



# **“Models, Simulation, Optimization: Mathematical Technologies for Industrial Innovation in Europe”**

**Rome  
19-20-21 December 2016**

**Conference venue:** Accademia dei Lincei, Palazzina dell’ Auditorio, via della Lungara 230.



## **Scientific Committee**

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Alberto Tesei

## Programme

### “Success Stories of Mathematical Technologies for Industrial Innovation”: I Session

19 December 14:30 – 17:10

**14:30 - 14:40: Opening Session**

**14:40 - 15:05:** Bulgaria: **Tihomir Ivanov:** “*A success story from the Bulgarian ESGIs*”

**15:05 - 15:30:** Germany: KoMSO (Committee for Mathematical Modelling, Simulation and Optimisation) - **Hans Georg Bock:** “*Optimum Experimental Design for Nonlinear Dynamical Models - Mathematical Basic Research of High Economic Impact*”

**15:30 - 15:55:** Hungary: HU-MATHS-IN – **Tibor Csendes:** “*Optimization of LED based public lighting units*”

**15:55 - 16:20:** Ireland: Mathematics Applications Consortium for Science and Industry - **Sinead Burke:** “*Feedback from 10 years of industrial mathematics in Ireland*”

**16:20 - 16:45:** Norway: Norwegian EU-MATHS-IN Network - **Markus Grasmair:** “*SURF imaging for contrast improvement in ultrasound imaging*”

**16:45 - 17:10:** Sweden: Swedish EU-MATHS-IN Network - **Ozan Öktem:** “*Inverse problems in mathematical imaging sciences and applications to the health care sector*”

### “Success Stories of Mathematical Technologies for Industrial Innovation”: II and III Sessions

20 December 09:00 – 13:10

**09:00 - 09:10: Opening Session**

**09:10 - 09:35:** Austria: IMNA (Industrial Mathematics Network for Austria) - **Peter Kritzer:** “*Platemod: A model-based production system*”

**09:35 - 10:00:** Czech Republic: Czech Network for Mathematics in Industry - **Miroslav Tuma:** “*Modeling and Simulation of Float Glass Forming Process*”

**10:00 - 10:25:** France: AMIES (Agence pour les mathématiques en interaction avec l’entreprise et la société) - **Stephane Cordier:** “*Some AMIES supported success stories in France with EDF, St Gobain, PREDICAL, Cie du vent, POLLEN, Hager*”

**10:25 - 10:50:** Poland: Polish Service Network for mathematics in Industry and Innovations PL-MATHS-IN - **Wojciech Okrasinski:** “*Modelling of the machines damage detection for Polish mines*”

**10:50 - 11:15:** Portugal: PT-MATHS-IN - **Manuel Cruz:** “*Modeling, Simulating and Optimizing the stock of an automotive spare parts wholesaler*”

**11:15 - 11:30: Coffee Break**

**11:30 - 11:55:** Spain: math-in (Red española matemática-industria) - **Carlos Parés:** “*Some successful stories of the Spanish Network for Mathematics & Industry math-in*”

**11:55 - 12:20:** The Netherlands: Platform Wiskunde Nederland - **Kees Vuik:** “*Boosting Productivity of an Alumina Cement Plant through Computational Fluid Dynamics*”

**12:20 - 12:45:** United Kingdom: **William Lee:** “*Predicting Alumina Quality*”

**12:45 - 13:10:** Italy: Sportello Matematico per l’Industria Italiana - **Maurizio Ceseri:** “*Innovating Confocal Microscopy at Crestoptics: a Success Story of the Italian Network*”

## **Institutional Round Table**

**20 December 14:30 – 17:00**

Moderator: **Eugenio Occorsio**, *La Repubblica*

*Official Greetings*

**Mario Stefanini**, Centro Linceo Interdisciplinare

*Introduction: The potential benefits of Mathematical Technologies for Industrial Innovation*

