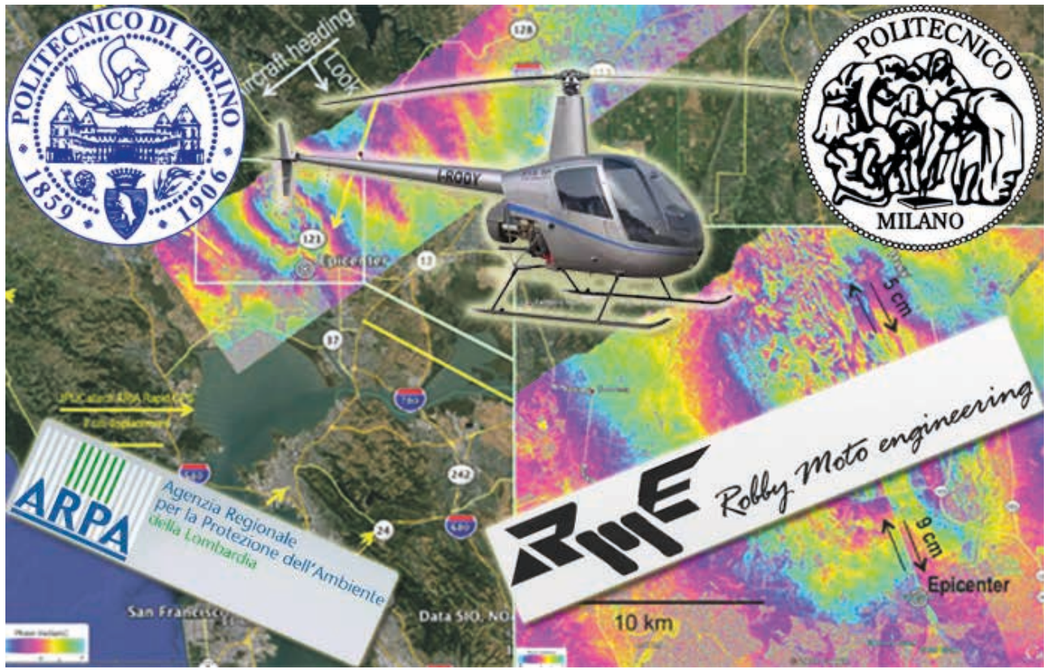
Tasks and skills

Alessio Barbato: Mechanical engineering. Took care of the market analysis, drive train of the helicopter and of the engine analysis.
Andrea Carbonara: Aeronautical engineering. Took care of the market analysis, aerodynamics and mechanics of the helicopters. Group coordinator.
Smaranda Chifu: Urban planning and policy design. Took care of mission profile definition, sensor identification and alternative mission profiles.
Salvatore Costagliola: Mechanical engineering. Engine analysis, helicopter performances and configurations, state of the art of the helicopters.
Luigi Grimaldi: Electronic engineering. Took care of mission profile definition, sensor identification and alternative mission profiles.
Tommaso Guffanti: Space engineering. Mission profiles, FMS and cockpit.
Giorgio Riva: Aerospace engineering. Engine analysis, helicopter performances and configurations, state of the art of the helicopters.

Abstract

The need to monitor the territory, as can be seen from Regional, National and International requests, is strong and growing. The development of technologies for environmental monitoring and regional safety represents an important aspect for the management and control system. Fixed or rotary-wing aircraft are currently used in this role for monitoring coastlines and borders, traffic surveillance, fire prevention and photographic surveying. Today the operation of these aircraft are characterized by high costs. A better solution could be obtained by exploiting a new class of vehicles: small-sized helicopters defined as VLR (Very Light Rotorcraft) characterized by low design, production, maintenance and operative costs. Crucial for the development of this new class of aircraft is the selection of an innovative engine system that will ensure the aircraft to be A-class certified. In base to the EASA CS-27 regulation, this feature can allow the helicopter to operate for aerial work and to fly over urban centers and bodies of water. The solution analysed is represented by the piston engine TEPS (Twin Engine Pack System). Despite coming as a “single unit”, the TEPS is in fact the integration of two engines capable of operating in synch. The added value is represented by the capability to work individually and independently, despite coexisting in a single engine body, in case of emergency. Scope of the project is the design this new class of rotorcraft for territorial and environmental monitoring missions. Up to now the aerial photogrammetry has always been carried out by airplane and satellite. This project aims to deduce the technical requirements of an environmental photogrammetric mission as it is done today and to apply and adjust these parameters to an



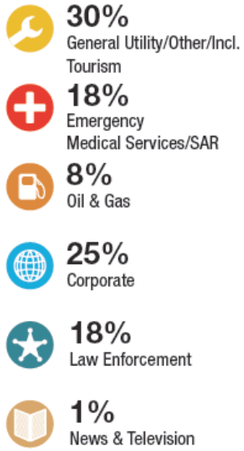
Main stakeholders involved in the project

innovative technology that would allow to implement environmental missions also by helicopter. The team also defined alternative mission scenarios and identified viable design configurations, together with the study and the integration of the TEPS engine, sub-systems and an innovative FMS (Flight Management System).
Up to now the aerial photogrammetry has always been carried out by airplane and satellite. This project aims to deduce the technical requirements of an environmental photogrammetric mission as it is done today and to apply and adjust these parameters to an innovative technology that would allow to implement environmental missions also by helicopter.
The revolutionary piston twin pack engine contains two engines in a single unit, making it possible to reach noticeable performances while keeping the flight safe. The helicopter can overfly cities and densely inhabited areas without the limitations of a single engine machine. The simple construction and aerodynamic choices, together with the compact size make it a reliable and cost-effective vehicle.

Understanding the problem

The main focus of the project dealt with the creation of an helicopter capable to execute environmental monitoring missions. ARPA Lombardia, the main contractor of the project, expressed the need to realize a vehicle capable to reduce costs and increase the operational efficiency of a flying machine in this field. In fact the main issue linked to environmental missions is the limited availability of specific tools (i.e. complete packages of vehicles and sensors) capable to deliver good results with reasonable costs. Another problem is linked to the helicopter market, which still doesn't propose a light vehicle able to perform such missions with a sufficient level of performance, redundancy and safety. That is the reason why the company sponsoring the project, Robby Moto, developed a special engine that can let a very light helicopter (VLR) obtain an A-Class certification. This makes it possible for the helicopter to fly over densely populated areas or water bodies with the needed safety requirements. In fact, since the engine is a twin system, once a single unit stops working, the other can be used to land the vehicle.
A market analysis was important to find the potential application of the helicopter past the environmental monitoring, in order to forecast a cost production reduction thanks to higher selling volumes. In order to best fit the machine to the main mission, an analysis of the state of the art techniques and sensors required by photogrammetry and environmental safeguarding was required as well.
The exploration of the current state of the art in the field of multiengine and very light helicopters made it possible to understand the possibility to penetrate a market niche which is still almost unexplored. Proper design criteria had to be chosen in order to define a set of constraints capable to deliver a solution which is a trade-off between performances and low acquisition/operation costs.
Another challenge the project had to face was the understanding of a human-machine interface capable to add value to the project itself and to justify the acquisition cost by a contractor. Hence the study of a suitable mission-oriented avionic system was required, concentrating on the mission components.

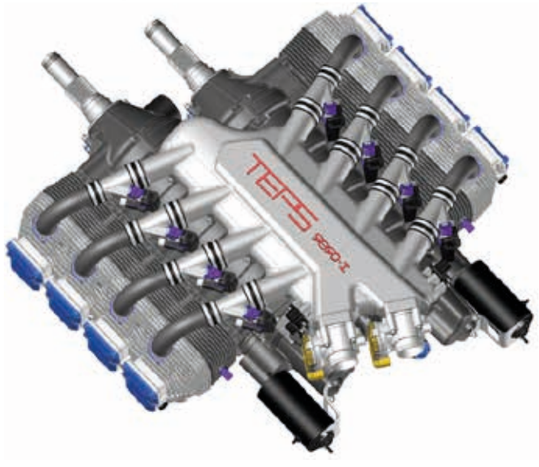
Dual-use or multi-purpose aircraft allocated to primary usage category.



Planned usage of new delivered helicopters 2015-2019

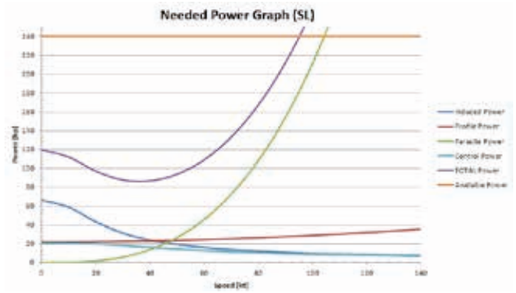
Exploring the opportunities

Along with the traditional two and three blade solutions, we explored other helicopter configurations, according to the historical state of the art of helicopters. It is important to notice that the standard configuration (main rotor plus tail rotor) fits almost all the helicopters currently flying around the world because of ease of construction and economy of design and use. Another solution is the tilt rotor: it combines the advantages of an airplane in terms of cruise speed together with vertical takeoff and landing capability typical of helicopters. It is also earning a good success thanks to the evolution of digital engine control solutions, but it takes place in big machines (MTOW over 5.000 kg), so at the end we have not considered it. Another opportunity is represented by the use of two intermeshing or coaxial rotors: with some differences between each other, they both allow for elimination of the tail rotor, increasing safety of ground and air operation and requiring a shorter and lighter fuselage. Unfortunately, they require a dedicated gearbox and shows aerodynamic interference drawbacks that are not worth to be studied in a VLR. The lesson learnt is that the main requirement of such a machine is the design, construction and maintenance simplicity.
The exploration of opportunities went also in the direction of searching the best instrumentation to perform the environmental monitoring mission. We compared several kinds of sensors, such as metric cameras, multispectral cameras, LIDAR, thermal infrared sensors. Eventually, we opted for a combination of instruments being adaptable to either an emergency scout-



TEPS 9890i twin engine rendering

ing mission or an extensive monitoring. The basic equipment, including an optical cameras and a GPS/IMU system for geolocalization, can be sided by a specific sensor required by the customer.



Performance chart at sea level
Takeoff weight breakdown

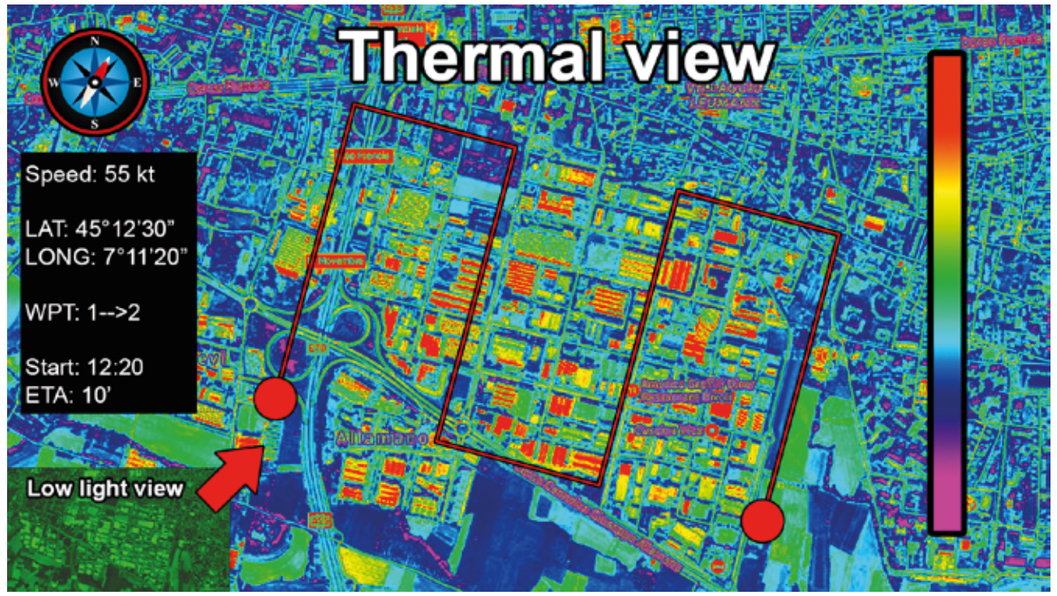
Primary flight instruments
Mission related and engine instruments
Mock-up of the new digital cockpit

Generating a solution

The great flexibility of the project made it possible to outline many different solutions that can make the aircraft a resource in different operational fields. The identification of simple technical solutions made it possible to realize a reliable and simple machine, satisfying the cost requirements posed by the contractors. The idea of a twin engine unit made it possible to develop an highly transversal machine. A double engine light helicopter can answer the needs not only of the main missions for which the project was intended for, but it is also able to give room to the development of other mission scenarios. Hence a straightforward and (as far as possible) complexity-free design process, made it possible to expand the usability also to private leisure users, to military or civilian flight school trainers and to other support missions (like law enforcement and search and rescue). Simple modifications to blades and engine parameters can promptly adapt the helicopter to its new needs.

The team analyzed and studied a set of methods to integrate the new propulsion system in the helicopter, a sizing methodology for the drive system and a procedure to evaluate the mass budget (i.e. the weight subdivision inside the aircraft). The sizing procedure was taken from a rich literature of design books. At the same time it was needed to choose among different types of transmission drives. The choice regarded a simple and effective belt-drive system, capable to promptly exclude an engine in case of failure. The mass budget definition was based on a statistical analysis of different comparable vehicles, that made it possible to extract general parameters to express a breakdown of the weight of the essential components of the aircraft.

The generation of a concept passed from the identification of the constraints to the inspiration to current and past solutions, capable to drive the design choices.



Detail of the environmental mission screen with the flight path

The methodologies used clarify the feasibility of a VLR twin engine solution, which can become a strategical and cost-effective instrument in the hands of current contractors, but that could also attract other customers in other fields.

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ENERGY PARK

SMART GRID and MOBILITY
for an ENERGY PARK

Project

8

ENERGY PARK

ENERGY PARK

SMART GRID and MOBILITY for an ENERGY PARK

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Project description

In the last decades mountain areas experienced a significant reduction in the population, which harshly affects the socio-economic status of these territories. Consequently, due to the lack of infrastructures and services, a severe decrease in attractiveness both for inhabitants and for tourists lead towards a vicious cycle, which is arduous to overcome. In order to challenge this negative trend it is essential to abandon the traditional thought of mountain areas as uninhabited and isolated regions and, on the contrary, to create a positive thinking to encourage the rediscovery of the great wealth that characterizes these areas.
The Energy Park project aims to provide new approaches to face depopulation, lack of attractiveness and isolation of mountain and rural areas, developing innovative solutions to reassess and strengthen those territories taking into account the peculiarities of the area, in order to increase the well-being of population and to foster the touristic vocation. This change could be done through the proactive use of technology. If in the past there was a sort of conflict between innovation and conservation of nature, nowadays the valorization of local patrimony by using ICT tools has become an opportunity to improve tourism and restocking alpine area. Thus, networks and technologies interface with environmental structures favor interaction, reducing the distance that often separates cities from valleys.

The case study considered in the project is focused on Orco valley (located in the North-Western part of Piedmont). The area is characterized by its natural landscape with the presence of Parco Nazionale Gran Paradiso and by the existence of several artificial lakes exploited for the energy production in hydroelectric power plants.
To reverse negative trends that are characterizing the valley new initiatives and proposals, aimed to create a grid that links "*smart*" people living the valley to use their energy to repopulate the area preventing the migration and socio-economic marginality phenomena, are needed. The holistic approach required is based on the creation of a series of practical actions (even of small entity) that will be able to rise the value of the local patrimony of the valley, connecting together each of the positive elements peculiar of the area.
The complexity and cross-sectorial nature of the project suggests developing of an integrated solution, structured on different timescales. Alta Scuola Politecnica students generated several concepts (addressing different issues characterizing the valley) and therefore, thanks to a multi-criteria analysis, have been outlined the most promising and effective solutions to be implemented first, such as:

- The creation of a web-platform, able to collect the whole tourism supply of the valley in a unique, easily accessible portal. It provides also greater exposure for local products and services of excellence and opportunities for inhabitants to develop new business in the valley;
- The creation of a touristic itinerary closely related to energy topic and to hydroelectric massif presence in the valley.

From outcomes resulting from ASP students project, it will be possible (in the medium and long term) to extend the analysis to other case studies creating a connection of areas, all over the Italy, sharing the same common philosophy based on Energy Park.

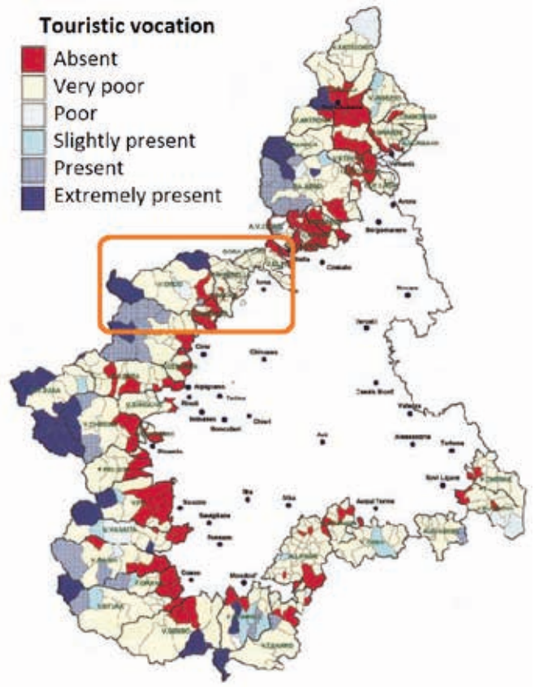
Tasks and skills

Davide Castignone: as team communication coordinator he was in charge of the organization and scheduling of the activities, acting as interface between his colleagues and tutors. Moreover he dealt with SWOT analysis and he participated as speaker during the workshop held on 27th of July in Rosone.
Damiano Federico: thanks to his civil engineering background, he deepened the state of the art in Orco valley especially taking into account mobility issues and he investigated possible improvements in the mobility with the help of sharing economy initiatives. Besides that he carried out the video interview with local artisans and personally worked on the video-editing phase.
Monica Genito: she was involved in the architectural aspects related to the project deepening the widespread hotel key concept and its applicability to the case study considered. Moreover she collaborated with other team members in the implementation of Geographic Information System (GIS) supporting the analysis of the valley.
Luca Migliorini: he deepened technical energy issues related to building retrofit and refurbishment. Moreover he worked on the implementation and spreading of questionnaires and collaborated with other teammates to the feasibility analysis of the chosen concept.
Nevena Sreckovic: in the state of the art analysis she investigated the successful examples of mountain area in the alpine area and she worked on GIS. Besides that she took advantage from GIS outcomes in order to identify new touristic itineraries in the valley.

Giulia Laura Suardi: she manly contributed to the creation of the web platform defining its contents. Moreover she collaborated to the GIS selection of the main points of interest in the valley.
Ekaterina Vernezi: her engineering and management background were exploited in the feasibility analysis phase of the project. Moreover, in the state of the art analysis she deepened EU projects related to alpine areas.

Abstract

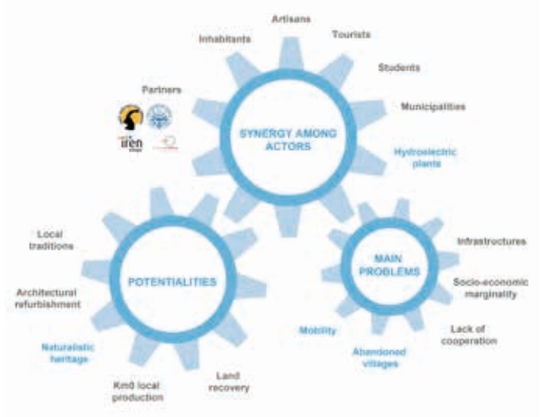
In the age of urbanization, mountain areas are facing a continuous depopulation and a decrease in socio-economic standards, which entails a disharmony development leading to a substantial marginalization of these territories.
Energy park project intends to emphasize the strength points of the alpine areas, exploiting the use of new technologies and innovation in order to outline new development strategies, taking Orco Valley as a case study. In this way the distance that separates these regions from urban areas has been shortened and a new revitalization is possible, which is beneficial for both.
The investigated problem concerns a high level of complexity and numerous stakeholders; hence a careful study of the context and the current state of the art have been performed. Starting from a SWOT analysis the team developed several concepts regarding different technical and social fields which together create a beneficial impact on the valley.
Considering the short period available to ASP students compared to the entire project, the different concepts were investigated and evaluated through a multi-criteria analysis.
The outcome of this analysis suggests that the most promising concepts deal with the creation of a multi-use touristic web-platform and the design of a new itinerary proposal within the valley. Therefore feasibility analysis has been considered.
Other tools adopted by the team to deepen the viability of the concepts and to investigate the attitude of valley inhabitants towards these initiatives are the diffusion of several questionnaires and the organization of a workshop in the valley gathering the main stakeholders of the project together.
The team has reached an agreement with the municipality of Locana, which will maintain and manage the web-platform in the future. In conclusion, the project aims to combine physical and digital structures to better value the mountain areas heritage and to increase attractiveness currently extremely reduced (**FIG 1**).



Valle Orco touristic vocation in Piedmont

Understanding the problem

The Energy Park project tends to properly address the need of "reinventing" the territory in order to create better living conditions in the valley, contributing to limitation of the migration phenomena and enhancement new job opportunities for the inhabitants of the valley (especially regarding to young people). In particular in order to reverse the negative trends that are characterizing the valley the most important thing is to define new



Framework of the project

initiatives and proposals aimed to convince local people to change they way of living in the valley.

Poor integration between the different actors in the territory and lack of recognition of the valley through a strong shared identity are one of the main points of weaknesses (**FIG 2**). The Energy Park key concept is intended to overcome (or at least address) the main weakness of the area (mobility, abandoned buildings, poor offer of touristic itineraries) encompassing all the points of strengths of this area such as:

- Presence of Piedmont side of Parco Nazionale Gran Paradiso and its beautiful natural sites (almost unknown by the tourists because of its location);
- Great number of artificial lakes due to the massif exploitation of hydraulic resources that concurred to create a heritage of the impressive dams construction.

Due to the scarce investment opportunities in the first part of the project it is important to be focused on those initiatives that require low effort (especially in terms of financial resources) but they are able to change the impact that the valley has on tourists. For this reason the first driving force should come from local people (the motto could be defined as “Energy From People”) in order to create a grid that joins together all the successful and valuable activities already existing (most attractive touristic paths, accommodations, restaurants, etc.).

In order to better value the whole local heritage is needed to implementing several interventions able to valorize the main assets of the valley through comprehensive approach addressing different issues.

In a second stage, once having improved the attractiveness of the valley, the project (that has a timescales of several years) will be more focused on attracting external investors. In fact, within the prosperous environment of the Energy Park, new companies could be attracted to move part of their business in the valley, participating in the capacity development of the area. Finally, even if the Energy Park has to take into account the peculiar elements that characterize Orco Valley, it is of note that solutions provided to Energy Park can be adapted and replicated in other mountain territories, in order to launch similar projects in other locations all over the Italy.

From SWOT analysis to concept generation

Exploring the opportunities

Due to complexity and societal impact of the project the results of the SWOT analysis underlined that *no silver bullet exists* (**FIG 3**). In other words, the Energy Park project involves different actors and stakeholders that are collaborating in a project with a timescales of several years; moreover the issues addressed by the project are extremely wide and therefore it is not possible to solve all the problems by using a single concept. This means that are needed interconnected solutions, using an integrated approach.

Analysis of the State of the Art allowed to underline the current situation in the valley; since the project is focused on wide geographical area, it was necessary to provide a specific cartography and database in order to manage all the existing and important data. For this purpose, the most appropriate tool was a Geographic Information System (GIS in **FIG 4**), in order to create a complete map of the points of interest in the region and the possible improvements in the valley attractiveness.

Geographic Information System analysis

In the concept generation phase, starting from point of weaknesses and potentialities of the valley, ASP students addressed each of the issues by using a holistic approach. Concepts deepened cover an extremely wide range of fields either technical or social. By way of example:

- Joining together the needs of tourists for accommodation and the presence of abandoned building the solution proposed is the widespread hotel and the building retrofit also in terms of energy consumption.
- A particular kind of enhancement for the creation of job opportunities in the valley is related to the potentialities provided by telecommuting or teleworking.
- Mountain tourism can be fostered through the use of innovative technologies by exploiting new forms of communication based on the last generation of technology (sharing economy in mobility).
- A web platform can be a great opportunity to collect in a single, easily accessible place all the information that tourists and locals might be interested in concerning Orco Valley.
- In accordance with the Energy Park philosophy, new touristic itineraries can be defined closely related to energy topic by using GIS outcomes resulting from the State of the Art analysis.

Due to the short amount of time at disposal of ASP students (2 years) respect to the time scale of the project (10 or more years), priorities of intervention and implementation of the concepts have been assessed through a multi-criteria analysis, identifying the most congenial solutions to be developed. The macro-criteria selected were based on partners commitment, inhabitants and local entrepreneurs expectations, ability to engage tourists, time for implementation of the concept, job opportunities created, bureaucracy and legal issues and, above all, the capability for the concept to solve at the same time more than one problem that Orco valley faces.

Generating a solution
Web platform

One of the outcomes of the project is the creation of a web platform able to collect all of the information that both locals and tourists might be interested in knowing about the valley. So far such kind of information is available in different and extremely fragmented websites (each municipality of the valley has its own website, Parco Nazionale Gran Paradiso initiatives uses other communication channels, local artisans have no possibility to advertise their work, etc.).

Therefore one of the main requirements is to collect in a single, easily accessible website all the points of strength of the valley (**FIG 5**). The website should satisfy needs of local people and tourists and in particular:

- For tourists: a selection of the most attractive points of interest in the

Screenshot of the web platform created by students

valley, useful tips about local food products, mobility to reach the valley and move inside, all the practical information that tourists could be interested planning the visit in the valley (key areas are food, mobility and accommodation).

- For locals: useful hints about how to generate a positive change in the area, enhancing the attractiveness of their valley. In particular are proposed and explained initiatives or tools that can come in handy, for instance since one of the main criticalities of the valley deals with abandoned buildings, the website aims to propose alternatives and solutions that locals can undertake in order to refurbish buildings currently unused. The idea is to create a positive effect on local economy by convincing people to invest in their buildings and to refurbish them (by commissioning renovation work to the local craftsmen) and then use the refurbished area to host tourists.

Rosone-Teleccio Itinerary

Given the high environmental quality of the valley, an important intervention is the valorization of the existing itineraries, making value of the existing points of interest and creating new facilities in order to characterize them, improving the energetic aspects. The energetic concept is strictly linked to water: the existence of IREN hydroelectric plants gives a particular connotation to the territory through the presence of dams and artificial lakes. The focus of the analysis is small area in the Piantonetto side of Orco valley, from Rosone (where the hydroelectric power plant is placed) to Teleccio dam (**FIG 6**). Thanks to GIS analysis have been defined the main features of the new proposed itinerary, also taking into account the two buildings currently unused particularly close to the dam, which can be easily refurbished.

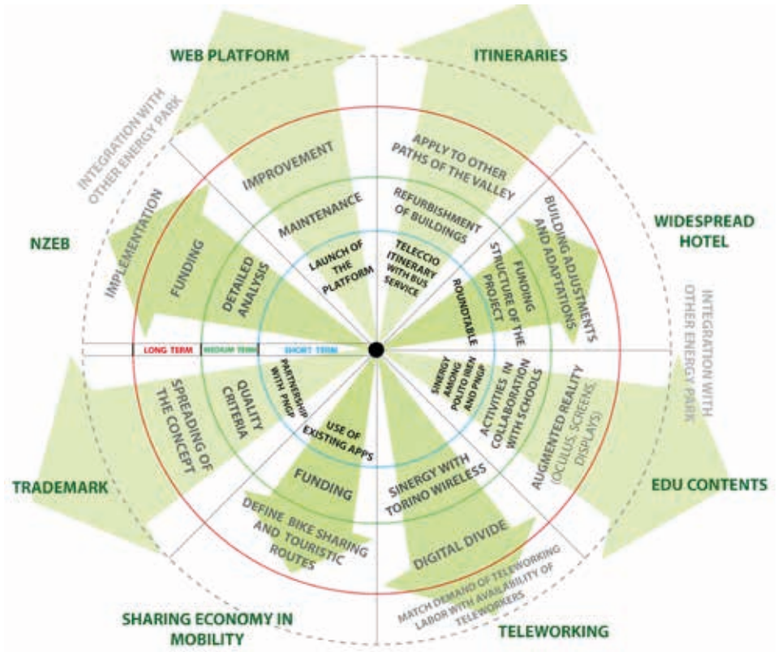
Itinerary proposal Rosone-Teleccio

The approach used for the Teleccio itinerary could be applied to the entire valley, starting from the valorization of the other plants by IREN and using the theme of energy as a connection between already existing heritage and new educative and social proposals.

In conclusion a plan for the continuation of the project in terms of time scale have been reported, distinguishing among short, medium and long term (**FIG 7**). Given the complexity and ambitious nature of the project Energy Park, the time horizon is of several years and the success of this process will surely depend on numerous factors.

