10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

10.1. STRATEGIC PRIORITIES

The ACS Group is an organisation which is continually evolving, adapting to the needs of its clients and demands from society. The diversification process through which the ACS Group is passing during these years has led it to undertake a wide range of activities which approach innovation and development differently, but resolutely. Through this commitment to technological development, the ACS Group responds to the growing demand for improvements in processes, technological progress and quality of service from its clients and from society.

Its involvement in research, development and innovation are clear in its increased investment and the R&D+i[18] efforts the ACS Group makes year after year. This effort leads to tangible improvements in productivity, quality, client satisfaction, occupational safety, the obtaining of new and better materials and products and the design of more efficient production processes and systems, among others.

The ACS Group's largest companies have governing bodies for technology, which are usually the Technological Development Committee, which leads the development of research activities in each company. The existence of this governing body or committee was reported by companies representing 89.9% of ACS Group sales in 2015.

R&D management takes place through a system which, in the largest companies and in general, follows the guidelines in the UNE 166002:2006 standard and is audited by independent specialists. There is a formal management system in companies representing 92.3% of Group sales. Furthermore, independent audits are carried out in companies representing 88.6% of sales.

This management system serves the general research strategy of each of the companies which, whatever their specific features, share the following lines of action:

- Development of strategic lines of research individualised by company.
- Strategic collaboration with external organisations.
- Growing and responsible investment in order to promote research and generate patents and operational techniques constantly and efficiently.

Each Group company's strategic decisions on the execution of R&D projects seek to maximise the positive impact of ACS's technical and technological progress. The companies have analysis and discrimination procedures to decide which projects to undertake.

At 31 December 2015, the ACS Group had 203 projects in progress[19] and had registered 8 patents during the year. During the last 10 years, the Group companies have registered a total of 60 patents.

Furthermore, collaboration with external organisations is crucial for the success of the projects tackled. Hence, ACS Group companies collaborate with

18 The data referring to the ACS Group included in this section were calculated by analysing the information supplied by the Group's different companies, weighted by level of turnover. The data are expressed in terms of percentage of total Group sales in 2015.

19 In total projects for 2015, the scope is 41.78% of the Group's sales.

The involvement in research, development and innovation is materialised in an investment of 50.6 million euros in 2015.

research and technological centres and with universities, as well as will other diverse centres, institutes or institutions related to R&D+i. These prestigious international research institutions complement the ACS Group's own research capabilities. The ACS Group has invested more than 50.6 million euros in research, development and innovation in 2015.

10.1.1. CONSTRUCTION

The majority of ACS Group Construction[20] companies have a system for managing research, development and innovation. Such a system is reported by companies representing 93.3% of ACS Group sales in this area. Generally, these management systems are implemented around the UNE 166002:2006 standard.

Although decentralised, management is coordinated by Dragados' departments and, also, independently in HOCHTIEF's companies. To meet the objectives set by their respective lead companies, the ACS Group's construction companies had 97 projects in progress[21] at the end of 2015, managed by the different R&D+i managements. ACS's Construction companies invested €21.5 million in R&D+i in 2015.

20 The data referring to the ACS Group's Construction companies included in this section were calculated by analysing the information supplied by the different companies in this area of activity, weighted by their level of turnover. The data is expressed in terms of percentage of total Construction area sales.

21 In total projects for 2015, the scope is 24% of the Construction area's sales.

10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

DRAGADOS/ VÍAS: AVANRES PROJECT

The AVANRES R&D project, approved in the INNPACTO 2012 call to tender, was co-funded by the Ministry of the Economy and Competitiveness as part of the 2008-2012 National Scientific Research, Development and Technological Innovation Plan, and was implemented between 2012 and 2015 by a consortium of companies and public bodies coordinated by DRAGADOS, one of which was VIAS.

This project is aimed at developing a set of collaborational computational models mainly based on Computational Intelligence and on acquired knowledge which can be used to estimate the volume of construction and demolition waste generated at a construction site, depending on its characteristics. The model has much lower and more specific margins of error and levels of tolerance than the methods currently used. These types of models can be used not only to estimate the volume of waste, but also to economically appraise the different waste treatment methods, in order to apply a preliminary technical decisive criterion when faced with different options. There are different options because of the different possibilities and standards existing at national level and in each Autonomous Community in Spain.