**Massimo Inguscio**, President of the National Research Council

*MISE Policies to foster Knowledge Transfer in the field of Mathematical Technologies*

**Antonio Bartoloni**, MISE, Sustainable Development and Competitiveness Policies Department

*Mathematical Technologies and Innovation: CNR-Confindustria and the SPIN platform experiences*

**Nicoletta Amodio**, Confindustria, Industrial Policies Area

*Future and Emerging Technologies (FET) in Horizon 2020*

**Daniela Corda**, National Research Council, Italian Delegate for Horizon 2020

*Innovation: a driver for boosting employment in Europe*

**Cinzia Maiolino**, CGIL, Industrial Policies Coordination

**Discussion and Conclusions**

## **EU-MATHS-IN Council Meeting**

**21 December 09:00 – 13:00**

## **A success story from the Bulgarian ESGIs**

**Tihomir Ivanov**

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European Study Groups with Industry (ESGIs) have proven to be an efficient way to establish collaborations between academia and industry. Four ESGIs have been organized in Bulgaria so far (ESGI'95, ESGI'104, ESGI'113, and ESGI'120).

From my point of view, a particularly instructive example is the following. The problem of “Laboratory calibration of MEMS accelerometer sensors” was proposed by a company, developing software for mobile devices in 2013. Even though this problem did not lead to a further collaboration with the company, it turned out to be a very positive experience. Three years later, we were approached by a firm in the borehole drilling industry, which was facing a very similar problem.

Thus, in the present talk, I will focus on the implications that even a seemingly unsuccessful project can have in terms of experience, know-how and future opportunities.

# **Optimum Experimental Design for Nonlinear Dynamical Models - Mathematical Basic Research of High Economic Impact**

**Hans Georg Bock<sup>1</sup>,**

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Abstract: Mathematical modeling, simulation, optimization and control have become a powerful mathematical enabling technology for understanding and mastering the challenges of present days' industrial technologies, from automotive and aerospace engineering to mechanical, chemical and biochemical process engineering - providing a significant potential for innovative industrial solutions. This talk will present a particular success story: the optimal design of experiments to validate and calibrate nonlinear dynamical models. Here, fundamental research on instruments suitable for everyday industrial practice led to immediate high economic impact in industrial applications. This success motivated the BASF Company to sponsor a whole junior research group in Mathematics with 2 postdocs and 3 doctoral students for 7 years. The presentation will highlight new methods to optimize and accelerate the often expensive yet ambiguous experiments to provide the necessary data for model validation as well as new algorithms to compute non-linear mixed-integer control solutions for such models under uncertainties. Applications for chemical and biochemical processes are given.

## Optimization of LED based public lighting units

Tibor Csendes<sup>1</sup>, Balázs L. Lévai<sup>1</sup>, and Balázs Bánhelyi<sup>1</sup>,

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The issue of light pollution, unnecessary lighting of outdoor areas, came into focus in the last ten years. This is the reason why observatories should not be built in highly populated areas, it also disturbs the wild life, and it raises questions about energy conservation too. Based on its capabilities, LED technology offers a solution to this problem. Nowadays, travelers can visit many cities in developed countries and encounter LED street lights in public places as application of this technology spreading in public lighting. Designing orientation of LEDs in such street lights is a difficult problem as we need to use multiple LED packages to light an as large area as an incandescent light bulb can. Determining correct angles is a global optimization problem [1], a complex mathematical task related to the field of covering problems [3]. In this talk, we present an automatic designing method to construct LED configurations for street lights and a light pattern computation technique to evaluate these configurations [2]. To speed up the whole designing process, a possible way of parallelization is also discussed.

We developed the optimization model, found a suitable solution algorithm, and demonstrated that it can well be used for real life problems. The procedure has been patented, and the final report of the industrial partner has been accepted by the innovation program that supported the work.

