# DII NFORMA

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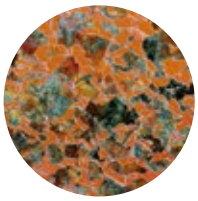
ANNO 1

## NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE



## COPERTINA

*Miglioramento della resistenza a corrosione di leghe metalliche*
**Micrografia di una lega di ottone alfa-beta (Gruppo Metallurgia)**

PAGINA



DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Andrea Stella

Direttore del DII

# DIInforma, inauguriamo un nuovo strumento del Dipartimento di Ingegneria Industriale

Il Dipartimento di Ingegneria Industriale, nato nel 2012 dall'unione di sei Dipartimenti dell'Ateneo, sino dalla sua fondazione si è posto l'obiettivo di perseguire risultati di assoluta qualità e eccellenza nel campo della ricerca, della formazione e della terza missione.

Per perseguire tali obiettivi il Dipartimento ha promosso lo sviluppo di progetti di ricerca di grande rilievo sia nel campo dell'ingegneria industriale che a carattere interdisciplinare, ha sviluppato un'offerta formativa di elevata qualità professionale e scientifica che comprende, oltre ai corsi di laurea e di laurea magistrale, anche dottorati di ricerca, master universitari e corsi di perfezionamento, ha favorito la dimensione internazionale degli studi, dell'insegnamento e della ricerca, attraverso un crescente sviluppo di scambi internazionali di docenti, ricercatori e studenti, ha concorso al progresso culturale, tecnologico, sociale ed economico del territorio sviluppando rapporti con istituzioni pubbliche e private nel campo della ricerca e della formazione.

Nel 2015, dopo tre anni di intensa attività, il nostro Dipartimento ha raggiunto una sua maturità come polo multidisciplinare per ricerca, formazione e competenze in numerose aree dell'Ingegneria e anche piena consapevolezza delle proprie potenzialità e opportunità. Ne è prova l'elevato numero di collaborazioni scientifiche in essere tra i ricercatori operanti nel DII, prima divisi nei Dipartimenti di origine, spesso non comunicanti tra loro. La collaborazione non si estende alla sola ricerca, ma si realizza pienamente nell'organizzazione dei nostri numerosi corsi di Laurea (quattro di Primo Livello, sei di Secondo Livello) e del nostro corso di Dottorato in Ingegneria Industriale.

La presente newsletter è intesa come nuovo strumento per favorire ulteriormente la collaborazione tra tutti i membri del DII (oltre 400 persone, contando docenti, ricercatori, studenti di dottorato, assegnisti, borsisti, tecnici e impiegati amministrativi) e rendere visibile al pubblico più ampio, anche all'esterno del DII, la vitalità scientifica e didattica del Dipartimento.

La redazione di una newsletter non è una prova di originalità, in sé, se si pensa alle numerosissime esperienze presso Dipartimenti di università americane ed europee. DIInforma, tuttavia, mira a presentare le attività del DII in modo assolutamente specifico, tenendo sempre presente la missione del Dipartimento, ovvero l'eccellenza nella ricerca, l'eccellenza nella formazione e la valorizzazione dei giovani. In particolare, le prime otto pagine seguenti mostrano, in forma di extended abstracts, esempi degli studi effettuati presso il DII, nell'ambito delle sue tematiche di ricerca caratterizzanti, dall'ingegneria dei sistemi meccanici ed elettrici al management, dai materiali avanzati alla mobilità sicura e sostenibile, dai processi e prodotti industriali alla sicurezza ambientale e industriale, dalla bioingegneria e biotecnologia all'energia. Due delle pagine successive sono dedicate alla presentazione dei corsi di Laurea e di Dottorato. Nel corso delle prossime uscite si conta di ospitare, a rotazione, contributi da parte di tutti i gruppi di ricerca e presentazioni di tutti i corsi.

La valorizzazione dei giovani è attuata su molteplici livelli. Il lavoro di studenti, dottorandi e assegnisti è presentato, in primo luogo, in forma di brevi comunicati ("Achievements") e di poster. Questi ultimi sono comunemente preparati dai giovani di tutti i gruppi di ricerca, in occasione di congressi nazionali e internazionali, ma ricevono spesso una limitata attenzione, rispetto al lavoro svolto. DIInforma intende riconoscere l'impegno dei giovani e dare ulteriore visibilità alle ricerche. Infine, la copertina di DIInforma è dedicata alla valorizzazione dei giovani attraverso una "sana competizione". Le prossime uscite, come la presente, si avvarranno anche di immagini rappresentative del lavoro di dottorandi e assegnisti.

Buona lettura!

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Bioingegneria, biotecnologia e tecnologie per la salute
*Bioengineering*

**DII research group**
**Chemical Bioengineering**

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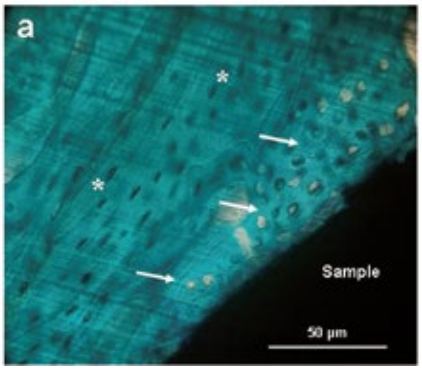
Major experimental activities are carried out in collaboration with: Prof. G. Gerosa (Cardio surgery Unit, University of Padova), Prof. I. Castagliuolo (Dept. Molecular Medicine), Prof. G. Marletta (University of Catania), Prof. G. Polzonetti (University Roma 3), Dr R. Martini (Angiology Unit, Azienda Ospedaliera di Padova), Prof. L. Di Silvio (King's College, UK), Prof. N. Seidah (IRCM, Canada), Prof. V. Samouillan (CIRIMAT, France), Prof. D. Piatier-Tonneau (CNRS, France), Prof. M.W. Lingen (University of Chicago, USA), Dr E. Cline (Loyola University, USA).

