

The logo features a large, dark purple rounded rectangle on a light grey background. The rectangle is partially overlaid by a white wireframe grid that curves around its top and right edges. The text 'itmati' is centered within the purple area in a bold, lowercase, sans-serif font. The letters 'i', 't', 'm', and 'a' are white, while '2' and 't' are dark purple, and the final 'i' is white.

itmati

**Technological Institute
for Industrial Mathematics**

ITMATI = INNOVATION + TECHNOLOGY + MATHEMATICS + INDUSTRY
Service catalogue for innovative companies

Mathematical solutions for innovative companies

The main goal of the Technological Institute for Industrial Mathematics (ITMATI) is to enhance the mathematical technology transfer to companies. ITMATI is a public consortium set up in 2013 by the three Galician Universities of Galicia: University of A Coruña (UDC), University of Santiago de Compostela (USC) and University of Vigo (UVigo).

ITMATI is steadily becoming a world reference centre for technological research in the field of industrial mathematics. The best guarantee to achieve this is our capacity to respond to the most demanding needs of enterprises, by offering the state-of-the-art and most innovative solutions through the use of the mathematical technology.

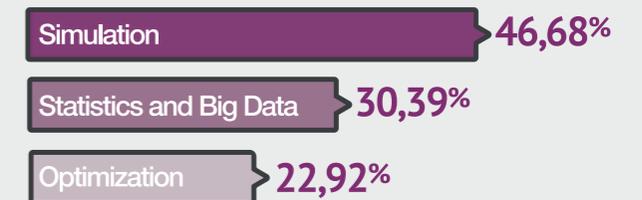
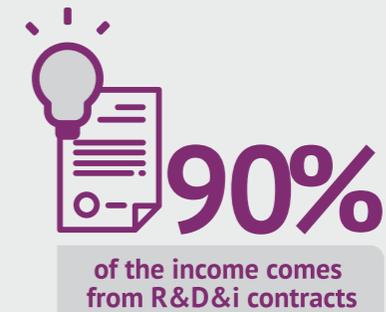
We are strongly committed to internationalization, as evidenced by the increase in the last few years in the number of R&D&I projects carried out with technology and research centres from different countries. Participation in international initiatives is a source of new ideas, approaches and abilities in line with the latest global market needs. This framework clearly gives our customers a competitive advantage, benefi-

ting from an avant-garde and forward-looking vision.

Our purpose focuses on the following aspects:

- To enhance and strengthen the industrial and entrepreneurial competitiveness.
- To generate added value for society.
- To support innovation in the manufacturing sector through excellence in research.
- To develop advanced mathematical technology intended to be transferred to industry.

ITMATI at a glance



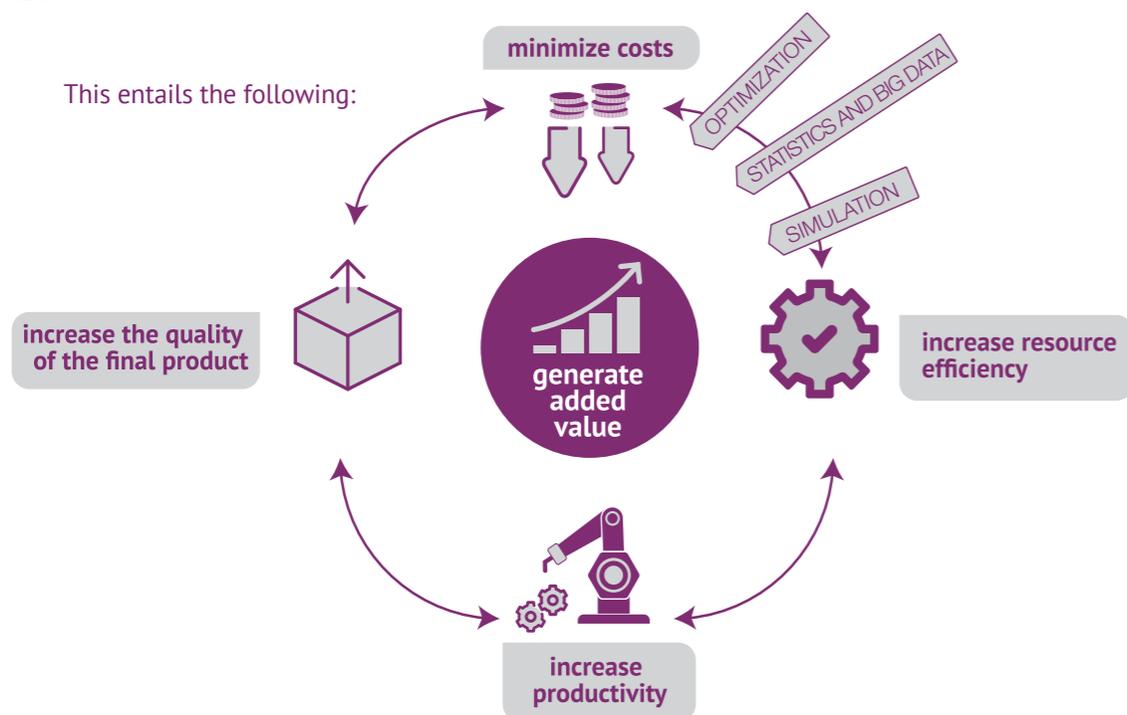
Our goal: to improve business competitiveness