**Keywords:** global optimization, circle packing.

### REFERENCES

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## **Feedback from 10 years of industrial mathematics in Ireland**

**Dr. Sinead M. Burke<sup>1</sup>, Professor Stephen B.G. O'Brien<sup>1</sup>,**

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MACSI10 held December 8th and 9th 2016 aimed to empower the future of Irish industrial mathematical and statistical modelling. This event brought together mathematicians, scientists and industrialists to reflect on the gains made in industrial mathematics over the past ten years and identify fresh challenges that could be solved by applying mathematical and statistical modelling techniques. Large multinational companies and small indigenous Irish companies, in addition to large state funded scientific research centres were consulted on their needs from applied/industrial mathematics during a Visioning Exercise. This workshop was held to inform a needs based strategy for MACSI going forward.

## **SURF imaging for contrast improvement in ultrasound imaging**

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SURF imaging, currently developed by SURF Technology AS, Trondheim, is a method for ultrasound imaging intended to improve the behaviour of micro-bubble contrast agents. The main idea of this method is to make use of the non-linear behaviour of the contrast agent with respect to applied pressure in order to further improve the contrast and to suppress spurious noise. This is done by overlaying the high frequency measurement pulse by a low frequency tuning pulse that either decreases or increases the scattering of the measurement pulse at the micro-bubbles. Applying two different tuning pulses and computing a difference image of the two reconstructions, we could therefore, in principle, single out and detect the presence of the contrast agent in the tissue. However, because of the non-linearities involved in ultrasound imaging, such a direct approach is not possible and it is instead necessary to pre-process the recorded signals in order to obtain the desired contrast enhancement. This can be achieved by employing regularisation methods for the approximate reconstruction of the sound speed variations produced by the pressure changes due to the tuning pulses. In this talk we will discuss the mathematical challenges faced in this type of ultrasound imaging, and also briefly discuss the employed solution strategies.

**Keywords:** Ultrasound imaging, signal processing, regularisation, inverse problems.



## **Inverse problems in mathematical imaging sciences and applications to the health care sector**

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The presentation will give an overview of mathematical research & development associated with imaging sciences. The presentation draws upon selected real cooperation between mathematicians and companies within the field of imaging. I will outline the challenge, both from a commercial and societal view, as well as the mathematical methods that have been developed to address the challenge.

**Keywords:** Imaging, inverse problems, optimization, health care.

## Platemod: A model-based production system

**Peter Kritzer<sup>1</sup>, Michael Aichinger<sup>2</sup>, Andreas Binder<sup>3</sup>, Stefan Janecek<sup>3</sup>,  
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Modern pipelines for natural gas are made of heavy steel plates that have to withstand mechanical (pressure), thermal and also chemical loads (e.g., very sour natural gas). To obtain a highly resistant heavy plate, the crystallization and the history of phase changes between different steel phases (austenite, martensite) must be tightly controlled via sophisticated cooling and reheating loops. In this talk we present a joint R& D project of *voestalpine* and *MathConsult* named “Platemod”. In this project, different model hierarchies and simulation tools are developed for laboratory and production environments, for office simulation and for online control.

**Keywords:** Thermomechanics, simulation, heavy steel plates.

## Modeling and Simulation of Float Glass Forming Process

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In this presentation we will present some basic features of the ongoing collaboration of the Mathematical Institute of the Charles University (research group Mathematical Modeling) with the company Glass Service, Inc. This company is an advanced solution supplier in the field of glass melting, conditioning and forming in the sector of production of materials. The industrial challenge in this collaboration covers the following two goals. First, to control thickness of the produced glass sheets using not only distribution of temperature in the material but also other auxiliary tools. Second goal is to control spread of contaminants in the glass sheets. The basic mathematical approach is the Diffuse interface approach coupled with Thin film approximation. The governing equations are discretized using the Finite element method. Numerical solution of these equations offers a lot of possibilities to combine direct and iterative solvers of systems of equations. New research related to this problem involving members of the mathematical modeling group could enable to improve existing methodology of the company and should lead to more efficient simulation of the melting process as well as of the related processes that are run under different conditions without the need to perform costly experiments. This abstract and presentation are based on the existing collaboration of the Faculty of Mathematics and Physics, Charles University with Glass Service, Inc.

