DESCRIPTION OF UPC ASSETS IN RELATION TO INDUSTRY 4.0
The Universitat Politècnica de Catalunya · BarcelonaTech (UPC) is a public institution dedicated to higher education and research, specialised in the fields of engineering, architecture and science. With campus located in and around Barcelona city, 31,224 students, 3,015 teachers and research staff, and 1,832 support staff, UPC has become one of the leading technical universities of the southwest Europe area.

Industrial manufacturing has always played an important role in the UPC. Since 1851 – when the industrial engineering school was established - this discipline has been a cornerstone of UPC activities. Obviously, since then both society and manufacturing have evolved into what we now understand as **industry 4.0** by incorporating disciplines such as robotics, electronics, computer and IoT or data and resources management.

UPC has also managed to adapt to this societal change and labour and business demand, with the development of new departments, research bodies and teaching curricula in the field of industry 4.0. It is this multidisciplinary approach that enables today the UPC to lead the fourth industrial revolution in Catalonia. This document summarizes the main assets of the UPC in relation to industry 4.0.
INDUSTRY 4.0 DEFINITION

The definition with which we are most identified is the proposal by the Task Force sponsored by the European Parliament in 2015, which proposes:

*Industry 4.0 is a term applied to a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products. The 4.0 designation signifies that this is the world's fourth industrial revolution, the successor to three earlier industrial revolutions that caused quantum leaps in productivity and changed the lives of people throughout the world.*

*In short, everything in and around a manufacturing operation (suppliers, the plant, distributors, even the product itself) is digitally connected, providing a highly integrated value chain.*

As with such a broad definition is hard work, we have chosen – according to Government of Catalonia definition- nine technologies being fully aware that the wealth of the asset is at the intersection thereof. The nine areas of work and challenges on which we focus our proposals and deploy industry 4.0 activity are:

- **Big Data and Analytics:** mass data analysis to support real-time decision making.
- **Autonomous Robots:** interaction with humans and improvement of performance.
- **Simulation:** reproduction of the real world in a virtual model to perform tests and optimise machine programming.
- **Internet of Things:** based on the connection of machines and systems in the productive space and a fluid exchange of information with the outside world.
- **Horizontal and vertical integration of systems:** manufacturers, suppliers and clients are closely connected via computer systems, providing truly automated value chains.
- **Cybersecurity:** to protect critical industrial systems and production lines against hacking, industrial copyright, personal data and privacy.
- **The cloud:** for task enabling and to make more computer services work in production.
- **Additive manufacturing:** 3D printing reduces raw materials, stocks and transport distances.
- **Augmented reality:** this will give workers real-time information in order to improve decision making and work processes.

Whatever the name it takes, what is clear is that nowadays manufacturing requires a **industry 4.0** and an easy access as is the case in UPC. Most of the topics mentioned in official documents related to industry 4.0 can be found at our university. Furthermore, the variety of solutions and knowledge fosters innovation and facilitates the emergence of collaborative entrepreneur projects. The following sections describe the main business
and research initiatives at UPC related to industry 4.0 that demonstrate this cross-cutting approach.

UPC INDUSTRY 4.0 RESEARCH ACTIVITY

The UPC structure comprises 21 schools and some 205 research groups. At least 100 out of them are directly related to the aforementioned nine areas.

A more detailed description of most featured of these research groups follows in the next paragraphs

ACES - ADVANCED CONTROL OF ENERGY SYSTEMS
The group's aim is to contribute to the progress of scientific knowledge, the training of specialised staff and the dissemination of technological advances in the field of modelling and monitoring complex systems, and their application to problems related to the generation, conditioning, management and storage of electrical energy.

ANTENNALAB - ANTENNAS AND WIRELESS SYSTEMS LABORATORY
The aim of the group is to promote research and education in electromagnetics applied to antennas, wireless systems and imaging, whilst addressing the needs of industry and fostering the advancement of knowledge.