At ITMATI we produce new knowledge in order to provide innovative solutions to both present and future industrial issues by using mathematical technology.

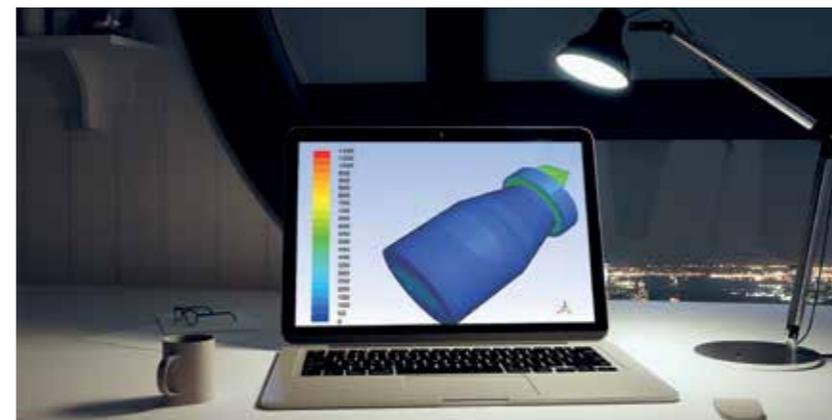
The cross-cutting nature of mathematics allows us to suit the needs of companies from any sector. In order to do this, we have an extensive team of experts in our three areas of specialization subject to transfer:

- Numerical Simulation (CAD/CAE).
- Statistics and Big Data.
- Optimization.

Close collaboration with the company's professionals allows us to develop tailor-made products, which guarantee an increase in the competitiveness of our customers.



Numerical Simulation (CAD/CAE) Area



Numerical simulation of the combustion inside furnaces used in metallurgy.

Modelling, simulation or prediction of the behaviour of devices, products and processes can be carried out through computer aided design (CAD) and computer aided engineering (CAE), also known as numerical simulation.

Technological capabilities in this area, in which ITMATI holds extensive experience, are applied to very different phenomena and processes, namely the following:

- Acoustic and vibroacoustic.
- Chemical kinetics.
- Combustion.
- Electronic and electromagnetic.
- Environmental.
- Financial derivatives.
- Fluid structure interaction.
- Gaseous and liquid fluids.
- Manufacture (injection, forging and stamping amongst others).
- Mechanical and structural.
- Multiphysics coupling.
- Thermal and thermodynamic.

In this area, ITMATI professionals develop solutions that cover all stages of the value chain, from mathematical modelling to software development, plus mathematical analysis and numerical discretization of the obtained models.