**Keywords:** Mathematical modeling, glass melting, flow governing equations, energy conservation, finite element method, preconditioned iterative solvers.

## **Some AMIES supported success stories in France with EDF, St Gobain, PREDICAL, Cie du vent, POLLEN, Hager**

**Stéphane Cordier,**

Head of AMIES, UMS 3458 CNRS and UGA and professor in Université of Orléans

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AMIES, Agency for Interaction in Mathematics with Business and Society, was created in 2011 at the initiative of the National Institute for Interaction in Mathematics ( INSMI ) of the CNRS. AMIES is a national organization that aims to develop relations between academic research teams in mathematics and business, especially SMEs. AMIES is a founding member of the European network Eu-Maths-In, created in December 2013, which shares the same objectives at European level. Note that AMIES is in charge of the jobs service that has been deployed at European level in 2014. AMIES relies on a network of facilitators and works in partnership with the many french structures in mathematics. In particular all mathematics departments have a so called “AMIES correspondant”. AMIES initiated recently a network of regional structures called “MSO network” that includes successful initiatives like MaiMoSiNE in Grenoble or CEMOSIS in Strasbourg among others. AMIES published in 2015 a socio-economic impact study of Mathematics (EISEM).

The two main AMIES programs are: the **PEPS** (First Exploratory Projects support) aim at supporting the initiation of new collaborations, and the **SEME** (Week Study Mathematics-Enterprises) that draw from European Study Groups International (ESGI). In this talk, we shall briefly present some of recent successful collaborations which have been funded by AMIES.

### **AMIES’ supporting PhD recruited by the compagny**

- EDF (Electricité de France) Develop robust numerical method for sediment transport. A new well balanced method has been proposed and is currently implemented in industrial software (TELEMAC),
- Saint Gobain. Control the coalescence and break-up of bubbles & drops in melted glass A level-set model has been developed (preferred to a phase-field model) and validated with classical tests.

### **Support to recently created start-up to gain market and take off**

- Pollen Metrology : Control and measurements of nanomaterials by aggregation and analysis of different sources of images. A thesis in progress allow automated full image analysis, reaching accurate 3D process control and higher production yield. The breakthrough of genuine data fusion in industrial metrology opened the door to the international market. They already hired 3 mathematicians.
- Predical : Interpret data collected in the vicinity of elders to identify behavior changes (drop of the social link, change in the meal frequency, sleep duration and any other activity drop or abnormal situation) A machine learning mechanism has been put in place by a post-doc for 1 year. With convincing results, helped by academic labs, Predical raised 226 k€ in nov. 2016

**Growing projects** , with la Compagnie du vent, a PEPS was funded in 2013 to reconstruct the wind velocity field approximation from sparse data for new wind farm installation. The wind field is modeled at a regional level from (very) sparse data, taking into account the (inland) topography. This study, supported by AMIES for 10k€, has allowed the emergence of a 1M€ project with Total.

**Develop new product** . During a six months PEPS project for Hager, a control component of an energy management system at home equipped with photovoltaic cells and batteries was developed. Electricity is stored or restituted by the controller in order to satisfy an energy roadmap provided by a smart grid. The main mathematical contributions consisted in the mathematical modeling and the efficient and robust formulation of the optimization algorithm. This product is commercialized since spring 2016.