Nevertheless, the key to a sustainable growth of the mountain area and the increase tourist attraction is represented by the synergies that can be established between the various actors, companies and partners involved in the project.

The only key for the success of the project is the integration and collaboration among the various forces; in this way it will be possible to reach the main goal of the project: a beautiful environment extremely recognizable, with its territorial and cultural identity and touristic attractiveness but also very responsive to the needs of its inhabitants.



Future project implementation phases

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ARCHe_Tool

Adaptive Reuse of Cultural Heritage Tool

Project

ARCHe_Tool

Adaptive Reuse of Cultural Heritage Tool

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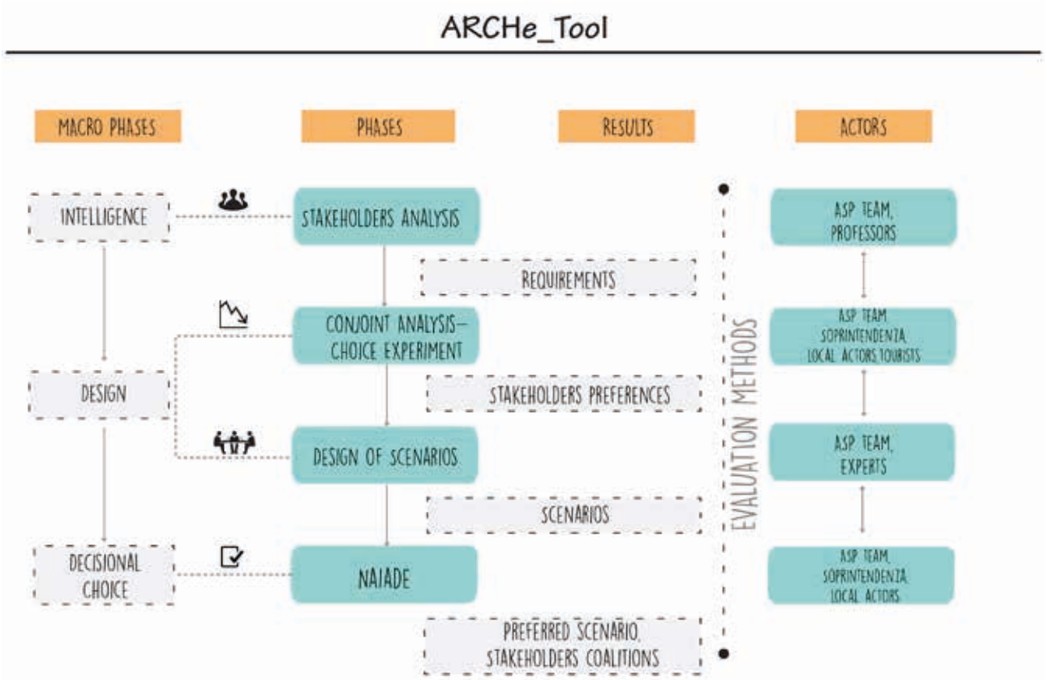
Project description

The European Commission's 2014 Communication "Towards an integrated approach to cultural heritage for Europe" underlines the importance of maximising the intrinsic, economic and societal value of cultural heritage, in order to promote cultural diversity and stimulate people to engage with their environment. Therefore, interest and support for cultural heritage is changing: preservation of historic or obsolete architectures and protection strategies of local traditions, generally considered as costs for the society, are now recognised as positive contributor for local economies and environmental sustainability. The promotion of innovative use of cultural heritage should follow the principles of adaptive reuse, in order to choose specific inclusive and compatible functions which could enhance tangible and intangible aspects linked to the historical building. This conservation strategy is deeply interlinked to these three different areas, which are also the three pillars of sustainable development: environment, society and economy.
The conservation strategy of adaptive reuse is aimed at preserving cultural heritage and, at the same time, at generating social value in addition to respecting feasibility and sustainability requirements.
Starting from the idea that the systematic application of analytical tools in support of decision-making represents an innovation in the field of cultural heritage valorisation processes, the goal of the project is the development of an innovative multicriteria evaluation model – ARCHe_Tool – to assess the best adaptive reuse scenarios for three castles located in Valle d'Aosta region. Such complex choices require analytical tools in at least three different phases: intelligence phase for framing the complexity of existing and conflicting values; design phase for developing alternative scenarios; decision phase for selecting methods to support the final choice.



The Arche_Tool_The phases of the decisional model

Therefore, the decision making process has been divided in a series of steps combined together by the application of a multi-methodological approach based on the use of Choice experiment combined with Multicriteria analysis.

The ARCHe_Tool has been applied to the Arnad Castle as a pilot. The application of the tool has allowed to obtain the following results:

-Requirements, through the identification of stakeholders and the analysis of their expectations, a list of requirements for the development solutions has been established;

-Stakeholders' preferences, the definition of the requirements has brought to a set of criteria that have been evaluated by stakeholders in order to find out the intensity of their preferences;

-Preferred scenario and Stakeholders coalitions, through the introduction of Social Multicriteria Evaluation, it has been possible to analyse the proximity of interests of different categories of stakeholders.

The ARCHe_Tool has been developed with the support of the Valle d'Aosta Region, the Soprintendenza per i Beni e le Attività Culturali and the municipality of Arnad.

Tasks and skills

Cecilia Ferrando: (architect) investigated the adaptive reuse topic and state of the art, contributed in the CA-CE questionnaires design and in the elaboration of new reuse scenarios for Arnad castle.

Mila Gandino: (environmental engineer) participated in the CA-CE questionnaires design and administration, contributed also with statistical skills in the analysis of the results and WTP evaluation.

Melissa Marcelli (architect) participated in the CA-CE questionnaires design and administration, as well as in the elaboration of reuse scenarios for Arnad castle and in the workshop organization.

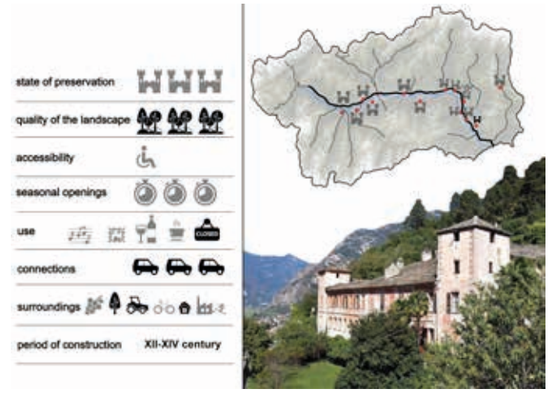
Maria Mittica (management engineer) identified the stakeholders involved in the project, contributed with econometrics skills in the analysis of CA-CE questionnaires results and in the workshop organization.

Mattia Pancerasa (environmental engineer) identified the stakeholders involved in the project, participated in CA-CE questionnaire design and administration as well as in the analysis of the results and in the workshop organization.

Giulia Quaglia (architect) identified the stakeholders involved in the project and participated in the CA-CE questionnaires design. She concentrated on the Naiade application and results analysis.

Carlo Turuani (architect) investigated the adaptive reuse topic and state of the art, as well as the previous work done on VdA castles. He participated in the elaboration of new reuse scenarios for Arnad castle and in the workshop organization.

Ilaria Vigna (architect) investigated the adaptive reuse topic and state of the art, contributed in the CA-CE questionnaires design and in the elaboration of new reuse scenarios for Arnad castle.



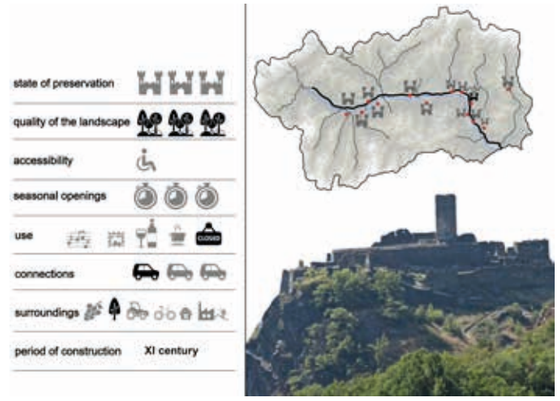
Case study_Arnad

Abstract

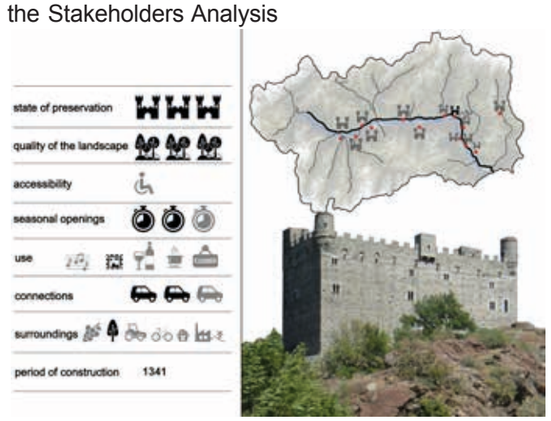
Guaranteeing a future for cultural heritage in an era of rapid technological innovation is a complex challenge. The aim of this project is to develop a **tool** to support the choice of an **Adaptive reuse** for three castles in Valle d'Aosta (Chateau Vallaise in Arnad, Sant-Germain castle in Montjovet and Ussel castle). Adaptive reuse is aimed at preserving the building or site while at the same time generating social value and respecting feasibility and sustainability criteria.

In order to build a comprehensive and solid tool, we addressed all the phases of a decisional model: intelligence, design, choice as theorised by Simon (1960) and Newell and Simon (1972). We decided to employ analytical tools for each phase of the decisional process in order to make it as transparent and objective as possible. In the intelligence phase, the Stakeholders Analysis has been used to frame the complexity of the stakeholders system; in the design phase, Conjoint Analysis – Choice Experiment has been employed to support and guide the design of alternative scenarios; in the choice phase, NAIADE has been used to support the final choice among scenarios. The combination of tools was chosen as an experiment to include together qualitative and quantitative results. The systematic application of **analytical tools** in support of decision-making, together with a **bottom-up approach**, represents an innovation in the field of cultural heritage reuse assessment.

The proposed approach to decision-making in cultural heritage stands out from the state-of-the-art for being participatory, transparent and as more inclusive as possible. Our case study application can be useful in the future as a positive example



Case study_Montjovet



Case study_Ussel

Crafts University scenario
Food&Commerce scenario
Museum&Expo scenario
Interactive museum scenario

to promote analytically supported decision processes in the field of cultural heritage adaptive reuse, so that this becomes the common practice; the adoption of such methods can increase the social value of adaptive reuse projects and bottom-up participation to decisions regarding cultural heritage.

Understanding the problem

The recent European Commission's interests on cultural heritage reflects how its conventional paradigm is changing: in order to guarantee a future for cultural heritage in an era of rapid technological innovation, the problem of finding a new function to historic or obsolete architectures and sites is increasingly relevant.
The promotion of innovative use of cultural heritage should follow the principles of **adaptive reuse**.
The adaptive reuse strategy promoted in the ARCHe_Tool project indicates a contemporary conservation practice that avoids abandonment and decay of cultural heritage through the production of both economic and social resources, able to preserve the architectural object from an historical and cultural point of view.
The goal of the project is the development of an innovative multicriteria evaluation model –ARCHe_Tool – that supports the design of adaptive reuse scenarios for three castles located in Valle d'Aosta region.
We developed the project in collaboration with the Soprintendenza per i Beni e le Attività Culturali of Valle d'Aosta, who wishes to set as a guideline in the adaptive reuse process the concept of "Restitution": this can be defined as the idea of bringing cultural heritage back to the people of the valley, while at the same time encouraging tourism.

Exploring the opportunities

The research of case studies about contemporary transformations and adaptive reuse of castles has been fundamental to understand the processes linked to conservation strategies in complex contexts and the variety of actors involved.
In the current paradigm for cultural heritage reuse, decisions are taken by public administration looking at funds and technical necessities, without using any appropriate method of analysis. Furthermore, in current practices the adaptive reuse concept has been applied only from an architectural point of view, since projects in literature do not take into account participative decision-making, flexibility of the solution and the adaptiveness to the external context (the local community). Our project aims at overcoming these limits.

Generating a solution

The aim of our work is to promote a shift in the cultural heritage reuse field from a traditional top-down approach towards a bottom-up, socially inclusive one. In order to build a comprehensive and solid tool, we addressed all the phases of a decisional model: intelligence, design, choice as theorized by Simon (1960) and Newell and Simon (1972). The full coverage of all the phases with evaluation methods strengthens the effectiveness of the decisions since they allow to frame the problem in a more comprehensive way and to take into account all the possible aspects in advance.

1. *Intelligence*

The intelligence macro-phase is carried out through a Stakeholder Analysis, where the stakeholders of the project are identified together with their needs and expectations about the three castles considered in the case study (Montjovet, Ussel, Arnad castles). The main stakeholders involved in the project are:

- Soprintendenza/Valle d'Aosta region;
- Tourists;
- Municipalities and mountain communities;

- Touristic facilities;
- Local producers;
- Festival organizers;
- Cultural associations;
- Local communities or residents.

The output of this phase is the translation of stakeholders' expectations in requirements for the final solution. Requirements are the input for the following phase, Conjoint Analysis-Choice Experiment.

Workshop

2. *Design phase*

Conjoint Analysis-Choice Experiment (CA-CE) allows to investigate stakeholders' opinion through questionnaires and to obtain stakeholders' preferences over a set of attributes (Multifunctionality, Conservation, Exclusivity, Interaction and Cost), related to adaptive reuse scenarios. The result of CA-CE is therefore an order of preferences by stakeholders: the most preferred attribute for residents is Multifunctionality, while for tourists it is Conservation.

Taken into account those preferences, we designed two reuse scenarios aimed more at satisfying the needs of multifunctionality expressed by the local inhabitants (the Crafts University and the Showcase for local products), and two scenarios aimed more at responding to tourists' need for maintaining a good state of conservation of the castle's structure (the Museum & Temporary exposition and the Interactive Museum).

We decided to use Arnad castle as a pilot since the application of the tool was more likely to be successful (thanks to the high interest and participation of the surrounding community) and the realisation of the adaptive reuse could be less expensive given that the castle is not a ruin.

3. *Decisional Choice*

An innovative and sustainable evaluation process includes in its definition the possibility of stakeholders participation. To achieve such social requirement, a workshop in the Municipality of Arnad was organized, where concerned actors could intervene in the decisional process. Collected data were analysed through NAIADE (Novel Approach to Imprecise Assessment and Decision Environments, Munda, 1995) which is a suitable method for the treatment of quantitative and qualitative information regarding strategic decisions in the field of environmental policies.

NAIADE was useful to:

- order the alternatives on the base of a set of evaluation criteria;
- provide information on the relative distance among the various interest groups (convergence of interests, forming coalitions, etc.).

From the resulting rankings, it is possible to affirm that the most suitable alternatives are Museum & Expo scenario and Craft University. However, from a social conflict analysis, Craft University is the most critical in terms of target and accessibility -important criteria for stakeholders-, because such vision is not enhancing a large tourist flow since most of the time spaces are used for lectures. Finally, the output should be a combination of the winning scenario (Museum & Expo) with some of the interesting functions described by the other alternatives.

In conclusion, our case study application constitutes a positive example to promote analytically supported decision processes in the field of cultural heritage adaptive reuse; the adoption of such method, even if it requires an initial investment of time, can increase the social value of adaptive reuse projects and bottom-up participation to the decisions in a transparent and objective way. In conclusion, we hope ARCHe_Tool will promote a wider use of analytic evaluation methods in complex decisions regarding cultural heritage, making them more socially inclusive and adaptive.

WCM@FCA

New forms of work in the Automobile Industry: toward the Factory of the Future

Project

WCM@FCA

New forms of work in the Automobile Industry: toward the Factory of the Future

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Project description

Teamworking

New technologies and global competition are profoundly changing factories in Western countries. Beyond implementing new technologies, today factories need to redesign the content of work in order to combine three strategic objectives that have traditionally been seen as conflicting: being cheaper in production processes (despite a cost disadvantage in production factors compared to emerging and poorer nations), being better (in terms of the overall quality of the end product), and being faster in implementing innovation in the product and in the related production processes.
In this scenario, the WCM@FCA project has analysed some of the main challenges faced by Fiat Chrylser Automobile (FCA) to make factories smarter and work more sustainable in the combination of being cheaper, better and faster. Specifically, the project has analysed the organizing principles of World Class Manufacturing (WCM), the lean production system that FCA introduced in 2005. The challenges posed by FCA to the "ASPers" were two:

- Analyse how the principles of blue-collars involvement in continuous innovation could be fostered in order to make innovation part of the culture and the DNA of all the people in the factory. One of the characterizing traits of smart and lean factories is the suggestion system through which employees provide ideas for improving the stages of the production process in which they are involved. In this vein, FCA asked students to understand how the organization of self-directed teams of blue collars in the shop floor, and their related job rotation mechanisms, could foster their creativity and problem solving attitude in proposing and implementing new suggestion for continuous improvement.
- Analyse how the layout of the factory should be modernized in order to foster communication flows at the base of each innovation processes.

Students have conducted plant visits, collected data about communication and suggestions within teams of blue-collars, and have interviewed various roles in factories (i.e., blue collars, supervisors, technical specialists, WCM managers at the corporate level), have performed a benchmark analysis on the architecture of modern factories. Through their research process, students have developed a profound understanding of the context of "smart factories" and have been able to conceptualize some of their essential traits. Based on this knowledge, students have made some proposals for improving continuous innovation.

1. They have defined a framework for managing participation to continuous innovation within blue-collar teams. The framework identifies the variables that affect the most employees' creativity in giving suggestions and it may support managers in understanding how to intervene in order to foster the generation of innovative ideas.
2. A framework has been proposed for developing team leaders' self-efficacy and leadership attitude, since these preconditions are of utmost importance for the quality and the applicability of the improvement ideas proposed by self-directed teams.
3. A new WCM pillar for "communication & spaces" has been proposed,

and it is based on a set of Key Performance Indicators to manage communication flows and understand how such flows and the use of multiple media affect a team's creativity and its generation of ideas for continuous innovation.

Tasks and skills

- Marco Alforno led the analysis of communication flows and carried out a benchmark analysis on architectural solutions in the automotive industry.
- Nicole Blandin Savoia formalised the scope of intervention, the context and the related theoretical framework.
- Silvia Bucelli led the analysis of communication flows, carried out the focus group on media and information devices and set up the KPIs for the new WCM pillar on communication and spaces.
- Giacomo Levi led the analysis of the data gathered and designed the statistical framework for finding correlations and highlighting evidence.
- Alberto Nebiolo designed the questionnaires for gathering data and analysed the role of the team leader.
- Enrico Terzi along with Giacomo analysed the data and deeply focused on providing the theoretical framework for job rotation and suggestion system.
- Yimin Xu Yimin carried out a benchmark analysis on architectural solutions in the automotive industry.

Abstract

The ASP multidisciplinary project "New forms of work in the automobile industry: toward the factory of the future WCM@FCA" broadly aims at studying new technological paradigms and new forms of organization in manufacturing contexts, with a particular focus on the automotive industry. To understand how to increase productivity, quality and cost efficiency, the team has been required to understand the long-term trends in strategy, technology and organizational forms that are relevant to the future of the automobile industry.

The implementation of World Class Manufacturing programs in FCA plants has represented the setting of the research. Concerning this specific subject, students have been asked to analyse the current state of application of organizational innovations such as WCM principles and practices in FCA plants, to study the problems of replication of WCM best practices across plants, to determine the evolution that WCM application should take in the future depending on industry changes, as well as on specific plants' conditions, by looking at how the workplace should be redesigned and employees' skill profile changed.

The World Class Manufacturing is a real integrated production system, already deeply developed with respect to the most "traditional" manufacturing aspects, spread among ten technical pillars. Anyway, especially in regard to the 2020 horizon and the Factory of the Future topics, the manufacturing companies cannot leave out of consideration the support of technological tools and devices for the carrying out of their activities. Technological innovation is not enough if only applied to robots and manufacturing machineries, but it can represent a strong support for the everyday practices of a plant.

Through leveraging new organizational models, innovative layout frames, technological clouding/online platforms, this project aims at providing feasible solutions to enhance workers involvement, productivity and contribution to continuous improvement.

Overall aim of the project is the individuation of standard organizational best practice frameworks based on the analysis of selected model plants, Giambattista Vico in Pomigliano d'Arco (Fig. 2) and Avv. Giovanni Agnelli Plant in Grugliasco (Fig 3), through the understanding of the feasibility and applicability of proposed solutions in different productive environments.

Vico plant (Pomigliano)

Understanding the problem

As mentioned above, focus of the project research is organizational innovation and how this can heavily affect company's performance. In fact, over the last two centuries, from Fordist factory model on, the problem of workers' perspective about their work life has increased at a fast pace. Lately, important steps ahead in work redesign has been taken. The perspective for the evolution of work model mainly in the factory environment was the overall business efficiency and effectiveness. Thesaurus more complex the work model became, the grater the focus over workers' experience rose, but again, in such a way to improve workers efficiency and reduce the likelihood of mistakes. A clear example of this focus is the introduction of Kanban techniques by the Toyota Production System. WCM, of course, is no exception since it is a production system whose hard variables are very well established and defined, with an increased complexity that often lead to greater stress for the workers.

AGAP plant (Grugliasco)

That is why starting point of the project was the survey 'Le Persone e La Fabbrica' promoted by FIM-CISL, carried out in order to investigate stress and other work-related emotions and social issues in FCA plants after 8 years of WCM introduction; the survey highlighted that in most of the plants there is a misalignment between the actual boost in factories performances and the expected boost in manpower satisfaction and perception of a better work.

It is clear how, in this scenario, the organizational aspect plays a fundamental role: team members profiles and involvement, team structure and features, team management, inner and outer communication are key aspects of this analysis; for this reason, a significant part of the project has been dedicated to organizational issues.

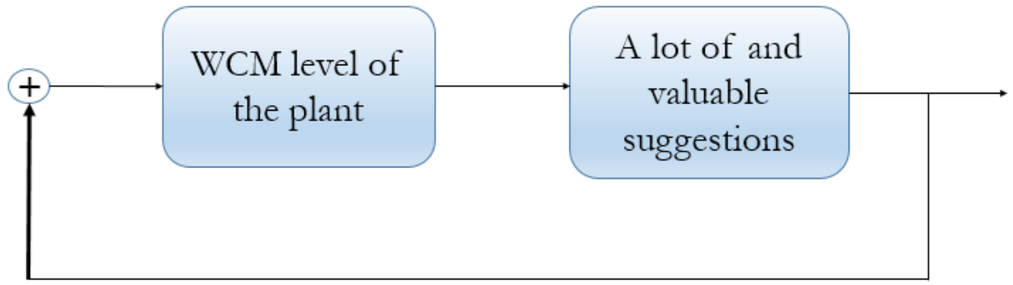
In order to investigate properly the topic we carried out AS IS analysis and arranged plants visits that have led the team to better understand the issue and to come up with a macro problem definition that articulates in two different fields of analysis that are strictly interdependent and complementary between each other.

1. **Job rotation and suggestion system**: takes place within the team and takes into account the variables strictly related to team (members, structure, features, dynamics…).
2. **Plant layout and communication flow**: considers the upper process (from team outward) thus focusing on variables that directly or indirectly affect communication processes.

Exploring the opportunities

Job rotation and suggestion system

Participation of blue collars to the **continuous improvement** of the plant



Positive feedback system

and of the company is one of the key pillars of WCM philosophy and it has held a key role for FCA over the past years. One possible tool to maximize it is the **suggestion system**. This mechanism is modelled as a positive feedback system (Fig. 4).

The research aimed at identifying relevant parameters to enhance this process, and at constituting a **structured framework** to be known and properly managed by the company. In the first place the correlation with **job rotation** has been hypothesized, both studying the literature and interviewing workers and team leaders on the field. The field analysis has been carried by observing for 4 domains (48 blue collars in total).

Plant layout and communication flow

After the understanding of the variables impacting on the generation of suggestions, it has been necessary to leave the boundary of the WCM team, to analyze the effectiveness of the information flows along the whole production lines and to understand how physical spaces and communication tools can enhance the spread of informal and horizontal (opposed to the vertical and hierarchic) information flows. ASP students have analyzed the aspects that can ease the communication among technical staff and workers through a field analysis, interviews and focus groups, parallel to a literature review about social networks and media theories, as well as benchmark analysis of architectural solutions implemented in manufacturing factories.

Generating a solution

Framework for the improvement of the suggestion system

The first identified solution proposes a new framework to address the management of the different variables. Exploiting this tool, companies will be able to maximize the output of their suggestion system.

First, there are **individual characteristics**, such as age, education and proactivity.

Secondly, we identified **team-related** variables. They represent the dynamics of the team and its propensity toward suggestions.

Lastly, we have the **plant environment and top management support**, for which a rough unit of measure can be the WCM score of the plant itself, and that is highly dependent on managerial strategies and perspectives.

The three layers have different impacts on the suggestion system.

This means, to a first approximation, that the individual level is less influential than the team one, that in turn impacts less than plant environment- related variables. This statement is confirmed mainly by literature [a], [b] and is corroborated by the qualitative analysis performed through interviews to the blue collars.

It is therefore on the last two layers that the management should focus its time, attention and resources. Nevertheless, the analysis showed clearly

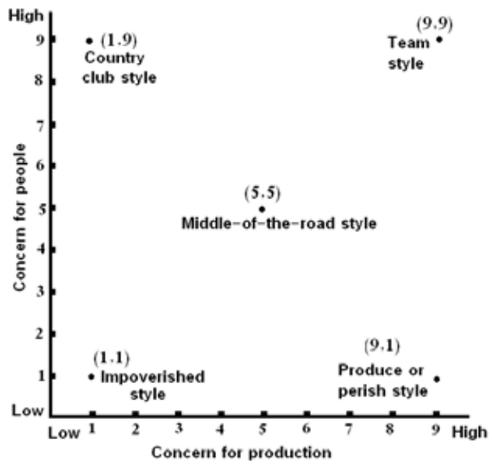
dominant trends in the suggestions- age correlation, with an unexpected drop close to 40 years of age, that is explainable looking at the story of Pomigliano in recent years.

Of course, the number of suggestion is supposed to be monitored at least yearly. The ideal index to measure the proactivity would integrate the number and the quality of the suggestions, the latter being measured by savings, for example.

A useful information about the propensity to suggesting could be derived via **creativity tests** to be administered at least each time the car model to be assembled changes [c]. They are specific for assessing the innovation potential along several dimensions (openness to experience, conscientiousness, extroversion, agreeableness, neuroticism) of the personality and can provide advice on how to improve them.

Once available a performance index for each blue collar, this can be exploited to build new teams, in particular mixing best with least performers, and older with younger people. This mix enhances the training of more propositive and experienced people toward the others, specifically the younger and less expert ones. Other variables such as gender, absenteeism and education show a negligible influence on suggestions, so they are less relevant in this phase.

From a practical point of view, when problems are detected within a team as for the number of suggestions, three corrective actions are applicable, in growing order of impact. First, it is possible to provide teammates with a specific workshop on suggestions and creativity, in the second place a more stimulating team leader could be appointed, and last, if the performances are really critical, the team could be rearranged with other blue collars.



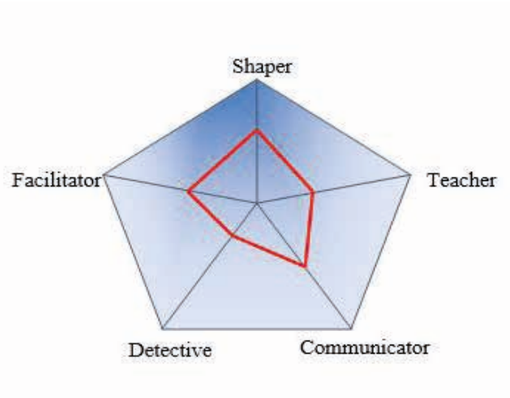
Blake-Mouton Managerial Grid Model

Team Leader Empowerment

Given the critical role of Team Leaders and referring to Blake-Mouton Managerial Grid Model (1964), Team Leaders should be extremely focused on both production and team members caring, approaching the “Team Style” (Fig. 6).