The next concrete applications are some examples in which ITMATI has used numerical simulation in order to solve industrial problems:

- Alloys solidification.
- Combustion optimization in thermal power stations.
- Forecasting of the water quality of a lake.
- Gas flow calculation in gas pipelines.
- Heating of induction furnaces.
- Improvements in vehicle comfort.
- Strength of structures calculation.
- Valuation of financial products.
- Wind turbine design.

Statistics and Big Data Area



For most companies, the **efficient management of a huge volume of data** has become a necessity partly arising from the challenge of operating in the global market. The proper organization and exploitation of information is a strategic factor making statistics and Big Data techniques very useful.

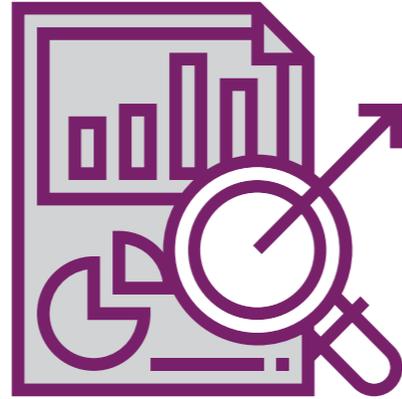
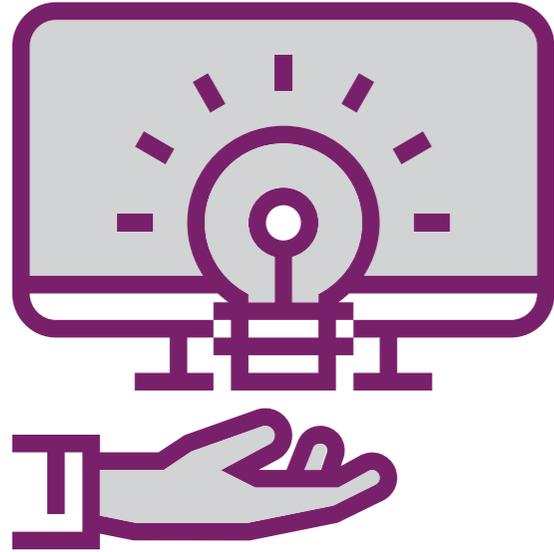
Our technological capabilities in the Statistics and Big Data Area are very valuable when used in the following **fields**:

- Production process and stock control.
- Quality control and reliability.
- Client, market and product surveys.
- Financial and risk analysis.
- Exploitation of internal information. Data mining (Business Intelligence, Big Data).
- Risk prediction in devices and processes.
- Design of experiments and clinical trials.
- Biostatistics and epidemiology.

Technologies developed in this area fall under the categories of statistical inference, biostatistics, geostatistics, sampling and resampling techniques, time series, non-parametric inference, categorical data, censored and/or truncated data, forecasting and multivariate analysis, inter alia. At IMATI we have developed **technology to meet the demands** concerning, inter alia:

- Statistical advice and data analysis.
- Time-series forecasting.
- Map production from spatial data.
- Financial modelling.
- Environmental and energy modelling.
- Development of health statistics.

Optimization Area



This transfer area combines **numerical simulation**, **statistics** and **operational research** techniques for:

- Optimal decision-making.
- Optimization of industrial and business processes.
- Optimization of resources and its location.
- Product and stock optimization.
- Route planning.
- Services location.
- Strategy, logistics and planning.
- Work planning.

Our expertise in this area focuses on:

- Modelling and optimization of gas transmission networks.
- Incorporation of uncertainty that exists concerning prices, demands and quality of raw materials and products in the decision-making processes relating to production planning in industrial plants.
- Development of expert systems for monitoring and managing resources dedicated to fight fires as well as to assist decision-makers.
- Harvester route planning in agricultural cooperatives.

Technological capabilities ready to meet the needs of all sectors

ITMATI is a **totally business-oriented** technology centre. Our work team has therefore the following capabilities:

- It has **solid experience** in a broad range of business sectors.
- It is **committed** to responding to all type of new demands raised by the business fabric.
- Its **research potential** and **proactive attitude** are applied to the exploration of mathematical solutions applicable to new needs and productive areas.