## Modelling of the machines damage detection for Polish mines.

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Mining is one of the key industries in Poland. Issues related to safety and efficiency are of particular importance in every mining operation. Today, in the era of mechanization, automation and robotics, performance of miners increasingly relies on condition of the machines that they are operating. Such machines are often designed exclusively for particular application, taking into account specific environment in which they will work. For instance, loaders used in specific underground mines have to be low-profiled, but they still have to carry appropriate volume of mined rock. In order to prevent from long and unexpected downtime the machines and structures are monitored using lots of sensors (temperature, pressure, current, tension, etc.). The sensors might be attached on the machine and then the measurements are performed online. Sometimes, such frequent measurements are not necessary or they are even physically impossible and then measurements might be performed e.g. on daily or monthly basis. From four years scientists from the Hugo Steinhaus Center together with engineers from Faculty of Geoengineering, Mining and Geology WUST are cooperating with one of the largest Polish mine companies in the area of application of mathematical methods to technical diagnostics. Application of mathematics in local damage detection comes down to vibration signal processing using several different domains, e.g. time, frequency, time-frequency or bi-frequency. These methods incorporate discrete Fourier transform and its inverse, Hilbert transform, analysis of autoregressive models in both time and frequency domains (including AR models with constant or time-varying coefficients), cyclostationarity, deconvolution under a non-Gaussianity criteria, wavelets, empirical mode decomposition etc. One of the methods for impulsive signal extraction relies on searching for a frequency band containing series of impulses. A promising approach is to quantify impulsivity of each frequency band using a specific measure (e.g. a non-Gaussianity measure) or periodicity demonstrated as an impulsive amplitude modulation of the carrier signal. The key problem related in particular to mining machines is an impulsive noise contaminating the vibration signal. Such noise might be caused by specific operation of the machine (e.g. copper ore crusher) or during data acquisition. A solution to this problem might be provided by an impulsivity measure sensitive to a series of impulses, not to a single one. Already mentioned mathematical tests improve the monitoring of mines machinery by the company. It allows to avoid unexpected damages. Because of that also economic results of company seems to be better.

**Keywords:** Mine machine, damage detection, signal processing, time series.

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## Modeling, Simulating and Optimizing the stock of an automotive spare parts wholesaler.

Manuel Cruz<sup>1</sup>, Margarida Pina<sup>2</sup>, Ricardo Costa<sup>2</sup>, Sandra Ramos<sup>1</sup>

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The Nors Group, through their aftermarket spare parts business for the automotive industry, identified the need to develop a tool to support the activities of their operations department. This challenge was presented to LEMA, in order to know if industrial mathematics could help Nors to solve the following problem. Daily, the operations department - the group main responsible for the stock management of this business - processes a big amount of data in order to give an efficient response to the company needs in terms of stock, regarding the more than 200.000 part numbers commercialized by the group. With that purpose, an efficient tool for forecast analysis was needed, as well as a model that allowed some parametrizations in order to accomplish the manager's decisions regarding the quality of service ratio desired. A particular characteristic of this challenge is that the references set have very different behaviors regarding the amount of sales per month. Indeed, the same product family may have high rotation references and also very low rotation products leading to the need of applying very different methodologies and forecast techniques. As so, industrial and mathematical partners agreed on developing a new tailor-made model[1], based on updated techniques of forecasting that allows the managers to parameterize the amount of risk they want to take in terms of quality of service parameters. One year after the model implementation being implemented with several families of products, the level of service raised 1.5%, the mean stock value decreased about 18%, in a period where the sales volume increased around 9%. These results contributed for this project to win the Nors innovation prize, an award to recognize the best practices towards innovation inside this group of almost 4000 collaborators and with a 1.4 billion euros turnover. Nowadays those algorithms are included on the software created by this team specifically for this purpose, reducing the order processing times in more than 70% when compared with Nors native system. The project as evolved to a new stage, where a new optimization model was developed and it is currently being tested. This mathematical model, that uses the predictions developed in the first part of the project, aims to produce efficient orders management system that minimizes the overall stocks costs, while guarantees the service level threshold and other constrains defined by Nors management policies. This collaboration, that continues for the 2<sup>nd</sup> consecutive year, is entirely funded by Nors. It is also important to notice that, in the beginning of this partnership, Nors never had a mathematician on their staff since its foundation, 85 years ago. Nowadays, there is one full-time mathematician plus another one working on an internship regimen. Meanwhile, there are some other side projects being developed as this partnership proceeds. Indeed, increasing the knowledge within the business allowed mathematicians to identify additional areas where industrial mathematics was useful to improve Nors efficiency. This presentation will address those early results, the main questions that arose during this work, as well as some interesting side effects from this partnership.