PROJECT GENERAL FRAMEWORK

The idea for this project came about because according to present construction and demolition waste management laws, it is necessary to estimate the type and volume of this kind of waste which will be generated on the site to be able to properly plan the waste management.

A number of general studies have been made, but what is needed are studies which analyse all the variables which have an impact on the type and the scale of the waste generated on each unit and type of site.

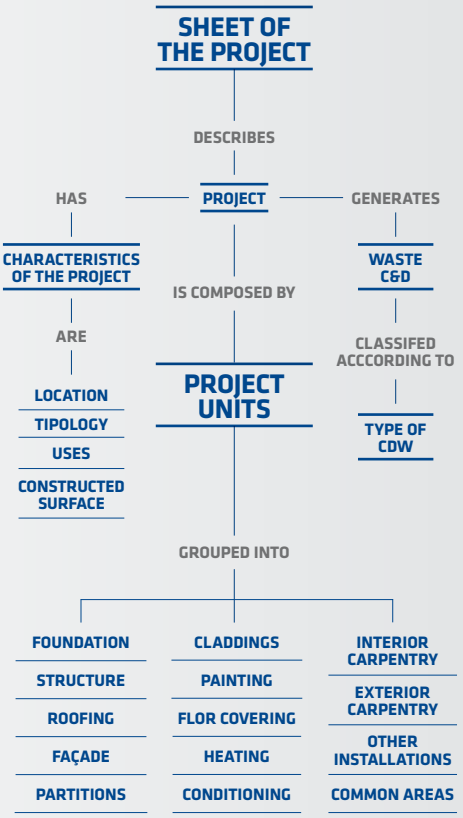
The goal of this project is to find a mathematical project which can be used to correctly estimate the amount of construction and demolition waste produced on site, depending on the waste types and characteristics. This is done through an IT platform which allows employees to update and improve results by entering new data both in the project development and in the future.

This project tackles the following tasks:

- How to obtain and analyse expert knowledge and in-depth information of ERP and similar systems and about the waste types caused by each site type and unit.
- Characterisation of waste and calculation of cost and resources needed for each segregation type, using allocation of optimisation management techniques (from reuse, to recycling, and also elimination, if applicable).
- Analysis and evaluation of relevance/importance/impact of knowledge and available variables to estimate waste.
- Characterisation of site units in accordance with waste generated, and the impact of such waste from a multi-criterion/multi-target standpoint.
- Development of computational models based on variables with greater estimation capacity so as to be able to make a global reliable estimate of all the waste to be generated.
- Development of a decision-making support solution so as to be able to apply these computational models in a systematic and expedite way, using site data and measurements. The system has to be able to adapt based on new real waste generation data entered once the works on the site have begun to be executed, gradually adjusting the reliability of the existing model using comparison and analysis.
- Multi-target modelling of different management possibilities and segregation systems at source, using evidence from results, and using real data to correctly validate the model.
- Development of a concept test so as to evaluate the solution agreed upon.

From the standpoint of innovation in this project, the system can be used to create a set of computation models which manage waste management in an ideal way, achieving improvements in the **design of management alternatives** focused on reducing waste and on optimum segregation. Furthermore, because the waste to be generated on a site can be calculated more accurately, both **waste management and administration expenses** arising from deviations between estimates and final results will be reduced.

In short, this project provides the Group with a tool which it can use to enter general data and measurements of a site so as to estimate the monthly production of waste generated on it.



The image below shows the tool, with its different applications.

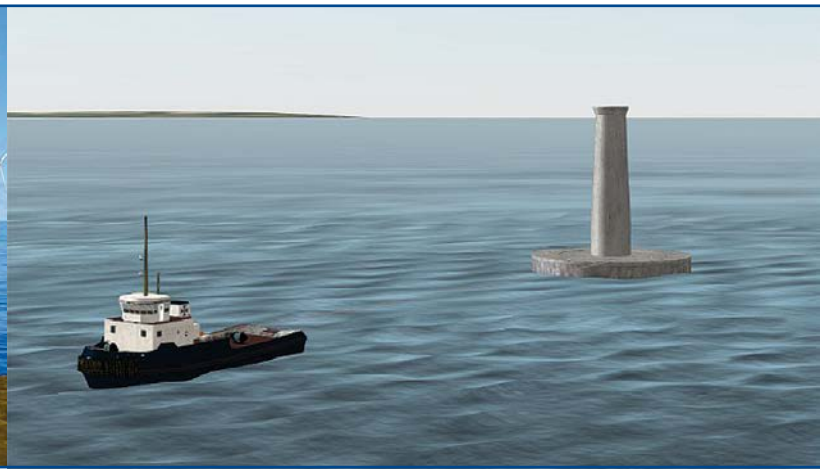
10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