Our **reference sectors** are the following:



Administration



Aeronautics



Agriculture



Automotive



Biomedical and pharmaceutical industry



Construction



Defence



Economics and finance



Energy



Environment



Food industry



Heritage management and preservation



Information technology and telecommunications



Logistics



Marine resources and aquaculture



Maritime



Materials



Social studies



Space



Tourism and leisure



Transport

Capabilities grouped by sector



Aeronautics, automotive and maritime

- Multiphysics coupled simulations that include thermomechanical, thermo-hydrodynamic, aerodynamic, thermoelectric and thermomagnetic phenomena.
- Numerical simulation of industrial equipment and processes, namely induction furnaces, air flows in spray booths, heat exchangers, solidification processes of metal parts, radial and axial bearings, bearings for marine propulsion, automotive components and electronic devices.
- Calculation of aerodynamic coefficients.
- Active and passive noise control.
- Design of steering wheels, sails and underwater hulls.
- Use and training on free and commercial CFD software in this sector.
- Estimate of the vessels energy demand during docking.
- Vessels reliability.
- Image-based obstacle identification to create automatic alerts in case of potential danger of collision.
- Real-time decision-making to optimize ground and aerial means during firefighting.
- Numerical verification of ISO standards.



Agriculture and food industry

- Analysis and optimization of sterilization procedures of packaged food.
- Determination of the height and thickness of vegetation by using LIDAR images.
- Efficacy of phytosanitary products. Epidemiological risk maps.
- Food quality and preservation.
- Agricultural machinery logistics.
- Optimization of packaging.
- Study of the properties of materials for their manufacture and quality control.
- Optimization of food freezing and thawing processes.



Biomedicine and health

- Analysis and design of experiments and clinical trials.
- Biostatistics.
- Comprehensive control of medical variables and prediction of their impact.
- Reliability and security of treatments. Epidemiology. Mortality and survival tables.
- Surgery waiting lists. On-call roster schedules. Patient multi-appointments.
- Numerical simulation in biomechanical issues, such as bone formation, fractures, dental implants and orthodontic brackets.



Economics and finance

- Analysis and prediction of interest rates. Quantitative finance.
- Development internal measurement, management and control models.
- Incorporation of the market uncertainty in the decision-making processes.
- Measurement of financial and operational risk.
- Stochastic modelling of the accident rate.
- Markets studies and quality of services.
- Valuation and optimization of flows in portfolios with assets and liabilities and financial products.



Energy and environment

- Development of advanced technologies in firefighting.
- Pollution control. Impact estimation and emissions reduction.
- Noise control and acoustic impact assessment.
- Development of expert systems for monitoring and managing firefighting resources.
- Computational Fluid Dynamics (CFD). Heat transfer, chemical kinetics, hydrodynamics and combustion processes.
- Renewable energies: wind energy, solar energy and biomass. Wind forecasting maps.
- Market studies on energy trading.
- Identification of kinetic parameters in energy processes.
- Impact of works in rivers and coastal areas.
- Use and training on free and commercial CFD software in this sector.
- Modelling and simulation of complete-mixture digesters.
- Statistical modelling for the characterization of the energy-demand operational profile of docked vessels.
- Modelling and simulation of pulverized-coal oxycombustion with flames.
- Modelling and simulation of forest fires.
- Statistical models for the energy and environmental sectors.
- Design and load optimization for energy storage systems.
- Combustion optimization in metallurgical furnaces.
- Optimization of facilities and design of new generation plants.
- Optimization of energy-distribution networks.
- Optimization of the design of floating platforms which generate energy from marine currents.
- Optimization of process plants under uncertainty.
- Breakdown prediction in energy-production processes and devices.
- Air contamination forecasting in cities using systems which monitor pollutant emission from a focal point.
- Forecasting the risk of events affecting air conditioning systems.
- Simulation of air and water quality.
- Simulation of combustion in coal and oil-fired furnaces.
- Simulation of electric machines.
- Simulation of dynamics models for the integration of suspended particles.
- Simulation of electric batteries charging and discharging processes.
- Simulation of processes in energy installations. Energy efficiency.
- Simulation of hydrological systems.
- Simulation of pollutant propagation and dispersion.
- Simulation and optimization of gas transmission networks.
- Numerical simulation of pollutant dispersion within rivers, estuaries and oceans.