**Keywords:** Industrial Mathematics, Modeling, Simulation, Optimization, Forecasting.

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## Some successful stories of the Spanish Network for Mathematics & Industry math-in.

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In this presentation some recent successful stories of cooperation between research groups belonging to math-in and companies or public institutions will be presented:

- Collaboration between the group Transfer of Mathematical Technology (University of the Basque Country) and Montajes Luan Arzubia whose goal was to find two parallel cutting lines on an irregular piece of lumber so as to eliminate the bark or wane and obtain the largest possible rectangle of usable wood. The problem was solved by using algorithms for solving optimization problems with constraints as well as techniques of analytic geometry. The implementation of an efficient algorithm allowed the company to minimize the loss of material and to improve the stability of the production rate, that is 3 times faster than in manual mode.
- Collaboration between ITMATI (Instituto Tecnológico de Matemática Industrial, Galicia) and Fundiciones Rey S.L. whose goal was to develop a tool for the virtual analysis of the thermal problem arising in the solidification of a metal casting inside a sand mold. The software package CastFEM was developed. This software includes from CAD and meshing pre-processing to comprehensive visualization post-processing. It is based on the discretization of the nonlinear system of Partial Differential Equations that model the thermal problem by means of the Finite Element Method, using a domain decomposition technique. This software allows the company to avoid making expensive experimental tests in metal casting processes.
- Collaboration between the group EDANYA (University of Málaga) and INGV (Istituto Nazionale di Geofisica e Vulcanologia, Italy) whose goal was to develop a faster-than-real-time tool for the simulation of tsunami generation, propagation, and flooding. The Tsunami-HySEA code, based on the numerical discretization of the shallow water system of Partial Differential Equations by means of high-order Finite Volume methods, was adapted and improved to develop such a tool. The implementation of the algorithms in GPU architectures allow INGV to obtain numerical simulations whose quality is comparable to the software previously used much faster (the time reduction is of around two orders of magnitude). Tsunami-HySEA is now the simulation tool of the Italian Tsunami Early Warning System.

**Keywords:** Optimization with constraints. Numerical methods for Partial Differential Equations. High-Performance Computing. Lumber cutting. Solidification of metal casting. Tsunami waves.

## Boosting Productivity of an Alumina Cement Plant through Computational Fluid Dynamics

Michele Pisaroni<sup>1</sup>, Miguel Romero<sup>2</sup>, Rudy Sadi<sup>3</sup>, Domenico Lahaye<sup>4</sup>, Kees Vuik<sup>4</sup>

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### ABSTRACT

What impact can numerical simulation have in the production industry? Our partnership with Almatris B.V. ([www.almatis.com](http://www.almatis.com)), the world-leader in alumina cement manufacturing, resulted in the complete elimination of unscheduled plant shut-downs. Almatris now reports a much more stable manufacturing process and hence a very significant productivity increase. The key to our success resides in the deployment of advanced mathematical modeling and numerical simulation techniques. It is currently driving a long-term collaboration expanding into different branches of Almatris [1].

For the production of calcium-alumina cement, Almatris Rotterdam employs a rotating cylindrical kiln. As the kiln rotates, the raw material is mixed and heated up. Solid state sintering reactions are induced. Stringent quality specifications require the control of the critical process parameters such as the temperature and NO<sub>x</sub> emissions. Experience at the Almatris plant in Rotterdam has shown that neither trial and error nor empirical modeling provide sufficient insight into these operating conditions. Measuring the temperature inside the kiln has proven to be difficult due to the harsh operating conditions.