The Grid, though, has been revised by rethinking of the 5 souls of Team Leaders, accordingly to the project team research. This model ideally foresees the best Team Leader to fully score on all the 5 dimensions (Fig. 7)

- Communicator. Since team Leaders are the *trait d’union* between the team and supervisors, they should be assisted by professionals in providing effective and transparent communication in both directions.
- Teacher. Communication training for Team Leaders is required, so to teach team members how to correctly perform their activities on-the-job, leading to less errors and easier reaching of quality goals.
- Detective. To improve Team Leaders’ analytic skills and to spot work station technical issues and aftermaths, case studies should be provided periodically plus monthly meetings among Team Leaders for sharing

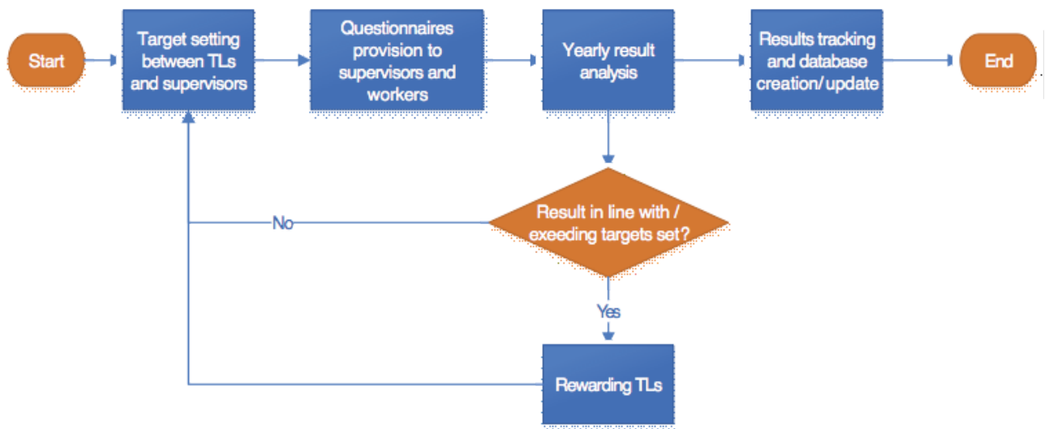


Team leader dimensions

experience in relation to how issues have been detected and learning from peers' experience.

- Facilitator. HR department should train Team Leaders on managing workers mental fatigue, stress and cohesion, leading to a lighter work environment which let workers calmly focus on their activities, improving performance and morale. The meetings mentioned above will be extremely useful for sharing team management experiences.
- Shaper. To empower workers and connect their sense of identity to the collective one of the firm Team Leaders need to be trained for being a role model, challenging workers to take greater ownership for their work by specialist in cultural change and role modelling

The development & rewarding of Team Leaders is tracked in the flow chart (Fig. 8), in compliance with the WCM Suggestion System philosophy.



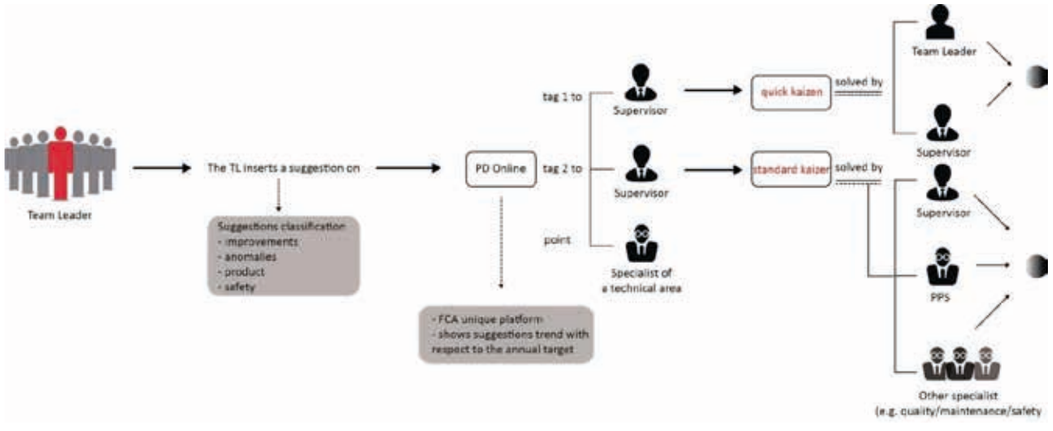
Development and rewarding of team leaders

The WCM pillar of spaces and communication

Apart from vertical, formal communication flows, **informal** and **horizontal** links can be individuated among blue and white collars, specifically among the team leaders, the supervisors and the product - process specialists.

The **WCM 21st pillar** has been identified after the understanding of the immense number of communication acts present in a plant, with the aim of analysing and managing the way people communicate, which tools they adopt as support and the capabilities this media have, as well as which requirements the communication places should present in order to foster

Sociogram of a Social Network



communication, which have a crucial importance in the generation of suggestions and then in continuous improvement.

This pillar is structured according to the World Class Manufacturing *reactive*, *preventive* and *proactive* approach, starting to define space and communication standards from a model area up to the spread to the whole plant.

All the people involved in a communication act represent the **nodes** of a **social network;** they are connected through links and they are represented through graph called **sociograms (**Fig.9**).** Their communication flows can be measured through:

- direct observation;
- questionnaires;
- oral interviews;
- analysis of the agendas and the emails;
- *sociometers*, badges with a microphone, an infrared transmitter and accelerometers to measure the number of people met and the length of the conversation.

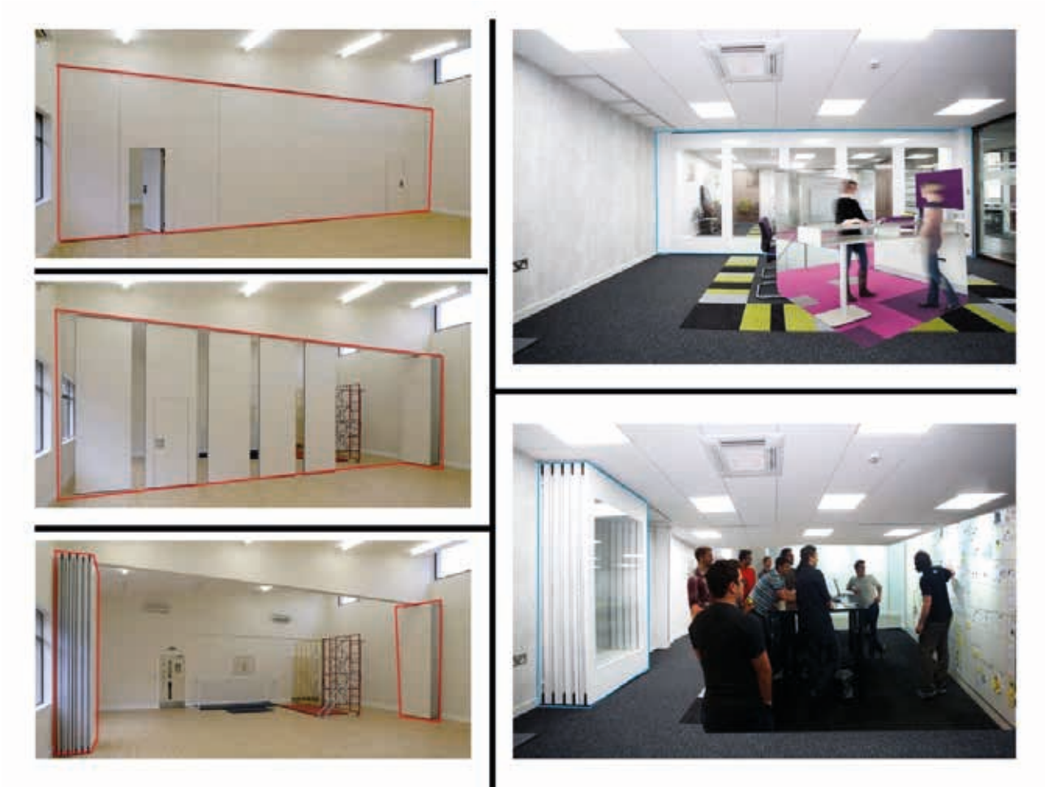
Meaningful KPIs for this pillar could be:

- the **size** of the network (the number of workers involved in a communication network);
- the **density** of the network (actual number of ties in the network over the potential number);
- the **direction of the interaction**;
- the **intensity** of the communication (number of communication acts in the temporal unit);
- the **centrality** of a node in the network.

Instead, the capabilities the support media can have are:

- **immediacy of feedback** (ability to give rapid feedbacks);
- **parallelism** (presence of simultaneous conversations);
- **reprocessability** of a message.

Cloud and tablets in the diffused office



Meeting rooms with flexible layouts

Potential standard layout and communication solutions that the new pillar should include to foster communication could be, for instance, **Cloud & tablets** (Fig. 10) and **Meeting rooms with flexible layout** (Fig. 11), made by movable elements in order to resize and subdivide the room when needed.

This 21st pillar thought in a manufacturing context can be applied to every new sector with the aim of applying the challenges proposed by the factories of the 2020 horizon.

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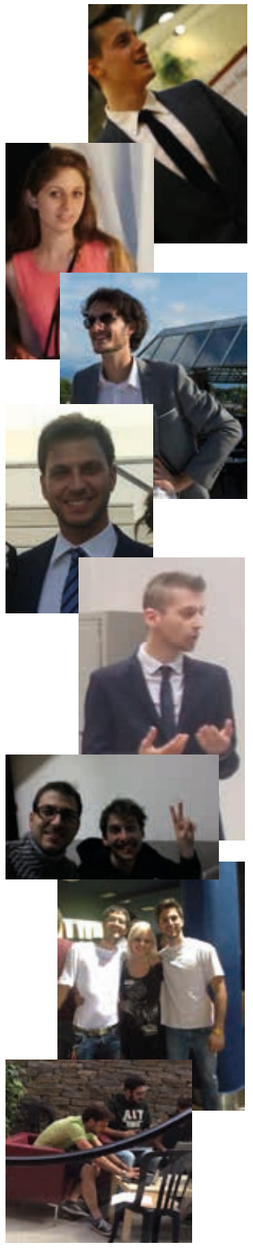
PASL

Pushing Athletes to Safe Limits

Project

PASL

Pushing Athletes to Safe Limits



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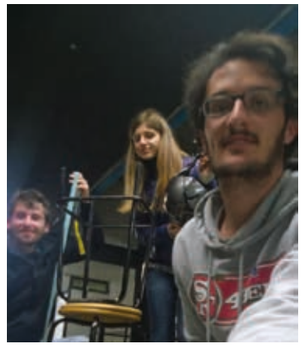
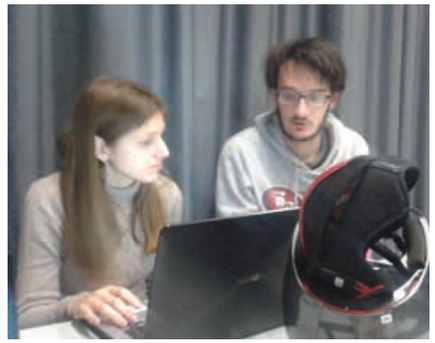




Project description

Sport-related traumatic brain injuries (TBIs) are one of the most serious accidents professional and amateur athletes can experience, both in terms of clinical risks and rehabilitation times. Furthermore, full and complete recovery rarely happens, mostly because the provided treatment is not specific for the particular occurred trauma, due to a lack of information about the dynamic of the injury and of quantitative parameters for its characterization. This problem affects of course athletes' performances and careers, but it has also severe side effects on their daily lives and in the worse scenario can lead them to experience emotional problems as depression and a great difficulty in social integration.
At the current state, the adopted strategy aims just to prevent TBIs, basically with the usage of helmets, but there are not systems or products trying to support or enhance the effectiveness of treatments when a TBI occurs. In this context, sport engineering is proving the most reliable approach in proposing proper solutions and effective methods to face the great challenge of sport-related TBIs. Therefore, the main goal of PASL project is to exploit sport engineering philosophy, thanks to a multidisciplinary team of engineers, to provide a concrete tool that can actually go beyond the simple prevention of concussions and give support for their treatment.
The project wants to reach a solution which is as versatile as possible. Therefore, it targets all sports where head impacts can occur and where there are already adopted strategies for their prevention, i.e. where the usage of helmets is mandatory (like in American football or ice hockey) or strongly recommended (like in alpine skiing and biking). In particular, the work of the team was focused on the enhancement of the functions of traditional helmets, creating an innovative class of helmets which do not just protect from impacts, but also record them and monitor their effects, choosing the right set of parameters that can quantitatively describe a concussion.
All this work was possible thanks to the use of microelectronics and embedded systems. Indeed, MEMS sensors are already used in different fields to measure a great set of physical characteristics like accelerations, velocities or forces. Moreover, the feasibility of inserting a network of sensors inside a helmet to accurately measure impacts was assessed, in order to better understand how to realize the sensors-equipped helmet. This evaluation was made as a relevant part of the project through numerical simulations of different types of impacts. Lastly, the project has involved the realization of a functioning prototype which is able to work in different modes.

Tasks and skills

Nicolò Magri: Biomedical Engineering, Politecnico di Milano [Communication Coordinator]. He worked on the analysis of state of the art and existing

solutions, identifying the clinical parameters of TBIs and the requirements of the solution.

Giacomo Ripamonti: Nanotechnologies for ICTs, Politecnico di Torino. He took part in the choice of the proper sensors and electronic components, he developed together with Debora the firmware for the microcontroller, he managed the interface between the embedded system and the PC software designed by Gianluca and he took part in the final tests.

Debora Russo: Biomedical Engineering, Politecnico di Milano. She developed together with Giacomo the firmware for the microcontroller for the management of the sensing network, implementing different working modes. She also took part in the experimental validation of the prototype.

Gianluca Scolfaro – Biomedical Engineering, Politecnico di Milano

He developed the Graphic User Interface in order to guarantee a clear and easily visualization of data from sensors. He took part in the experimental validation of the prototype.

Matteo Tratta: Civil Engineering, Politecnico di Milano [Team Controller]. He carried out computational Finite Elements analysis for the evaluation of the mechanical behavior of the used helmet and to establish the right positioning of the network of sensors.

Abstract

Traumatic brain injuries (TBIs) are nowadays a widespread issue in sports, both at the professional and at the amateur level. The severity of their consequences and the difficulty for athletes to fully recover in their sports and daily lives have convinced public opinion that prevention can not be the only strategy to face this problem. Indeed, reducing the possibility to experience concussions just decreases the total number of TBIs, but it does not have an added value to treat them when they occur.

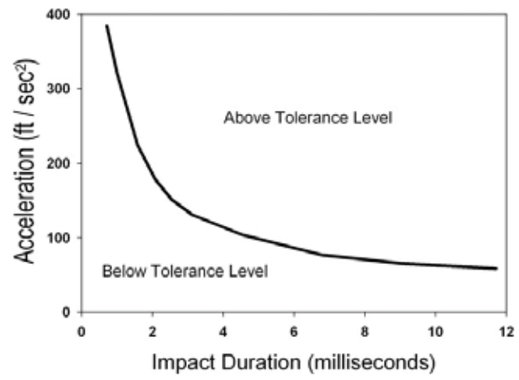
Therefore, the aim of PASL project has been the enhancement of the traditional function of sport helmets of protection from impacts integrating them with an embedded system to track impacts and monitor their temporal trends. Indeed, thanks to a deep analysis of the state of the art, it has become clear that the intensity of the blow is not the only relevant factor to establish if the impact causes a TBI or not, but also the duration of the blow itself has a strong correlation to TBIs. Therefore, it was fundamental to make a network of sensors that could measure intensity and duration of impacts. Moreover, the realization of such a tool had to respect stringent requirements related to the proper functioning of this system during sport performances without interfering with them.

For this purpose, PASL team proposed an embedded network of sensors made by five linear accelerometers and one gyroscope controlled by a microcontroller and integrated with an on-board memory and a battery inside the helmet. This led to the creation of a stand-alone system which is able to both protect by impacts, as traditional helmets do, and measure them, recording data in a memory or sending them to a different device for real-time or further analysis, thanks to a user interface developed by the team. Furthermore, the feasibility of inserting a network of sensors inside a helmet to accurately measure impacts was evaluated as a relevant part of the project through numerical simulations of different types of impacts.

As a final result, a working prototype was realized and tested. The obtained data were then compared with the results of FEM simulations, with the aim of validating the numerical model.

Understanding the problem

Clinically speaking, a traumatic brain injury is defined as an event involving an injury to the head due to acceleration/deceleration forces that produces an immediately apparent disruption of brain function and/or structure [1]. Not all blows or jolts to the head result in a TBI, but it only occurs when the shock received by the head goes beyond a specific threshold. The brain injury thresholds in a biomechanical analysis are set as a function of linear and rotational accelerations of the head under a shock. Moreover, the magnitude of linear or rotational acceleration itself is not the only factor that determine if an impact may cause a TBI or not, since possible damages depend both on the force impressed by the hit to the head and on the time during which this force is imposed. The correlation between the magnitude of the impact and its duration can be described by a hyperbolic function that represents the threshold through which one can classify and distinguish tolerable and not tolerable impacts to the head (Figure 1) [2]. Therefore, it is clear that it is crucial to evaluate not only the intensity of the impact for a correct discrimination between not risky traumas and TBIs, but also its duration.



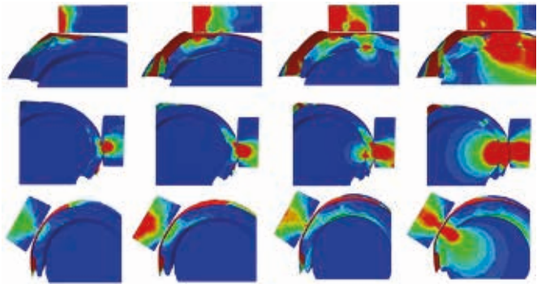
Hyperbole identifying impact over tolerance level according to acceleration and duration, by Greenwald et Al. [2].

Concerning the realization of a possible solution which is able to monitor and measure impacts during sport activities, there are a set of technical requirements to take into account. First, the solution must not interfere in any way with athlete's movements, so all its required functions can't rely on external tools in terms of energy supply, and it has to be limited in size. Furthermore, the solution has to actually measure the relevant parameters (intensity of the blow and duration) to evaluate if a TBI occurred in an accurate and efficient way, using the best sensors for this application. Then, since this project targets all sports where head impacts can occur, the final solution is required to be multitasking, working in different modes according to the specific sport. Lastly, all the exploited resources have to be optimized, in order to avoid redundant information and to minimize energy demand.

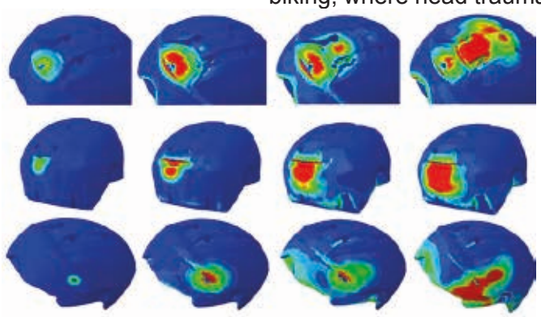
Exploring the opportunities

At the current state of the art, there are few existing solutions in the market to monitor impacts during sport activities, mostly in the American market, and specific to few sports, usually American football or ice hockey. These products can be divided into two categories: portable boards equipped with sensors that can be attached on the helmet, or helmets in which sensors are inserted into their structure. Considering the first kind of product, it is clear that the same device can be used with different helmets but it can suffer of helmet compatibility problems. Moreover, since generally it is positioned in correspondence of the top of the helmet, it measures helmet impacts and not the effects on the head. With regards to the second kind of product, instead, it reveals head impacts but lacks in the capacity to spread to other sports. Considering the communication of hits data, all the available products in the market use wireless communication. Furthermore, all products in the market are characterized by one working mode. Depending on the product final user, the hardware component is coupled with a software, which can be designed for a smartphone or for a computer.

After the comparison between these two different strategies, PASL team decided to focus on the development of a system to be integrated in an helmet in order to detect and record impacts, but that could also work in different modalities according to the specific sport. Therefore, the first step was to determine the correct position and number of sensors inside



. FEM results of wave propagation across the layered thickness at 0, 0.5, 1, 1.5 and 2 ms. Top: upper impact, middle: rear impact, down: lateral impact. Max stress=0.5 MPa (traction, in red), Min stress=1 MPa (compression, blue)



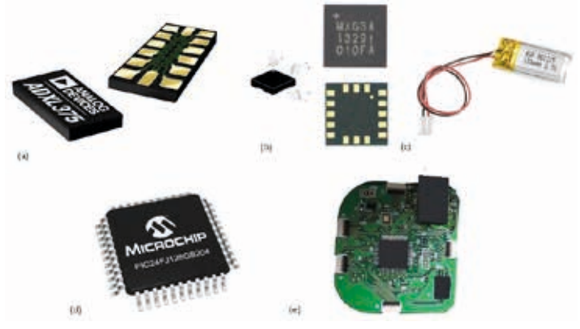
FEM results of stress field of external surface of EPS foam at 0, 0.5, 1, 1.5 and 2 ms. Top: upper impact, middle: rear impact, down: lateral impact. Max stress=0.5 MPa (traction, in red), Min stress=1 MPa (compression, blue)

the helmet. For this purpose, different kinds of head impacts (upper, rear and lateral) were analyzed through numerical simulations using finite element modeling (FEM) techniques. Results gave information about stresses and accelerations distributions in the polycarbonate (PC) helmet shell and in the expanded polystyrene (EPS) foam between shell and head (Figure 2 and 3).

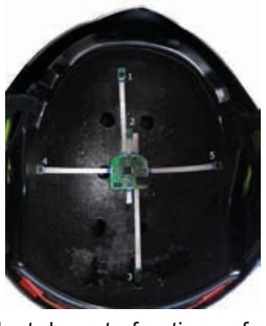
Then, the team focused on how the network should work according to the specific sport. The sports in which TBIs can occur were classified into two categories. In the first category there are sports, like ice hockey or American football, where head blows continuously happen during the game; in this case, the head impacts are on average rather mild, and therefore they are not often a cause of TBIs. Hence, in these sports it is important to monitor athletes all the time during their performance, and comparing the impact history to thresholds values. On the other hand, there are sports, like alpine skiing or biking, where head traumas are not frequent, but, when they happen, they often have severe consequences that require medical intervention. In this case, the athlete may be unconscious, so it would be really helpful to provide physicians with data about the dynamics of the impacts, previously recorded in a memory connected to the sensing system.

Generating a solution

The work carried out by the team led to the realization of a final solution, *Head Guardian*, an integrated network of sensors (Figure 4) that is embedded in the helmet. The electronic circuit was positioned in the EPS foam (Figure 5), in order to measure impacts close to the head. This allows a correct evaluation of the trauma experienced by the athlete despite the damping of the impact due to the action of the helmet. The measuring system of the circuit consists of five linear accelerometers, which measure linear accelerations, and one gyroscope for the measurement of rotational speed. These sensors belong to the family of MEMS (Micro Electro-Mechanical Systems), which are small in size, are able to detect high levels of linear accelerations and rotational speeds, and are capable of sampling the analog information at high frequencies.



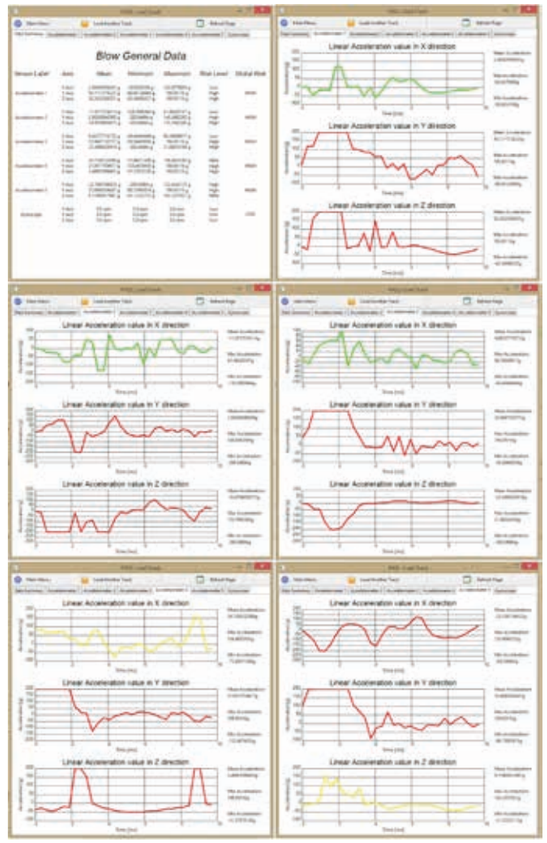
Electronic components of the integrated circuit. (a) linear accelerometer (b) gyroscope (c) LiPo battery (d) microcontroller (e) FLASH memory.



This allows the detection of impacts that last down to fractions of milliseconds. The number and position of the sensors were decided following the indications provided by the FEM simulations. All the sensors are controlled by a microcontroller, which can be programmed to manage the sensing network in different ways. In order to make the circuit energy independent, it is powered by an integrated Lithium-Polymer battery. This kind of battery is rechargeable through a wireless inductive mechanism. Moreover, the system includes a FLASH memory for data storage and a Bluetooth module to wirelessly send data to a PC. In addition to the development of the hardware part, a Graphic User Interface was developed, in order to provide a user-friendly application for the data analysis (Figure 6).

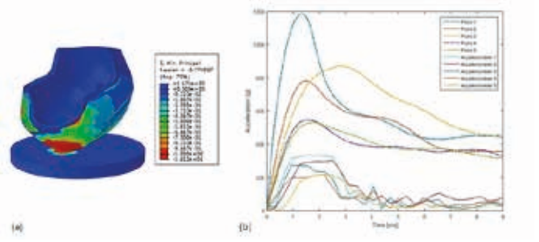
Since *Head Guardian* is a versatile tools suitable for a wide range of sports, it can work in two different modalities:

1. *Real-time* connection between the network of sensors and a remote interface to allow the constant monitoring of the impacts that an athlete is experiencing. This function is useful in sports like American football or ice hockey, where head impacts occur frequently and there is the need to constantly monitor the conditions of athletes: this allows a quick intervention in case of potentially dangerous head impacts.
2. *Black-box* mode: the data are recorded in an on-board memory, and they can be downloaded to a PC or to another device later on. This mode is excellent for sports that do not involve frequent head impacts, like cycling or alpine skiing. In addition, in case a TBI occurs in these sports, it is often related to a serious accident that requires help and ready intervention. Downloading from the device the data related to how a head trauma occurred can help physicians and medical staff who have to treat unconscious patients or subjects who are experiencing a state of amnesia.



Picture of the network of sensors inserted in the EPS of the prototype.

A working prototype was built using a ski helmet and it has been tested, in order to evaluate the efficiency of the sensing system and to have a correlation with the results coming from the FEM analysis. Results highlighted the correct functioning of the prototype (Figure 7) and provided valuable suggestions for further improvements aimed to the industrialization of the prototype.



Screenshot of recorded impacts showed by the User Interface.

Prototype validation. (a) Geometry of the validation test and numerical results. (b) Comparison between numerical simulation (dashed lines) and experimental measures (continuous lines)

Main bibliographic references

- [1]. Marr A, Coronado V.G., *Central Nervous System Injury Surveillance Data Submission Standards,* **National Center for Injury Control and Prevention,** 2002
- [2]. Greenwald RM, Gwin JT, Chu JJ, Crisco JJ, *Head Impact Severity Measures for Evaluating Mild Traumatic Brain Injury Risk Exposure*, **Neurosurgery**. 2008 April; 62(4): 789–79

CAPs

Cre-A(c)tive-Places

Project

12

Creativa
stazione

CAPs

Cre-A(c)tive-Places

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Project description

In contemporary society and, consequently, in its city, innovation is one of the main aspects. The innovative capacity is directly tied to the creative ability as a manifestation of attitudes and cultural values. Today creativity involves multiple disciplines such as economics, politics and sociology. This is particularly relevant in a moment in which creativity and its related activities are considered as a resource for the development and transformation of the city, thus defining a new paradigm of strategic urban planning oriented to the reactivation of urban reality through a variety of "creative actions", which a multidisciplinary project aims to investigate and test with study cases.
The main objective of CAPs project was to investigate processes of creative clusters generation, with particular attention to hybrid spaces, with a strong contamination of streams and functions, their role in the re-signification of the abandoned places, and of the medium or small urban realities involved in weak contexts and distant from the main creative circuits.
The project aimed to experiment new models for the creation of hubs and new services which are capable of becoming meeting places between creative minds, entrepreneurial actors and citizens, capable of triggering processes of change and development in cultural, social, technological, economic and productive terms, a model that is replicable and at the same time adaptable to different urban contexts with a sustainable economic point of view which can produce significant social benefits for the community.
The objective was to define strategies, operating assumptions, scenarios,

study of feasibility for the development of innovative incubators which are able to become attractors of operating talent in the field of creativity, and, at the same time, to identify the necessary conditions for the activation of the processes of incremental change of the places which, through the phenomena of urban creativity and practices of sustainable urban development, allow the creation of innovative experimental cluster.
The recent changes in the creative and cultural industries, pose new demands of space, work organization forms of interaction and collaboration, networks, infrastructure and intangible assets that require effective and to some extent “revolutionary” responses, that can lead to new models of intervention that can be reproduced from the national to the international scale.

Main Achievements

1. The construction of a repertoire of significant cases of hubs, incubators and creative clusters in Europe and in the world in order to understand the logic, dynamics, implications and effects;
2. The experimentation of interdisciplinary and multi-scale processes, network framing in strategies;
3. The development of pilot projects, strategies and actions aimed at the creation of new creative hub in and complementary actions (living labs / action labs) weak contexts;
4. The definition of the framework of social and economic feasibility of the project;
5. The definition of scenarios on the possible / probable / expected effects of the project in terms of urban regeneration, re-signification of places, reactivation of “life” cycles.