Main research topics:

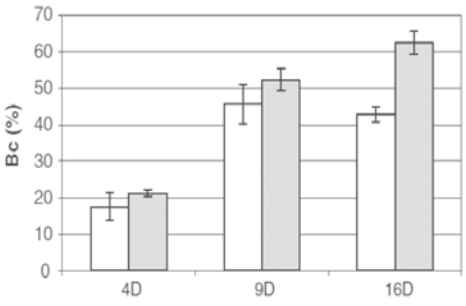
- Innovative biomaterials: synthesis of bioactive peptides and covalent functionalization of surfaces
- Synthesis of DNA mimetics for biosensors
- Matrixes of self-assembling peptides chemoselectively modified for regenerative medicine
- Biomechanical characterization of animal pericardium for prosthetic heart valves
- Functional assessment and classification of mechanical heart valve prostheses
- Analysis of skin perfusion by laser Doppler fluxy metry

# Synthesis and exploitation of bioactive peptides for the production of endosseous devices

A wide range of biochemical signals promoting cell functions (adhesion, migration, proliferation, differentiation) and thereby improving osseointegration are currently investigated. Unfortunately, their application is often hampered by insolubility, instability, and the limited availability of large amounts of inexpensive, high-purity samples.
An attractive alternative is the use of short peptides carrying the minimum active sequence of the natural factors. Synthetic peptides mapped on fibronectin and vitronectin have been demonstrated to enhance cell adhesion to polystyrene, acellular bone matrix, glass, titanium oxide and electrospun polyester scaffolds; in particular, a nonapeptide sequence from the Human Vitronectin Precursor (HVP) operates via an osteoblast-specific adhesion mechanism. This mechanism involves interactions between cell membrane heparansulfate proteoglycan sand heparin binding sites on extracellular matrix proteins. After in vitro assays, the ability of the (351–359) HVP sequence to promote osteogenicactivity was assessed in vivo. The peptide was covalently bound to titanium implants, surgically inserted in the femurs of white New Zealand rabbits; then, it was measured how and how much its effects change with time across three bone regions surrounding implant surface.
The presence of the (351–359)HVP peptide improves the osteogenic activity immediately after implantation, thus accelerating bone ongrowth. This preliminary stimulus of the osteogenic activity might result in faster and better osteointegration. Advantages for clinical exploitation of the (351–359) HVP peptide are evident.



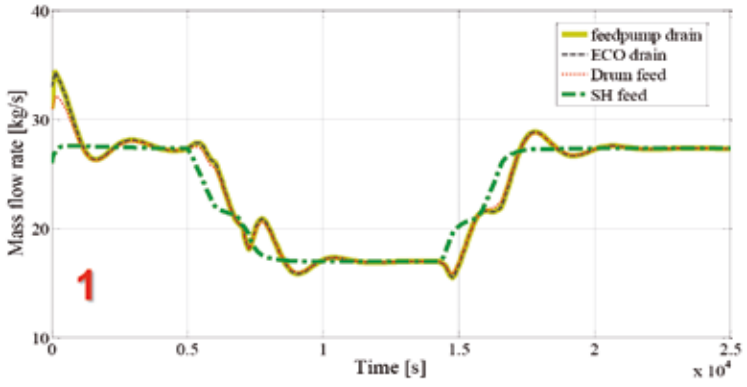

Goldner's trichrome stain evidences the formation of newly grown bone in direct contact with sample surface (original magnification), 16 days after surgery. Double asterisks indicate preexisting bone tissue; arrows, newly grown bone.

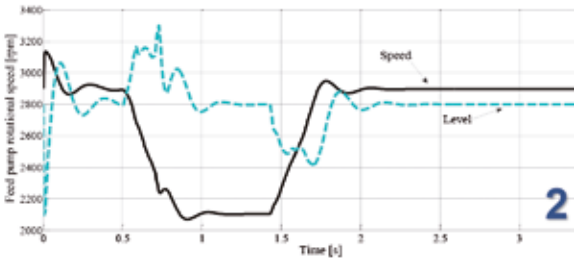



Bone-to-implant contact (Bc) is the ratio between the length of the bone profile in direct contact with the implant surface and the length of implant profile. It was measured 4, 9, and 16 days after surgery on the functionalized implant (grey bars) and on controls (white bars). It showed an increasing trend, significantly higher for the functionalized samples.

# Waste heat recovery technologies for offshore platforms

The deregulated energy market and the increasing quota of electrical capacity covered by non-predictable renewable sources require strongly irregular and discontinuous operation of thermoelectric plants to satisfy users demand and compensate the variability of renewable sources. As a consequence, due to thermo-mechanical fatigue, creep and corrosion, a lifetime reduction of the most critical components occurs.
The availability of a procedure able to predict the residual life of plant devices is necessary to assist the management decisions about power plants' operation and maintenance scheduling. The first step of this procedure is the capability of simulating the plant behaviour versus time by evaluating the trends of the main thermodynamic parameters that describe the plant operation during different transient periods. In this context, the main contribution of the present research is to propose a complete procedure able to simulate the plant dynamic behaviour and estimate the residual life reduction of some components. Indeed, a complex model, developed by means of Modelica modelling language, of a gas steam combined unit is implemented and utilized to characterize the dynamic behaviour of the power plant. The main thermodynamic variables during different transient operation conditions are predicted [Figures 1 and 2].
Moreover, a residual life estimation of the most stressed component is performed. The most stressed point results the inner diameter in the hottest position the of superheater wall. For the load variation from the design point to the technical minimum, the strain corresponds to about 1600 cycles before failure. Considering a management strategy which expects about 200 cycles/year, and adding creep effect, it means a lifetime of 6 years.