DRAGADOS/DRACE: CAPEMA PROJECT

The CAPEMA R&D project: Cajones Autofondeables para Marine Wind Farms, was co-funded by the Centre for Industrial Technological Development (Centro para el Desarrollo Tecnológico Industrial, CDTI) and was executed between 2012 and 2015 by a consortium of companies and public bodies coordinated by DRAGADOS, one of which was DRACE Infraestructuras. The purpose of this project was to develop a foundations system based on anchoring of gravity-based structures with towers, holding masts with offshore wind turbines attached located in deep waters. The project will be carried out at depths of approximately 35-50m, using concrete base technology manufactured in advance base docks.

The project development has been focused on the following goals:

- Acquiring the knowledge necessary for the **optimum design of a reinforced concrete base** which can be used for anchoring at different depths as a gravity anchoring for offshore wind turbines.
- Design of a **towing system** suitable for the features of the designed base.
- Design of the **anchoring process** for the bases in the open sea.
- In-depth analysis of the **filling process** of submerged compartments.
- Study of **impacts on the foundations and design of protection elements**.
- Conceptual incorporation of **disassembly of structure** in overall design with a view to reducing the long term environmental impact of these types of structures.
- Development of a **marine wind energy generation cost analysis** model, to analyse the impact of the cost of foundations in the final cost of Kw/H.
- **Analysis of the carbon footprint** of the foundation process, analysing how to reduce the carbon footprint due to the foundation manufacture and installation process.



By meeting these targets it has been possible to reach a series of innovations which are a major step forward in the State of the Art of the current available techniques for the deep foundations of wind farms. The results with regard to some of the targets set in the project are referred to below:

- **Design of towing system:** Numerical simulation in the CEDEX simulator has been used to design and analyse the towing system. The simulation has been performed using a set of towing tests made with a small-scale physical model of the foundation in the Testing Channel of the Escuela Técnica Superior de Ingenieros Navales de la Universidad Politécnica de Madrid (ETSIN).

- **Anchoring process:** Physical model tests have been used to design the anchoring process in the CEPYC of the CEDEX, using different configurations of the anchoring process.

- **Compartment filling process:** The compartment filling process has been designed and defined once the base is anchored in its definitive spot. The process includes the definition of the necessary maritime resources, the way the material is introduced in the foundation, the material's arrangement, the equipment installed in the structure, the control of efforts and the filling level.

- **Disassembly process:** The disassembly process follows the reverse process to the installation. First, the material used to fill the cells is removed, then the structure is refloated, and is then towed to port, before it is finally dismantled.

- **Carbon footprint analysis:** Fewer emissions are generated in these types of foundations compared with other techniques because as they are built directly on the dock, transported by floating and anchored without drills or special cranes, the method is more sustainable in terms of greenhouse gas emissions.

An application has been filed for the International Patent (PCT) and it has been published in February 2016.

10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

VÍAS Y CONSTRUCCIONES/ GEOCISA: 3DCONS PROJECT NEW CONSTRUCTION PROCESSES USING 3D PRINTING

The 3DCONS project, approved as part of the ESTRATÉGICO CIEN programme by the Centre for Industrial Technological Development (Centro de Desarrollo Tecnológico Industrial, CDTI), addresses the development of new technologies to allow 3D printing in construction using a real scale.

A consortium has been set up for this purpose, led by Vías y Construcciones and made up of Geocisa, Lafarge, Saint-Gobain Placo Ibérica, Proingesa, Cype and Atanga. Other partners are the Foundation CIM-UPC, the Instituto de Ciencias de la Construcción Eduardo Torroja (CSIC), the University of Burgos, the Centro Tecnológico CARTIF and Universidad Politécnica de Madrid.