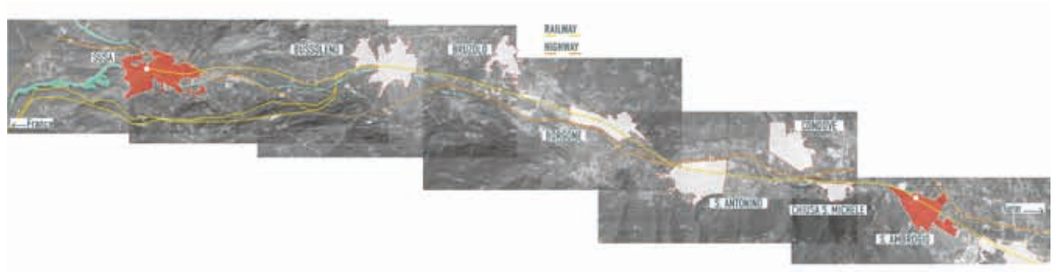
Team A: STAZIONE CREATIVA

Tasks and skills

Violetka Slavova: actively participated in all the project phases giving contribution both in the research part and in the system proposal. She gave particular effort in developing the ideas and concepts behind the project, framing and coordinating the team’s activities as well. Furthermore, she held the presentation of the project in both the midterm review and in some external activities as the contribution to Area Odeon with Ivanka. For what concerns the report she particularly curated the theoretical explanation of creative production as well as the craftsmanship and maker movement sections connected to the innovation in the production system.
Francesco Munì: as management engineer, studied subjects like project management, marketing and strategy during the Master degree. He applied the knowledge coming from these courses to the project in building a business plan, performing the market analysis, creating the business model, the financial strategy and evaluating its economic feasibility.
Anica Andric: dealt with a contextual analysis considering the terrain analysis so as the creative spaces analysis. After this initial phase she developed the web platform of the project including both the site structure and its graphic design.
Chiara Cuatto: worked actively since the beginning with the other architects of the group developing and structuring the main idea. Being originally from the Val di Susa, she then contacted the municipalities and institutions on the territory, organizing and holding the public presentations. She managed the contacts with the GAL, CNA and FabLab Torino as well as the creation and spreading of the online questionnaire. On the theoretical point of view she developed the communication strategy, structured the layout of the report and cured the graphic design and image of the project.
Ting Zheng: as a management engineering student, used the knowledge from business innovation and marketing to structure a competitive analysis in the market as well as the market planning which constitute part of the business model.
Ricardo Alexis Nader: has been involved in the definition of the main framework of the project and the research on related topics of community making and user centred design, which includes the investigation of similar case studies for the designed system.
Regarding the project, he contributed in the concept generation and idea development in each phase. For what concerns the report, he particularly curated the kick-off activities and the communication of the project, branding and website simulations in the different sections and phases. Additionally, he used his competences of video making for the presentations.
Ivanka Ivanova: as part of the architects in the team, was part of the research and concept development of the project in all of its stages. Together with Violetka, she held a public presentation at Area Odeon, in Monza and had an open discussion on the problems that could appear when passing from theory to reality.
In the final report she was responsible for the final development and description of the reactivation process applied in the seven stations and to create the system to connect them. She structured in detailed the steps of the project and also imagined possible future scenarios.

Abstract

The definition of the Cre-Active Places (CAPs) project brief is a challenge in itself: to empower creative production in a creative way, by activating an abandoned place outside of large metropolitan context, while simultaneously actuating a communication platform to support the reactivation by establishing a critical mass of participants in the project.

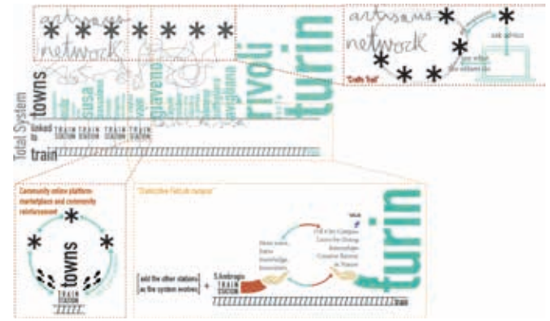


From a theoretical standpoint, CAPs enters within the broader discussion of the creative cultural industries (CCI) sector and its potential to ignite and maintain sustainable economic regional development by tapping into people’s capacity for innovation and entrepreneurship. It tackles the urgent need to understand the importance of stimulating the creative economy, which has ultimately proven itself as one of the world’s most rapidly grow-

ing sectors not only in terms of income generation, but also for job creation and export earnings.
CAPs' project tries to promote this new sustainable approach in the specific context of the abandoned places. Instead of building new structures over and over again, it could be learned to use for a second time what already exists. Having abandoned buildings in cities or in their neighborhoods is not only a waste, but it also brings troubles, that, in a long term perspective, becomes costly for the public sector.
CAPs team wants to create an efficient process to reuse abandoned structures, with the participation of local communities that will be able to affect or even contribute with projects and ideas on an online platform. The main purpose of the project is to elaborate a strategic model for the reactivation of abandoned places through creative activities and production that will be developed through both digital and physical expedients.
Creative infrastructure is a combination of hard and soft. The latter includes a city mindset, how it approaches opportunities and problems; its atmosphere, incentives and regulatory regime. To be a creative city the soft infrastructure must include: a highly skilled and flexible labor force composed of dynamic thinkers, creators and implementers. Creativity is not only about having ideas, but also about having the capacity to implement them.
Team A responded to CAPs challenge, by choosing to develop not only a single site but a territorial system of towns in Val di Susa, Italy; we based our decision on the actual availability of the abandoned train stations of the towns in the valley, given on concession by RFI, that allowed us to deploy the CAPs model on a territorial scale.
After a careful analysis of the problems and assets of Val di Susa, our team decided to focus on the cultural sector of crafts and artisan production because it is well-represented at the location (4182 individual businesses). However, the sector needs to develop further in order to become a truly sustainable engine for future economic and social development of the region, which currently suffers low employment and lack of social activities. This analysis led to our project definition.

Understanding the problem

After a long research, we decided to work in Val di Susa [IMG.1, IMG.1A] because of the many factors compatible with the initial requirements of CAPs. We have an entire area which is connected by a train line with a series of abandoned stations that could potentially create the system we would like to achieve and economically the entire area is dying. On the other side there is a well developed group of artisan that gives us the great chance to create this reactivation through creative processes.
We started with a deep analysis of the area, selecting the part of the Valley which suffers more compared to the towns close to touristic attractions, like the skiing facilities. The seven identified towns [IMG.2] have been studied in terms of demography, location, population and activities related to the cultural sector. From this local analysis we realized an interesting, and useful, fact; even if the activities and job offers are decreasing in mostly the entire area, the population, since 2008, is increasing. This is probably due to the world crisis and the consequence rise of rents and life price in Turin, closest big city.
Through an online questionnaire handed out to the population (Valsusini) we then discovered a general perception of the Valley, described as beautiful but underrated with extreme potentials and no plans to value its treasures. Mostly everyone agreed on the necessity to increase responsible tourism and investments, as well as pointing out that the area lacks of youth activities, cultural offers and job offers. Small realities are actually dying as well as traditional commerce and industries, unable to keep up with the world production trend. As already mentioned the middle-lower part of the valley, the one in between Turin the skii facilities (Bardonecchia, Sestriere, Oulx…) is gradually losing everything apart from inhabitants, which in the other towns where the activities are more lively are decreasing.



Exploring opportunities

We then started a deep analysis of the creative industry, trying to identify the how to exploit the existing creative sector of the Val di Susa.
The dynamics of the contemporary world have brought about the knowledge-based economy[1] that moves away from the production of consumer goods, use of natural resources or low-skilled labor as primary driver for economic growth in developed countries. Although less tangible than the above-mentioned, intellectual capital (information and knowledge) has been recognized as an important asset: “more than 50 per cent of GDP in the major OECD economies is now knowledge-based.” This value is created outside the space of the factory or even the office floors of large multinational companies. A call for innovation has come about in all that is produced nowadays – from the most tangible realities like products to the immaterial – services, business plans and ideas in general, all of these put under the common denominator of creativity.” The creative sector builds upon culture and uses it as input to produce non-cultural goods.
Craftsmen, or artisans, have always inspired the collective imagination with an almost mystical romantic idea of nothingness being tuned into beauty by the human hand; it is the quintessential dream of human race as creators, makers. But this only to scratches the surface of a phenomenon that has been discussed and studied a lot because of the intrinsic values it offers to humanity.

Instead of keeping it on the romantic level of popular perception, the sociologist Richard Sennett searches deeper for what constitutes craftsmanship on multiple levels of philosophy, ethics and historical significance: “Craftsmanship names an enduring, basic human impulse, the desire to do a job well for its own sake.”[2]
Craftsmanship offers also very tangible benefits to society, craftsmen being natural entrepreneurs that need to sell their product to real clients. This artisan trait for producing quality objects and doing business is especially strong in Italy, which is famous for its crafts know-how.

Our team proposes a possible answer by introducing the craftsmen to the new digital fabrication technologies that have lately come to revolutionize the process of “making” to such a degree as to be labeled the third industrial revolution, the Maker Movement being its standard-bearer.
What digital fabrication tools have done is to essentially democratize production, making it possible for the average person to have an idea. What is even more important and defining for the whole process is variability at no additional cost. By employing algorithms and parameterization, the 3D printer has cancelled the need for using molds and would print no matter what file is fed into its system.

[1] OECD. “The Knowledge-based Economy.” Web. 16 Nov. 2015.
[2] Sennett, Richard. *The Craftsman*. New Haven: Yale UP, 2008. Print.

Generating a solution

From the analysis and the deep understanding of the craftsmanship and maker movement, our proposal is to unite them to enhance both parties by combining different knowledge. The idea is to attract the makers from the town to collaborate and work in a natural environment to share knowledge and benefit from the surroundings. The system will be composed by the interaction of different elements: [IMG.3] Turin and its makers; train representing the physical link between Turin and Val di Susa; the stations in which the cooperation between makers and artisan will occur; and the towns and their individual artisans’ laboratories; all of this will be glued together with an online platform that will give visibility and create a community for makers and artisans.
We are well aware of the problems that could come up, after meeting with the interested stakeholders we identified several issues that could mine the success of the project, for this we dedicated particular attention to those aspects to avoid failure.
The project will be divided in three steps, the prior to the start consists in promotion, teasers, community building, both online and offline [IMG.4], and the construction of a strong contacts network. In this phase the regular train will be used for promotion and we will not own our own yet. It is fundamental to create a strong basis and curiosity in the people to boost the initial activities once we start.
This step [IMG.5] is then followed by the starting phase which will be initiated by a kick-off event in the pilot station. A pilot station because it is impossible to think to develop the system all at once, so we decided to start from Sant’Ambrogio, first of the seven stations coming from Turin. After the kick-off event we planned several activities to start reinforcing the community of makers/artisans as well as the general community formed by the population; we need a critical mass of interested people for the project to survive. In order to do so we think to develop specific and nonspecific activities, like a crafts trail to meet the artisans laboratory and specific markets with products designated for artisans and makers. But in parallel to this we are aware we need to develop parallel activities to attract the inhabitants and create the creative environment we would like to achieve. To do so, we believe cultural events as well as recreational ones will work perfectly, in combination with fairs and food events.
To tackle the generational problem we believe that investing in the education and the youngsters will fill up the gap and reduce the possibility of unsuccess. So workshop in the schools and specific activities that involve artisans, makers and kids.
In this phase we will own a train, Treno Creativo, that will serve as promotion and events container.
After the definition of these detailed steps for the two initial phases, we also tried to think of possible scenarios, imaging three possibilities. Best scenario, the community grows and attracts interest from other stakeholders that want to replicate the idea in the other stations of the valley, the system enlarge and the model is replicated in other areas; the Treno Creativo will also leave the Valley entering other territories.
In the average scenario each station functions on its own but they fail to form a system. All the stations are developed and functioning but as autonomous elements. The offline community will function in each town but not on a territorial scale. The train would no longer be necessary, unless for its promotion purposes.
In the worst scenario only one station functioning and a few collaborators that are connected to it.

Team B: SearchTheChurch

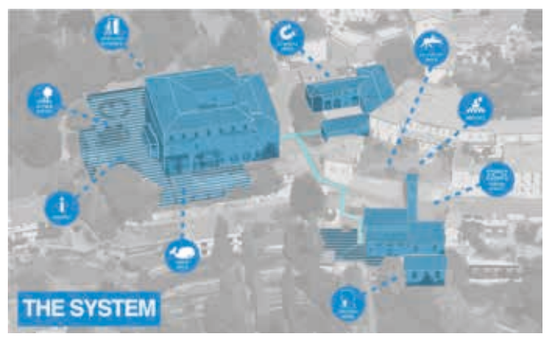
Tasks and skills

Lazar Belic: contributed to the project with the research about reuse of abandoned spaces, symbolic values of churches, and post-production of related data.
Sofia Celli: as an architect, has taken part to the research and analysis of existing case studies involving “crea(c)tivity” and has actively participated throughout the whole process of definition of CAPs Team B’s strategy.
Neri D’Alessandro: participated in the analysis of the creative production state of art. He contributed as an architect in developing the concept and layout of the platform.
Silvia Nelba: as a management-engineering student participated during the research phase and collaborated to the management part of the project.
Giulia Maria Palazzolo: as a management-engineering student, was responsible for the Business Model definition, using the Canvas tool, for its economical sustainability and for the budget allocation.
Rossella Moscarelli: as architect, has been involved in the designing of the strategy of the platform *SerchTheChurch* and in particular in the best way to communicate the project.
Jacopo Spinelli: contributed defining a general strategy of intervention in the preliminary phase. He collaborated as an architect in *SearchTheChurch* model in terms of service and of platform design.

Abstract

Innovation means trying to solve problems in a creative way. We want to face, with an innovative perspective, the issue of the regeneration and reuse, as well as the one of temporary use of abandoned or underused spaces, both public and private. The management of this task requires creativity, in order to generate a transformation that is not only morphological, but also social and cultural. In the last years, we have witnessed constant investments in new construction, leaving millions of abandoned old buildings behind.
This process has led to the phenomenon of land consumption in most of the world, but the recent economic crisis has stressed the problem even more, condemning new constructions to remain vacant.
The solution to this problem is taking an altogether new approach, according to which abandoned buildings are not to be considered

Preliminary Phase: partnership with the Municipality of Casciago Morosolo, context analysis



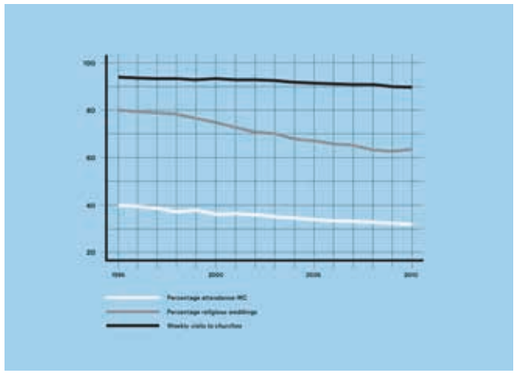
liabilities, but assets from which we should take the most possible advantage.
CAPs' project tries to promote a new sustainable approach: instead of building new structures repeatedly, we can learn to utilize what already exists. The presence of abandoned buildings in our cities or in our neighbourhoods is not only a "waste of space", but it also brings trouble, that, in a long-term perspective, becomes costly for the public sector.
Moreover, if we consider the economical aspect, it is more feasible to go toward reuse rather than destruction. Many cases show that the expenses of demolition are higher than those of restoration followed by the introduction of new functions.
Our CAPs team wants to create an efficient service to reuse abandoned structures, with the participation of local communities which will be able to affect the process and even to contribute with projects and ideas on an online platform. Benefits coming from the project concern both public and private investors and the team of reactivators. The first ones will be able to make a use out of the reactivated spaces, while the second kind of actors will be able to carry out their project, reaching their goal with all technological, professional, and financial support needed.
The main purpose of the project is therefore to elaborate a strategic model for the reactivation of abandoned places through creative activities and production that will be developed on both a digital and a physical layer.

Understanding the problem

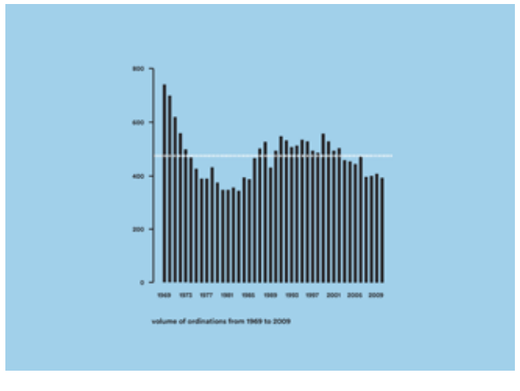
CAPs group B deals specifically with the creation of a network of small-medium size villages. Reuse in a big city context is always related to a dynamic economical system and to a structured critical mass. Dealing with small-medium urban environment is more challenging. In order to reach a proper critical mass, the first goal of CAPs group B research work, has been the creation of a network of different communities that could face a generic problem in a common way. In our operative model, to structure a network in the territory, we recognized in abandoned churches the core of underused areas.
Abandoned churches were identified as the first significant step towards a reactivation process because of their high availability on the Italian territory, because of the fact that they are already structured as a network, because of the central position they have in urban areas and, most of all, because of their memory value. Through the involvement of people and through the possibility to become part of a network under CAPs brand, abandoned churches could represent a new symbol for the citizens.
People awareness of abandoned realities will be risen using the participatory design event model.

Abandonment of churches, data to support the choice. Decrease of civil marriage

Abandonment of churches, data to support the choice. Decrease of participation in "Religion courses" at school



Abandonment of churches, data to support the choice. General decrease



Abandonment of churches, data to support the choice. Decrease of ordinations

Exploring opportunities

Churches are places of worship – which means that they are spaces where both church services and private prayer take place - but they are also places of memory. In fact, people often remember particular events, elevated for their lives,that actually happened in a church building (e.g. weddings, funerals, christenings…)
These features (churches as places of worship and of memory) carry an emotional value so strong that people connect churches not only with the religious institution, uplifting that specific building and that particular place to a precise significance. Therefore, these buildings become places of identity.

SearchTheChurch Service, actors involved

Nowadays preserving religious assets heritage is one of the main problems confronted by Church authorities, in Italy as well as in the whole European Community.
In fact, a new phenomenon arose in the latest years: the abandonment of churches or religious places that lost their previous function as places of worship. This event could be related to several reasons, from the simple closure to the public, to a formal decree issued by the ecclesiastical authority, and it opens different scenarios for the future. Religious buildings can in fact be demolished, sold or even forgotten and therefore, become a part of a slow degradation process. Alternatively, in the best cases, they can transform into something new, perhaps changing their function.

SearchTheChurch Manifesto

Differently form the past, this problem currently does not only affect religious communities, but also civil authorities and public opinion. In fact, these actors are very sensitive to the protection of the artistic and historical heritage of the country and, as explained before, churches constitute a relevant component and an irreplaceable testimony of the historical memory and of the culture of communities.
Our project started by setting a specific partnership with the abandoned Church of S. Giovanni owned by the Municipality of Casciago Morosolo; afterward we enlarged our vision *moving from local to global scale,* looking for a general strategy.

Example of abandoned Church

Example of reactivation

Generating a solution

SeachTheChurch service and its web platform.

SearchTheChurch is a crowd-sourced project, which aims to create a valuable database of abandoned churches and to reactivate this heritage establishing a link between unused spaces and spatial demand for compatible creative and productive activities.

SearchTheChurch motto “tell us what, we know where; tell us where, we know what” is a declaration of intent. CAPs team B wants to enable people to interact proactively with their context, boosting their awareness on possibilities they can exploit and subsequently transforming a set of information into innovative reuse’s processes with a set of simple tools.

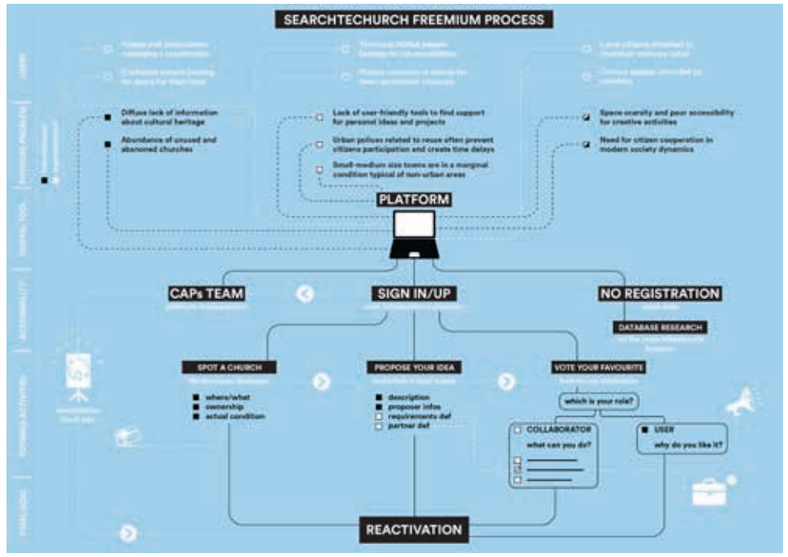
The first goal is to create a shared database with the contribution of every user, collecting the position and the characteristics of abandoned churches through *SearchTheChurch* Web Platform. This will for sure create a rich set of easily accessible data that will be valuable for everyone. Moreover, every reactivation project hosted in the platform will benefit from *Search-*

SearchTheChurch web platform

SearchTheChurch web platform, browsing churches

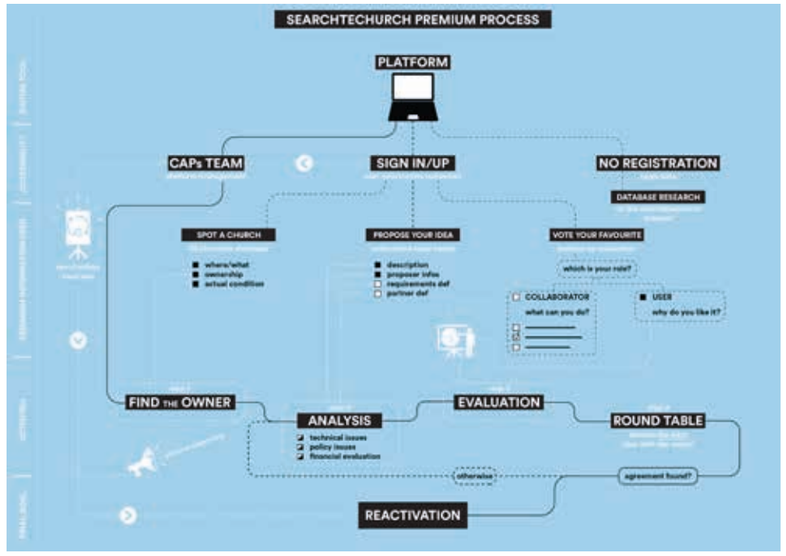
TheChurch network, which will increase its visibility and will offer the possibility to find similar projects on the website, allowing the user to learn from others’ experience and to set useful partnerships.

The second goal is to trigger a process around collected data, using the same platform to match the availability of abandoned buildings with the needs of people, involving them at different levels.



SearchTheChurch Freemium Model Diagram

There are already several examples of ancient churches that have been brought to a second life. Other reactivation platforms such as “ImpossibleLiving.com” or “CityHound Project” have already tried to accomplish a mission similar to ours. The main weakness here is that all these solutions

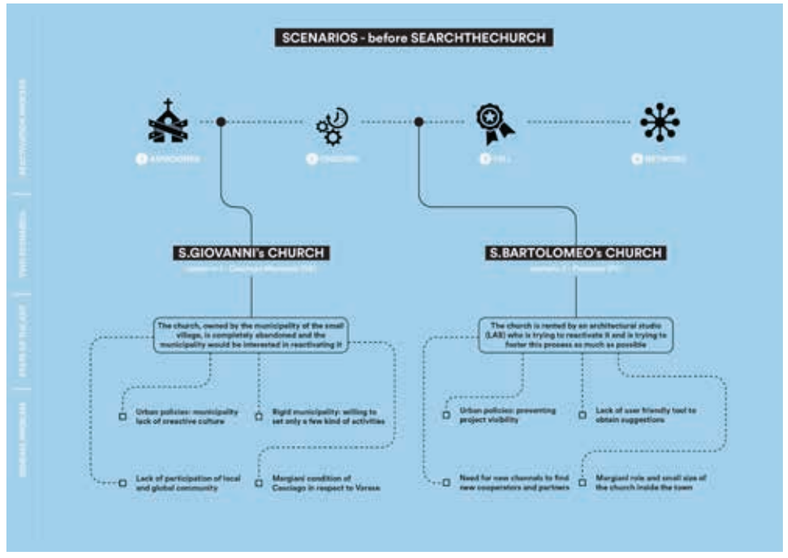


SearchTheChurch Premium Model Diagram

only come up with stand-alone reactivation episodes without trying to create a link between them nor to build a network among them. The shared database described above will allow CAPs team B to create a potential network of reused churches, useful to share not only ideas but also real resources in terms of knowledge, experience, stakeholders, partners and opportunities.

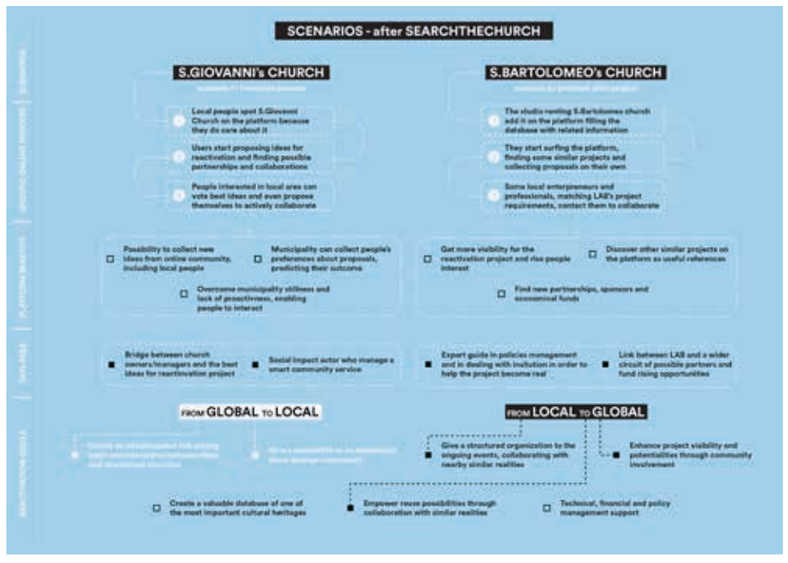
Analysing technical elements, the platform allows the entire reactivation process management; it goes from the spotting of a church and hence the creation of a page for the abandoned building, to a first brainstorming on possible reactivation ideas, up to activities’ definition. Other existing platforms failed because of their unwillingness to actually overcome the very

Before SearchTheChurch scenario



first steps of the reactivation process, conceiving it as a single event to attract people's interest. CAPs team B instead believes that the reactivation process has to be supported throughout all its phases: from the "call for ideas" and draft design to the funding campaign.
The platform enables two different developments of the project: the *"Freemium Model"* and *"Premium Model"*.

After SearchTheChurch Scenario



The *"Freemium Model"* has the aim to fill a general lack of information and organization concerning abandoned churches as cultural heritage. Its tangible outcome will therefore be a trigger for a bottom up reactivation.
Every user, without the need of any registration, will be able to browse the database of churches completely for free, learning about activities in reactivated places. Then, after a simple registration, *SearchTheChurch*'s users will also have the possibility to suggest their own reactivation strategy, to vote for other members' reuse proposal and even to candidate themselves as collaborators or partners for any project collected. In fact, everyone will be able to propose an idea or to get information about needs and requirements of each project suggested. Everyone will also be able to concretely become involved in the process by offering his expertise to a specific proposal that best matches his skills or resources. In this way, the platform will foster new collaborative economy exchanges and will represent a new channel for job possibilities.
Differently from other platforms such as "ImpossibleLiving.com", *SearchTheChurch* will collect information about users (age, location, occupation and preferences), in order to create a map of people interests as a tool for making better strategic decisions.
As soon as some information will be collected about the person or institution/association that owns or manages an abandoned church, this actor will be automatically contacted by *SearchTheChurch* team in order to attract his attention to the specific church page on the platform. Following this process, or even discovering the web page by chance, they will be able to request the "ownership" of a specific abandoned building on the platform, making a general church page the "official" one.
The final best proposal will be chosen by the manager of each *SearchTheChurch*'s building page. He will be able to evaluate every idea collected considering both vote's results (important to measure the possible appeal of a project for local and non-local users) and relative requirements (finding out which they are and how many users would be interested in participating or collaborating).
When a reaction gets started, the *SearchTheChurch* official page of a church will become a powerful communication channel between reactivators and the community, increasing the visibility of the project and the opportunities of development.
The *Freemium Model* will therefore constitute a first tool for reactivation and a smart infrastructure for social cohesion and innovation.
SearchTheChurch Premium Model represents a possible follow up that we are actually testing through a partnership with San Bartolomeo Church in Piacenza. Setting contacts with actors that own or manage an abandoned church will help us define the possibility for our group to have an active role in the reactivation process of a specific abandoned building. Thanks to the information collected on the platform about existent projects and about users of the platform, *SearchTheChurch* team will be able to provide a consultancy service that will guide the process from the evaluation of proposed ideas up to the realization of a creative reuse model *shifting successfully from global to local*.