Energia
*Energy*

DII research group TES

***Investigation conducted in collaboration with Ing. Stefano Bracco and his group at the University of Genova***

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Assisted by
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Main research topics:

- Aerodynamic optimization of rotors ofhelicopters and of high efficiency profiles isolated and detached
- Design and management of Pumped Hydro plants
- Design and optimization of hydro and wind turbines (VAWT and HAWT)
- Cavitations, instability and pressure pulse in turbomachinery operating at design and off design load
- Design and management optimization of energy systems by means of multicriteria methods, Life Cycle Assessment (LCA)
- Gas turbines: development of numerical codes for performance provision

Ingegneria dei sistemi elettrici
*Electric systems*

DII research group
Nanotec

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# Aluminium nitride films for energy harvesting

In recent years the number of sensors mounted in vehicles has strongly increased due to novel safety and energy saving constraints. Since in many applications of automotive engineering remote sensors with radio frequency transmitters are used, the limited lifetime of batteries is a crucial problem. This holds in particularly for sensors mounted inside tires, which should comply with tight requirements in terms of durability and robustness. Batteries can be avoided if the sensor is able to harvest energy from the environment, typically from vibrations, by converting mechanical energy into electrical energy.
In this sense energy harvesting by means of piezoelectric materials appears to be very promising in developing battery-less power supply systems for wireless sensor networks.
Aluminium nitride films with preferred crystal orientation realized by using a magnetron sputtering system [Fig. 1] at different pressure values constitute a research activity of high potentialities. Explored operative pressures have been 0.07, 0.12, 0.3 and 0.7 Pa. Reactive Ar-$N_2$ mixtures (50%-50% and 0%-100%) and a DC-pulsed power supply have been used, and films have been deposited on glass substrate. Films thicknesses have been measured with surface profiler, and XRD analyses have been performed.
The aim of the research activity is the individuation of the best conditions for realization of AlN thin films in order to possible application to energy harvesting.

Main research topics:

- Realization of nano-structured films by magnetron sputtering
- Thin electromagnetic shields
- Realization and characterization of thin piezoelectric materials for energy harvesting
- Modelling of electrical and electromagnetic devices
- TEM cell design for EMC/EMI tests

Fig. 1

# The Global Entrepreneurship Monitor (GEM) highlights some key areas to promote entrepreneurship growth in Italy

Also this years, the research group on Management and Entrepreneurship of DII at the University of Padua studied the **Italian nascent entrepreneurship** in comparison with the rest of the world. The research was developed within the International Research Program called **Global Entrepreneurship Monitor** (GEM), the largest ongoing study of entrepreneurial dynamics in the world. The Management and Entrepreneurship Research Group is an active part of GEM since 2012. Initiated in 1999, currently the GEM project is set to cover 72,4% of world population and 90% of world GDP.

The main entrepreneurship indicator used by GEM to compare entrepreneuship in different countries is the ***Total early stage Entrepreneurial Activity (TEA)*** i.e. the combination of nascent entrepreneruship and new business ownership. In the last year, Italy ranked the lowest for TEA within the group of European and North American countries. In addition, perception of entrepreneurial opportunities in Italy was quite low, about one-third compared to the economies of Northern Europe, while the fear of failure was particularly high.

A longitudinal analysis reveals that TEA has always been very limited in Italy in recent years, especially after 2007. In 2014 there was a slight recovery of early stage entrepreneurship, while, from a geographical point of view, the most lively early stage entrepreneurial activity is in the North and the South of Italy.
The analysis has highlighted a number of fairly established constraints that hinder entrepreneurial activity in our country and a series of proposals to improve the Italian TEA, for instance the need to improve educational programs and training.

The full report is available at: www.scentproject.org

| | Early-stage entrepreneurial activity (TEA) | Nascent entrepreneur-ship rate | New business ownership rate |
|---|---|---|---|
| United States | 13,8 | 9,7 | 4,3 |
| Canada | 13 | 7,9 | 5,6 |
| Lithuania | 11,3 | 6,1 | 5,3 |
| Romania | 11,3 | 5,3 | 6,2 |
| Slovakia | 10,9 | 6,7 | 4,4 |
| United Kingdom | 10,7 | 6,3 | 4,5 |
| Portugal | 10 | 5,8 | 4,4 |
| Netherlands | 9,5 | 5,2 | 4,5 |
| Estonia | 9,4 | 6,3 | 3,5 |
| Hungary | 9,3 | 5,6 | 3,9 |
| Poland | 9,2 | 5,8 | 3,6 |
| Austria | 8,7 | 5,8 | 3,1 |
| Croatia | 8 | 6 | 2 |
| Greece | 7,9 | 4,6 | 3,4 |
| Luxembourg | 7,1 | 4,9 | 2,3 |
| Sweden | 6,7 | 4,9 | 1,9 |
| Ireland | 6,5 | 4,4 | 2,5 |
| Slovenia | 6,3 | 3,8 | 2,7 |
| Finland | 5,6 | 3,4 | 2,3 |
| Denmark | 5,5 | 3,1 | 2,5 |
| Spain | 5,5 | 3,3 | 2,2 |
| Belgium | 5,4 | 2,9 | 2,5 |
| France | 5,3 | 3,7 | 1,7 |
| Germany | 5,3 | 3,1 | 2,3 |
| Italy | 4,4 | 3,2 | 1,3 |

## Management e imprenditorialità *Management and entrepreneurship*

**DII research group Management and Entrapreneurship**


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This study was carried out in collaboration with:
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University Politecnica of Marche
Dott. Alessandra Micozzi,
University Politecnica of Marche
Financial support to this research was provided by the University of Padua and Polythecnic University of Marche.

SCENT SCHOOL OF ENTREPRENEURSHIP

www.scentproject.org

Main research topics:

- Global Entrepreneurship Monitor
- Entrepreneurship for Growth
- Young Entrepreneurs and innovative startups
- Performance Measurement and management
- Technology Transfer

Materiali avanzati
*Advanced Materials*

DII research group
Advanced Ceramic
and Glasses

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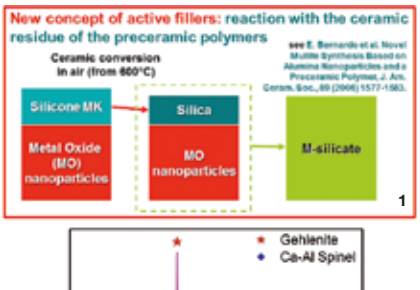
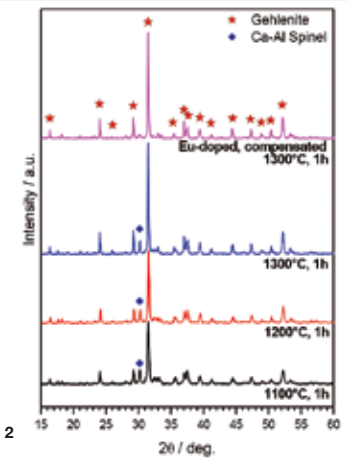
Main research topics:

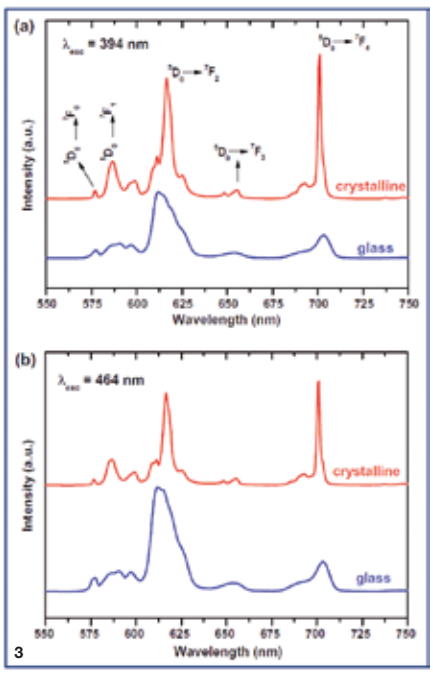
- Nanostructured ceramic composites from preceramic polymers and fillers
- Advanced porous ceramic components
- 3D printing of ceramics
- Bioceramics from novel formulations and novel processing
- Monolithic and cellular glasses and glass-ceramics
- Novel construction materials from inorganic waste and/or recycled glasses
- Porous geopolymers

# Gehlenite-based red phosphors from a silicone resin and nano-sized fillers

Silicates of the melilites group may constitute efficient inorganic phosphors, by the introduction of rare-earth ions in the relatively large octahedral sites, normally occupied by $Ca^{2+}$ ions, (sandwiched between layers of interconnected coordination tetrahedra, e.g. $Al_2SiO_7^{4-}$ for gehlenite, $Ca_2Al_2SiO_7$, or $MgSi_2O_7^{4-}$ for akermanite, $Ca_2MgSi_2O_7$).
Gehlenite ceramics have been successfully prepared by the heat treatment of a silicone resin embedding $CaCO_3$ and $Al_2O_3$, in the form of nano-sized particles that act as reactive fillers. This novel approach allows for a very homogenous mixing: a silicone resin, in fact, is easily dissolved in isopropyl alcohol, and nano-sized oxide particles are easily suspended in silicone solutions. In addition, the fillers may react easily with the amorphous silica, provided by the oxidative decomposition of silicone polymers, possessing a particularly defective network and consequently prone to very favorable reaction kinetics [Fig. 1].
Luminescence was due to the use of nano-sized $Eu_2O_3$ as secondary additive, particularly adopting a charge compensation formulation, corresponding to $Ca_{2-2x}Eu_{2x}Al(Al_{1+2x}Si_{1-2x}O_7)$, with x=0.07. The phase development and the emission characteristics could be adjusted by simply changing the thermal treatment applied to powders of silicone/fillers mixtures. While conventional firing in air at 1300 °C (for 1 h) led to practically phase-pure crystalline Eu-doped gehlenite [Fig. 2], exhibiting a strong red luminescence, flame synthesis (silicone/fillers powders directly sent into high temperature $CH_4/O_2$ flame) yielded amorphous powders, exhibiting an emission in a much broader range. When excited at 394 nm both gehlenite glass and polycrystalline gehlenite emitted light, which CIE chromaticity coordinates were found to be (x=0.65, y=0.35), indicating that both systems are good candidates for red light emitting phosphors [Fig. 3].



# Field Load acquisition and variable amplitude fatigue testing on maxi-scooter motorcycles

Aim of the present work was the instrumentation of a maxi scooter for the field collection of service loads acting on the scooter main components such as frame, fork, handlebar, rear frame and suspension.
Service loads were collected on an instrumented Yamaha Tmax scooter equipped with 22 channels during a set of field tests that were representing a predefined road mix, covering a mileage of 270 km. Field load histories were used to develop an accelerated test procedure for the accelerated bench fatigue testing of a new model prototype whose mission was set to 50000 km. The acceleration procedure allowed a time reduction from 1600 hrs to 122 hrs bench equivalent testing. Both the benchmark scooter Tmax and a maxiscooter prototype under development underwent the bench ariable amplitude fatigue testing. The results of the fatigue tests on the prototype allowed to identify some critical bolted connections and to reduce some stress concentration features causing the appearance of small cracks that were found also after during 50000 km of driving tests.


**Fig.1**: examples of calibration tests on scooter Yamaha TmaxS. (a) Front fork and Frame channels calibration. (b) Handlebar Horizontal calibration. (c) Rear Damper tensile calibration.

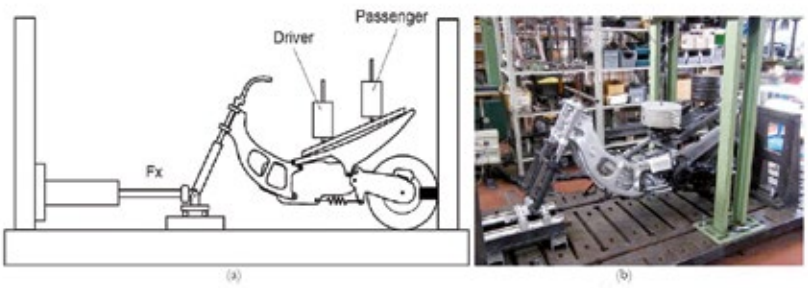



**Fig. 2**: Horizontal fatigue test bench (a) Sketch of the Horizontal Fatigue test bench. (b) Yamaha TmaxD undergoing the horizontal fatigue test.

Mobilità sicura e sostenibile
*Safe mobility*

**DII research group**
**Machine Design**

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Investigations in collaboration
with Eng. M. Saraceni
EnginLab - Laboratory of Engineering
www.enginlab.it

Main research topics

- Development of numerical and experimental methods for the evaluation of the structural integrity of components and mechanical structures
- Mechanical characterization of metallic and polymeric materials
- Development of local approaches for structural analysis and fatigue design of components and structures weakened by the effects of geometric carving
- Development of methods for the analysis and design for sports equipment and rehabilitation

Processi, prodotti e servizi
*Processes, products and services*

DII research group
CAPE-Lab

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(Dpt. of Medicine, Univ. of Padova Medical School)
**Prof. Alessandra Casonato**
(Dpt. of Dept. of Cardiologic, Thoracic and Vascular Sciences, Univ. of Padova Medical School)

