



INVESTING IN SMARTER RESEARCH

Enabling small and medium-sized businesses to invest in research and innovation, a network of Spanish research centers provides support and infrastructure to help these institutions develop new technologies for a changing world.

In a cavernous hall in Valladolid, Spain, test vehicles can plow into a wall at speeds up to 125 miles per hour. This high-speed facility for materials testing and vehicle safety, housed in the Research and Development Center for Transportation and Energy (in Spanish, Cidaut), provides both automotive and materials companies—as well as Cidaut’s own researchers—the tools needed to test novel materials and evaluate the safety of different forms of transportation.

Cidaut is one of a private association of Spanish technology centers, whose organizing body is known as Fedit. Fedit comprises 67 such centers around the country; some of them have been in existence since the 1960s.

For decades, Spain functioned largely as a manufacturing facility for the rest of Europe, importing new products and technologies from outside the country. “We realized that we needed to improve our products if we wanted to compete,” says Diego Lafuente, director of the network of Fedit centers. But not so long ago, most Spanish companies were small—often family-owned—businesses, and lacked the capital to invest in appropriate tools for in-house R&D. Then, in order to compete, companies in complementary fields began to pool their resources and form privately-funded research facilities. These centers also work in partnership with local universities and governments.

The new parts for automobiles, made out of lighter, highly resistant composite materials, can cause rapid wear and tear, even to the breaking point, on the tools used to make them.

“These technology centers were created to be close to the market,” says Ricard Jiménez, scientific director of Ascamm, a materials research center in Barcelona. “We work for industry and conduct research and development, and the goal is to sell a final product.”

There are many different models for these partnership centers. Cidaut, for instance, which works primarily in transportation and energy, may develop new technologies for companies that produce automobile parts. Or technology center researchers may work simultaneously with companies that compete directly against one another. At times research projects are formed as partnerships among companies and centers, while in other cases the center may sign exclusivity and confidentiality agreements with a single company.

At least 51 percent of the shares of each technology center are owned by private companies, while the rest may be held by universities and local and national associations. At least 40 percent of center funding comes from contracts with private companies, and the remainder is sourced from competitive local, national, or EU grants. “It’s an unusual model,” says Lafuente of outsourcing R&D to private research centers, but it works. The centers have a track record for enabling the creation of patents, new products, and spinoff companies, and Fedit has shown that they also demonstrate the payoff of R&D investment to small companies, which may not have realized their potential in the past. One Fedit study shows that an increase in private R&D investment over the past five years can be attributed to the work of the technology centers.

The centers can also help guide company research. “If centers work with a variety of companies in a particular field, they gain a great deal of expertise,” observes Lafuente; that expertise in turn enables these technology centers to anticipate the needs of the marketplace. Juan Carlos Merino, director of Cidaut, agrees: “Our [research] ideas are generated by the fact that we work in the real world, every day, with companies.”

TRANSPORTATION

Cidaut’s high-speed crash test facility, which can move up to 700 kilos at more than 100 times the acceleration of gravity, is just one of the services it provides to its customers. At the same time, the center’s original work in molds and manufacturing for automation has expanded into materials, manufacturing processes, and products for transportation, energy and the environment. Its lab allows characterization of materials and composites on the nano-scale. Its services have resulted in a variety of successful enterprises, including a spinoff company (Aleaciones Ligeras Aplicadas), which designed components for the new Alfa Romeo.

At the applied mechanics department of the CEIT research center, visitors can step into a reconstructed truck cab. Through the front window, a simulator projects the driver’s route on a screen ahead. Grasping the gear stick, the driver feels resistance as the transmission shifts into first, then second gear. Then the wheels resist as the driver turns the steering wheel and navigates down the road.

This combination of imagery, motion, and haptics technology was originally created by CEIT engineers for driver training. CEIT has already created a spinoff company, Lander Simulation, to market simulators for automotive and railway training to companies around the world. Together, CEIT and Lander are now researching an intelligent simulator that can learn from expert drivers. This will increase the simulator’s expertise at teaching other drivers how to cope with extreme driving conditions.