R. Florida, *Who's Your City?: How the Creative Economy Is Making Where to Live the Most Important Decision of Your Life*, Basic Books, New York, 2008.
C. Landry, *The Creative City. A Toolkit for Urban Innovators*, Earthscan, London, 2000.
S. Marini, *The Landscape of Waste*, Skira, 2011

Additional material

Temporary link to *SearchTheChurch* webplatform
http://searchthechurch.o5510979444.v1.s4.ams.boa.io/
Official link to *SearchTheChurch* webplatform
http://www.serchthechurch.it/

ECOBikePrint

EcoBikePrint: bicycling toward a sustainble tourism

Project

ECOBikePrint

EcoBikePrint: bicycling toward a sustainble tourism

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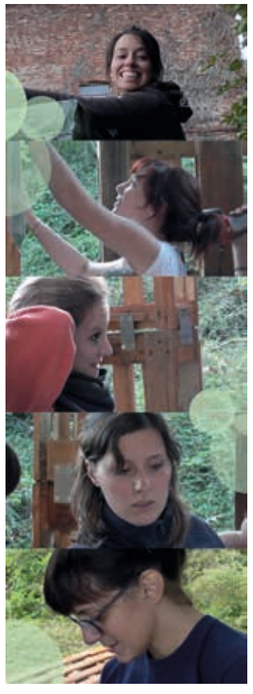

Team A Members

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Francesco Pinat
Architettura, Politecnico di Milano

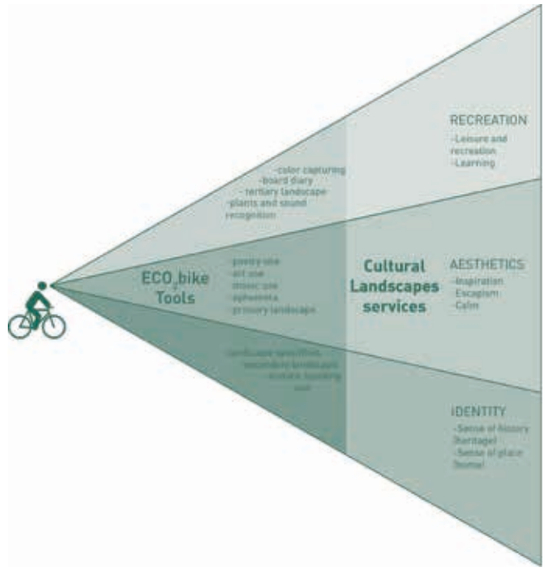
Project description

Cycling Tourism is a new and great challenge for enhancing our territories thanks to its powerful ability to generate green jobs, economies, cultural actions involving people. In this general topic, a project named VENTO, born by DAStU - Politecnico di Milano and based on the idea to realize a green infrastructure – a cycling tourism backbone – on the areas between Venice (VENezia) and Turin (TOrino) along the River Po. It will become the means to generate a number of important effects on the territory, with multiple repercussions, especially on those who live in the area, who are in search of new interpretations after the economic crisis, as well as on tourists who are drawn to the imagery that VENTO will foster through cycling, the beauty of the landscape and the exploration of new, beautiful places.
VENTO project could even be a learning cycling tourism experience through which we can both teach and learn some lessons coming from the local places, local identities, landscapes, heritage, environment, cultures etc., EcoBikePrint sub-projects intend to focus on two crucial topics as Landscape and Food. Making experience of Landscape and Local Food can become an additional cultural opportunity for those cycling along VENTO. But we need solutions to transform them into a real impressive experience, able to raise awareness of something good to everybody. So, the project idea developed by students has had the goal to make cycling experience more attractive, more connected to local dimension and able to start a real learning-by-doing process. To appreciate Landscape we need something that guide us into it, discovering stories, tales, scientific issues, curiosities even using new technologies that everyone has in his pocket as the smartphone. Even food can become a learning experience if a tool helps people identify low emission food, local foods along the route. A food-print counter, usable in our smartphone, can make our bicycle experience cleaner and more virtuous. Both groups have developed a project to reach these two specific goals.

Team A - Landscape Experiences

Subproject introduction

The Vento project has been the frame for unfolding the idea of giving a new value to the landscape. Unless how it is commonly perceived, landscape is encompassed in our cultural heritage, and besides its management we have to find a way to valorise it. The uniqueness of using Vento cycle path as a research study in order to understand how to make users appreciating its environments, is related to the multitude of different landscapes that the path crosses. From Piedmont's rice-pads to the Po river delta, the chance of living the evolving of a nature always in mutation is priceless. The other important ingredient of the Vento project, cared by the DASTU department of Politecnico di Milano, is the goal of promoting a strong cycle-tourism all along the track. In fact,



Cultural Landscape Services according to CoE 2000, Article 1

according to ICOMOS Charts, a primary objective for managing heritage is to communicate its significance and need for its conservation to its host community and to visitors. But, what do we mean by landscape?
Landscape is environment as it is perceived by people. Being an essential component of people's surroundings, landscape concerns wellbeing; its experience is a key for getting people in touch with the environment, to rise education and awareness. Thus, landscape experience is an important dimension of the ecotourism and of the EcoBikePrint project.
In terms of scientific paradigms, landscape is considered an essential dimension of the so-called "cultural ecosystem services". As a consequence, territories can be interpreted in terms of provision of multiple landscape experiences. This means analyzing multiple layers but, above all, interpreting their relationship. In fact, landscape is an approach: going beyond boundaries, linking material and immaterial factors, linking people and environment. Landscape is a sort of hypertext, dynamic and open to active readers. The

Pavilion prototype construction in Verrua Savoia, 10th October 2015

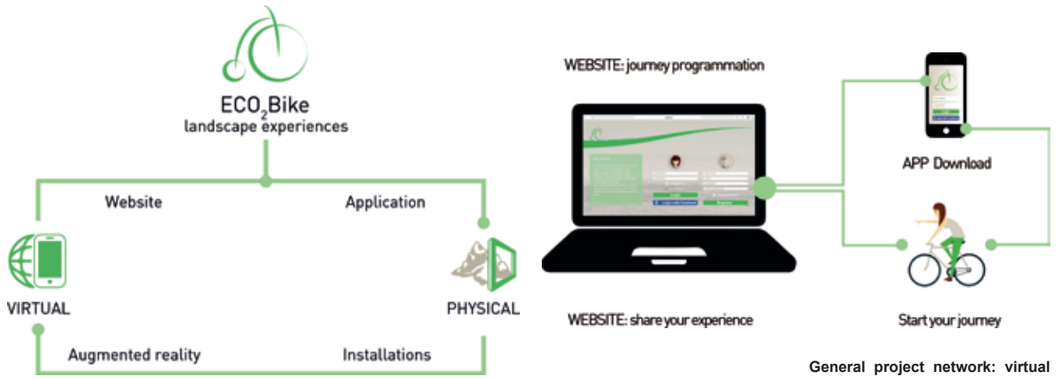
Team field trips

Landscape Team of the EcoBikePrint Project offers an architecture designed to let you experience the landscape and go beyond the screen: linking cycle-tourism with a structured knowledge of the territory and of its multiple values, enriching the individual experience by a net of cultural dimensions, allowing the sharing of perceptions and reflections.
Indeed, as regards the objectives and expectations of the team we can first of all say that there is a strong educational purpose behind the whole project and its contents, since we want to make the user rediscover the landscape as complex and common good. Therefore, a second intent is to provide the visitor the right tools to deepen the layers of the surrounding territory, moving beyond the aesthetic aspect with which we are used to judge the value of a landscape. At last, this projects would recover local richness of traditions and products, connecting them with a systemic approach. Thus, what Eco-2bike tries to achieve is evoking a new sense of awareness and belonging of the landscape using non conventional tools to involve tourists and visitors.

Tasks and skills

Martina Bonardo: thanks to her theoretic approach, at first, dealt with the preliminary research around the landscape topic that later she developed the contents of the mobile app as well as the Frame design. Finally, she focused on the output of the application.
Valentina Marchetti: at first focused on the preliminary map survey and the questionnaires for the users' engagement. Besides, she brought her designer competences to develop the coordinated image of the whole system, and later she focused mostly on the contents and graphic of the website and Pavilions' projects.
Letizia Monti: contributed to the map survey during the analytic first step, deepening the presence of environmental indicators in the case study area. In the following period, she took care of the info-graphic design and contents for the project, composing an abacus of information tools.
Francesca Palandri: in the first phases of the work studied the landscape language, approaching also the GIS software, and managing the coherence of the theoretic contents in the whole project. In terms of design, she cared about the mock up realization and contributed in the Frame project.
Erica Zorzi: in the first period analyzed the landscape services in form of map realization, while for the design phase she was as well in charge of the Pavilions projects. Thanks to her multitasking approach, she administered most of the relations with public administrations and institutions.

Abstract



General project network: virtual and physical worlds

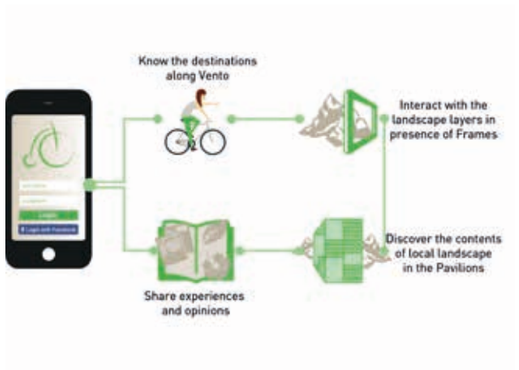
How to use the virtual system in your journey

The EcoBikePrint team is supported and contextualized within Vento, the project for a cycle path, already partially realized, that connects Turin to Venice along the river Po. Vento doesn't only aim to be a cycle-tourism project, but even to recover the relationship between people and landscape, considered as the most valuable common cultural good. Within this context was born the idea of focusing on the sustainable aspect of tourism, enhanced by the realization of the infrastructure, in order to sensitize the future users. Therefore, EcoBikePrint aims at developing two solutions able to foster awareness of the users' impact and increase the sensibility about the environment and its quality, with two research teams: one on the landscape and one on the food topic. ECO_2bike - Landscape Experiences is the outcome of the research carried by Team A on the valorization of the land intrinsic features and on the rediscovery of the culture that this preserves, to carry the visitor to the right contact with Nature. The project, that support Vento with services and thematic installations, has its foundations partly in digital and in physical worlds alongside, in order both to reconnect the digital users to the real environment, and to give to visitors of the cycle path a more complete experience through digital tools. In fact, the landscape studies are dominated by an outdated approach, hard to communicate to those who aren't experts in this field. So our system wants to connect these two aspects, creating an experience both educational and enjoyable, through different tools: digital and physical. The final output of the work is a system of services composed by digital devices: a website to plan the trip, share impressions and events, and an application to support the on field experience; and by physical devices: Frames, Infographic and Pavilions. Considering this approach, we aim to involve not only cycle-tourism experts but a broader audience letting them experience the landscape in an unconventional way, setting a higher sensibility toward the cultural, social and environmental legacy of this country.

Understanding the problem

Considering our foreignness to the specificity of the landscape disciplines, the first phase of the work was dedicated to the learning of its technical and scientific language, looking at the main European researches in this field. Basically, the complexity of the environment, reflected in the complexity of the topic, was disassembled to consider which are the landscape indicators, components, and the related cultural services, as identity, aesthetics and recreation. Indicators such as tranquility and hemeroby, together with the mapping of local services and interest spots, helped to classify the different natural values on the cycle path. Instead, the components that together constitute a territory are scenic, cultural, anthropic and environmental; these layers drove us in the analysis of the Vento landscape, helping us to see its different features from Turin to the Po delta. In the meanwhile, we tried to understand the way to use this technical information in order to communicate and sensitize the users on the main landscape issues, as its cultural, traditional, scenery and natural values. In order to find an immediate and appealing way to communicate these contents and reach the target we were addressing, we decided to involve the users in a more playful and emotional way, indirectly broadcasting even an educational content once gained their attention.

Another important issue to investigate was actually the range of these users: which typologies of visitors do we address to? To answer this question,



Conferences and presentations attendance

App contents and use in the journey

we referred to the definition of cycle-tourism as an activity directed not only to professional cyclists, but even to travelers of all levels, which interests and requirements were deepened with a questionnaire.

As we said, Vento is composed by a multiplicity of environments, so to reach a good level of detail in our proposal we decided to select one of these sections. After this choice and its theoretical analysis we got to physically know the area and tried to understand how to apply our concept, getting in touch with local associations and in particular forecasting a collaboration with the Parco Fluviale del Po e Dell'Orba, as another major issue concerns the cooperation and unification of these local authorities, nowadays still scattered.

Finally, it was important to structure the output, with a last complexity due to the will to have both a physical and a virtual support, as we want to communicate with users on different levels, figuring out what kind of activities would fit each tool. The content definition was extremely relevant to understand also the technology we were going to adopt, for which the individuation of a counselee allowed a rapid and efficient analysis of the possibilities of the output implementations.

Exploring the opportunities

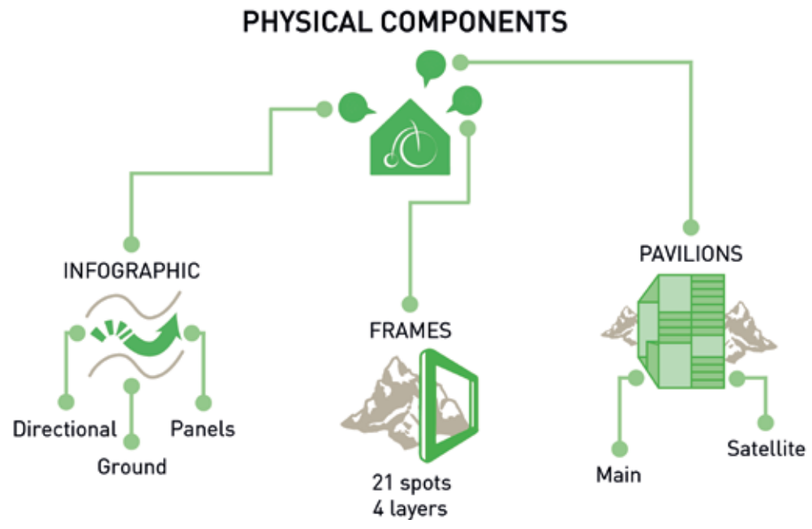
The first important step of our work has been the analysis of a survey based on interviews and questionnaires. Thank to the answers we have been able to consider what should be the main contents of our system, as we have been able to explore the different users' preferences in terms of required services on a cycle way. As a confirmation of the project basic assumption, most of the interviewed expressed their interest in the chance of using an online community dedicated to cycle-tourists that could spread information about the track and its interest spots, while a high share affirmed the willingness to use a specific phone application to gain information directly on the cycle path. As regards physical services, the most appreciated idea is to create a network of both water stations and cycle repair spots, as well as map sings and information points.

To complete the study on the basic requirements we made a map survey on the existing services, access points, hospitality structures and their spread around the selected portion of track. Furthermore, to prepare a proposal for future interventions, another relevant step in understanding the user's needs has been the first path field trip on the area. In fact, embodying the users themselves helped us to deepen by heart their problems and needs, and to understand better how to get in contact with the surroundings.

After the research analysis, we set the concept of a digital and physical system, which main objectives are:

- to provide the possibility to reach a serviced area each day of the trip, so we planned a network of structures along the path connected and equipped with the minimum services;
- to connect a practical service to a cultural one through the same physical installations, treated as a diffused museum on the landscape heritage;
- to find a way to make the landscape an interesting topic, as the project's main goal is still to foster people's education and awareness of the environmental value, and cycle tourists on Vento can really dive in the surrounding landscape;
- to spread ECO_2Bike not just on the site, but to let users know the project even before the travel itself, for a better planning of their visits
- to enhance a green economy of local services and associations around the Vento path.

Examples of App's layers in the Frames



Physical components and installation

Examples of Pavilions interactions

Prototype in Verrua Savoia and special thanks

A special thanks goes to Parco Fluviale del Po e dell'Orba, in particular mrs Maria Teresa Bergoglio, and to Fondazione Piazza, in particular mrs Caterina Borgondo, for the willingness and support toward the project and the construction of the prototype in Verrua Savoia.

Once fixed these, a preliminary research of the existing applications, services and websites on the topic allowed us to focus on more innovative ideas and technologies, pointing especially on what distinguishes this system from other cycle tourism networks: the landscape experience as a driving factor for a complete journey.

Generating a solution

The designed solution embodies the principal aims of the project, proposing a tool to read landscape with a more sensible approach, communicated to users in a friendly and engaging way.

ECO_2bike develops from a conceptual model based on the idea that landscape is a complex and layered network shaped by the ecosystem, biodiversity and anthropic contributions. Starting from the assumption that the landscape is something material that can be touched, heard, seen, smelled and tasted through it products and at the same time it covers even an intellectual role in a specific culture, we shaped a physical and virtual system able to bond and reflect all these aspects as a fil rouge. Indeed, Eco_2Bike provides a set of services to guide and encourage the cycle-tourist to enjoy the surrounding: physical services along the way, a website and a mobile application.

At the first step, users can use the web platform to select routes according to their personal interests and needs [https://youtu.be/W5xbKlVAexM]. From this website, at home, the tourist can download the app and upload his itinerary, becoming aware of the physical interventions proposed on the track. As the physical base level, we designed a specific info-graphic to orientate the cycle-tourist along the trip: signs, directional panels, and graphs about local stories to discover during the journey. In addition we developed three kinds of physical installations, all able to interact with the mobile app: main and Satellite Pavilions, and Frames. Main pavilions are placed on the Vento track and provide basic services and rest areas to users. Above all, they work as a diffused museum, spreading landscape topics. Satellite Pavilions support and promote the project and track from important localities nearby Vento, enhancing the relation with local associations. [https://youtu.be/OYR88US5hxk] At last, Frames are designed to highlight some characteristics of the surrounding landscapes through the interaction with the app; in fact what completes the physical experience is the ECO_2bike Mentor. This core function of the application allows you to get into the landscape layers and contents. Education, interaction and emotion are the keywords of the application concept to create engagement and awareness toward the landscape assets. The cycle-tourist will be able to unveil as many layers as his curiosity pushes him to [Mock up download at: https://invis.io/VJ4S7LU2Z, https://youtu.be/fsHppwTeG_Q]. What characterize the ECO_2bike application is its nature: not just a tool for a virtual experience but a guide for users to look deeper to real landscapes. We chose the beacon technology, because it activates specific information in determined positions around the installations, so only by undertaking the cycle-path and crossing the real nature, it is possible to truly explore the application's contents. Finally, a web platform helps to select routes ad hoc according to the user profiles and interests [https://youtu.be/W5xbKlVAexM].

Thank to the system proposed by ECO_2bike, the journey can be costumed, better organized and more enjoyable.

Team B - Ecobites

Subproject introduction

"All journeys have secret destinations of which the traveler is unaware"

We all travel in modern times. Sometimes for leisure, many times for work, other times to discover some bizarre beauties of either nature or culture or both. However, we often keep along the way the same efficient attitude we have at home and try to optimize almost everything, including the rate of discoveries.

Rarely, we give ourselves the chance to really open our eyes and let the novelty enter. Which in the end is the true essence of travel: renewing the way we look at our surroundings. EcoBikePrint is the project of an application designed to change how people experience tourism, making it more sustainable and conscious. It acts on the track of VenTo, a project for a 679 km cycling track to be built along Po River from Venice to Turin.

Tourism, as the majority practices it today, is very distant. The tourist visits and "takes" images and experiences from the space in a passive manner. Most tourists don't take an extra action towards getting involved and understanding more about the culture of the environment, and most tourists do not even consider what it is they "give" back.

Cycletourism is a wonderful way of revolutionizing this irreflective behavior. By changing speed, the tourist is more aware of the environment being visited, further establishing a more intimate and productive connection between the self and the environment. This approach towards tourism can be considered ecological, as the traveling carbon print is reduced to practically zero. Not zero, really. The energy propelling the tourist comes by the food she consumes, that can contribute to carbon emissions in quite a relevant way too.

In the year of EXPO Milan 2015, EcoBikePrint came to focus on the sustainability question through two main poles: food and landscape. This is how our project recognizes the two major axes that, together, form a base to raise awareness of one's impact on the environment.

On the one hand, the "Landscape Group" focused on the direct relationships between the visitors and the visited space. On the other, the "Food Group" took a direct approach to the ecological question through the analysis of the "foodprint" of the products users consumed during their trip.

This division was further motivated given the external institutions involved in the project: Vento and SlowFood. This Report focuses on the findings of the "Food Group", who primarily addressed the role of alimentary choices in the environmental panorama.

Our chosen strategy was that of the design of an application (App) envisioned to let the tourist calculate the sustainability of her diet. In so doing, the app promotes environmental friendly dietary choices through collective knowledge empowerment.

In order to accomplish our objective, we further subdivided our group in the two interacting elements that had to be equally developed for its resolution:

_Engineering

_Design

Based on scientific and technical literature, the Engineering involved the calculation of the indicators that would generate the engine behind the information provided in the application, while the Design focused on the how to appealingly communicate such information. Along the process, both groups would be in constant interaction: some of the indicators were too technical to reach the goal of being understood and useful to the tourist, while design needed to communicate in quite an engineered fashion.

As the identity of our solution defined itself, different proposals came to the table – each a development from the previous. As such, three Mock-ups were designed, each a representative of the different stages of our research.

Ecobites, our final proposal, can be defined as an application where users are able to calculate the environmental impact of their meals, review their progress and learn about "eco" alimentary choices.

Tasks and skills

Ottavia Burzi: is a potential environmental engineer. She took care of researches and data analysis, and faced the challenge of communicating to the app users their environmental impact.
Alessandra Girón: was largely involved in the communication aspect, mainly with brand development and user interface design; she produced 3 mock-ups throughout the process.
Nicoletta Grillo:researched on general topics and worked on the app UI and UX, developing graphic solutions. She collaborated with the external developers to implement the web app.
Giacomo Guazzolini: worked mostly on the app design: development of the structure, selection of contents and design of mockup. He also met with the developers to supervise the app progress.
Silvia Mariano: is an environmental engineer. She focused on the development of the app datasets, in particular on the calculations of water footprint and profiling dishes.
Francesco Pinat: is an architect wannabe, lent to the engineering field of data entry. Passionate of the Italian diet, he developed topics related to a healthy food approach for the app.

Abstract

Sustainability has come to play a bigger role in the public discourse in recent years. The development of its research has pointed out how sustainable practices can also involve everyday activities. By raising our own consciousness about the effect our choices have, we can also become more aware with our own behavior.
In the year of Expo Milan 2015, attention has been brought to the role food plays as an important contributor to the environmental discourse. It has been noted how modifying regular dietary patterns with more sustainable options can have benefits for our future. The environmental cause has been approached with the sensitization of the public through an awareness campaign led by a mobile application.
The proposal was that of an application designed to calculate the impact users have on the environment, communicate such information to the user itself, and provide him with a set of knowledge on how to improve his environmental performance. In the first section, the user can explore the database of traditional dishes, or provide input on the ingredients composing his meal, so to calculate the impact of his choice. It furthermore provides nutritional information and a diary where to visualize personal progress.
The challenge was to condense all of this information in an attractive product for the general public. The approach was to combine this rather dense information with lighter communication tools, so that the user found a user-friendly and appealing interface where to learn and reconsider his actions. It is thus a project that has as an objective to attract the mass in the still-niche topic.
The strategy was that of attracting users by creating an appealing brand. Simple and easy to use, the design of the app was destined to attract the most general of publics.
Ecobites is the first stage of the reconnection of users with the lived environment. As consciousness is raised, the much-needed changes of behavior ought to start to take place. Let this proposal be part of the increasing cultured pop-culture, let it be the beginning of a change.

Understanding the problem

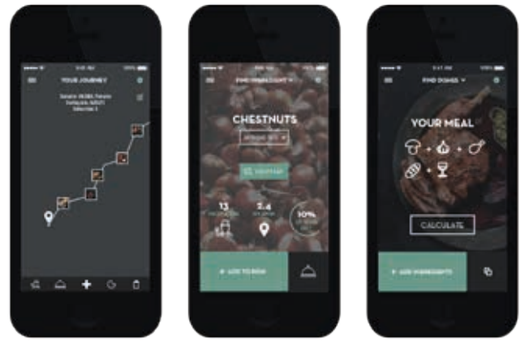
VenTo, a proposal for a cycling track that connects Venice with Torino, was the context on which Ecobites took place. Encompassing such a large area, it involved a new kind of proposal for tourism as well: Cycletourism.
Cycletourism has innovated the way we experience travelling. It allows for a more direct interaction between the traveler and the visited space. The reconnection with the local is a concern also shared with SlowFood, another external institution involved with our proposal. Both institutions have an “eco-friendly” approach; on one hand, cycletourism can be considered a “green” form of tourism where the ecological impact of the mean of transport is reduced to zero. On the other, with the encouraging of sustainable food practices, SlowFood is promoting a more active lifestyle of raised awareness.
Food, along with its production choices, is responsible for a great part of greenhouse gases emissions worldwide. As much as food consumption has an effect on global warming, global warming affects food production itself. For example, the extreme events caused by climate change can have dramatic consequences for agricultural practices. Hence the importance of raising the common knowledge about it.
This is how, a change on dietary patterns can have a greater effect as a preventive measure. Being aware not only of where food comes from, but also on the consequences of our choices, seems a starting point for the much-needed behavior transformation the Earth is asking for.

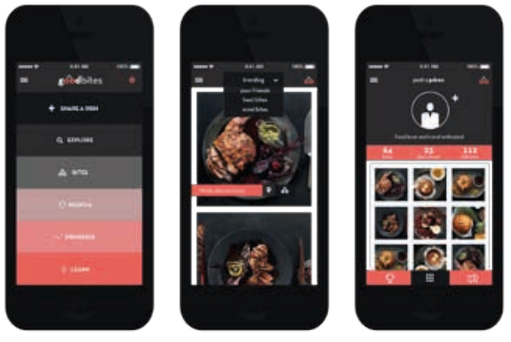
Exploring the opportunities

Recently, the “foodprint” topic has started to rise in the general conversation. As such, various projects that foment awareness/reduction of unsustainable food choices have taken place. Nevertheless, the topic has not been able to fully leave its “niche” approach. As such, we made it a main concern for the success of our proposal to design a clear, coherent, and appealing communication strategy.
As such, our project was developed throughout three main phases, each addressing a specific market and therefore presenting a specific identity.

First mockup logo_slowbites and first Mockup_Slowbites

Second mockup logo_goodbites and second Mockup_Goodbites





Third mockup logo_eco-bites and 3 Third Mockup_ Ecobites

At a first glance, the future visitors of the proposed VenTo track seemed as our main target market. As such, our first proposal **Slowbites**, directly addressed the emerging sector of the cycletourist. As such, it came as an ideal proposal to transform our “foodprint calculator” into an application that would seem attractive to anyone visiting the Italian cycletrack. As such, this first acting group not only involved the regular tourist, but also those seeking for a more healthy lifestyle, and anyone that enjoyed food.
The challenge was that of translating very detailed/technical data to a language the “everyday consumer” could relate with. On the other hand, we also set as our purpose to attract such a wide crowd. For this, we researched on the actual trends present on mobile applications, and we discovered that the “food world” has had a large sum of added “fans” in the last couple of years. The “foodies” culture has become regular, and highly present in most of today’s social media.
This is how, for our second proposal, **Goodbites**, we destined our efforts into attracting this seemly larger crowd. As such, the identity of the application was redesigned so that it would attract *anyone*. Goodbites sought to incorporate knowledge with entertainment, making the learning process a fun one. We sought to include successful characteristics of other social platforms, highly taking inspiration of Instagram as an image sharing platform, all in order to improve our attractive social aspect.
In our third proposal, **Ecobites**, the strategy was narrowed to that of focusing on our initial market and on the main objective of providing a food impact calculator. In here, the user finds a “food journal” on which he can keep track of his own environmental impact and thus, be further motivated to make a change.

Generating a solution

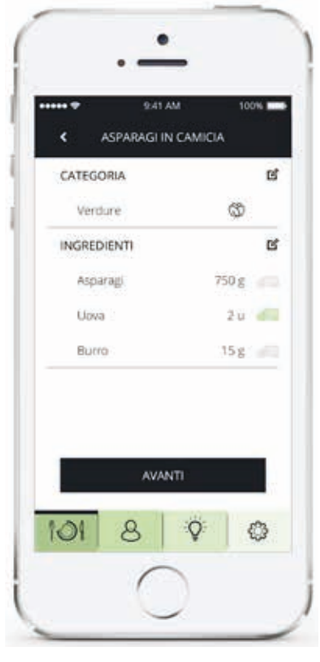
The user interface was simplified so enhance its easiness of use. Four main sections defined the app’s structure and came to form its menu:

- Add a dish: the user finds a list of default dishes or composes the dish by inserting the ingredients. The dish’s impact is calculated, and communicated through a comparison with the average Italian. The “bite” may be added to the user’s profile.
- Profile: an overview of the user’s progress organized by time period. The user can review the dishes consumed, his environmental impact, statistics, and nutritional performance.
- Learn: tips and suggestion on how to improve one’s foodprint
- Settings: data management and information about the app

The engine behind the app was intended to relate food consumption to its own impact. Carbon footprint was chosen as the measure to assess global impact, due to global warming issues, while water footprint has been selected to evaluate the local impact-and natural resources exploitation-associated to food production and consumption.