Defence

- Calculation of the reliability of submarines.
- Definition, validation and representation of indicators of reliability, availability and maintainability in railroad infrastructures.
- Development of advanced algorithms related to critical emergency missions with both manned and unmanned aerial vehicles in cooperative flight.
- Design and diagnosis, by means of statistical models, of the impurity content in aviation fuel.
- Study of pyrotechnic substances combustion.
- Orbit predictions and navigation satellite clocks.
- Numerical simulation of large ice masses.
- Numerical simulation of structural strength and rollover resistance tests of heavy vehicles with heavy loads.



Information technology and telecommunications

- Development of customized mathematical-technology software applications in the areas of numerical simulation, statistics, big data and optimization.
- Development of data protection and electronic security systems.
- Operation of databases: Business Intelligence.
- Optimization of non-conventional hardware.
- Optimization and parallelization of algorithms.
- GPU and FPGA programming.
- Optical fibre simulation.
- Simulation and design of electromagnetic and electronic devices.



Logistics and transport

- Development of expert systems for characterizing the territory.
- Development of expert systems for enhancing the efficiency of unloading operations during firefighting.
- Development of expert systems for decision-making in order to control the cooperation between manned and unmanned aircrafts.
- Study of the incidence and impact of promotional periods on the demand regarding different types of articles.
- Management and distribution of goods.
- Optimization of the logistical flow of components for wind industry.
- Optimization of transport planning.
- Planning of loading and unloading arrangements.
- Route planning and optimization.
- Simulation of new transport technologies.



Materials and construction

- Mechanical, structural, thermal, thermodynamic and acoustic calculations.
- Numerical characterization of the behaviour of materials.
- Use and training of free and commercial CFD software for structure calculation and electromagnetism in this sector.
- Mathematical modelling of scaling processes in metallurgical production.
- Multiphysics simulation: thermomechanical, thermoelectric, electromagnetic, magneto-hydrodynamic or fluid-structure interaction.

- Simulation of combustion and electrical behaviour of arc furnaces used in the metallurgy sector.
- Simulation of purification of materials and industrial grinding.
- Simulation of fire resistance of buildings.
- Simulation of the resistance of buildings to climatic impacts.
- Simulation of strength of materials.
- Simulation of bridge resistance during load tests.
- Simulation of metal and ferro-alloy solidification.
- Process simulation in micro-nano alumina.
- Simulation of thermal and acoustics insulation on housing facilities.
- Thermoelectric simulation of aluminium electrolytic cells.
- Thermo-electromagnetic simulation of metallurgical electrodes.
- Thermomechanical simulation of ventilated facades.
- Thermal stresses in structures subject to low temperatures.
- Structure vibrations.



Tourism and services

- People's habits analysis.
- Demographic change analysis.
- Survey design, development, analysis and filtering process.
- Studies on labour insertion.
- Statistical study on the behaviour of tourist networks

Open services portfolio



ITMATI's services portfolio is always open to developing specific solutions fully adapted to our customers' needs.

We are highly experienced in the following areas:

Development of products and solutions. Our team, which is made up of international benchmark researchers and technologists, designs and develops innovative solutions fully adapted to our customers' needs by using mathematical technology as a tool.

Our team is specialized in the development of turnkey projects taking full responsibility for the overall work process and being committed to providing a comprehensive, agile and efficient answer.

Our team also includes staff specialized in project management and technology transfer and innovation. This enables us to optimize the transfer of knowledge generated by universities for its application in the area of industrial mathematics in the manufacturing sectors.

High-level technological consultancy and scientific advice. The service we offer in the area of technological consultancy team allows us to address projects that require a great customization and the adaptation to the customers' needs of every solution. This implies the full involvement of ITMATI, both during the problem specification stage and the solution development, which invariably arises out of a continued close cooperation with the company.