Financial support to this research was entirely provided by the University of Padova under Progetto di Ateneo CPDA127585/12 "Towards a mechanistic description of the von Willebrand disease: a process systems engineering approach to model development and design" and Project CPDR110403-2011 on "Optimal design of pharmacodynamic and pharmacokinetic experiments for the identification of physiologically-based models for drug development"

Main research topics:

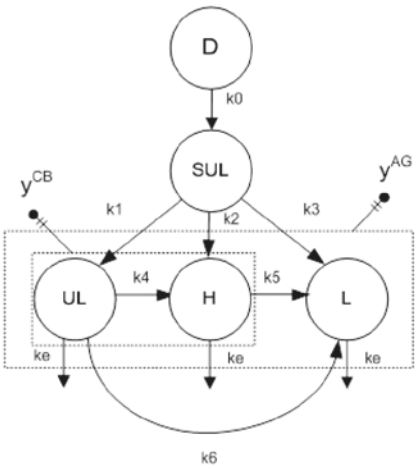
- Product design and quality control
- Data analysis and process control
- Model development and identification
- Design of energy systems
- Biomedical systems modeling and control

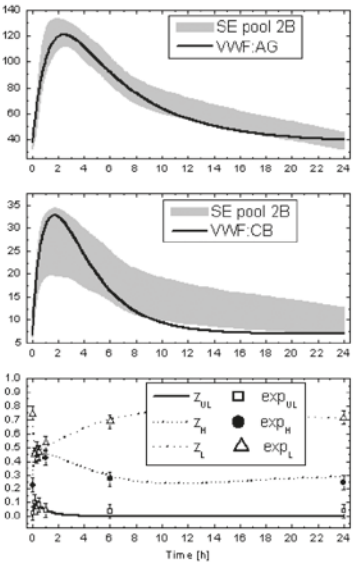
# Toward personalized care of blood coagulation disorders

The von **Willebrand disease** (vWD) is the most common inherited blood coagulation disorder in humans. The disease is characterized by a deficiency and/or dysfunction of the von Willebrand factor (vWF), a large multimeric glycoprotein mediating the adhesion and aggregation of platelets to the subendothelium and carrying the coagulation factor VIII in the blood circulation. The predominant clinical symptoms of vWD include nosebleeds, bleeding from small lesions in skin, mucosa or the gastrointestinal tract, menorrhagia and excessive bleeding after traumas, surgical interventions or childbirth. According to a recent estimate, over half a million persons suffer from vWD worldwide, with ~80% of them living in the emerging countries. Diagnosing vWD is complicated by the fact that several variants of the disease exist, which are not easy to capture from conventional tests.

An interdisciplinary research between CAPE-Lab and the University of Padova Medical School has shed new light into the characterization of vWD.
Two mechanistic models of the vWD have been formulated based on clinical data, and can now assist physicians to describe the mechanisms of release, distribution and elimination of the vWF from the blood stream. This is an important step toward faster and more effective vWD diagnosis, as well as toward the development of shorter and easier-to-carry-out clinical tests, improving the comfort and safety for the subject. The research was granted the prestigious Model-Based Innovation Prize 2014 by Process Systems Enterprise Ltd. (London, U.K.).

Current work is devoted to extending the model applicability, and to engineering a model-based diagnosis procedure in order to automatically discriminate among the possible vWD variants.

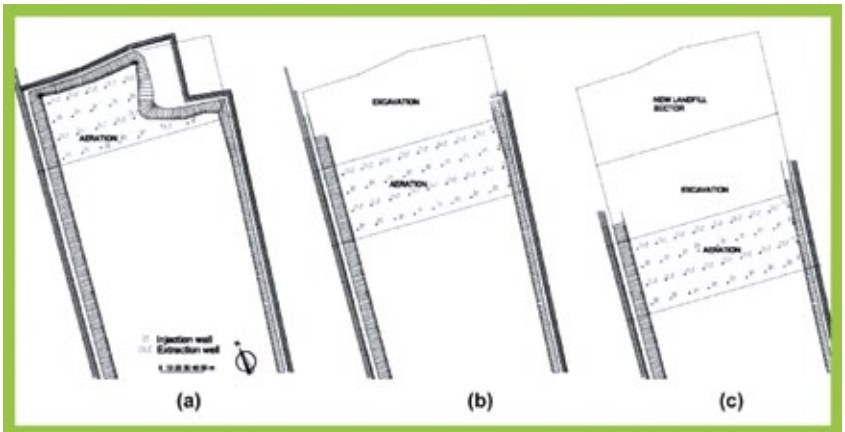



Galvanin, F., M. Barolo, R. Padrini, A. Casonato and F. Bezzo (2014). A model-based approach to the automatic diagnosis of Von Willebrand disease. *AIChE J.*, **60**, 1718-1727.

# Landfill aeration in the framework of a reclamation project in Northern Italy

In situ aeration by means of the Airflow technology was proposed for landfill conditioning before landfill mining in the framework of a reclamation project in Northern Italy. A 1-year aeration project was carried out on part of the landfill with the objective of evaluating the effectiveness of the Airflow technology for landfill aerobization, the evolution of waste biological stability during aeration and the effects on leachate and biogas quality and emissions.
The main outcomes of the 1-year aeration project are presented in the paper. The beneficial effect of the aeration on waste biological stability was clear (63% reduction of the respiration index); however, the effectiveness of aeration on the lower part of the landfill is questionable, due to the limited potential for air migration into the leachate saturated layers.
During the 1-year in situ aeration project approx. 275 MgC were discharged from the landfill body with the extracted gas, corresponding to 4.6 gC/kgDM. However, due to the presence of anaerobic niches in the aerated landfill, approx. 46% of this amount was extracted as $CH_4$, which is higher than reported in other aeration projects. The $O_2$ conversion quota was lower than reported in other similar projects, mainly due to the higher air flow rates applied.
The results obtained enabled valuable recommendations to be made for the subsequent application of the Airflow technology to the whole landfill.




First stages of the reclamation project proposed for landfill C. *a*: old landfill sector where the 1-year in situ aeration project described in the paper was carried out; *b* and *c*: planned activities.