App entry screen

Instructions



Add aplate from dish list

Check dish recipe

See dish footprint

Share the summary of your impacts

Monitorate yourslef in your profile pacts

Graph of your water footprint

Conclusion

In the recent years, it has become apparent that the world needs a more sustainable way-of-thinking. With Ecobites, we aim at introducing “niche” concepts into the everyday life of regular citizens. The approach is that of raising awareness of a topic that involves us all, taking advantage of today’s mediums of expression: mobile applications. In this way, we are looking for an innovative solution that seeks to be in coherence with current trends in order to attract the most wide of publics.

We sought to reach our goal our sensibilizing the general crowd by appealing to their everyday consumes. Food is part of everyone’s everyday ritual, it was even evolved as a concept and the knowledge that surrounds it today continues to grow. Let us take advantage of the food culture and empower the people with the knowledge to act *right*.

Graph of categories of food consumed in respect to the suggested quantities

Example of tip to improve users consciousness

Complete overview of app functioning

Main bibliographic references

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LAMP

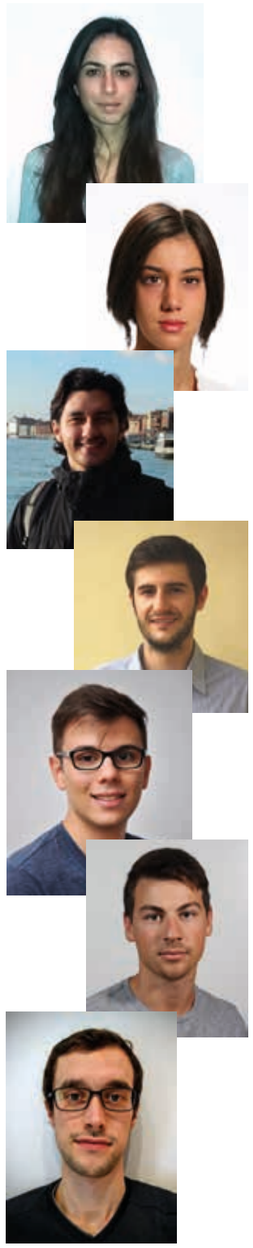
Laser Additive Manufactoring &
Prototyping

LAMP

• LASER ADDITIVE MANUFACTURING & PROTOTYPING •

LAMP

Laser Additive Manufactoring & Prototyping



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Project description

Additive Manufacturing (AM) is an emerging production technology for the realization of three-dimensional objects layer-by-layer that is attracting great attention because it allows overcoming many design restrictions and thus simplifies the production of complex geometries (i.e. structures with undercuts or hollow spaces). Moreover, it also offers the possibility to produce features internal to parts, and even functionally graded components, which are components having gradual changes of material composition and microstructure throughout the part. Finally, it typically enables a remarkable weight reduction combined with less waste of raw materials. Despite all these advantages, AM of metal parts for industrial applications is still far from being a mature manufacturing approach, mainly for limitations in currently available machines and for the necessity of further investigating the resulting material properties.

The ASP Multidisciplinary Project originated from the interest of its industrial partner, Prima Industrie, a world leading manufacturer of metal sheet machinery, for the development of new metal 3D printer machines leveraging on its present know-how in the fields of high power laser sources and material processing machinery. In this framework, the aim of the Project was to provide guidelines to help in the identification of novel technical solutions and market strategies.

Starting with an in-depth analysis of the State-of-the-Art of metal 3D-printing from powders (including processes, materials and properties of printed parts), the LAMP team has highlighted the main features needed by next generation machines in order to boost the AM business and gain acceptance in new markets and in new industrial sectors. The technology assessment has been carried out through a trade-off analysis that required strong multidisciplinary interactions, with contributions ranging from photonics to material science, design and mechanical engineering.

Then, following an overview of the current fields of application, the final part of the Project has been devoted to the selection and development of a technological demonstrator to allow the team to analyze in a practical case the strengths and weaknesses of the new production process. A part belonging to the aerospace field has been chosen because representative of various aspects required in a key application sector. The device, originally conceived for conventional machining, has been completely re-designed for additive production, including a topological optimization from a strength-to-weight standpoint, and manufactured. For comparison, the same device has also been produced through a conventional milling process. The most evident difference is that with the AM approach it is possible to fabricate a device with the same functionality as the "traditional" one, but much lighter. A more detailed critical review of the obtained results has also been conducted to meet the Project objective.

Tasks and skills

Veronica Bianchi: investigated the different sectors where AM has a large influence detailing the more relevant applications and took part to the topological optimization of the 3D-printed demonstrator.

Arianna Decaneto: provided an in-depth analysis of AM costs and future economic trends; moreover, she was involved in the stakeholders and requirements analysis.

Felipe Hernández Villa-Roel: contributed with design competencies to the conception of the case-study; in addition, he made it possible to manufacture polymeric prototypes.

Francesco Maja: exploited his CAD-modeling competencies working at the topological optimization of the demonstrator. Furthermore, he examined in depth the properties of metal 3D-printed parts and went into a comparison of AM machines.

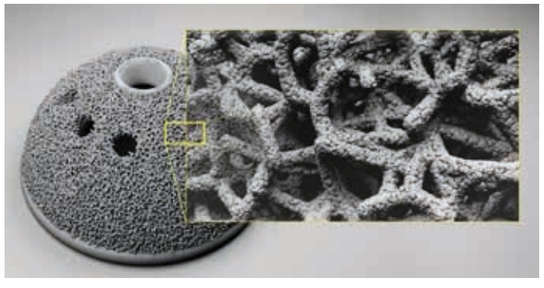
Gianluca Nicosia: as team controller coordinated the work of all the team components and verified the consistency of the final report; he was also involved in the state of the art study of AM processes and in the stakeholders and requirements analysis.
Andrea Pavanello investigated the latest software used in the AM design phase, was in charge of the graphic aspects and carried out the CAD modeling activity of the mechanical case-study.
Diego Pintossi examined in depth the metallic materials available for different laser AM processes, analyzed the properties of the 3D-printed parts and was involved in the stakeholders and requirements analysis.

Abstract

AM is a technical innovation with the potential to turn around the way in which companies manufacture end-products and do business, giving a new shape to both internal and external processes (concerning the firm-client relationship). As a matter of facts, its market, consisting of all products, materials and services, was worth around 3.07 billion USD in 2013 and is expected to show a double-digit growth in the next decades. There is also a strong commitment by the public sector to push forward the development of AM. This is proven by the huge funding that the European Union, through the so-called Horizon 2020 program, is providing to foster research into this emerging technology.
As it represents a disruptive innovation, crucial to be embraced in order to stay on the market, as well as a potentially profitable field, AM is sparkling the interest of large machine manufacturers. However, the highly competitive environment, together with the existing problems related to intellectual properties and issues concerning the technology readiness level, make it difficult for new actors to enter the market. In this framework, the LAMP Project aimed to provide a comprehensive picture of the present situation and future evolutionary trends of metal AM to its industrial partner Prima Industrie, which is planning to enter the market in the next few years. This objective has been accomplished by pointing out the requirements of the manufacturing industry, developing a detailed analysis of the State of the Art (SoA), which focused on AM history and main patents, AM processes, currently available machines, metal powders, properties of 3D-printed parts, fields of applications, software, costs and economics. The team also gathered information about the challenges that companies already involved in metal AM are facing with the current technology. However, industrial exploitation of SoA technology is facing several issues in satisfying stakeholders' needs, as it is limited by technological trade-offs.
The "machine of the future" concept was developed in order to break the existing trade-offs, thus leading AM to get acceptance in new markets and by new industries, boosting the metal 3D-printing business. However, for the LAMP concept to become technologically feasible, fundamental breakthroughs have to be achieved in different fields, such as the laser one, through advances in research and development.

CAD image of a tea cup with further images showing the effects of building using different layer thicknesses

Hip implant with lattice structure for improved osseointegration



Understanding the problem

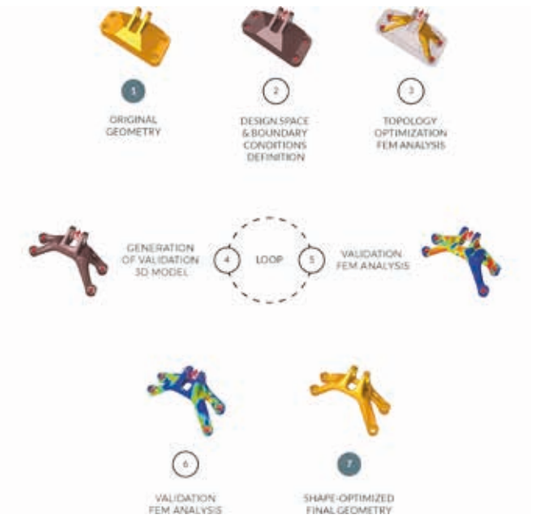
The theoretical part of the project was organized into two phases: the first devoted to understanding the stakeholder needs and translating them into requirements, and the second to the development of the "machine of the future" concept through a trade-off analysis of technical requirements.
The project stakeholders included end users of AM systems, both in the industrial and in the consumer market, direct competitors, consisting of players already involved in the AM sector, indirect competitors, who are defined as the companies in the traditional metal supply chain, metal powder, printing software and components suppliers, public institutions and standard-setting bodies. The requirement elicitation process was carried out through a substantial bibliographic research, complemented by interviews to technology experts and industrial players, leading to a drafting of a technical report. To this purpose, Avio Aero production plant in Cameri (NO, Italy) and Sinteaplustek headquarter in Assago (MI, Italy) were visited, while Medacta (Switzerland) was interviewed. The identified requirements were then classified into four categories (human-based, functional, corporate and regulatory requirements).
Once requirements were clear, the team proceeded with an in-depth analysis of technical requirements of AM, in order to understand its present limits and how they will evolve in the near future.

Additively manufactured Gold necklace

Exploring the opportunities

To explore the potential and actual limitations of the technology also from the end user point of view, the LAMP team re-designed, optimized and 3D-printed a real component presently manufactured by using a traditional subtractive approach. This process allowed the team to understand the design possibilities and processing issues of AM technology. The selection of the specific case study was influenced by the availability of product specifications and by considerations about the relevance of AM in its production. After some research, a metal structural part for the aerospace field was chosen as demonstrator. The existing component, best suited for traditional subtractive machining, as FEM analysis proved, was not fully optimized for both performance and weight due to manufacturing constraints. Therefore, exploiting the possibility offered by AM to grow practically any shape, it was re-designed through structural and topological optimization, conceiving it for the AM production. Such process was carried out using specific software, like *SolidThinking Inspire* by *Altair Engineering*. As a result of few design iterations, a part fully optimized from a strength-to-weight standpoint has been conceived, capable of still matching the interface dimensions and bearing the given loads with-

Workflow of the topology optimization design process



3D printing of the designed bracket

Printed bracket with support structure

out failure. Indeed, such part has proven to be 76.5% lighter than the original one. To understand the impact of redesigning lightweight parts for AM production, an analysis of the cost savings over the component life-cycle was carried out, highlighting the benefits in terms of fuel consumption and CO_2 emission savings over the airplane's lifespan. Finally, the optimized component was printed at Istituto Italiano di Tecnologia (IIT) of Turin. Moreover, the original geometry was machined with subtractive techniques, in order to better appreciate the final results.

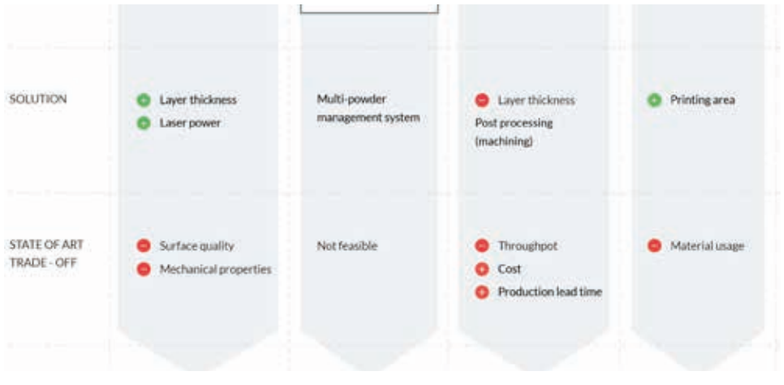
Generating a solution

The stakeholder study, requirement elicitation, and State of the Art analysis made the LAMP team aware of the fundamental technical requirements that end users need for AM machines, namely high build rates and surface quality, capability to manufacture functionally graded components, large building volumes, and superior process reliability with consequently high product quality. However, from the SoA analysis, it was evident that current AM technology cannot satisfy all technical requirements simultaneously, due to the presence of several trade-offs between these characteristics. Within this framework, with our industrial partner, Prima Industrie, willing to develop a revolutionary laser metal 3D printer, the LAMP team efforts to bring forward a concept solution overcoming the current limits of AM took place. The "machine of the future" concept developed by the team is capable of breaking the examined trade-offs by integrating a multi-nozzle Direct Energy Deposition system with an innovative direct diode laser source, capable of processing multiple materials at the same time, a laser ablation system for surface quality improvement, a closed-loop control system to constantly monitor process parameters, and a machining head. The adoption of a direct energy deposition approach consists in a paradigm shift with respect to the actual scenario, in which powder bed fusion is the dominant technology. This different design enables larger building volumes without the need to use huge amounts of expensive metal powders and the use of a deposition head paves the way for the conception of a hybrid machine, which integrates a subtractive head for high-precision CNC milling of components, overcoming the shortcomings of SoA AM technology with respect to dimensional accuracy and couplings. Furthermore, by employ-

Comparison between original geometry and optimized geometry

The original part object of the case study (on the left) and its optimized version (on the right)

ing a head equipped with multiple nozzles, our concept machine will be able to produce functionally graded components through the deposition of different powders. These materials will be melted by a direct diode laser source, which enables the achievement of high power without compromising on laser quality, thus opening new opportunities with respect to build rates. Furthermore, the laser ablation system represents an innovative strategy for the improvement of surface quality. Finally, closed loop control based on real-time 3D scanning of the component will boost process reliability, with a consequently enhanced product quality.



SoA technology leads to trade-offs that can be broken only through innovative solutions

Other possible solutions, such as improved powder bed fusion machine with larger printing beds and multiple laser sources or the first hybrid machines combining additive and subtractive technologies that are currently hitting the market, represent an evolution of the present technology. Therefore, they address only some of the SoA trade-offs without being able to solve all the issues intrinsic to the present AM technology. On the other hand, the design process that led to the LAMP concept solution with all its innovative features ensures the satisfaction of all the requirements.
Regarding the feasibility of the project, the team performed an accurate analysis through top-down and bottom up approaches, which led to the present value cash flow delta and break-even point. The outcome of our feasibility evaluation shows a potentially profitable investment.

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FRUC

Future of Retailing in Urban Cities

Project

15

TORINO PASS

FRUC

Future of Retailing in Urban Cities

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Project description
The project TORINO PASS was aimed to achieve an increment for customer traffic in small shops in the center of Turin. The idea came out from the analysis of the Turin's commercial environment that is characterized by a strong competition of shopping centers and big chains of supermarkets, which undermine the survival of the small shops in the center.
The project TORINO PASS focused mainly on tourists, to propose a pilot

solution that then could have been extended to the entire customer traffic. All those retailers who offer products typical Turin, recognized for the quality of their products, were involved in the project.
In particular, TORINO PASS developed a platform (trip-advisor like) aimed at supporting the tourist experience at the different stages of their visit in Turin: from the gathering of information before the trip, through the visit, to the desire to bring the experience of Turin in their own house. During the city tour in particular they are offered personalized paths, according to tourist interests and the time available. These routes, for instance, can be thematic (i.e. focused on specific product typologies, such as the route of chocolate) or connect the commercial offer to the monuments of interest, providing information on the specialty shops located in proximity.

This mechanism not only allows tourists to activate personalized consumer routes, but it lets retailers to activate mechanisms for cross-selling. These mechanisms surely are useful to increase traffic in retailer stores, but also lead to experiment with alternative business models.
The project was in partnership with ASCOM TORINO and the developed TORINO PASS platform is currently being evaluated by a start-up operating in the tourism sector.

Tasks and skills

Andrea Benedetti: Industrial Production Engineer, analyzed the economic feasibility of the project and developed the beta version of the service web site. He was the team controller in charge of the project's budget.
Birhanu Shanku Dura: Textile Engineer, studied the locations of the touristic as well as the commercial points of interest within the city and designed visit paths answering the needs of the different customers' segments.
Francesca Pagnanelli: Management Engineer, studied the logistic aspects and the optimal solutions to transport goods within the city. She was also in charge of the communication with internal and external stakeholders.
Cristiana Maria Passarella: Management Engineer, studied potential customers for the service and understood their needs from a marketing perspective. She constructed the personas used as target segments in the design phase.
Gabriele Roncoroni: Product and Service Designer, shaped together with Davide the characteristic of the final solution, focused on defining the customer journey and designing the service touchpoints.
Davide Trimarchi: Product and Service Designer, shaped together with Gabriele the characteristic of the final solution and designed the Torino Pass mobile app and website.

Abstract

Small urban retailers, in European cities, are facing a decrease in attractiveness because of the increase number of shopping malls, big chain shops and internet retailers. This led to the closure of a relevant number of stores and to the consequent reduction of people's traffic in cities' street. These closures are negatively affecting the vivacity and vibrancy of cities

The app

The website

which should rather be pleasant and safe places.
The FRUC, Future of Retailing in Urban Cities, project was carried on in collaboration with ASCOM Torino, branch of the Italian trade union, and is focused on the Turin reality. The city of Turin is indeed affected by the previously mentioned issue, which is in this instance further relevant, being 96% of city retailers very small and family owned.
An in-depth analysis of the retailing situation in Turin allowed developing a service, Torino Pass, aimed at tackling the above mentioned issue with the objective to increase small retailers' shops attractiveness. In particular, Torino Pass is meant to higher customers' traffic in small urban retailers' shops by addressing tourists' needs. Indeed, the core element of the service is the creation of customized visit itineraries guiding tourists through the city of Turin to experience both Turin's architectural and historical heritage and the offer of its retailers. On top of the customized itineraries, Torin Pass offers a number of ancillary services which allow to give tourists a 360-degree experience, covering all the phases of a travel. Worth of note is the e-commerce service which allows to turn tourists' one time purchases into repeated purchases.
The main advantages of Torino Pass are linked to the fact that it is a solution which it is not only ideated to solve the issue faced by small retailers but it also satisfies all the main requirements of the stakeholders involved: it does not require big time and cost efforts to retailers, it offers an innovative solution answering tourists' needs for a time and cost convenient experience and it offers benefits in a win-win fashion to other stakeholders (such as the hotels). The feedbacks the team got from all the stakeholders (ASCOM, retailers, tourists and hotels) were indeed extremely positive and Torino Pass was also granted the Municipality of Turin's official patronage.

Understanding the problem

As previously mentioned, ASCOM Torino, main interlocutor of the team, had one specific objective for this project: to find a solution which could help urban retailers in regaining competitiveness over other players.
In order to develop this solution, the problems faced by retailers had to be analyzed. The "retailing problem" is an extremely broad topic and the team mainly used three techniques to understand it:

- on field visits in all the areas of the city in order to understand the methods of work of different retail players (ranging from urban markets to big malls);
- interviews with retailers and with categories' representatives;
- literature reviews.

All the identified problems were clustered in a comprehensive "problem tree" on the basis of which the levers to act on in order to solve them were pinpointed. Problems were mainly divided into internal problems (those a retailer can act on) and external problems. The former were the focus of the team work, being them linked to actionable levers.
Given the broadness of the issues faced by retailers, the team discussed with ASCOM and decided to focus on those internal issues related to the business model. More specifically, the focus was on the issue related to the bad communication of the store identity to the customers.
The need to focalize the attention on a specific issue required the team to carry on further analyses on similar project and customers' requirements in order to better shape to service to be developed. These were carried on through further literature reviews and interviews.

Exploring the opportunities

The biggest challenges for the project are:

- to offer an innovative service pushing customers into visiting shops and buying their products;
- to reach the highest number of customers;

- to incorporate a mechanism allowing to reach the highest number of targeted customers;
- to trigger fidelity mechanisms. Two main possibilities have been identified to answer the objective of improving retailers' communication;
- a traditional one targeting Turin's citizens and promoting the shift back to the independent shops;
- an innovative one targeting the increasing number of tourists visiting the city.

The former one is the most suitable as far as the number of customers is concerned. Indeed, a citizens-focused service addresses a bigger pool of users. Furthermore, citizens' purchases in small retailers shops are repetitive by nature and thus a citizens-focused service opens to door to fidelization opportunities. On the contrary, a tourists-focused service addresses a lower total number of customers, which only purchase retailers' products when in Turin.

At the same time, a tourists-focused service allows to more easily target customers since all tourists get in contact with one or more touch-points out of a limited and well-known set of them. Tourists can also be more easily influenced since they are in a lack of information position and get usually informed through the previously named touch-points. In other words, given the same number of potential customers being contacted, a higher number of tourists are expected to respond with a purchase to a tourists-focused service as compared to the number of citizens answering to a citizens-focused one. A tourists-focused service also opens the doors to more innovative services, answering to tourists' need which are not completely targeted yet. Indeed, even though fidelization opportunities arise with citizens-focused services, these are hardly innovative and fidelization is extremely hard to obtain.

Considering the challenges of the project and the possibility to solve them through one of these services, the tourists-focused one was chosen as the more appropriate. Indeed, other than noticing the pros of this service, the team noticed how fidelization is extremely hard to obtain even when focusing on citizens, being today customers less and less loyal. At the same time, a tourists' one-shot purchase might be turned into repetitive ones through e-commerce sales. In this instance, once the possibility to repeat purchases is given, customization might be obtained by leveraging on the uniqueness of Turin products.

Generating a solution

Torino Pass is a service supporting tourists over the different steps of the Turin travel experience, starting from planning the trip until the after travel phase.

The core of the service are thematic itineraries, which are of different product categories, which constitute typical Turin specialties (food in the first project phase). In particular, the itinerary consists on a number of cultural stops and a number of "shopping" stops. The tourist can either access premade itineraries, especially for the elders that are not accustomed with the usage of digital devices, or build their owns. In the latter, the itinerary is obtained by inserting information such as the tourist's available time, weather conditions and preferences (both in terms of cultural interests and purchase interests).

The service is not limited to the itineraries. Indeed, the service is to guarantee an experience covering the different activities connected to a touristic trip to a city (the preparation ones, the during-the-visit ones and the after travels ones). Thus, a number of ancillary services were added to the core service (for instance the possibility to leave reviews over the service and over the itineraries' "stops" and the possibility to buy typical products from home through the e-commerce service).

The idea behind the service is to make tourists easily access to information and services related to on typical food and on those shops selling them. The higher traffic in shops would consequently derive from the better exposure of retailers to tourists, the higher number of services offered and the association of their service to the idea of a unique Turin experience.

Other than the Mobile App and the website, that are the main assets of the service, physical touchpoints were developed. These include the involvement of touristic Info Points, hotels and the retailers' shops themselves. Hotels in particular will play a relevant role, in a win-win environment, as they will sell welcome packages made up of typical products of the city retailers, making a profit while promoting the Torino Pass service and the participating retailers.

In order for this to work, the team reached an agreement with Federalberghi, the hotels' association, who liked the project and guaranteed an initial involvement of 16 hotels in different areas of the city.

Torino Pass service is an innovative solution that answer both retailers' (no excessive resources or effort to be dedicated to something not related to their core activities) and customers' (unanswered demand for seamless trips encompassing both cultural and architectural heritage and the typical city experience urban retailers are able to offer) requirements contributing to the solution of the overall retailing problem: indeed retailers' revenues are increased thanks to the new segments of customers. A tourist alone is often consider not appealing, as it stays in the city just for a few days, but considering tourists as a constant flow of people that exchange opinions between themselves, they become an extremely profitable target. Moreover, thanks to the e-commerce service provided by TorinoPass, even single tourists might become loyal customers.

HEWIT

High Energy Wind Turbine

Project

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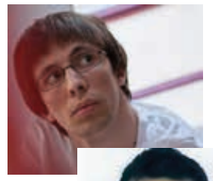
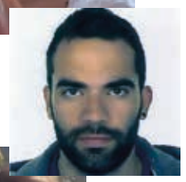
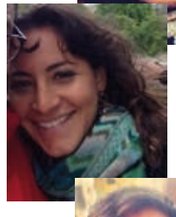
HEWiT

High Energy Wind Turbine







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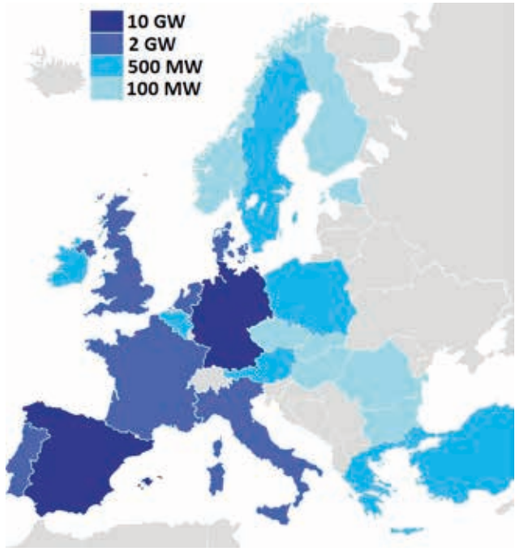
Project description

Nowadays, there is a strong interest in wind turbines able to produce hundreds of kW. However, with classical machines, increasing their power means that the blades diameter has to increase over 30 m and weighs hundreds of kilograms. Therefore, the HEWiT project is based on the idea of optimizing current wind turbines in order to enhance their competitiveness in the energy market.

The HEWiT team was subdivided into four main groups: aerodynamic, structural, materials, and environmental part. All these subgroups were obviously not independent one from the other but their activities and studies were strongly correlated. Specifically, the main objective of the aerodynamic team was focused on designing the blade geometry in order to obtain the maximum efficiency with fixed wind speed (9 m/s) and tip speed ratio (TSR=8). According to literature, the optimal chord and twist distributions were chosen. Afterwards, in order to obtain the optimal blade geometry, three different airfoils were chosen for the root, middle and tip of the structure. Once the design was defined by means of a blade element momentum theory analysis, a total power coefficient of 0.544 was assessed, corresponding to 92% of the theoretical maximum efficiency for the selected design. Moreover, it was observed that, changing the tip speed ratio, the efficiency varies from 66% to 92% of the maximum theoretical efficiency.
The structural team was focused, once the aerodynamic optimal profile and correlated stresses were defined, on the analysis of the configuration to verify if it was able to sustain such loads with the composite features provided by the materials team. First, the team studied a simple geometry in order to obtain optimal turbine blade working conditions (rotational speed). This was carried out initially by means of analytical methods and, then,



Example of land-based wind turbines

Panorama of generating capacity from wind power in the European countries

the results were compared to those obtained with numerical tools (finite element software packages). Afterwards, the blade structural model, with the optimal aerodynamic profile, was realized and studied through numerical methods to verify the structural integrity during working conditions.
The reinforcement of the polymeric matrix was achieved by dispersing pristine and functionalized carbon nanotubes (CNTs) in an epoxy matrix. The aim of this reinforcement was to produce a stronger and stiffer matrix, in order to obtain a lighter blade, thus saving materials and limiting the environmental impact of this part of the wind turbine. Different dispersion techniques, as well as different CNTs contents were investigated. The results from mechanical testing highlighted the high potential of CNTs as fillers in composite materials.
Considering the environmental impact study of the project, a review of Life Cycle Assessment (LCA) aspects of the wind turbines was carried out. The environmental impact analysis of a traditional wind turbine, in terms of embodied energy and CO_2 emissions, played an important role for the final project work. Then, embodied energy and carbon dioxide emissions were computed by means of CES Edupack commercial software.