ITMATI has a highly specialized panel of experts of recognized standing and experience in mathematical technology, who are capable of providing advice to our clients on any technology demand, with guarantees of success for a broad range of challenges posed by virtually all industry sectors.

During the implementation of consultancy projects, a solid management and monitoring of the project is carried out, in order to comply with specifications, planning and deadlines. This ensures results in line with technical and budgetary requirements as well as a customized service.

Collaboration in R&D&I projects. Research and development of new mathematical technologies applicable to industry is one of ITMATI's priority areas. The new approaches and techniques in mathematics developed by our experts help economic efficiency and raise productivity in companies, providing innovations and generating added value to the productive fabric.

Research conducted by ITMATI arises out of the needs perceived by companies and communicated to our experts. They are focused on the resolution of real industry problems. Our customers are afforded the opportunity to order specific research and development, on a purely confidential basis if required, in order to provide solutions to their exclusive and particular demands. ITMATI also offers customers collaboration in the pursuit of financing, as well as advice to protect and commercialize the results obtained, in the light of the progress made in R&D&I projects undertaken.

Courses. We offer both tailor-made and modular courses. Course contents are defined in order to meet our customers' requirements and needs. All our training activities are implementation-oriented and they always include relevant examples adapted to our customers, so that the acquired knowledge has an immediate application in the business processes.

Development of custom software. At ITMATI we develop customer-driven specialized software. Our experts have a thorough experience in different programming languages, as well as in the development of specific tailor-made applications which can meet needs not sufficiently covered by existing standard software that is already on the market.

ITMATI software development ensures intuitive and user-friendly environments in order to facilitate its use, as well as to achieve a full integration with the business processes. In line with this, such developments can be integrated with software packages available in the market, both enterprise application and open-source software.

All our software developments include user training, as well as relevant documents and technical characteristics. A warranty period is included and a maintenance service can be hired as well, which ensures software updates.

Success stories: REPSOL-ITMATI JRU

Founded jointly with Repsol enterprise, the major objective of the REPSOL-ITMATI Joint Research Unit (JRU) is to carry out research on mathematical and numerical methods by which recurrent problems present in Repsol's daily activity are solved, especially in the areas of device and process simulation and optimization.

The Repsol-ITMATI JRU allows the initiation and development of cutting-edge research lines at the frontier of knowledge in the energy sector, such as:

- How to increase the working life of batteries used in electric vehicles.
- How to improve the fast recharging process of the battery.
- With regard to the production planning in industrial facilities, how to integrate into the decision-making processes the uncertainties

relating to prices, demands, and the quality of raw materials and products.

- How to infer complex and rigorous models from physical and chemical phenomena based on a limited number of observations.

Testimony of Repsol: *"The competitive advantages obtained by Repsol within the framework of this collaboration are the optimization of our industrial processes, an improvement in the company's processes and product design and the development of decision-making tools. This research will enable the company to reduce production costs as well as to shorten development times of new technologies and bring about more noteworthy innovations as compared with our competitors".*



Award for Technology Transfer in Galicia 2016 for the best success story under the category of big companies (REGANOSA) for the application of the software developed by ITMATI.



Spanish National Network of Natural Gas displayed in the graphic interface of the GANESO software.

Success stories: GANESO

The project entitled *Gas transmission network modelling, simulation and optimization* (GANESO) has as its primary objective the research and development on the integrated and optimal management of natural gas transmission infrastructures.

In particular, ITMATI has developed the GANESO software, a computer application for obtaining, in an interactive way, an optimal distribution of flows based on different criteria, the calculation of tariffs, the transient simulation and the planning of network extensions under uncertainty. This tool allows user to monitor the use of the current infrastructures and optimize them, as well as to assess investments

in future infrastructures, thus enabling user to decide on the management and extension of a given gas transmission network.

The main project milestones have been the design and development of an innovative simulation software based on a new simulation algorithm, for which it has been necessary to determine the equations and restrictions concerning the specific case of the Spanish gas network, as well as a new optimization algorithm based on both the equation of state and control theory techniques. Through these two approaches this model has been successfully implemented.