Ambiente
*Environment*

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Environmental Engineering

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Main research topics:

- Sustainable landfill management
- Remediation of old landfills
- Treatment of contaminated soil


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# Corso di laurea triennale in Ingegneria Aerospaziale

**Obiettivi formativi**

Il Corso di Laurea (triennale) in Ingegneria Aerospaziale ha lo scopo di iniziare un percorso formativo finalizzato alla progettazione, gestione e collaudo di veicoli e vettori spaziali e dei relativi sottosistemi per applicazioni civili, industriali e scientifiche.
Lo studente deve quindi acquisire una solida preparazione di base tecnico-scientifica applicandosi, oltre che ai campi comuni all'ingegneria industriale (meccanica dei fluidi, meccanica dei solidi, termodinamica, scambio termico, elettrotecnica, e altri), anche a filoni culturali specifici quali l'Aerodinamica, le Strutture Aerospaziali, la Dinamica del Volo, gli Impianti e Sistemi di Bordo. Nelle applicazioni prettamente spaziali, inoltre, è indispensabile possedere anche gli strumenti scientifici di base utili per operare in modo coordinato e sinergico con altri ambiti scientifici (quali, ad esempio, quello dell'Astronomia e le Scienze Planetarie, delle Bioscienze, della Fisica della Materia e dello Spazio) per cui lo studente deve dimostrare anche un'apertura intellettuale che gli consenta di affrontare la continua richiesta d'innovazione per prestazioni al limite delle conoscenze tecnologiche.

**Cosa si studia**

• base scientifica (matematica, fisica, chimica) -> fondamentali per tutti i rami dell'ingegneria

• base tecnologica e economica (disegno tecnico industriale, economia e organizzazione aziendale) -> formativa per tutte le specializzazioni dell'ingegneria industriale

• materie sinergiche appartenenti all'ingegneria industriale (meccanica applicata, elettrotecnica, meccanica dei fluidi, fisica tecnica) -> complementari e formative per la preparazione in Ingegneria Aerospaziale

• materie specialistiche dell'Ingegneria Aerospaziale (dinamica del volo spaziale, aerodinamica, costruzioni e strutture, impianti e sistemi aerospaziali) -> costituiscono il cuore aerospaziale della laurea triennale

• corsi a scelta in ambiti a spettro ampio (impiantistica, astronomia, teoria dell'informazione, scienza dei materiali, trasporto aereo) -> utili per l'arricchimento tecnico/scientifico e l'approfondimento in aree contigue all'aerospaziale

In generale, la Laurea in Ingegneria Aerospaziale mira a fornire capacità professionali quali: operare nelle industrie nazionali ed internazionali del settore; gestire efficacemente rapporti con le agenzie ed enti spaziali; interfacciarsi con enti pubblici e privati per la sperimentazione in campo aerospaziale.

# Corso di laurea magistrale in Ingegneria Meccanica

La **Laurea Magistrale in Ingegneria Meccanica,** che si sviluppa in due anni accademici, è la naturale prosecuzione degli studi per gli allievi che abbiano conseguito l'omonimo titolo di Laurea Triennale seguendo il percorso formativo. Alla Laurea Magistrale potranno accedere anche altri laureati, purché il loro curriculum precedente soddisfi ai requisiti minimi previsti dal regolamento. Possono accedere alla Laurea Magistrale in Ingegneria Meccanica i laureati triennali in Ingegneria Meccanica presso l'Università di Padova che abbiano seguito il percorso formativo. Per i laureati provenienti da altri Corsi di Laurea o da altre Università, i requisiti minimi (crediti formativi) per l'accesso e i debiti formativi sono stabiliti dal Consiglio di Corso di Laurea. Per l'accesso alle Lauree Magistrali è stata stabilita una soglia minima del voto di Laurea Triennale pari a 84/110.

La Laurea Magistrale in Ingegneria Meccanica si pone l'obiettivo di creare una figura professionale di alta competenza, adatta a progettare e gestire l'innovazione tecnologica nei diversi settori della meccanica. Per raggiungere questo obiettivo, nel primo anno di corso dovranno essere affrontati, con adeguato grado di approfondimento insegnamenti caratterizzanti i diversi settori fondamentali dell'Ingegneria Meccanica. Nel secondo anno i corsi sono articolati in indirizzi, ciascuno dei quali è dedicato a discipline di uno specifico settore. Gli insegnamenti di indirizzo potranno essere modificati di anno in anno per garantire un costante aggiornamento tecnico/culturale del laureando. L'ultimo semestre è dedicato quasi interamente alla tesi di laurea, che sarà svolta nell'ambito dell'indirizzo scelto. La tesi dovrà avere un livello tecnico-scientifico adeguato al titolo da conseguire, e potrà essere svolta, eventualmente mediante un periodo di stage, in collaborazione con aziende o enti esterni; in tal caso essa darà al laureando l'occasione per integrare la preparazione teorica con un'esperienza propria del mondo del lavoro. La tesi può essere svolta anche all'estero, ad esempio nell'ambito del programma Socrates-Erasmus.

**Cosa si studia**

Il corso prevede insegnamenti obbligatori di approfondimento delle conoscenze nelle discipline meccaniche: Materiali non metallici e criteri di scelta dei materiali, Macchine 2, Meccanica delle vibrazioni, Termodinamica applicata, Misure meccaniche e termiche, Impianti industriali, Sistemi integrati di fabbricazione, Costruzione di macchine 2.
Al secondo anno lo studente può definire in modo personalizzato il proprio percorso formativo, scegliendo da un'ampia offerta di insegnamenti organizzati in 6 indirizzi. Oltre alle lezioni in aula molti insegnamenti prevedono attività pratiche e sperimentali nei laboratori didattici e di ricerca in cui operano i docenti.

Gli indirizzi disponibili sono i seguenti:

**Costruzioni Meccaniche**
**Dinamica dei Sistemi Meccanici**
**Macchine**
**Termotecnica**
**Produzione e tecnologie manifatturiere**
**Progetto e fabbricazione con i materiali polimerici e compositi**

www.im.dii.unipd.it

Achievements

# FELDs: un nuovo sistema di docking per satelliti testato nell'ambito del programma "DropYour Thesis!"

L'esperimento FELDs (Flexible Electromagnetic Leash Docking system) ha concluso a Brema la campagna di prova nell'ambito del programma Drop Your Thesis! 2014 sponsorizzato dall'Education Office dell'Agenzia Spaziale Europea.
L'obiettivo dell'esperimento, concepito da un gruppo di cinque studenti (Davide Petrillo, Alessandro Cavinato e Marco Gaino di Ingegneria Aerospaziale, Federico Chiariotti di Ingegneria Informatica e Marco Buonuomo di Ingegneria Elettronica) sotto la supervisione del Prof. Alessandro Francesconi e dei dottorandi Francesco Branz e Riccardo Mantellato, era di verificare il comportamento di un innovativo sistema a filo (tethered) per la cattura di satelliti tramite interazioni elettromagnetiche. La campagna di prova si è svolta per due settimane (3-14 Novembre) a Brema presso il Center of Applied Space Technology and Microgravity, dove il funzionamento di FELDs è stato verificato con successo in condizioni di microgravità, ottenute in caduta libera nella torre ZARM, unica struttura di questo tipo esistente in Europa.