BAMPLA - DESIGN AND EVALUATION OF BROADBAND NETWORKS AND SERVICES
The group’s objectives are the design, analysis and evaluation of new communication protocols, transport and access networks and next-generation Internet services, based on the group's knowledge of traffic models; network tomography; medium access, network and transport protocols; the modelling and design of services; electrical, optical and wireless transport and access technologies; and network signalling and management.

CBA - BROADBAND COMMUNICATIONS RESEARCH GROUP
Most of the topics covered by this research group are strongly related with broadband networks and broadband services and applications: switching, protocol development and performance, traffic modeling, network resource management policies and bandwidth allocation, traffic and congestion control, routing strategies, internetworking, network management, IP and optical networks convergence, quality of service management and transport protocols.
CD6 - CENTRE FOR SENSORS, INSTRUMENTS AND SYSTEMS DEVELOPMENT
The centre activity is focuses on developing research and technology applications in the field of Optical Engineering. The centre's researchers are working on four major areas of research: metrology, visual optics, optical design and simulation, colour. Moreover, the knowledge gained in these lines, results in applications that are transferred to industry.

CDEI - CENTER FOR INDUSTRIAL EQUIPMENT DESIGN
CDEI professionals are experts in machine engineering. Their field of activity encompasses everything from the conception, design, simulation and calculations of equipment and products to handling their prototypes and testing stages.

CENIT - RESEARCH AND INNOVATION ON TRANSPORTATION, MOBILITY AND LOGISTICS
Its work areas are include Urban Mobility, Port logistics and Maritime Transport and Transport Infrastructure Management with a cross-cutting view (transport economics, operations research, travel behavior, sustainability, transport policy, demand analysis, ICT, etc.).

CEPIMA - CENTER FOR PROCESS AND ENVIRONMENT ENGINEERING
CEPIMA Works in the area of computer modelling and optimisation of Chemical Processes (CPI), including the application and development of artificial intelligence supporting techniques and software.

CERTEC - CENTRE FOR STUDIES ON TECHNOLOGICAL RISK
The objective of the Centre for Technological Risk Studies (CERTEC) is to carry out research in the fields of technological risk and environmental impact (mathematical modelling of major accidents, fires, explosions, toxic releases, transportation of hazardous materials, environmental impact, etc.).

CIEFMA - STRUCTURAL INTEGRITY AND RELIABILITY OF MATERIALS CENTER
The aim is to conduct R&D, training and technological innovation in the fields of integrity (fatigue, fracture, contact, etc.), micromechanics and the reliability of materials.

CITCEA - CENTRE OF TECHNOLOGICAL INNOVATION IN POWER ELECTRONICS AND DRIVES
CITCEA-UPC is expert in all types of applications requiring the control of energy and/or movement. It develops technologies in: electricity, control electronics, power electronics, industrial communications and digital control with processors and also the applications of these technologies range from the automation of processors and machines to renewable energies and the electrical grid.
CNTS - COMPUTER NETWORKS AND DISTRIBUTED SYSTEMS
The group carries out basic and applied research; training and dissemination in topics related to computer networks and distributed systems.

CODALAB - CONTROL, DYNAMICS AND APPLICATIONS
The group is active at the interdisciplinary meeting point of applied mathematics, systems and control theory, and engineering.

CTTC - HEAT AND MASS TRANSFER TECHNOLOGICAL CENTER
The research activities are focused on two main lines. The first one is dedicated to the mathematical formulation, numerical resolution and experimental validation of fluid dynamics and heat and mass transfer phenomena. Some issues in this line are: natural and forced convection, turbulence modelling, combustion, two-phase flow, solid-liquid phase change, radiation, porous media, numerical algorithms and solvers, high performance computing (parallelisation), etc. The second line involves the application of the acquired know-how from the basic studies mentioned above to the thermal and fluid dynamic optimisation of thermal system and equipment.

DAMA-UPC - DATA MANAGEMENT GROUP
To stand out in topics related to data management, with special emphasis in data quality, data exploration from diverse data sources and large data volumes. The group works with its own software and carry out research based on it.

DCS - DISTRIBUTED CONTROL SYSTEMS
The DCS research group investigates, designs and implements distributed control systems, ranging from networked and embedded control systems to automation and control systems.