The goals of the project are to develop new 3D printing systems to recycle packaging using direct printing and manufacturing of prefabricated "tailor made" items (without needing moulds or shapes). These printing techniques will work with a range of materials for interior and exterior designs based on cement, lime, plaster and mixtures, especially developed to be applied by extrusion.

In order to take full advantage of the benefits of these new materials and application methods, specific design tools will be developed based on Building Information Modelling. These tools can be used to overcome current restrictions in "multilayer" and "tailor made" construction materials, offering new construction methods applying excellent forms, dimensions and performance in each items and area of the building.

This innovative project is supported by various administrations and entities, which will comprise the Advisory Board and which will take part in dissemination, validation and (pilot) testing activities. Some of these entities are as follows:

- Technical General Secretary of the Ministry of Development
- Spanish Climate Change Office (Ministry of Agriculture, Food and the Environment)
- Institute for Energy Diversification and Saving (Ministry of Industry, Energy and Tourism)
- Department of Infrastructure, Transport and Housing of the Community of Madrid
- Spanish Construction Technology Platform
- Spanish Robotics Technology Platform
- Technological Construction Institute of Catalunya (ITEC)
- Official College of Architects of Madrid.

The **3DCONS** project was the only construction sector project approved within the 2014 Cien Strategic Programme call of the CDTI. The project was launched on 1 November 2014 and the estimated completion date is 30 April 2018.

HOCHTIEF: GEOVIEW

During the project construction and operation phases, a wide range of instruments is used to measure underground water, pore pressure, tension, deformation, field, loads and efforts, etc. The data obtained with these measures will be used during the project lifecycle to adjust the design, to check assumptions and to guarantee safety. In view of the increasingly more complex equipment and the fact that advice needs to be sought from external specialists, it is often difficult and costly to manage these data.

EIC has sought to overcome these hurdles by developing its own data management and instrumentation system known as "GeoView". This tool has been designed to improve our technical processes. It can be customised, is versatile, scalable, and can naturally bring down the duration and cost of projects.

The initial version of GeoView was used to control the stability and arrangement of embankments on soft terrains of the highway between Frederickton and Eungai, a 26.5 km four-lane road in the northern part of New South Wales (Australia). Since then, it has also been used in the Sydney Metro Northwest project, a 15 km double railway tunnel in which the Group invested 3.0 billion dollars, and the Moreton Bay Rail Link project, a 14 km double railway line in Brisbane, which is valued at 1.0 billion dollars.

HOCHTIEF: ICE STORAGE TECHNOLOGY

Under the right conditions, an ice deposit (a concrete tank full of water) can be used to provide buildings of virtually any size with a reliable, economical and environmentally friendly heating system using heating pumps, and also provide cooling during the summer months. Following a successful test project in Hamburg, HOCHTIEF launched the development and use of this state-of-the-art ice deposit with heat pump technology. We have created a skill set, and also set up an innovation project to supervise the installations of a number of different projects over several years. This will allow us to assess this technology from an economic standpoint, take a systematic approach to the knowledge acquired and let the entire Group learn about these new developments. HOCHTIEF's leadership in this advanced technology will give it a considerable competitive edge in the market.

10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

10.1.2. INDUSTRIAL SERVICES

The ACS Group's Industrial Services[22] area carries out significant work in promoting research, development and innovation through the various R&D+i departments in several of the companies in this line of business. Companies representing 70.7% of Industrial Services' sales reported the existence of a specific R&D+i department in their structure.

Total investment of €19.7 million was allocated to executing the projects managed by the different departments. These projects are carried out by virtue of a formal research and development management system, which is implemented in companies representing 84.8% of Industrial Services' sales.

The R&D+i strategy of many of the companies in this area is based on an external approach, aimed at its stakeholders, and an internal approach, aimed at process modernisation and improvement.

22 The data referring to the ACS Group's Industrial Services companies included in this section were calculated by analysing the information supplied by the different companies in this area of activity, weighted by level of turnover. The data are expressed in terms of percentage of total Industrial Services area sales.

COBRA: SOLAR FIELD OPTIMIZATION SOFTWARE PROJECT

The SFOpt_SW Solar Field Optimization Software project, developed by the Cobra Technology and Innovation area, concerns the development of an innovative computer modelling and forecasting tool for a molten salt thermal solar power plant, such as those developed by Cobra in Tonopah, Nevada (Crescent Dunes) or Fuentes de Andalucía, Seville (Gemasolar).