Success stories: GPEC

The aim of the project entitled *Green Port Energy Center* (GPEC) was to improve energy efficiency and reduce emissions related with port activities, developing a polygeneration clusterizable containerized system that supplies to vessels electricity and heat generated from liquefied natural gas engine, in order to prevent vessels from operating with their auxiliary power units while in port.

ITMATI is involved in this project through the characterization of the target vessels' energy-demand operational profile by using a statistical model and developing a calculation module to assess the economic and environmental sustainability of the GPEC system.

Testimony of VICUSdt: *"Collaboration with ITMATI has been highly important for the development of the GPEC Project systems. It has been a pleasure to work with them due to their researchers' ability and involvement".*

Testimony of INOVA: *"IMATI's participation in the Green Port Energy Centre project (GPEC), co-financed by the CDTI through the European Regional Development Fund, was of great value. In particular, they were responsible for developing a multivariate model to calculate the economic and environmental sustainability, which included the characterization of the energy-demand brief profile of a docked vessel from the analysis of recorded data. This allowed an ex-ante estimate of the emission and cost reduction associated with having a vessel connected to the GPEC System".*

Ferroatlántica R&D project

The project entitled *Modelling of the complete electrical circuit of arc furnaces in the production of silicon* has focused on the numerical simulation of the electrical behaviour of arc furnaces used in the production of silicon. This information avoids the increased wear that affects the electrode tip area in the central part of the cell in the event of an increase of power in the furnaces, thus improving their overall performance.

ITMATI's participation in the project consisted in creating and adjusting a mathematical model of the complete electrical circuit of the furnace, as well as in developing a computer tool that simulates its behaviour. On the basis of the results, the company was able to improve the design and operation of the furnaces without the need to conduct costly tests.

Success stories: Smart OTEA SE-01



OTEA platform interface.

During the implementation of the project entitled *Incident risk forecasting in an air-conditioning system in relation to the outside temperature* an algorithm was created, capable of forecasting the risk of incidents as well as nuisances in a network of commercial premises.

ITMATI thus collaborated on the enhancement of the OTEA platform, owned by EcoMT company, through the development of an incident risk forecasting system in air-conditioning equipment (both cooling and heating) depending on the outside temperature.

Testimony of EcoMT: *"Gurú Otea is one of the applications implemented by ECOMT. It shows, with a high degree of reliability, which commercial premises could pose problems throughout the day. Through the forecasting of potential incidents, which can be obtained before opening hours, and taking into account*

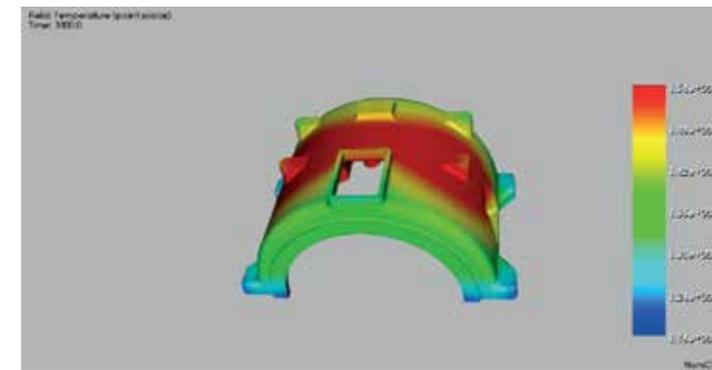
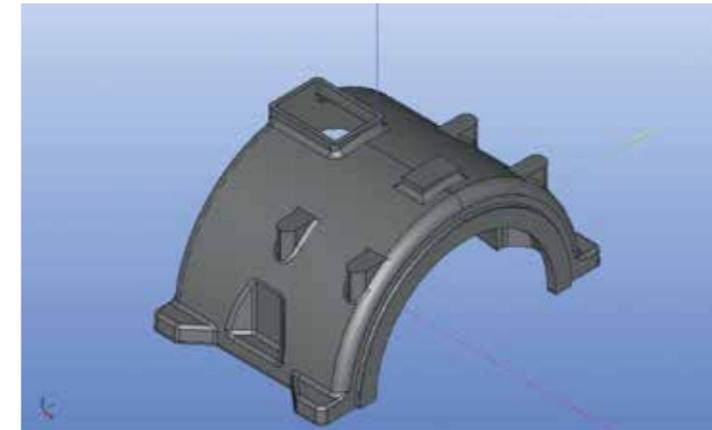
the number of machines each shop is equipped with, a list of the stores that are most at serious risk can be provided. This classification has a positive impact upon the welfare of the clients because those areas with high rates are kept under surveillance and that can avoid incidents or sort out problems before the effects are felt inside the establishment. Another advantage at industry level is the reduction in corrective maintenance costs, which are directly related to failure forecasting in air-conditioning systems. ECOMT wants to go further and has new objectives, such as the reduction of the energy demand, as well as energy and preventive maintenance costs and CO2 emissions by optimizing the schedule of visits, looking for methods to extend the lifetime of the equipment or optimizing maintenance contracts in line with the climate".