DONLL - NONLINEAR DYNAMICS, NONLINEAR OPTICS AND LASERS
General goal is to study the nature and effects of nonlinear phenomena in different systems, with emphasis in photonics, biophysics and complex systems. An important motivation of its work is to elucidate the potential use of nonlinear effects in applications.

EOLI - INDUSTRIAL ENGINEERING AND LOGISTICS
The group carries out research in production/operations management, management science, industrial engineering, supply chain management. The group develops systems for production management, interactive systems that use mathematical models, and software.

**GESSI - SOFTWARE ENGINEERING FOR INFORMATION SYSTEMS RESEARCH GROUP**
Research and studies on the principles, methodologies, techniques, languages and tools that conform the software engineering discipline and their application to the development and maintenance of information systems.

**GNOM - GROUP OF NUMERICAL OPTIMIZATION AND MODELLING**
The group works on both the numerical optimisation and the modelling of problems that can be solved through optimisation. Its work on numerical optimisation includes the analysis of new optimisation algorithms (linear, nonlinear, continuous and integer) and their convergence, the development of numerical procedures for their efficient computational implementation, and the comparison to existing algorithms.

**GOAPI - APPLIED OPTICS AND IMAGE PROCESSING GROUP**
The group's aim is to carry out research related to the applications of visible optics, including near infrared and ultraviolet spectral bands. It deals with images, vision, colour and laser processing. It embraces a variety of applications in the fields of machine vision, automatic inspection, image analysis and processing, pattern recognition, optical and visual qualities, instrumentation and measuring techniques, photometry, colour measurement, digital colour, laser processing of materials, laser marking, waveguides, etc.

**GPI - IMAGE AND VIDEO PROCESSING GROUP**
The research of the Image and Video Processing Group focuses on the areas of compression, analysis, indexing, representation and multimodal interfaces. The group specialises in basic tools for nonlinear filtering, mathematical morphology, segmentation, object tracking, face detection and recognition, emotion analysis and modelling of human activity.

**GRCM - MOBILE COMMUNICATION RESEARCH GROUP**
GRCM group has recognized expertise in 2G/3G/4G wireless network architectures and protocols, interworking, radio network planning and deployment, radio interface design and radio resource management strategies for QoS guarantee in heterogeneous radio access networks.

**GREC - KNOWLEDGE ENGINEERING RESEARCH GROUP**
The group's main fields of study are the theory and application of learning systems and qualitative reasoning. The group is involved in researching and developing ubiquitous soft computing technologies in areas of application that lead to the improvement of the quality of life of people and communities.

**GREO - OPTICAL ENGINEERING RESEARCH GROUP**
The aim is to carry out R&D activities and provide innovative solutions in the field of optical engineering. The main research areas are the design of optical systems and sensors, the development of instrumentation, optical metrology, laser applications, colour technology, radiometry and photometry, and biomedical instrumentation.
GREVTAM - RESEARCH GROUP ON VIBRATIONS AND THEORY AND ANALYSIS OF MACHINES
The aim of the group is to carry out research and development in Machine Theory, Machine Design, Mechanical Vibrations and Transportation; and to apply analytical, simulation and experimental methods in the mentioned fields.

GRESA - RESEARCH GROUP IN APPLIED STATISTICS
To carry out research, innovation and technology transfer in statistical methods that are useful in industry, service organizations and other scientific fields.

GREP - POWER ELECTRONICS RESEARCH GROUP
The research group is focused on the design of power electronic converters, taking into account both two-level and multilevel structures, including the synthesis of new topologies, the development of new analytical and modelling tools, and the application of new modulation and control techniques.

GRINS - INTELLIGENT ROBOTS AND SYSTEMS
The group’s main field of research is the study, analysis and development of systems that involve advanced robotic systems that have perception capabilities and distributed control, which can thus achieve more intelligent and flexible behaviours. The group focuses mainly on the development of multiagent systems (robots and persons) that have cooperation capabilities. It also works on the study, analysis and design of distributed control systems, where communication, real-time computing and advanced control algorithms are relevant issues.