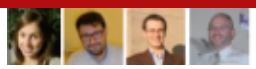
**Approfondimenti:**

**www.esa.int/Education/New_docking_system_tested_during_ESA_Drop_Your_Thesis!_Campaign**

**www.esa.int/Education/Meet_the_teams_FELDs_2014DIInforma**

# Process/model mismatch diagnostic by latent variable modeling

N. Meneghetti, P. Facco, F. Bezzo, M. Barolo



CAPE-Lab – Computer-Aided Process Engineering Laboratory, Department of Industrial Engineering
University of Padova (Italy)

## 1. MOTIVATION AND OBJECTIVE

- **The problem:** when a mismatch is found by comparing an available dataset to the predictions of a first principles model (FP) it may not be trivial to identify the cause for the process/model mismatch (PMM).
- **Objective:** diagnosis of a PMM using historical data and a data-based DB model.
- **Challenges:** uncertainties on several parameters of the models; limited plant data available; high non-linear correlations between the variables involved.
- **Strategy:** a DB model (Principal Component Analysis, PCA [1]) is used to assess the consistency between the correlation structure of a historical operation dataset and that of a similar dataset generated using the FP model.

## 2. CASE STUDY : MILLING PROCESS

A simulated **milling process** for the size reduction of a granular polymer is used as a case study. The FP model includes mass and population balances of the solid distributed phase. The population balance equation on mass basis for phase $p$ is [2]:

$$\frac{\partial M_p(y,t)}{\partial t} = \int_0^{y_{up}} P_{B,p}(z) b_p(y,z) M_p(z,t) dz - P_{B,p}(y) M_p(y,t)$$

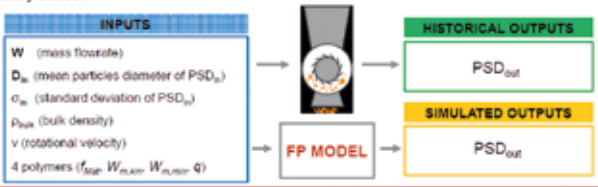
The empirical formulations suggested by Vogel and Peukert [2] for the grinding rate selection function $P_{B,p}$ and the breakage function $B_p$ have been used:

$$B_y = \left(\frac{z}{y}\right)^{\phi} \frac{1}{2}\left(1+\tanh\left(\frac{y-y'}{y'}\right)\right), \quad \frac{\partial B_y(z,y)}{\partial y} = b_y(z,y)$$

$$P_{B,p} = 1-\exp\left[-f_{Mat} k\left(W_{m,kin}-W_{m,min}\right)\right]$$

where $P_{B,p}$ and $B_p$ depend on several parameters ($f_{Mat}$, $W_{m,kin}$, $W_{m,min}$, $q$) specific of the type of material involved. The modelling package gSOLIDS® 3.0 [3] was used as a simulation tool to obtain the historical dataset.

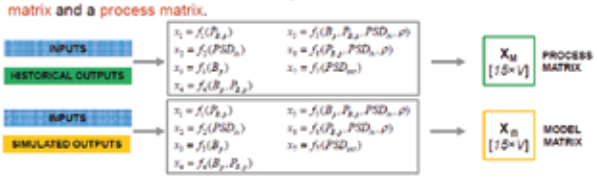
The historical and simulated datasets have been calculated, considering **15** different steady states.




## 3. DEVELOPMENT OF THE DATA-BASED MODEL

In order to simulate a PMM, erroneous values of the **parameter** $f_{Mat}$ (related to the strength of the material) was introduced in the FP model. The methodology proposed includes 4 steps:

1. **Auxiliary data designation.** For each sample, inputs, outputs and parameters are combined to obtain 2 **sets of V auxiliary variables** concatenated to form a model matrix and a process matrix.




- The presence of the population balance requires the discretization of integral term of the mass balance. The size range considered, has been partitioned into 40 bins (corresponding to a specific particle size). The mass balance must to be solved for each bin, consequently, $\mathbf{X_M}$ and $\mathbf{X_\Pi}$ become 3-D matrices [15×7×40].

2. **DB model development.** Both matrices are autoscaled on the mean and standard deviation of $\mathbf{X_M}$. A multi-way PCA (MPCA,[4]) model is built from $\mathbf{X_M}$ and the residuals matrix $\mathbf{E_M}$ is calculated from:

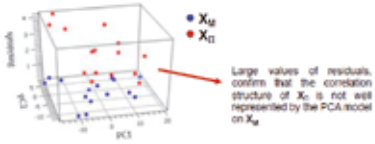
$$\hat{\mathbf{X}}_M = \mathbf{T}_M \mathbf{P}_M^T \qquad \mathbf{X}_M - \hat{\mathbf{X}}_M = \mathbf{E}_M$$

- The MPCA is equivalent to performing a PCA on a large two-dimensional matrix, formed by unfolding the three-way array X in such a way as to put each of its vertical slices, corresponding to a specific bin, side by side, resulting in a two dimensional matrix [15×280].

## 4. ANALYSIS AND RESULTS / 1

3. **Process matrix projection.** $\mathbf{X_\Pi}$ is projected onto the MPCA model space and the residual matrix $\mathbf{E_\Pi}$ is estimated.