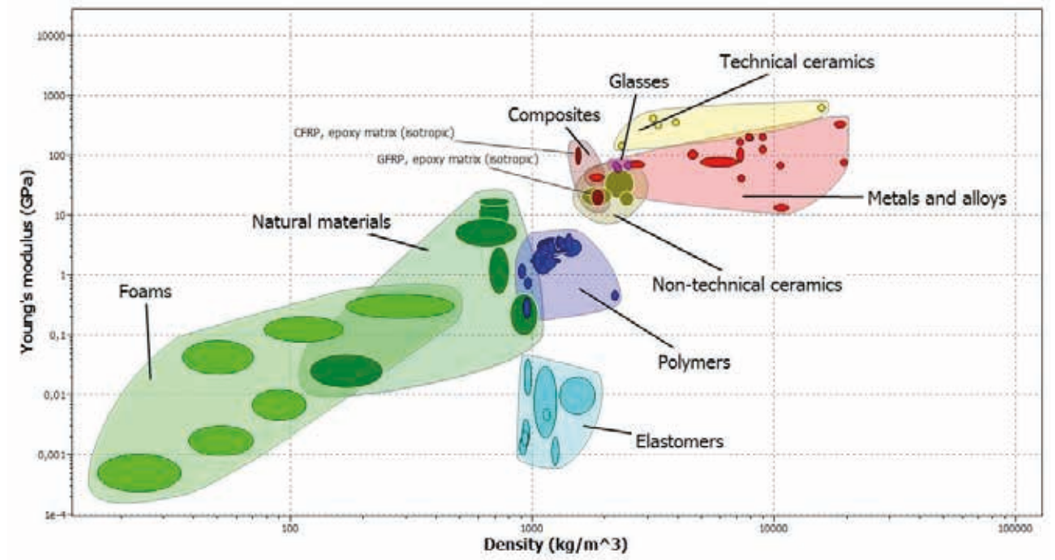
Tasks and skills

Masoud Ahmadinia: Petroleum Engineering, Politecnico di Torino [Team Controller]. Masoud's activity focused on life cycle assessment (LCA) of a 1 MW wind turbine, starting with a fundamental review of LCA state of the art, and, eventually, carrying out CES EduPack simulations evaluating energy consumption and environmental impact of the wind turbine technology.
Serena Aleo: Materials Engineering and Nanotechnology, Politecnico di Milano. Serena carried out preliminary researches on the state of the art of nanocomposite materials; she attended the preparation of tensile tests samples and finally managed the overall report drafting.
Gianluca Montanari & Edoardo Peradotto: Mechanical Engineering, Politecnico di Torino & Aerospace Engineering, Politecnico di Torino. Gianluca and Edoardo focused their work on structural analyses, from the realization of different blade configurations to reliability studies by means of proper engineering software, in order to evaluate the mechanical feasibility of the wind turbine blade.
Alberto Oregio Catelan & Francesca Roberto: Aeronautical Engineering, Politecnico di Milano & Aerospace Engineering, Politecnico di Torino. Alberto and Francesca focused their activity on stakeholders and requirements identification, developing the design of the blade shape, realizing the aerodynamic performance assessment tool exploited in the project.
Stefano Pisoni: Materials Engineering and Nanotechnology, Politecnico di Milano [Communication Coordinator]. Stefano carried out preliminary researches on the state of the art of current materials applied in wind turbine technology. He focused on the synthesis procedure and dispersion optimization process regarding the nanocomposite materials, comparing different carbon nanotubes concentrations and dispersion techniques.

Giorgia Scetta: Materials Engineering and Nanotechnology, Politecnico di Milano. Giorgia carried out preliminary researches about materials for wind turbine blades. She realized the samples for tensile tests and carried out the mechanical characterizations, studying and comparing the mechanical properties of the obtained specimens.

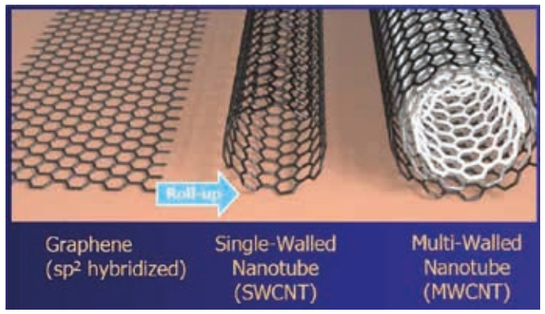
Abstract

Today's greatest global challenge is the need for more affordable, reliable, clean and renewable sources of electricity: according to EUROSTAT [1], the greatest source of man-caused greenhouse gas emissions is fuel combustion, which mostly takes place in energy transformation, responsible for nearly 80% of all emissions in the EU.



Ashby diagram, Young's modulus on y-axis, density on x-axis

The main goal of HEWiT project deals with the study and optimization of a wind turbine blade, considering different engineering standpoints, in order to enhance the wind turbine technology attractiveness in the energy market.
First, a stakeholder analysis was carried out in order to identify users' main requirements. The team performed an extensive survey of the state of the art pinpointing present-day solutions for wind energy exploitation, which is currently undergoing a substantial growth due to the support of governments and international institutions.
In this growing and dynamic context, the main challenge was to verify the structural feasibility once innovative composites materials and aerodynamic profiles were studied and developed.
The proposed material is made of a polymeric matrix, such as epoxy resin, for which both functionalized and non-functionalized carbon nanotubes (CNTs) proved to be effective fillers. After an optimization, ultrasound mixing showed several advantages with respect to mechanical one, such as a lower CNTs agglomeration and a greater amount of solution that could be prepared.
When the behavior of the material was fully characterized, the team delved deeper on modelling the turbine. Aerodynamics optimization of the blade showed that the three blades turbine operating, according to design conditions, could top more than 92% of the maximum theoretical efficiency. The static analyses on the defined structure displayed a maximum tip deflection in accordance to current regulations, likewise the dynamic behavior proved



Model of a single-walled carbon nanotube (SWCNT) as obtained from a graphene sheet. Multi-walled carbon nanotubes (MWCNTs) are obtained through rolling of some overlapping sheets

satisfactory at the design rotating speed. At this point, structural analyses were developed demonstrating the feasibility of the particular configuration, underlining the potential application of the product with innovative materials and aerodynamic profiles. All these preliminary technological studies were surrounded by a general life cycle assessment to evaluate the potential energetic and environmental impact of this technology.

Understanding the problem

Wind turbine technology, as renewable energy source, is playing, and will play, a crucial role for the worldwide electricity generation demand, minimizing carbon dioxide emissions.
In order to understand what the main challenges are, related to wind turbine technology, several preliminary lectures were attended, and an intensive bibliographic research was carried out as well.
The theoretical lectures provided a common starting knowledge for all the group members, focused on the main features and working principles of wind turbines.

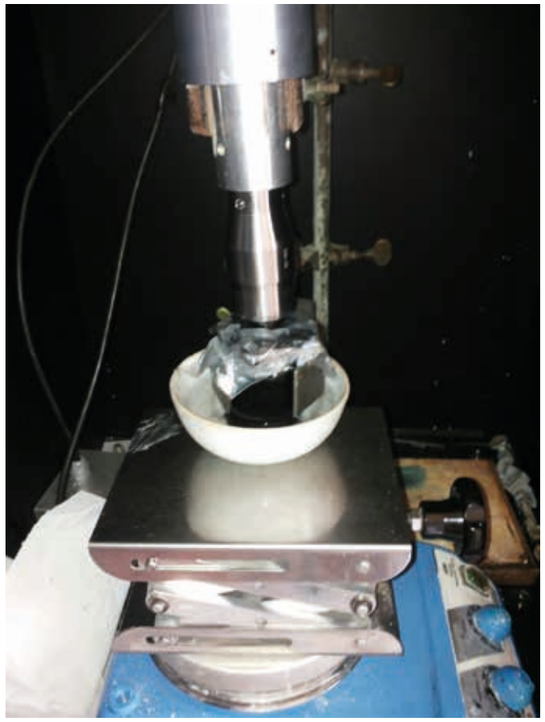
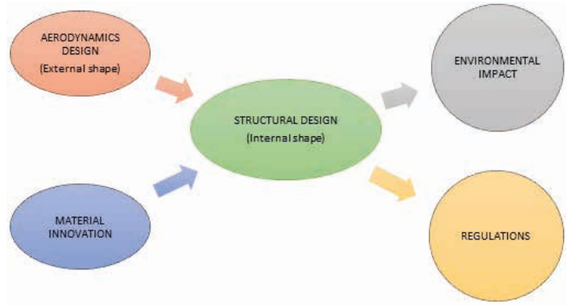


Image of the ultrasound technique arrangement during mixing.

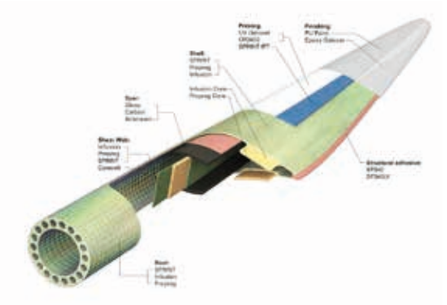
The bibliographic research enabled a deep understanding of the state of the art of the technology, from materials, aerodynamic, structural and environmental standpoint.
These initial steps were fundamental due to the significant interdisciplinary character of the project, which required a broad knowledge of different engineering aspects.
The main targets were:

- Preliminary studies of innovative nanocomposite materials: optimization of the synthesis procedure, trying to achieve a homogeneous dispersion of the nanofillers into the matrix and basic samples mechanical characterizations;
- Optimization of aerodynamic blade features: design a proper blade geometry in order to achieve the best performances under fixed conditions;
- Structural blade analyses: assessment of the structural and mechanical reliability of the particular blade configuration, starting from previous materials and aerodynamic considerations;
- Environmental impact assessment: general life cycle analysis of 1 MW wind turbine, from production to disposal.

It is clear that the foremost necessity was to have a good collaboration between the different sub-teams in order to guarantee a good proceeding of the entire project.
In conclusion, the principal need, behind these activities, is try to point out what could be possible improvements for a future progress in wind turbine technology, where the synergistic effects of materials, aerodynamic and structural optimizations will favor lower costs and a reduced environmental impact.



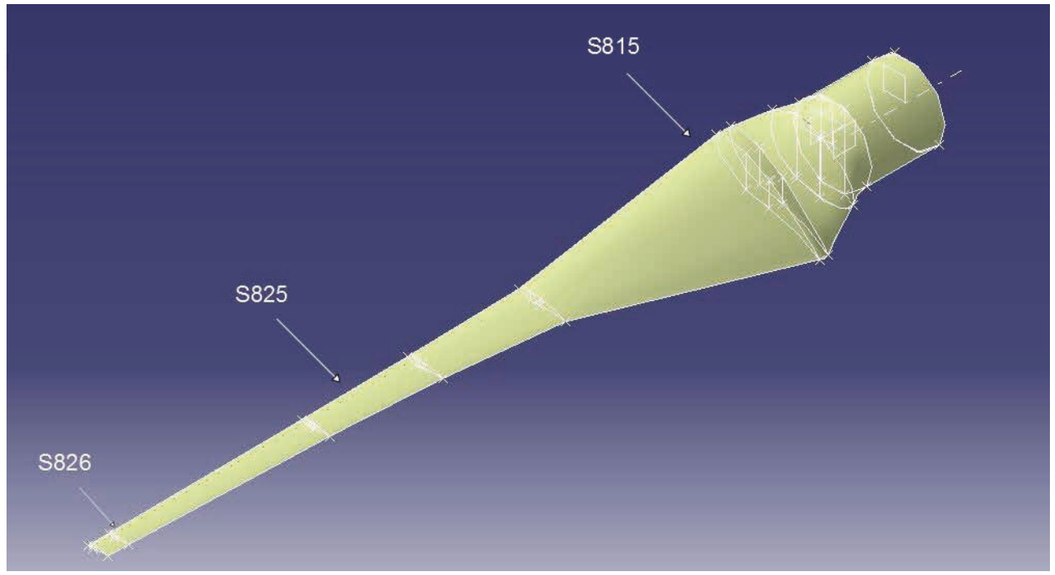
Relational scheme of the different project aspects



Representation of blade element groups

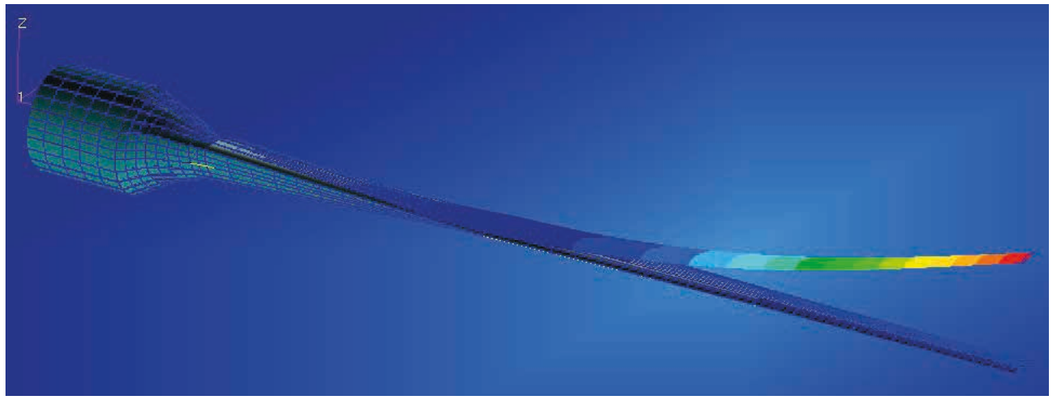
Exploring the opportunities

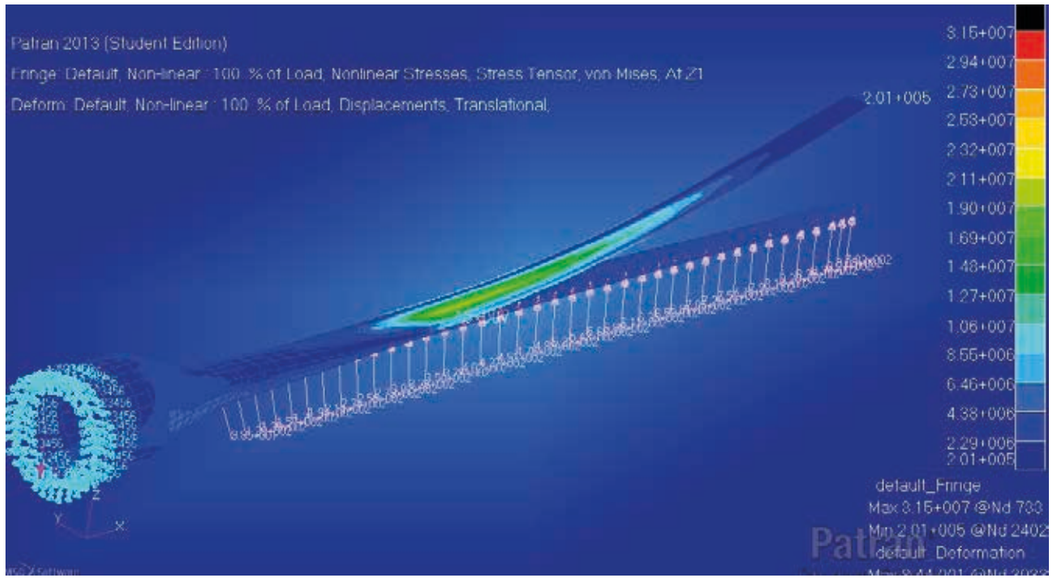
Nowadays, there is a strong interest in wind turbines able to produce hundreds of kW. However, with classical machines, increasing their power means that the blades diameter has to increase over 30 m and weighs hundreds of kilograms. Therefore, numerous challenges arise when the



Blade geometry in the definitive configuration

design and development of low cost, high performances wind turbines are taken into account in order to improve their future technology deployment. Particularly, the study and optimization of the wind turbine blade represents the most critical component to achieve better efficiencies, considering all the engineering issues behind this structure. Currently, traditional fiber-reinforced polymers are used as principal materials for wind turbine blades; however, it is necessary to further enhance the aerodynamic performances of these structures limiting their cost and weight. Therefore, from the literature, it is known that using nanomaterials could improve the material performances, giving the possibility to maintain the same efficiencies using a lower amount of materials reducing costs and environmental impact. Among different nanomaterials, we chose carbon nanotubes in these preliminary studies, thanks to their outstanding properties and their compatibility with molecular-based materials (e.g. epoxy resins) [2].
The blade configuration plays a fundamental role for the aim of the project; hence, two possible alternatives were evaluated: a further improvement in the aerodynamic profile optimization with respect to the state of the art, or a completely different and innovative configuration like the diffuser aug-





Non-linear static analysis showing stresses with the VM criteria for the not-optimized thickness GFRP configuration

Mode shape, flap case

mented wind turbine. The second option appeared unfeasible, mainly, for its high complexity for these preliminary studies, thus, we focused on the aerodynamic optimization of the wind turbine blade, considering the innovative configuration development as a possible future activity.
This project is largely based on an interdisciplinary approach, where the structural feasibility analyses depend on the aerodynamic and materials studies. This aspect embodied a critical passage for the team, but also a motivating aspect that explained us how team working could have a synergistic effect for the project. Furthermore, other challenges and obstacles had to be faced, such as fillers optimal dispersion, nanocomposite samples preparation for mechanical characterizations and available modelling software that are limited in terms of achievable level of complexity for the development of aerodynamic and structural studies.

Generating a solution

Two main bricks compose our solution: the exploitation of innovative materials and the design of a proper turbine blade airfoil, as both proved necessary to the overall structure optimization.
State of the art nanocomposites were employed to increase the mechanical properties of the designed turbine blade. In particular, composite materials obtained by reinforcing an epoxy matrix with carbon nanotubes (CNTs), both functionalized and not, were taken into account. As a result, elongation at break and ultimate tensile strength were clearly improved with respect to the basic resin properties, thanks to new, emergent toughening mechanisms. In addition, fatigue resistance improvements could be foreseen (although not verified in the present work). On the contrary, no significant effect on the material stiffness was observed, probably due to the experienced problems in effectively dispersing the CNTs.
Such improved properties, coupled with a proper choice of optimal blade parameters (chord and twist) and innovative airfoils (for instance less affected by leading edge surface roughness) that lead to high levels of aerodynamic efficiency over a wide range of operative conditions, allowed for a substantial optimization of the overall blades structure.
Extensive reductions of the blade weight were consequently achieved (around 40%, according to numerical model analyses), retaining the required structural stability of the blade (verified through both static and dynamic simulations) and improving the aerodynamics turbine performances. Such weight optimization would result, of course, in both lower costs and environmental impact, from the materials, manufacturing, transport, construction and disposal point of view. Both the energy consumption and the carbon dioxide emissions were taken into account in the overall life cycle analysis. Further improvements could arise from the exploitation of different nanoreinforcements (first of all graphene) or from the implementation of more effective dispersion methods. Moreover, the interaction between the different phases embedded in the matrix (CNTs and glass or carbon fibers) and the effects of CNTs functionalization should be further investigated.
Future structural and aerodynamic studies on diffuser augmented wind turbines, exploiting a more specific life cycle assessment, could guarantee potential breakthroughs for wind turbine technology.

Main bibliographic references

- [1] http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics
- [2] Domun N. et al. (2015), *Improving the fracture toughness and the strength of epoxy using nanomaterials-a review of the current status,* Nanoscale, Vol. 7, pp. 10294-10329

MICRA

Micro Combined Generation for Residential Applications

Project

17

MICRA

Micro Combined Generation for Residential Applications

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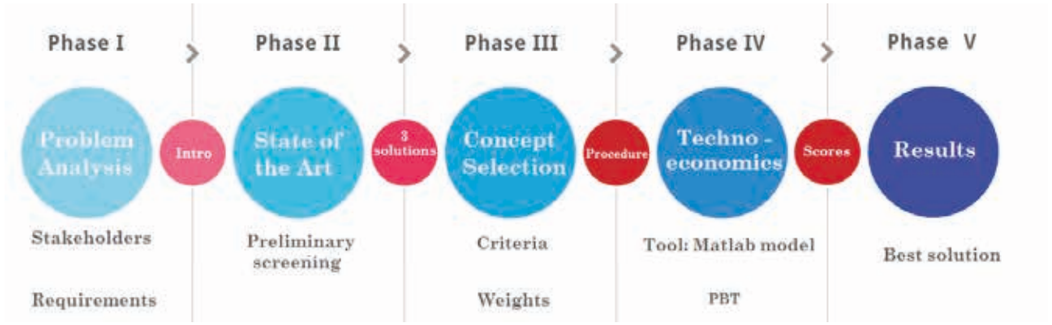
Project description
After a century of development and economic growth that relay on fossil sources and carbon products, human beings are starting to realize the threat posed by the uncontrolled exploitation of these sources.
The new renewable energy paradigms and the efficiency maximization mantra of the energy market have led to initiatives such as the 20-20-20 policy package, which has resulted in the commitment of the members of the European Union to reducing their energy consumption and pollution rates.
In this scenario, leading companies in the energy sector, such as AsjaGen S.r.l., have developed innovative solutions to address these issues. One of these solutions is known as Micro Combined Heat and Power (μCHP) generation, and consists of the self-generation of both thermal energy for heating terminals and Domestic Hot Water (DHW) and power for the operation of electrical appliances or industrial machines. The advantage of adopting such a technology is not only a decrease in the total energy bill, but also the actual production of nearly-as-needed energy, the minimization of transmission losses and the optimizing of overall fuel utilization through the adoption of machines that are able to provide the user with as much as 90% of the primary energy.
However, these machines have only proved to be economically viable for large-scale residential and industrial applications (e.g. large blocks of flats, hotels, factories) but have not yet been explored for small independent (i.e. single-family) residential applications.
In an attempt to explore the market for AsjaGen S.r.l., the MICRA project has dealt with a multi-criteria analysis on the aforementioned issues. After the Stakeholder analysis, the state-of-the art has been evaluated to further identify the needs and requirements. The μCHP environment has been analyzed as technical and economic description of the most promising candidate machines (i.e. Stirling Engines, Internal Combustion Engines, Fuel Cells).
In order to select the most promising technology, a systematic methodology has been adopted. The technologies have been analyzed for small, residential applications in terms of both their energetic and economic features through a dynamic MATLAB model that follows the machine operations in a nearly-minute-by-minute basis, owing to the exceptionally detailed energy load data embedded in the model. The quantitative results have then been coupled with the already performed qualitative analyses to assess the viability of the proposed technologies and identify the best candidate.
It should be underlined that the most important added value of the MICRA project is the creation of a simplified coupled energy and economic model that constitutes a tool for reliable comparisons of different technologies by simply changing the data provided as input to the model. Thanks to this tool, AsjaGen S.r.l. can evaluate other market opportunities in the energy production scenario.
The results of the project have been just submitted to an international referred journal for dissemination purposes.

Tasks and skills
Oghenewogaga Akposibruke analyzed the state-of-the-art for the Stirling engine technology, both from a literature and market analysis, and finalized the overall outcomes of the project selecting the most promising solution through a multi-criteria analysis;
Dario Gigliotti identified all the requirements of the project and then mainly concentrated on the economic assessment of the various alternatives by analyzing their payback time and the yearly savings coming from the adoption of such a technology;
Djordje Golic analyzed the principles of thermodynamics lying at the base

of the micro-cogeneration concept and produced a possible business model for the development and commercialization of a micro-cogeneration system;
Tanveer Hussain scoped the state-of-the-art situation of the Internal Combustion Engines technology;
Valerio Mascolino defined the stakeholders of the project analyzing their needs, proposed the mathematical formulation lying below the energetic dynamic model of the technologies analyzed in the work and implemented it into a MATLAB software tool;
Alessandro Tassone conducted a thorough and detailed identification and analysis of the suitable fuel cell technologies and addressed the issue of pollutants both in terms of composition and quantity for the designated technologies.

Abstract

Operating in the energy sector and interested in the new market possibilities offered by the **Micro Combined Heat and Power (μCHP) generation**, the group AsjaGen S.r.l. has proposed **a study of different technologies** in order to understand which is the most promising for innovative production systems to be installed in **single-family houses**.
In an effort to explore the market for AsjaGen S.r.l., in the present work a **multi-criteria analysis** is performed.

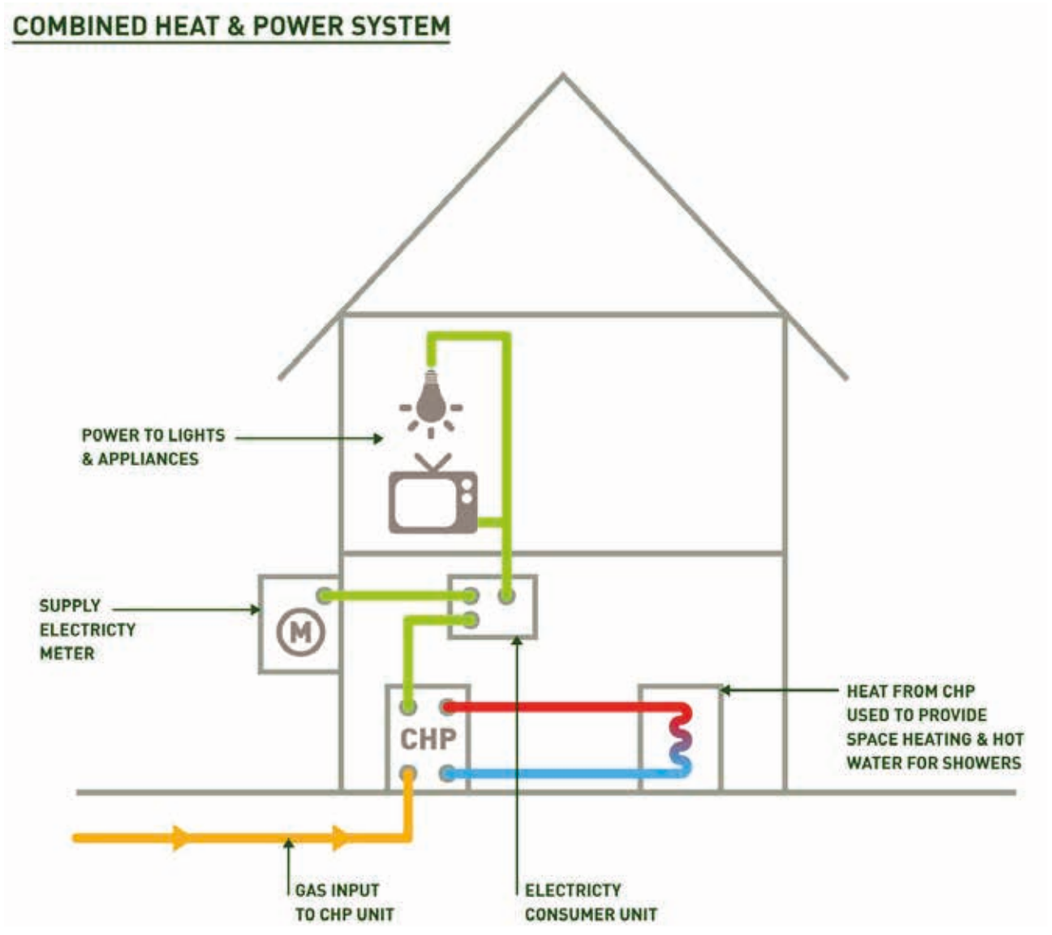


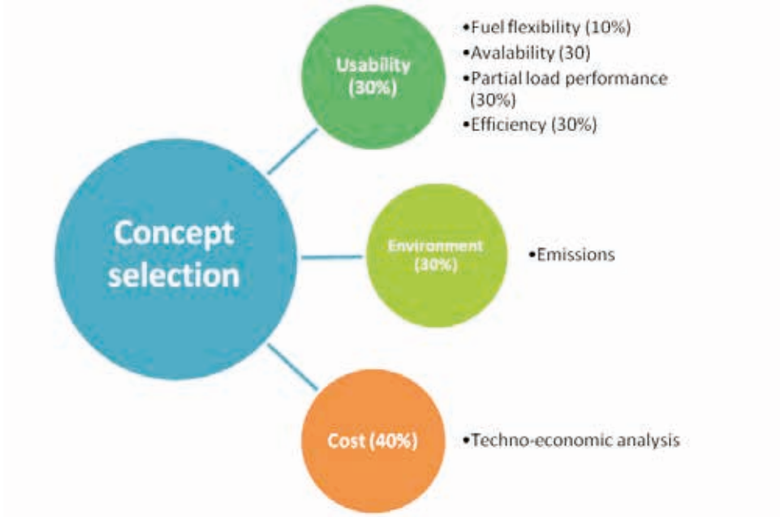
The first step is the **Stakeholder analysis,** necessary to deeper investigate the problem and to identify needs and requirements.
Then with the study of **state-of-the-art** for each technology, a **preliminary screening** is obtained. Micro-CHP environment is analyzed firstly in general and then going deep into the technical and economic description of the most promising candidate machines (i.e. Stirling Engines, Internal Combustion Engines, Fuel Cells).
A systematic methodology is adopted to select the most promising technology. This methodology needs a list of **criteria**, defined by clustering of requirements and weighted depending on their relevance. Fuel flexibility, availability, partial load performance, efficiency are grouped under the usability category, pollutants emissions account for environmental safeguard and the techno-economic analysis contributes to the costs category.
Before evaluating them, these technologies are analyzed for small residential applications both in terms of their energetic and economic features (techno-economic analysis). This is done through a **dynamic model** in MATLAB that follows the operation of the machine in a nearly-minute-by-minute basis, thanks to the exceptionally detailed energy load data retrieved, which the model has access to [1].
Technologies get a score for each criterion, so that the one with the highest score is the best technology. The final ranking sees the Fuel Cells as the best candidate, followed by the IC Engines and the Stirling Engines.