INLAB FIB
inLab FIB is a research and innovation laboratory of the Barcelona School of Informatics at UPC, specialized in applications and services based on the latest ICT technologies. inLab FIB UPC has over 35 years of experience collaborating in cutting-edge projects, creating customized solutions for public and private institutions and organizations, and providing learning labs specialized in informatics engineering.

IOC - INSTITUTE OF INDUSTRIAL AND CONTROL ENGINEERING
The fields of activity of the IOC, which continues the work done by the Instituto de Cibernética for more than twenty-five years, are automatics, artificial intelligence, computer science and industrial engineering, with a special emphasis on the analysis, the design, the management and the control of logistic and goods and services production systems and on the methods and the techniques
appropriate to solve these problems and on the fields of science and technique related to them as well.

**KEMLG - KNOWLEDGE ENGINEERING AND MACHINE LEARNING GROUP**
The main goals of the group are the analysis, design, implementation and application of various artificial intelligence and hybrid techniques to support the operation and behavioural analysis of complex real-world systems and domains. Management, operation state diagnosis, prediction, supervision and control tasks are key problems for most organisations.

**LABSON - LABORATORY OF OLEOHIDRAULICS AND PNEUMATIC SYSTEMS**
LABSON has made a wide range of services that cover the demands of national and international companies. LABSON conducts theoretical and numerical simulation studies aimed at applied research and has the advantage of strong experimental support in the field of fluid engineering, including PIV (Particle Image Velocimetry) methodology.

**LACAN - SPECIFIC RESEARCH CENTER OF NUMERICAL METHODS IN APPLIED SCIENCES AND ENGINEERING**
The research carried out at the LaCàN laboratory lies in the fields of mathematical and numerical modelling and computational mechanics. More precisely, the aims of the research are to develop and analyse numerical tools related to the following areas: 1) assessing and controlling the quality of numerical solutions; 2) improving the efficiency of numerical methods; 3) developing alternative approaches to specific problems; and 4) virtual prototyping/critical modelling.

**LARCA - LABORATORY OF RELATIONAL ALGORITHMS, COMPLEXITY AND LEARNABILITY**
LARCA is an international research group working on data mining, machine learning, data analysis, and mathematical linguistics. We typically approach problems from sound mathematical principles, using modelling tools and techniques from algorithmics, computational complexity, automata theory, logic, discrete mathematics, statistics, and dynamic systems.

**LEAM - LABORATORI D'ENGINYERIA ACÚSTICA I MECÀNICA**
The aim of the research group is to study the effect of noise on the environment and on human activity. The group analyses and models systems for the absorption and reduction of sound propagation and characterises the effects of noise on hearing. The group also works on solutions that counter the noise and vibrations produced by mechanical systems.

**LIAM - LABORATORY OF INFORMATION ANALYSIS AND MODELLING**
The objectives of the researchers working at the laboratory are to carry out research and innovation in the fields of modelling, simulation, multivariate analysis of data and information management, data mining and information analysis.

**LOGPROG - LOGIC AND PROGRAMMING**
The group carries out research in basic computer science. In particular, it has internationally-recognised expertise in the (closely related) fields of logic in computer science, computational complexity and constraint-solving problems, and in the use of advanced programming techniques (e.g. constraint programming, automated deduction, etc.) for the development of practical software tools.
MCIA - CENTER INNOVATION ELECTRONICS
The group's research is focused on modulation, simulation, control techniques, physical implementation and applications of electronic power systems for industrial and motion control. The digital control of converters by means of microprocessors, DSP and FPGAs is studied. Adaptive and intelligent control techniques are applied to the control loops that appear in industrial and motion control. The study of electronics systems for management and energy saving and the mining of a plant's data, for diagnosis and maintenance, are also relevant subjects.

MC2 - GROUP OF COMPUTATIONAL MECHANICS ON CONTINUOUS MEDIUM
The objective of this group is to institutionally consolidate the academic relationship of researchers who have been working together for more than 17 years. The members of this group are currently participating in 14 national projects and 20 European projects. They have also collaborated in the teaching of 60 courses (of between 30 and 40 hours each), 220 seminars and 51 international conferences. The establishment of this group will enable its researchers to propose and carry out joint projects under its name and with a critical mass that will allow them to take on greater challenges within their basic and applied research.