The TU Delft scientific computing group developed a mathematical model in two stages. In the first stage, a three-dimensional non-premixed turbulent combustion model for the temperature, radiative heat flux and NO<sub>x</sub> formation in the kiln was developed [2]. The CFD model allowed to identify hot-spots with locations in the kiln where rings were typically formed. Modifying the inflow air-to-gas ratio allowed to reduce the peak in temperature and to completely eliminate ring formation. The presence of the cement material was first neglected in the first project stage. In a second stage we constructed a system of coupled ordinary differential equations for the absorption of heat by the material as it traverses through oven and for the ensuing phase transformation and chemical reactions [3]. This modeled allowed to link the observed increase in productivity with the amount of liquid fraction of the material bed. The combination of the models in the two stages provided Almatris with a better grip on its production process. The partnership between Almatris and the scientific computing group is awaiting a bright future and invites motivated students to contribute to the success story.

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## Predicting Alumina Quality

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A soft sensor for measuring product quality in the Bayer process for extracting alumina from ore has been developed. The soft sensor uses a combination of historical process data recorded from online sensors and data from laboratory measurements to predict a key quality indicator, namely particle strength. Stepwise linear regression is used to select the relevant variables from a large dataset composed of monitored properties and laboratory data. The developed sensor is employed successfully by RUSAL Aughinish Alumina Ltd to predict product strength five days into the future with R-squared equal to 0.75 and to capture deviations from standard operating conditions.

**Keywords:** Bayer process; soft sensor; stepwise multiple linear regression.

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## Innovating Confocal Microscopy at Crestoptics srl: a Success Story of the Italian Network

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During its first year of activity, Sportello Matematico per l'Industria Italiana was contacted by an Italian Enterprise producing Confocal Microscopes. The devices produced by the Enterprise span a wide range of applications such as Life Sciences: Confocal Microscopy serves to obtain very detailed pictures of biological samples for subsequent analysis.

The Enterprises needed to innovate its products in the following aspects:

- (1) increase the quality of the images acquired by the microscope;
- (2) to speed-up production process of spinning disks while evaluating the limits of the device before actually producing it.

Confocal microscopy is an optical imaging technique to increase both the optical resolution and contrast of a micrograph by eliminating out-of-focus light. This is achieved through a mechanical spinning disk (Nipkow disk), with a series of pinholes drilled in it, placed at the confocal plane of the lenses: this tool filters out distortion frequencies of the collected signals.

When producing a new confocal microscope, special attention has to be devoted to the building of the spinning disk, since inhomogeneous distribution of holes may produce artifacts on the acquired image. Moreover, a suitable post-processing tool has to be used in order to properly process the acquired image. Moreover, the trial phase of development of new spinning disk is highly demanding: it requires 8 weeks for the physical building and 2 weeks for testing.

When dealing with image processing, one has to face the following general problems: Data Acquisition and Data Processing. From a Mathematical point of view, the above technical issues translate to the following concepts: Sampling, Deconvolution, Denoising and Superresolution.

Concerning problem (1), the proposed solution was split into the following three steps:

- i:** Design of novel patterns for the spinning disk (definition of a novel grid on the disk);
- ii:** Definition of a protocol for image acquisition;
- iii:** Development of ad hoc reconstruction algorithms for increasing the resolution of the acquired images.

Regarding problem (2), the Research Center proposed a software for the simulation of the acquisition process, focused on the simulation of spinning disk rotation and illuminated specimen points.

The final products of this collaboration are an original simulation software for the spinning disk and a patent for novel protocol for image acquisition and novel method for data processing.

**H2020 Societal Challenge:** Health, demographic change and wellbeing.

**Keywords:** Confocal Microscopy; Deconvolution of noisy data; Virtual Prototyping; Technology Transfer.