In addition to the actual analysis of the proposed technologies, it is important to stress that the most important added value of the work is the creation of a **coupled energy and economic simplified model** that constitutes a tool for reliable comparisons of different technologies simply changing the data provided as input to the model. Furthermore it can help AsjaGen S.r.l. in decision-making issues related to the eventual extension of their share of the market into this new window of opportunities in the energy production scenario.

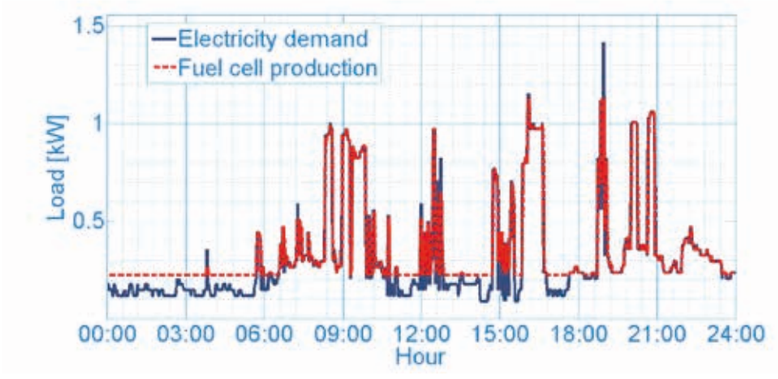
Understanding the problem

The innovative nature of the Project lies in the fact that the **domestic single-family scale** for μCHP is in the very first research phase in Europe [2], and has not been studied yet for the Italian environment.
In order to improve the knowledge of the problem, a fundamental step is the **Problem Analysis**, which consists of **Stakeholders Analysis**. Three very important Stakeholders were identified for the MICRA project:
AsjaGen S.r.l.: it aims at producing a competitive machine to sell to single-family houses, maximizing the profit and minimizing the costs and emission of pollutants. Therefore, the target size of the machine is around **1kW$_e$ of electrical output**.



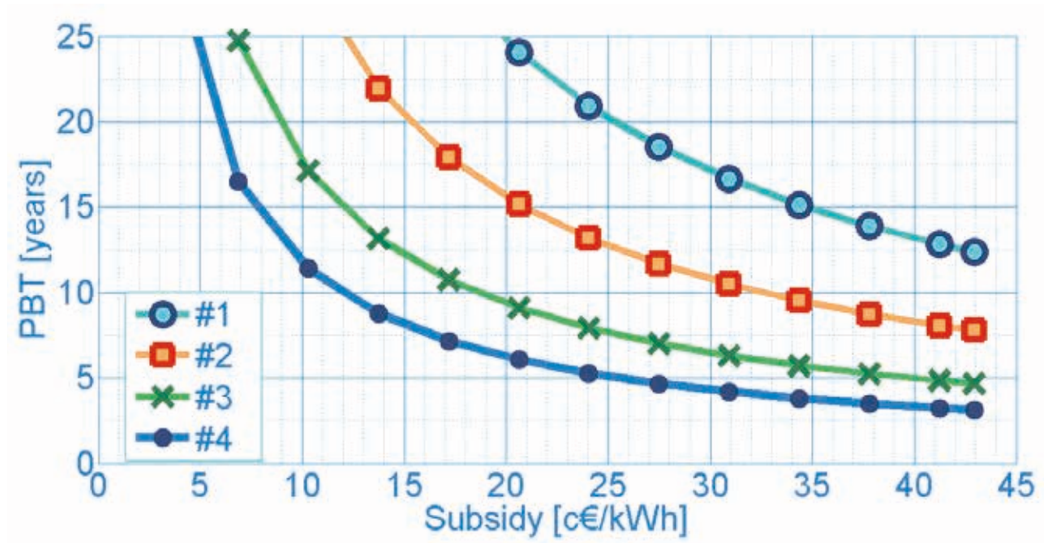


The End – Users (Residential Householders): families composed by about three people who live in **flats or little independent houses**. They will eventually buy the AsjaGen device willing to reduce their expenses by self-producing most of their domestic energy demand. In summary, they are the users, the buyers and the beneficiaries.
Authorities: they have to check that the AsjaGen's machine response meets their regulations (pollutants emission, safety of the device, noise produced etc.) and eventually approve the production and selling to the final users. It must be highlighted as well that the Italian government plays a fundamental role as the green technologies **subsidies** giver**,** since only with a strong political will an economic cost-competitive product can be achieved.



The next step in the analysis is to individuate and make a list of the requirements that the outcome of the project – the final product – has to fulfil. The requirements are mainly of four types and can involve one or more stakeholders.
End Users requirements: the device should minimize the bills and maximize the share of the demand covered by it, considering the different costs of electricity and heat.
Technical requirements: the design outcome will need a series of technological characteristics in order to work properly and with the requested performances: low polluting emissions, low maintenance, high efficiency, high availability, good performance at partial load, easy installation and low noise production.

Business requirements: since users should make profit from the machine proposed, the cost must be sustainable. Subsidies from Authorities can make the machine competitive in the market despite high investment cost.
Regulatory requirements: any device for the production of energy must respect a very strict legislation for what concerns the pollutants emission and the noise generation. Furthermore, any technical/mechanical device must be realized according to some defined technical standards.



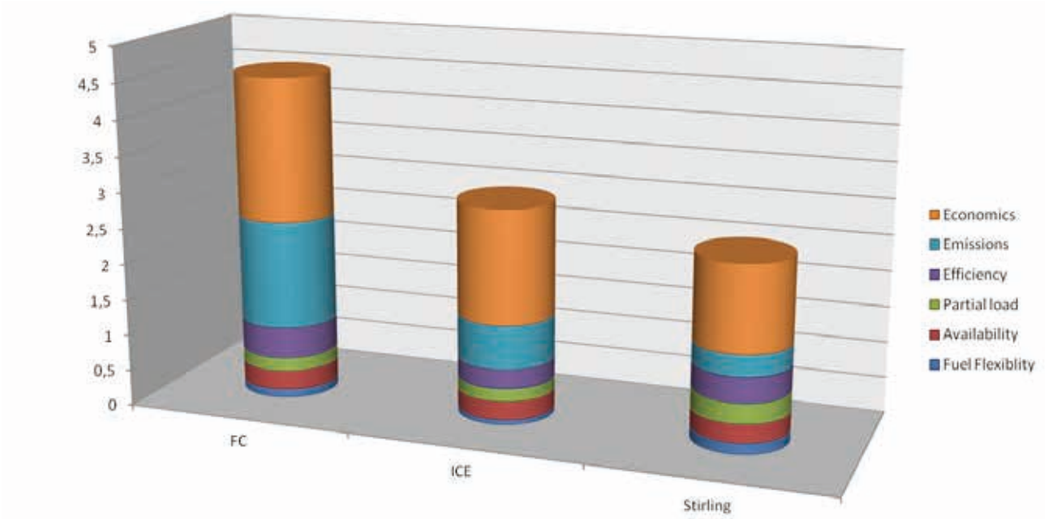
Exploring the opportunities

Analysis of the **state of the art** is fundamental to perform a **preliminary screening.** Some technologies are not suitable for the application of interest and the appropriate ones must be studied in detail. The most promising technologies analyzed in this Project are Stirling Engines, Internal Combustion Engines and Fuel Cells [3].
The internal combustion engine (**ICE**) is a heat engine that converts chemical energy present in a fuel into mechanical energy. This energy is usually made available on a rotating output shaft. The great advantage of ICE is that its performance and price data are well established, while data for the other technologies are not widely known, since based on a limited number of demonstration projects. In fact the ICE is characterized by the lowest installed cost, which ranges from 6'000 to 16'000 €/kW_e. The electrical efficiency is higher compared to Stirling engines, though they require more periodic maintenance than competing technologies and have higher emissions of CO, NO_x and particulates.
The **Stirling engine** is a heat engine of the external combustion piston engine type. This technology however has a good potential because of its ability to attain high efficiency, fuel flexibility, low emissions, low noise/vibration levels and good performance at partial load. Unlike reciprocating internal combustion engines, the heat supply is from external sources, allowing the use of a wide range of energy sources including fossil fuels such as oil or gas, and renewable energy sources like solar or biomass. The main drawback is its current average retail price of 10'000 €/ kW_e.
The final purpose of **Fuel Cells** is to produce electricity thanks to two electrochemical semireactions that occur at the different electrodes of a cell, the anode and the cathode. Fuel cells by nature of their lack of a combus-

tion process have extremely low emissions of NO_x and CO, and their CO_2 emissions are also generally lower than other technologies due to their highest electrical efficiency. They have few moving parts and therefore have the potential to very low maintenance. The main drawbacks come from the cost (average current retail price of 17'000 €/kW_e) and the lack of complete and reliable data since the technology is still in the research and optimization phase.

Generating a solution

A systematic methodology is adopted to select the most promising technology. This methodology needs a list of **criteria**, defined by clustering of requirements and weighted depending on their relevance. Fuel flexibility (10%), availability (30%), partial load performance (30%), efficiency (30%) are grouped under the usability category (30%), pollutants emissions account for environmental safeguard (30%) and the techno-economic analysis contributes to the costs category (40%).
As for the techno-economic analysis, these technologies are analyzed for small residential applications both in terms of their energetic and economic features. This investigation is possible thanks to the implementation of a dynamic model in MATLAB, which is able to follow nearly-minute-by-minute the operation of the machine, relying on detailed energy load data provided as input to the model.



PBTs of each technology are computed assuming four different values of investment cost and considering that μCHP is not economically sustainable in the present context a support scheme is therefore needed. Subsidies necessary to obtain PBTs of 12 years, 10 years and 5 years with 4 values of investment cost are computed.
The selection of the best technology is obtained compiling a ranking of the technologies, after having assigned them a score for each criterion. The results of this procedure identify Fuel Cells as the best candidate, followed by IC Engines and Stirling Engines.
ICEs and Stirling engines could be sustainable in countries with high thermal consumption and with subsidies supporting thermal production. FCs are the **most promising technology** though, considering that the high investment cost can be strongly reduced in case of wide industrialization of production processes and even more considering that it has a low heat to power ratio [4]. Therefore, it is suitable when electrical demand is the main source of energy bill, as it is assumed to be the immediate future in all the European countries.
Moreover, it can be highlighted that the results obtained are not the only valuable output of the project. In fact, the creation of a coupled energy and economic simplified model represents the most important added value of the present work, which could be used in the future for further analyses and other technologies evaluation simply changing the input data. Hopefully, it will be a valuable and effective tool for AsjaGen, which could use it to better exploit the new opportunities offered by the energy production field and acquire a considerable share of this market.

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PMM-HEV

Power Management and Modelling
of Hybrid Electrical Vehicle

Project

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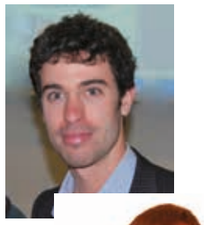
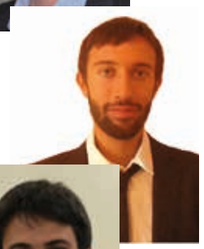
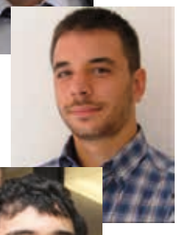
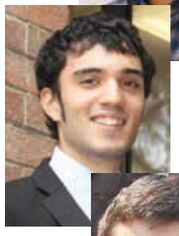
PMM-HEV

Power Management and Modelling of Hybrid Electrical Vehicle

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Davide Cardella
Mechanical Engineering, Politecnico di Torino
Alessio La Bella
Automation Engineering, Politecnico di Milano
Davide Moschetta
Mechanical Engineering, Politecnico di Milano
Giulia Musacci
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Valentino Peluso
Electronic Engineering, Politecnico di Torino

Tasks and skills

Luca Bellini: in his role of Team Controller and Communication Coordinator was in charge of group management. Particular focus on driving cycle simulation and emission profiles analysis.
Alberto Bolzoni: has focused his work on the development of the simulation model, in particular as regards the electric traction system and the storages, by analysing and implementing them into the software.
Alessio Canepa: has focused his work on the development of the simulation model and of the control logics. In the role of computer engineer he paid particular attention to some debugging problems.
Davide Cardella: has focused his work on the development of the simulation model, focusing in particular on the dynamics of the vehicle, as well as the combustion engine simulation.
Alessio La Bella: worked on the development of the simulation model, with a particular emphasis on the designing of the control logics for the vehicle power management.
Davide Moschetta: focused his attention on the definition of the innovation to the everyday life allowed through the project and the definition of future developments.
Giulia Musacci: concentrated on the definition of the macro-context of the new vehicle and the state-of-the art of hybrid vehicles developed so far, as well as the analysis of their principal components.
Valentino Peluso: carried out an analysis on the hybrid electric vehicle system modelling and simulation state-of-the art. Furthermore, he focused on the development of a driving cycle for simulation purposes.

Project description

In the context of the development of new electric and hybrid vehicles, it is necessary to develop a series of tools that allow an easy configuration of architectures, depending on the performance required.
The aim of the project is develop a simulation model of a commercial hybrid vehicle in order to implement new algorithms for the management of energy flows on board to improve performance and efficiency. The key point is the development of an innovative model that takes into account the battery and vehicle dynamics.
The team has considered the main cycles of operation in city and mixed-configuration driving. The team has evaluated the “Iveco Dual Energy” architecture and defined to model of the main components. The Iveco Dual Energy proposes extremely flexible technology for light commercial vehicles, capable of switching to the most appropriate source of energy depending on the vehicle’s mission.
The Iveco Dual Energy configuration, enabling immediate traction switching, depending on the type of itinerary and its conditions, is an important innovation towards an increasingly environmentally friendly mobility. Flexibility is its main characteristic: on the same chassis basis, it is possible to manage different motion architecture approaches and switch equipment for different missions. The purpose of the model is to choice technologies and strategies to push in order to develop at an innovative system ready for the market.
Energy management has become one of the most important features in a hybrid electric vehicle, with the primary goals to reduce pollutant emissions and minimize fuel consumptions. Pollution and traffic have motivated a revolution in the way people think about city transportation. The first measures taken by urban, national and international governments were standards and limitations on vehicle emissions, known as Euro-xxxx (followed by a year number starting from 1992), and limited traffic zones in city centers, such as Congestion Charge in London, Electronic Road Pricing in Singapore, Congestion Tax in Stockholm, and Area C in Milan. These measures have been initiated by European cities to address three different challenges:

- Achieving greater traffic flow in urban areas;
- Cleaner roads and air;

- Realizing smarter, safer and more accessible transportation solutions.

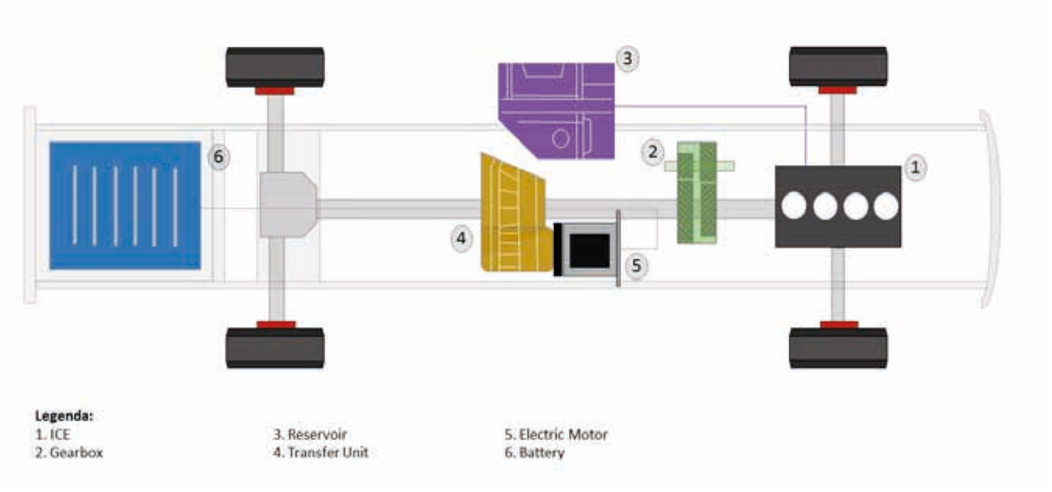
All these policies and measures combined have to improve collective and goods transportation. In particular this team has focused the attention on what car companies are developing for hybrid electric vehicles.
The application of the Hybrid technology on the Commercial Vehicles plays a fundamental role to address the current and the future Mobility needs and requirements.
In order to realize a strategy that optimizes the consumption of energy flowing in the whole system, the vehicle will be studied together with the devices and components present on board the vehicle. The hybrid electric is a mixed system that presents two different power sources that have different characteristics and have to cooperate to provide the requested amount of energy. The energy management is an open loop problem in which the input signal, represented by the requested power, is a known variable derived from the following of a desired trajectory defined by vehicle's speed. The objective of the problem becomes the determination of a control variable that defines the correct subdivision of the two energy sources, and thus, the operational mode of the vehicle.

Abstract

In the context of the development of the future mobility models it is necessary to consider the different aspects that may determine the feasibility of a proposed solution. For sure, the need to reduce the emissions and energetic consumption associated to the movement of people and goods has become a major issue of the policy makers both in the perspective of improving the quality of the urban environment and mitigating the effects associated to the climate changes. Anyway, the definition of new technological models needs to be considered under the perspective of economic feasibility, in order to be applied on an industrial scale. In particular, the introduction of hybrid powertrains on traditional vehicles may be a solution to adapt the automotive market to the new constraints in terms of pollutants emission, thus balancing the needs of both companies and end users. In this perspective, our commercial partner, Iveco CNH Ind., started to develop a new lightweight commercial vehicle with a parallel hybrid configuration, in order to comply with the new regulations in terms of pollutants emissions and, moreover, guarantee to its clients the access to the Congestion Charge Areas or the Low Emissions Zones, which have been introduced in many city centres and that constitutes a major issue, for example for a delivering company.
The task of the project, in particular, was to develop a flexible software platform that allows the company to assess in advance the performances of the vehicle architectures considered, in order to boost the design, assessment and prototyping times and, thus, to reduce the general costs associated to these activities. This task is associated, in general, to the growing interest toward the simulation and fast-prototyping techniques that are gaining more and more relevance in the automotive sector, but also in other industrial contexts. Another major goal was to go beyond the usual assessment techniques based on standard driving cycles, since they generally do not correspond to the real operating condition of the vehicle. This has been required in order to find more consistent data, allowing a higher optimization and the definition of ad-hoc control logics, designed to reduce the fuel consumption and pollutants emission of these architectures.
All these tasks were solved by implementing a simulation tool based on an object-oriented language that allows fast assessment of the vehicle performances under real operating conditions, included constraints on the congestion area, state of charge of the storage system, auxiliaries, inclination of the road etc, permitting the evaluation of possible architectures and design solutions. Moreover, two different innovative control logics have been developed and implemented for the power management of the hybrid powertrain, with a consequent test on the simulation platform itself. First of all, these models have been developed on an open-source software based on the Modelica language, then they have been exported on a commercial tool that has allowed a more detailed definition of all the components with a consequent higher reliability for the results of the simulations accomplished.

Understanding the problem

In the last years, the protection of the environment has become an objective shared by policy makers, governments, private companies and citizens. The major number of policies, such as the Plan 20-20-20, and companies that try to reduce the emissions and the energetic consumption, confirms this increasing interest.
In addition to the policies issued at an international level, there are several policies developed at a local level such as the congestion charge consisting in road pricing to reduce traffic congestion. In this restricted areas of the city, the circulation of vehicles is limited to low emissions vehicles and to electric vehicles (with zero emissions).
In this context, our commercial partner, Iveco CNH Ind., started to develop a new lightweight commercial vehicle with a parallel hybrid configuration, in order to gain access to this part of the city in which the restriction of the circulation of vehicles with combustion engines is enforced.



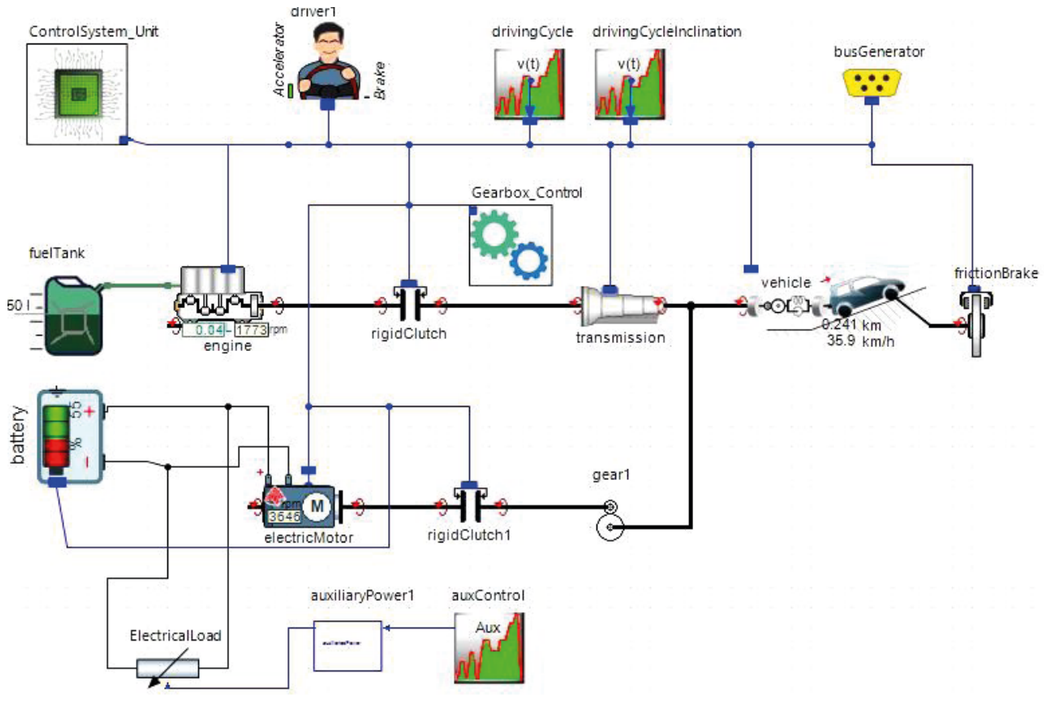
Hybrid architecture of the vehicle

In this case, the project has been developed with a collaboration with the producers of the elements necessary to create the actual configuration. The architecture itself, in addition, has been developed with the exploitation of the architecture of an already existing vehicle available in the market. In this way, there is the chance to convert, potentially, the vehicle already sold and circulating.
In addition, other stakeholders that have been considered in our evaluations are the carrier companies, specialized in last mile delivering. The importance of these companies is determined by their need of delivering packages in the city centres, where normal commercial vehicle are not allowed.
Given the already existing architecture of the vehicle, the main purpose of this project is focused on the creation of a virtual environment in order to test and optimize the control strategies and the power managements of the hybrid vehicle in this context.

Exploring the opportunities

Given that both an electric motor and an internal combustion engine (ICE) have been coupled in this new kind of vehicle, it is important to develop an efficient way of exploiting the power available from both the traction systems. Under these circumstances, the vehicle designed can work in five different modes (mechanical braking, regenerative braking, pure electric, thermic, hybrid).
As far as the acceleration phase is concerned, we have to consider the last three modes, which describe the way in which the torque is transmitted to the wheels. In the electric mode, the necessary torque is provided purely by the electric motor, while in the thermal mode the necessary torque is provided only by virtue of the Internal Combustion Engine.
The complexity of the model is approached considering the hybrid configuration, based on the exploitation of both the sources at the same time, combining them through the Transfer Unit, a mechanical element designed and patented from Iveco CNH Ind.
In this scenario a numerical model has been developed on a specific simulation software, such as Simulation X, exploiting a coding language called Modelica. In the created virtual environment, the real components of the vehicle have been modelled either starting from the constitutive equations in an energetic approach, or from experimental data acquired with the collaboration of Iveco. An iterative procedure to calibrate the parameters of the virtual model has been carried out, in order to achieve the required accuracy level for the simulation. In order to validate the model a preliminary test has been done, comparing the purely thermal configuration of a real vehicle with the simulation results.

Simulation model of the hybrid vehicle

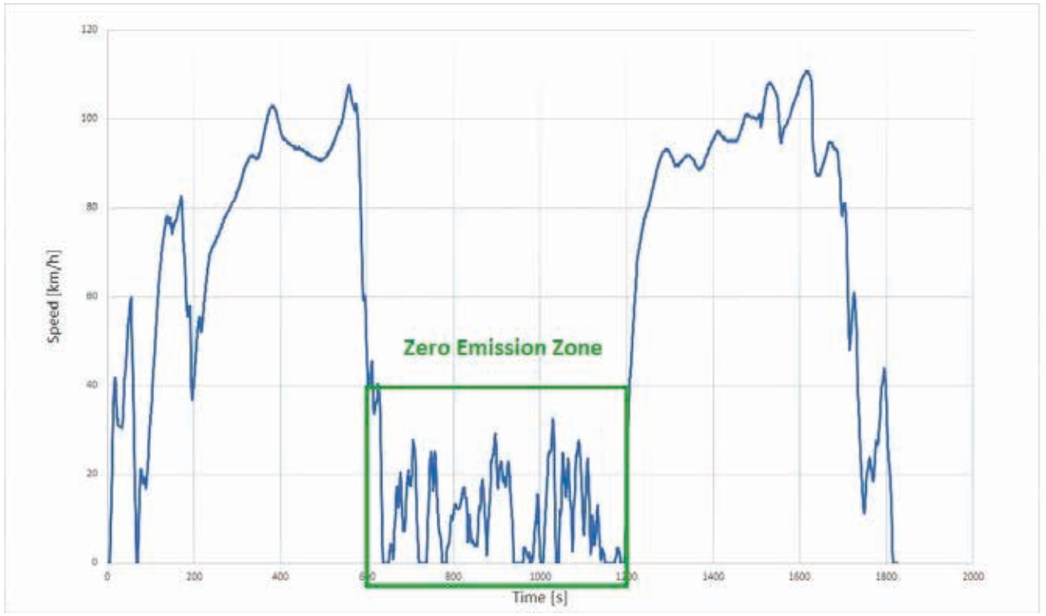


Once an effective virtual tool has been created, several control logics and configurations have been tested, aiming on the reduction of pollutants and the increase of the vehicle efficiency.

Generating a solution

In order to evaluate the performances of the vehicle exploiting different logics, the following step is the definition of a precise driving cycle in order to better simulate the operating conditions of the hybrid light-duty vehicle. In addition to the velocity profile of the driving cycle, other features have been added, such as:

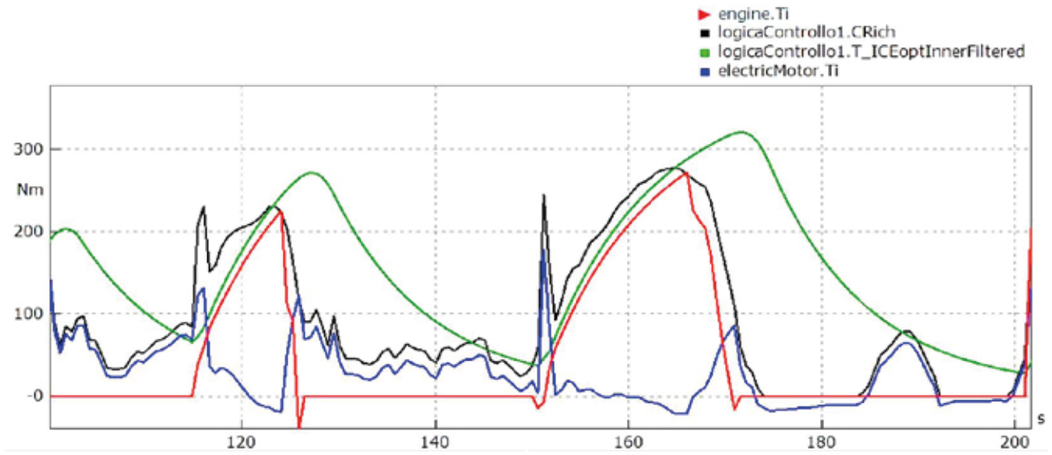
- the inclination of the road
- the position of the vehicle as a Boolean variable indicating if the vehicle is interacting with a congestion charge area, where the electric mode is compulsory.



Enforcing the possibilities offered by the coupling of the electric motor and the thermal engine, two different examples of control logic have been developed and tested. Both the control logics involve the regenerative breaking, and are designed to reduce the emissions and optimize the efficiency of the transmission, assuring a smooth transition between the two configurations. These control logics have been compared using the afore mentioned driving cycle, and the results have been used to maximize the exploitation of the battery charge as well as the optimization of fuel consumption.
As for the future possibilities, traffic conditions, as well as vehicle to vehicle communication can be added to the control logic, to add a level of complexity to the virtual model, having proved that the simulating environment is stable and trustable. The model can also be updated component by component, following the technological improvements and changes to the vehicle design.
For the reasons mentioned, the effectiveness of a virtual environment in which the behaviour of the vehicle response can be simulated has been proved, allowing the reduction of costs and time to market, together with an optimization of the efficiency of the vehicle, the reduction of pollutants and fuel consumptions.

Adopted driving cycle with suburban and ZEZ speed profiles

Power split management of ICE/EM torques



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