As their expertise in haptics and virtual and augmented reality has increased, CEIT engineers have expanded their virtual reality programs to assist in additional business sectors. For civil engineering, they’re designing a simulator to allow machine operators to “experience” drilling into rocks before they begin work on a new tunnel.

Emilio Sanchez, head of the robotics department, points out that the team has also moved into health care: it is working with surgeons to develop a program that emulates the feel of drilling into a skull. “If the doctor doesn’t have total control of the drilling process, he or she could damage the brain—or, in maxillofacial surgery, an important nerve. So instead of doing this training protocol on a corpse, let’s use a haptic device,” says Sanchez. The team is closely coordinating its efforts with local hospitals and neurosurgeons.

MATERIALS OF THE FUTURE

Carbon nanotubes hold out the promise of endowing the next generation of polymers with characteristics such as dramatically increased strength and resistance, even as their weight decreases. To develop these novel composite materials for fields such as transportation, health, and agriculture, a consortium of research centers, including Tekniker, Gaiker, and CEIT, are working together. For the agricultural sector, for instance, they’re developing films

To aid in making more precise measurements for meteorology, transportation, and aviation, the research center Tekniker, in partnership with the Spanish Center of Metrology, has developed the world's most precise barometer. Over the ten years of research it took to develop this tool, and building on its decades of creating tools for scientific research, Tekniker decided to approach this challenge from a novel engineering perspective. Instead of, say, measuring through ultrasound as the North American version does, the Tekniker barometer relies on a technique called laser interferometry. The barometer consists of two connected columns of mercury topped by a float that supports a laser reflector. The exact position of the mercury is measured by combining light from different receptors to create a high-resolution image.



that can allow the passage of only specified wavelengths of light. These films could help to control temperatures in a greenhouse, and stimulate plant growth at the same time.

One of the most significant contributions of these composite materials could be to the automotive and aeronautical industries, as engineers create materials that are significantly lighter, yet able to absorb impacts. The carbon nanotubes in the polymers give them the ability to spring back into shape after they are struck and deformed.

But developments in materials science are not limited to carbon nanotubes. CTM's experience in manufacturing and machine-tool development has allowed that center to lead in the creation of new surfaces for the machine tools that must handle these new, highly resistant components. The new parts for automobiles, made out of lighter, highly resistant composite materials, can cause rapid wear and tear, even to the breaking point, on the tools used to make them. In response, CTM and partner companies developed new steels, with molecular structures that allow them to form these parts without being ground down themselves.

The AIN center has traditionally assisted automotive companies in developing components with enhanced properties to resist higher temperatures or bear higher loads. Today they're applying that materials expertise to development of a surface coating for stents to increase blood flow. Since the growth of cells on stent surfaces can interrupt the flow of blood, AIN engineers developed an immersion treatment to coat the complex surface of the stent by bombarding it with ions. This bombardment creates an oxide layer that prevents cells from attaching to the stent wall. AIN engineers are also developing coatings to prevent surface wear on metal prostheses.

The nanotechnology research team at Ascamm, a center outside Barcelona, has partnered with the local Nanotechnology and

Nanoscience Investigation Center to develop a polymer that can adhere to any surface and give it superhydrophobic properties, so that water (or any other liquid) will roll right off. "We as scientists know how to work in the lab, but Ascamm knows how to scale up and work with industry, providing a bridge" between scientists and companies, according to Daniel Ruiz, a researcher at NNIC.

Ruiz and his colleagues have created a proprietary material of fluorinated chains, which adheres to a surface with only a single dip into the coating. This would be easy to integrate into manufacturing and is both more environmentally friendly and easier to apply than the products now on the market, says Ruiz, and could be useful for many industries, including textile and automotive enterprises.