MOVING - RESEARCH GROUP ON MODELLING, INTERACTION AND VISUALIZATION IN VIRTUAL REALITY
The group focuses on research in modelling, visualization and advanced graphics interaction and its application to virtual reality and advanced interaction.

MPI - INFORMATION MODELLING AND PROCESSING
The group works in the following fields: the conceptual modelling and design of information systems; database schema and information systems validation; and database update processing.

MTA - ENVIRONMENTAL MODELLING AND TECHNOLOGY
The group is active in the following fields: the mathematical modelling of pollutant transport in air and water; computational systems for environmental decision-making; the assessment of environmental impacts and risks; waste minimization; the study and development of clean technologies; the study and development of treatment techniques; environmental management tools (environmental impact studies, environmental assessment, etc.); and environment-energy interaction.

OPE - PRODUCTION AND BUSINESS MANAGEMENT (TECHNICAL, LEGAL AND ECONOMICAL ASPECTS OF PRODUCTION)
Study, analyze and solve problems of design, planning and programming in the chain of production and logistics operations in the sector of automotive, considering the influences of the Human Factor and the uncertainty of the Environment on the design of the production system and effective feasibility of plans and production programs.

SAC - ADVANCED CONTROL SYSTEMS
The group aim is to carry out applied research in the following areas: Modelling, identification and simulation of continuous and discontinuous industrial processes, advanced control of dynamic systems, optimization and constraint satisfaction, supervision and fault diagnosis of industrial processes and systems, fault-tolerant control; and related subjects.
TECNOFAB - TECNOLOGIES DE FABRICACIÓ
The main objective of the Manufacturing Technologies Research Group is to undertake applied research in the diverse manufacturing technologies, concerning the processes itself, the methodologies, the computer assisted systems and the integration of different technologies.

VIS - ARTIFICIAL VISION AND INTELLIGENT SYSTEMS
The Artificial Vision and Intelligent Systems Group (VIS) carries out basic and applied research with the aim of understanding and designing intelligent systems that are capable of interacting with the real world in an autonomous and wide-reaching manner. Such intelligent systems must perceive reason, plan, act and learn from previous experiences. The group works on the following topics: robust colour image segmentation and labelling, pattern recognition, viewpoint invariant object learning and recognition, object tracking, face tracking, biometrics, processing and analysis of medical images for diagnosis, document analysis, mobile robot navigation, simultaneous localisation and map building, visual servoing, and human-computer interaction.
Besides UPC has some **associate research bodies** -legal entities promoted by the UPC- generally located on campus premises. The ones related to industry 4.0 are the following:

- ICFO, Institute of Photonic Sciences
- BSC, Barcelona Supercomputing Center
- CTTC, Telecommunications Technology Center of Catalonia
- IREC, Energy Research Institute of Catalonia
- I2CAT, internet research center
- CIMNE, International Centre for Numerical Methods in Engineering
- CIM, Computer Integrated Manufacturing Center
- UPC School of Professional and Executive Development

### INNOVATION AND BUSINESS

Regarding business and innovation, UPC has a strong record on supporting the creation of spin off and start up, with more than 250 companies created in the last 15 years. Besides, the turnover with companies for industrial projects is larger than € 25m as an average for the last 10 years, and €25m more coming from competitive research funds.

Among the 2,494 companies that have signed collaboration agreements during 2015 we can outline the following ones that have manufacturing premises in Catalonia.

- Alstom
- COMEXI
- GIRBAU
- Iberpotash
- SEAT
- Canales y Puertos de Catalunya
- dSPACE GmbH
- Danone
- Epson
- LEAR CORPORATION
- OHL
- Schneider Electric España
- Solvay Ibérica
- Soler i Palau (S&P)
- Nissan
- Henkel
- ASCAMM
- HP
- IDIADA
- TMB