Success stories: LUMES

The project entitled *Advanced technologies for the extinction of large forest fires* (LUMES) implied the development of new technologies and tools to reduce large forest fires, in terms of both quantity and affected areas.

ITMATI collaborated on the implementation of an expert system to monitor and manage resources dedicated to fight fires as well as to assist decision-makers. In addition, an efficient and secure real-time air traffic control system has been developed. This system allows management of air assets, particularly with respect to distribution of air assets within the scenario of fires and operational instructions.

Testimony of Coremain: *"LUMES project results, through the development of the new technologies and the innovative application of statistical and operations research techniques can bring considerable benefits for administrations and agencies involved in fire management, both economically and in terms of protection and preservation of the environment and nature".*



Project of solidification of parts in moulds. Temperature distribution in the piece.



Success stories: Fundiciones Rey project

Under the Fundiciones Rey project, whose approach was centred on the solidification of metals, the mathematical modelling of heat transfer phenomena that occur during the solidification of metals in moulds as well as the further thermal and metallurgical treatment for tempering in bearings and rowlocks made of grey and nodular cast iron was carried out.

Testimony of Fundiciones Rey: *"Numerical simulation has significant advantages over experimental testing, helping reduce material costs and energy expenditure and, by extension, costs associated with the quality of the finished product".*

Our customers

SMEs

Adhex Tech Tapes S.L
Balidea Consulting & Programming S.L.
Consultores en Excelencia e Innovación Estratégica S.L. (INOVA)
Detegasa
Ecomanagement Technology S.L. (EcoMT)
Estaños y Soldaduras Senra S.L.
Fundiciones Rey S.L.
Magallanes Renovables S.L.
Resitec AS
SidernaVal, Equipos Siderúrgicos S.A.U.
Silicio Ferrosolar S.L.
VICUS Desarrollos Tecnológicos (VICUSdt)

Big enterprises

ALCOA Lista Norway
Analistas Financieros Internacionales (AFI)
Babcock International Group
CIE Galfor S.A.
Coremain S.L.U.
Elkem AS Technology
Endesa Generación S.A.
Eramet Norway AS Avd Kvinesdal
FerroAtlántica S.A.
Inditex
Regasificadora del Noroeste S.A. (Reganosa)
Repsol S.A.
Robert Bosch GmbH
Saint Gobain Ceramic Materials AS

Universities, foundations, consortia, research centres and technology centres

Centro de Tecnología Repsol (CTR Repsol)
Centro Superior de Estudios de la Defensa Nacional (CESEDEN)
Centro Tecnológico de Eficiencia y Sostenibilidad Energética (Energylab)
Fundación Pública Gallega Centro de Supercomputación de Galicia (CESGA)
IK4-Ikerlan
Instituto Español de Estudios Estratégicos
Norwegian University of Science and Technology (NTNU)
Oxford Center for Industrial and Applied Mathematics (OCIAM)
Teknova AS
TicSalut, Tecnología Innovació i Salut
Universidade da Coruña (UDC)
Universidade de Santiago de Compostela (USC)
University of Agder (UiA)



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UNIVERSIDADE DA CORUÑA



Universidade de Vigo