This tool, which is being developed jointly with the National Renewable Energies Centre (Centro Nacional de Energías Renovables, CENER), is based on simulating the behaviour of the solar field of these kinds of plants, taking into account the conditions of each of the heliostats – the mirrors which reflect solar light in the collector panels – and the instant solar position, the weather conditions and the positioning strategy applied to each one of the heliostats.

This tool resolves two complex problems which are critical in order to be able to understand and predict how these types of plants will behave. First, they simulate the trajectory of millions of solar rays reflecting off the thousands of mirrors in the heliostats (the Crescent Dunes plant, for example, has over 10,000 m^2 heliostats each of which with a size of 115 m^2). Second, the SFOpt_SW tool can integrate all the energy which reaches the central receptor, heating the molten salts circulating through the middle of these panels. The advantage of this simulation tool is that it resolves the physical heat transfer equations, calculating the energy which is reaching each of the collector's panels across its height. By this means, it is possibly to calculate very precisely the heat which the collector might lose under any circumstances, and a huge number of different conditions can be considered.

The design and operation of solar fields plants can be greatly enhanced by these kinds of tools. In fact, these kinds of plants, as well as hydroelectric and direct storage of electricity, are no doubt the future for firm, manageable and clean renewable energy.

The tool can also be used to try out new conceptual designs for solar fields, new receptors with innovative geometries or materials or pointing strategies of different heliostats following certain thermal energy requests.

This is a very useful tool for design new plant layouts, because it can be used in a simple way to analyse the many options which can be planned, not only in terms of the collector's performance and yield, but also the possible layouts of the heliostats in the solar field, i.e. improving the overall efficiency of the mirrors in terms of energy input and so saving a large part of the plant's costs (in which the solar field accounts for over 40% of the total budget).

The SFOpt_SW software can be used to improve daily operations in these types of plants. A priori, heliostat pointing strategies can be analysed, in order to standardise and establish procedures to be followed for difficult situations affecting ideal conditions in these plants, such as temporary passing of clouds, plant start-ups and shutdowns, loss of solar irradiation in part of the field or the need to defocus the heliostats. In all these situations, it is necessary to move thousands of heliostats with large mirror sizes, so it is important to know the effect each reflection has on the receptor.

The SFOpt_SW software will also be used to develop the multi-tower concept, where a solar field will distribute the sun's rays reflected between a number of receptors situated in towers, and also to enhance the efficiency of each mirror, as they are affected by different factors, such as, for example, the sun's angle, a factor which can be considerably improved in this type of plant.

Real data from the Crescent Dunes plant is being used to validate and to fine tune this software, using the highest level of detail. For example, the data is even being used to calculate the temperature of the central receptor tubing through which salts pass. The SFOpt_SW software, and the operating applications used such as the thermographic chambers, play a crucial role in enhancing the working of central collector thermo solar plants.

The strategy of integrating these systems in electrical power plants is essential for the technology to be correctly developed, and will enable plants developed in future years to be improved.

Calculation of solar power impacting on receptor panels.


Solar fields in these types of plants are made up of thousands of heliostats.

10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

COBRA: RENACE II HYDROELECTRIC TUNNEL PROJECT

The RENACE II Hydroelectric Project forms part of the hydroelectric use chain developed in the River Cahabón, in the Alta Verapaz Region of Guatemala.

As part of this Project, COBRA INFRAESTRUCTURAS HIDRÁULICAS has built a pressurised tunnel to channel water from the inlet site up to the piping feeding into the turbines.

Cobra has adopted a solution of a steel pipe which is 3,570 mm wide, inside the existing tunnel and which is on top of a concrete bed - with a different geometry - throughout its length. In order to cope with thrusts due to changes of direction on the ground, concrete lateral buttresses are provided, arranged in line with changes in the direction of the piping.

One of the major hurdles in this project has been having to operating in confined spaces. There was a space of only 15 cm between the metal tube and the tunnel in the top and bottom parts, and only 50 cm on the sides. These spaces also have to be used to carry the electricity and lighting fittings and vents.

Exclusive and innovative construction processes have been developed for these kinds of tasks in confined spaces, particularly for transport, transfer of piping sections and works between the metallic piping and the existing tunnel.