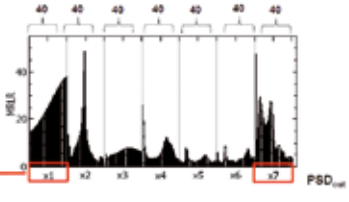
$$\mathbf{T}_\Pi = \mathbf{X}_\Pi \mathbf{P}_M$$
$$\hat{\mathbf{X}}_\Pi = \mathbf{T}_\Pi \mathbf{P}_M^T$$
$$\mathbf{X}_\Pi - \hat{\mathbf{X}}_\Pi = \mathbf{E}_\Pi$$




4. **Residuals analysis.** The two residuals matrices, $\mathbf{E_\Pi}$ and $\mathbf{E_M}$, are compared using the MRLR index to identify the auxiliary variables that are most responsible for the inconsistency in the correlation structures of $\mathbf{X_\Pi}$ :

$$MRLR_i = \frac{\sum_{j=1}^{N}\left(\frac{e_{m,i,j}}{CL_{95\%,m,i,j}}\right)}{N}$$

The MRLR index permits one to account for the contribution due to the PMM only, weighting the contribution related to the un-modeled variability of $\mathbf{E_M}$.

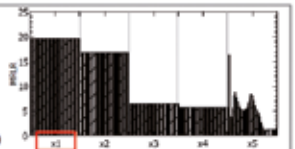



$P_{B,p}$ includes 3 parameters: $f_{Mat}$, $W_{m,kin}$, $W_{m,min}$

Which parameter is the cause of the mismatch?

The analysis was **repeated** considering 5 different auxiliary variables:

$x_1 = f_{Mat}$ $\quad x_2 = W_{m,kin}$ $\quad x_3 = W_{m,min}$ $\quad x_4 = q_M$ $\quad x_5 = f(PSD_{out})$

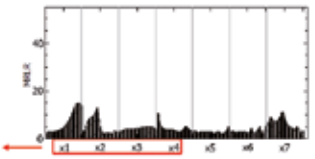



The parameter $f_{Mat}$ is correctly identified as the reason of the PMM

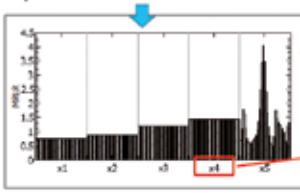
## 5. ANALYSIS AND RESULTS / 2

Modified values of **parameter** $q$, related with the rotational velocity, were purposely introduced in the FP model in order to cause a PMM.

The procedure is again applied considering 7 auxiliary variables, in order to identify which section of the model should be improved.




Variables related both with $P_{B,p}$ and $B_p$ present high values of MRLR




A further analysis is needed in order to identify which parameter is the most responsible of the PMM.

The parameter $q$, has been correctly identified as the reason of the PMM.

## 6. CONCLUSIONS

A methodology has been proposed to diagnose the causes for PMM and thus to support model enhancement. The methodology exploits the information embedded in the historical available data (no further experiments are required) using the same FP model and DB model. The idea is to provide the modeler with a tool for detecting which sections of the FP model are not consistent with the data, thus targeting subsequent theoretical and experimental efforts.

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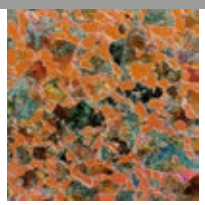
DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

## Cover story



**Miglioramento della resistenza a corrosione di leghe metalliche**

Il Gruppo Metallurgia del DII è attivo nella caratterizzazione della resistenza a corrosione di leghe metalliche di diversa composizione. È altresì attivo nello studio di soluzioni per il miglioramento della resistenza di leghe metalliche, in vari ambienti, attraverso trattamenti superficiali, quali l'ossidazione elettrolitica al plasma (PEO, Plasma Electrolytic Oxidation) e l'anodizzazione utilizzando elettroliti innovativi.

**Ing. Luca Pezzato**

Nato a Schio, il 27/12/1987. Dottorando in ingegneria industriale XXVIII ciclo. Dopo aver conseguito la laurea magistrale in ingegneria dei materiali nel dicembre 2011, ha iniziato la sua attività di ricerca presso il gruppo Metallurgia del DII prima come borsista e poi come dottorando. I suoi interessi di ricerca riguardano principalmente l'analisi della resistenza a corrrosione di materiali metallici, con particolare riferimento a metalli rivestiti mediante tecniche innovative come il PEO (Plasma Electrolytic Oxidation).

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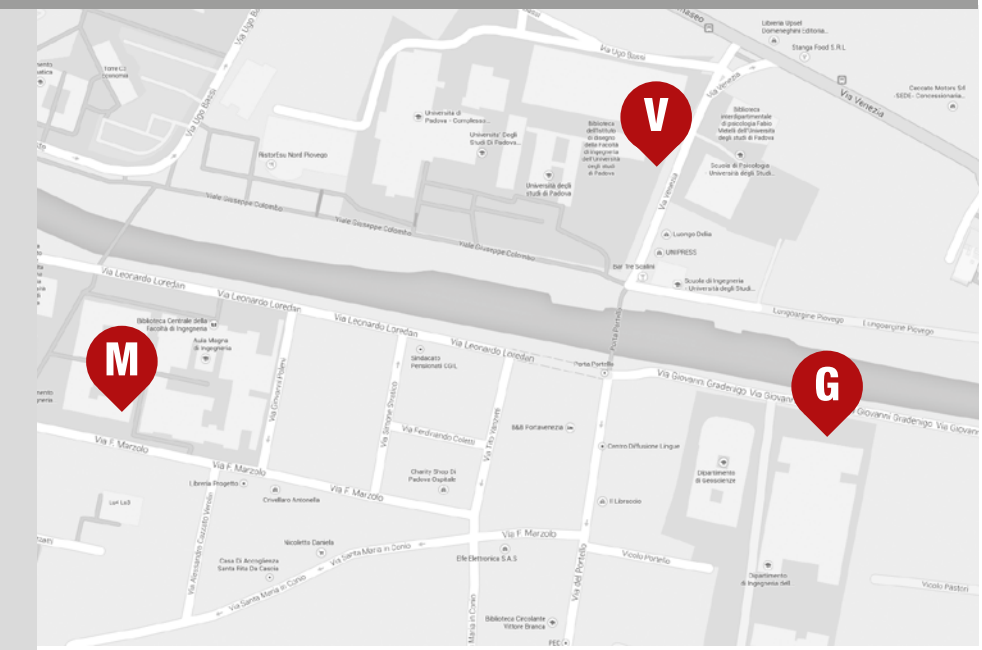


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