1. Piping transport: The existing tunnel is 3,900 metres long and has only three access points which can be used to introduce all the piping sections, materials and equipment needed to construct the tunnel. Trolleys have been designed to transport the 9.72 metre long piping sections inside the tunnel. These trolleys have been specially designed for this project and auto-adjust depending on the changes in level and the slope of the existing tunnel. The trolleys themselves must be extracted once each piping section has been put in its place.

2. Transfer of piping inside the tunnel: piping sections have been transported in platforms using tractor units, and once inside the tunnel they are put on the trolleys and are turned around 90°. The company used a solution attached to the rock on the upper part of the tunnel, using a hydraulic jack to perform the operation.

3. Operations between the piping plate and the existing tunnel: the welding works were an important part of this section. Because the upper part of the piping cannot be accessed to weld the parts of the pipe, the ceramic backing solution was used to homogenise the external cord, however there were no existing market solutions to place it on the upper part with so little space. A solution was designed attaching the backing sections to a metallic packing strap which, once aligned, was tightened with a strapping machine. Once the welding was performed, then it was removed without difficulty.

These techniques, and other innovative procedures, have been used to develop a technique which can be applied to existing hydraulic tunnels, as an alternative to the classic crack injection and seal solution, which cannot ensure that the original structure of the tunnel will be recomposed.

ETRA: NOBELGRID PROJECT

Nobel Grid
Smart energy for people

The Nobelgrid project consists of developing advanced applications and services to different agents on the energy market (distributors, cooperatives, commercialisers and end users) with the object of improving Smart Grid management and investigating new business models based on flexibility for prosumers consumers in active demand management.

NOBELGRID offers advanced services, using OP communication networks and validating the integration of renewable energies and active demand management systems, to all energy market agents to ensure that consumers benefit from lower prices, more secure and stable distribution networks and lower carbon dioxide emissions.

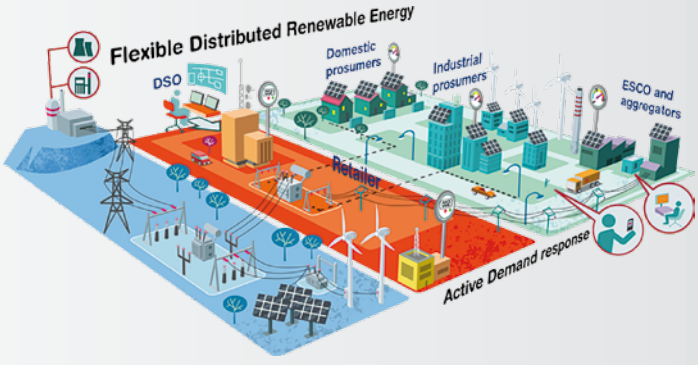
The project's results will be demonstrated and be validated in real environments with energy system agents playing an active role at all levels. These demonstrations will include assessing the use of new business models developed as part of the project.

ETRA I+D coordinates this project funded by the European Union within the framework of the 2020 programme. In view of the scale and the considerable number of companies and entities involved at different levels, from hardware and software development, up to evaluation or installation and maintenance, different tools and services covering a broad range of areas of smart grid management and operations are going to be developed and evaluated.

The following main tools are going to be developed:

- A new Smart meter with ETRA R&D technology.
- Development of a platform to run third party applications securely within electrical meters
- Development of a new energy product / gateway for the active management of different household appliances and items in the consumer's environment (heating, lighting, electrical vehicles, etc.)
- Development of a new electric product / inverter to use batteries more efficiently in the domestic environment.
- Development of a new electric product / inverter to manage auto-generated renewable energy in the domestic environment.
- Development of an electrical distribution network management platform at all levels: installation, maintenance, control, monitoring, recovery, etc. This application is designed for electrical distributors (DSOs), usually electrical cooperatives
- Development of an active demand management platform, aimed at obtaining the peak available flexibility for a group of consumers and to offer this flexibility for commercialisation. Consumers who sign up for these demand management campaigns will receive incentives for playing an active role in the electricity market. This tool is designed for consumer cooperatives, commercialisers or electrical services companies.

Development of an electrical usage monitoring platform and interaction with smart grid for end users. End consumers will be able to use this tool to have up-to-date information about their electricity usage and to connect it with their domestic appliances and also with other agents in the electrical system.



10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

SICE: VRUITS PROJECT.

Improving the safety and mobility of vulnerable road users through Smart Transport Systems applications

The VRUITS (www.vruits.eu) European project is part of a drive towards improving road safety for what are known as Vulnerable Road Users (pedestrians, cyclists and motorcyclists), analysing how to reduce risk situations based on the deployment of Cooperative Services in Intelligent Transport Systems (ITS) and the integration of these users.

The goal of the project is to set out recommendations on how to reduce the seriousness and number of accidents caused to these vulnerable users, based on experiments with innovative ITS systems validated in different test scenarios.

In order to integrate vulnerable users (pedestrians, cyclists and motorcyclists) in what are known as cooperative traffic services, SICE has developed an intelligent crossing, equipped with cameras which can detect pedestrians who cross the road; with LED lights enhancing the lighting at the crossing, Bluetooth signals and 3G communications to allow interaction with pedestrians (through their Smartphones) and WiFi mobile communications which can provide data to vehicles (through their OBUs). This crossing has been installed in Alcalá de Henares thanks to the support of the local city council.

In the next stage of the process, the evaluation tests will be developed with real users to identify positive impacts and to mitigate the negative effects of the implemented system, so as to apply the necessary recommendations to deploy these systems.

OBJECTIVES

The goal of the VRUITS project, co-funded by the European Commission via its Seventh Framework Programme, is to make vulnerable users (hereinafter, VRU) an active element in the vehicle-infrastructure-pedestrian approach, given that to date the Cooperative ITS services developments have been focused on equipping vehicles or infrastructures, with VRUs merely acting as passive participants.

The VRUITS project thus takes one step further in developing new ITS systems to seek this interaction with VRUs (such as cyclists, pedestrians, the elderly, the disabled, motorcyclists).

In the initial stage of the project, work sessions were arranged with experts to define the new ITS applications, and discussion groups were organised in which action requirements for systems were addressed in order to be able to cover their needs, in order to be able to improve safety and mobility.

Once these needs were analysed, the deployments of ITS prototypes were proposed, using real experiments

Figure 1. Architecture of the Smart Crossing (SAFECROSS 2.0)

Figure 2. Smart Crossing Details, view of Camera and Alert of pedestrian presence in vehicle.

to make practical recommendations based on evidence. The project analysed critical aspects in which VRUs can be integrated in smart transport systems and how designs of the Human Machine Interface (HMI) can be adapted to be able to meet these VRUs' requirements.

DESCRIPTION OF DEVELOPED INTELLIGENT CROSSING

This SAFECROSS 2.0 intelligent crossing is a huge step forward in terms of design of traffic light Regulators, because it allows:

- Activation of demand for green pedestrians, using the mobile phone Bluetooth channel, as another method instead of pressing the traditional button. The Bluetooth Low Energy (BLE) technology used in cutting-edge mobile telephones has been adopted.
- Deploy real time cooperative information services which can communicate with vehicles (using Mobile WiFi) and/or pedestrians (using 3G channel), in accordance with the CEN ISO TS 19091 European standard, which is still being defined. For that purpose, specific Apps have been developed.
- Providing mechanisms to increase road safety in pedestrian crossings to extend green pedestrian crossing periods by detecting the presence of pedestrians crossing using artificial vision cameras. This allows the green crossing period to be adapted to each pedestrian's needs.
- LED lights have also been installed to light up the pedestrian crossing at night by enabling the "green pedestrian" demand.

The pedestrian's mobile app can be used to activate the acoustic notification mode or vibration mode so that people with specific needs can be warned of the green phase activation.

CONCLUSIONS

Now that the implementation phase has been completed, we may conclude that it has been a success to have developed a modular prototype which can be potentially deployed with different functions, and which can be optimised depending on the actual layout of each crossing, in order to adjust the cost of the final solution.

Thus, a traffic light can be equipped only with bluetooth signals which can be used to extend, a priori, pedestrian crossing time for elderly people with reduced mobility, with visual or auditory deficiency, prioritising their privacy and guaranteeing their safety, mobility and comfort, given that they don't feel they have to walk more quickly to reach the other side of the street.

As far as executing the project is concerned, this last year will be focused on establishing practical recommendations to carry out actions at European level, conducting evaluation tests with real users (as mentioned above). The heads of the research groups taking part in the project will analyse the factors which influence road safety and user behaviour, pinpointing positive and negative impacts by conducting ex ante and ex post assessments which will be used as a basis for these recommendations. The evaluation techniques will take into account human factors and cognitive aspects.

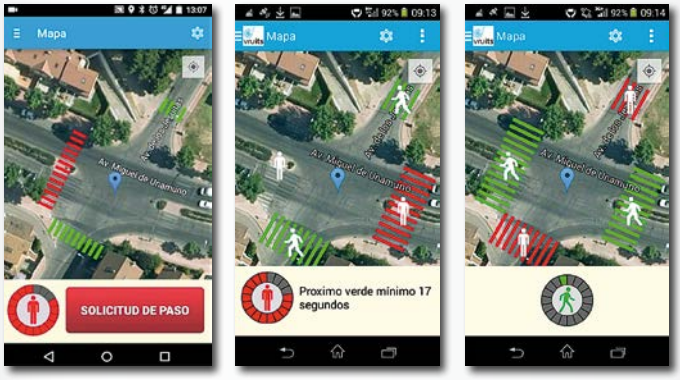


Figure 3. App details for Pedestrian.

10. TECHNOLOGICAL DEVELOPMENT. R&D+I IN THE ACS GROUP

10.1.3. ENVIRONMENT

In the ACS Group's Environment[23] business, innovation constitutes a basic principle both in management and in processes for recovery, reuse and recycling of wastes. To carry out this task, Urbaser has its own specific R&D+i department with a formal management system certified under the UNE 166002:2006 standard and audited by an independent third party.

At 31 December 2015, €9.4 million had been invested in 97 ongoing research and development projects.

23 The data referring to Environment included in this section were calculated by analysing the information provided by Urbaser and Clece.

URBASER: LINE FOR THE COMMERCIAL CLASSIFICATION OF GLASS CONTAINERS

Although a selective glass collection system has been deployed within the Cantabria urban waste collection system, and the fact that large amounts of glass have been collected, of 10,236 Tn in 2014, an average of 66 glass containers per inhabitant and year compared with an average of 56% per inhabitant and year for Spain a whole, it is estimated that 40% of total glass is still sent within the flow of mixed urban waste. Tircantabria, a company which is fully owned by the URBASER Group, has conducted a number of studies over the last 3 years which have confirmed that a very high proportion of the urban waste received at the plant was glass, which, until the new line was started up, was put through a manual separation process with unsatisfactory recovery outcomes, due to undergoing manual processes carried out on glass fragments with sufficient size to be extracted in this way.

The fragmented glass ended up in the flow of organic material in the pre-treatment process, and, consequently, was subjected to the aerobic and fine fermenting processes, and ultimately went into the rejected pile of the refining process, and thus the flow which was sent to the landfill.

Due to the technological progress made in the field of automatic separation, it is now possible to adapt industrial processes machinery similar to glass separation in this flow. Tircantabria, having collaborated with technological companies in the sector for many years, and with the help and support from Ecovidrio, has developed a complementary line in the refining separation area. This line can be used to separate a percentage of above 70% of the glass which was until now sent to the landfiill - as it was materially impossible to separate - of sufficient quality to be able to add this line to the conventional glass separation process. This line was deployed in February 2015. It was the first to be achieve the demanding quality standards established by Ecovidrio for recycling of selected glass. By April 2015, 700 tons of glass from waste disposal points had been recovered from the system. It is a pioneering project, underpinned by R&D&i, which will help to increase the rate of glass recycled in Spain.

This also improves the quality of the compost, i.e. the final product, by removing small-sized pieces, as well as reducing the waste rejected and sent to the landfill, given that these inappropriate pieces (glass, etc..) are recycled, thereby extending the lifecycle of the non-hazardous waste landfill of Cantabria.

10.2. MAIN INDICATORS

MAIN MANAGEMENT INDICATORS - R&D+I

	2013	2014	2015	Objective for 2016
Investment in R&D+i (€ million)	49.4	54.7	50.6	> 2015
Level of implementation of a specific R&D+i department	90.3%	92.2%	89.9%	> 2015
Level of implementation of a formal system for R&D+i management	71.5%	94.2%	92.3%	> 2015