Researchers at Cetemmsa, outside Barcelona, are taking materials science to the textile sector. They've developed conducting threads that heat up or become illuminated in response to a charge; these might be used in sports applications. They're also involved in an EU project to develop a textile for photovoltaic energy, with the goal of someday creating a shade, perhaps even an umbrella, that can also serve as a photovoltaic panel.

Cetemmsa has also applied this electronic textile concept to the health sector, creating a skin patch that releases the active material only when and where the user wants it, as opposed to the slow, continuous release available in today's patches. A slight charge triggered by a battery will cause a barely discernable temperature change in the fabric, and warm up the nanocapsules (developed by project partners) that contain the active ingredients. Stopping the charge would halt the release. Cetemmsa is now working with dermatologists to design a patch like this for use with skin treatment products.

HEALTH AND WELLNESS

Materials science is just one area in which the network of technology centers is assisting the health and wellness sector. Gaiker, located in the north of Spain, employs genomics, proteomics, and metabolomics to investigate the ways in which cells respond to chemicals, drugs and natural compounds. Gaiker is working on a number of EU projects to identify and develop in vitro tests that can replace animal tests for cosmetic and pharmaceutical safety.

“These tools allow you to see the reaction of the individual cells, and of course an animal is a pool of cells,” says Oscar Salas, Gaiker’s international projects coordinator. “This can represent the future behavior of any kind of substance in human beings.” These international projects are intended to aid cosmetic companies in replacing animal tests, since the EU has announced these must cease by 2013.

Gaiker scientists have also patented a biomarker for colorectal cancer and are partnering with research institutions across Europe to develop new nanoparticles for diagnostics and therapies for different kinds of cancers. This field of research has also led them into work on a lab-on-a-chip, which could be set on devices like intelligent phones to evaluate biomarkers, then send information to doctors.

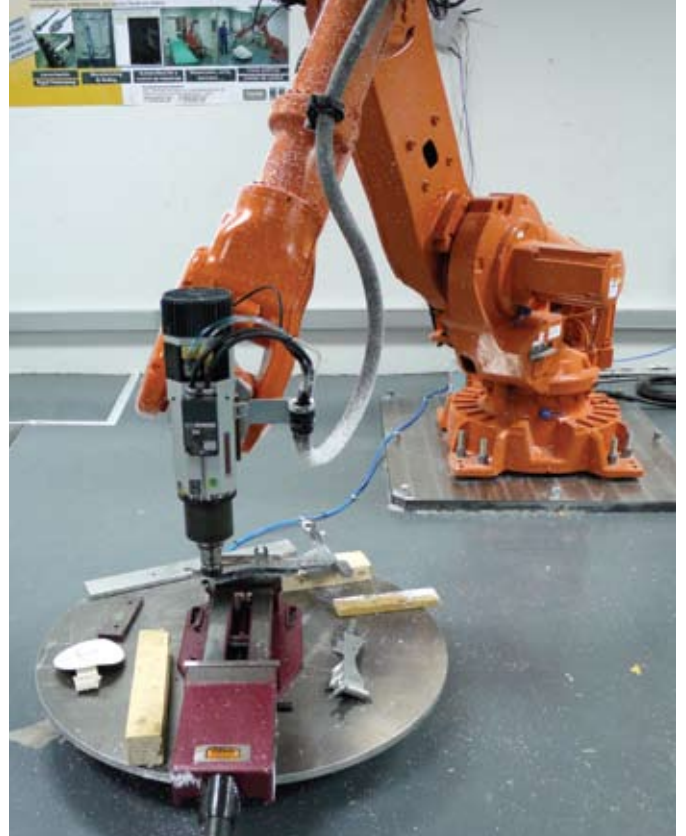
Creating sensors like these may be aided by manufacturing developments at Tekniker, which is developing nanofluidic devices that measure various parameters of blood. Tekniker has created a device with channels less than 100 nanometers wide that will allow DNA samples to be stretched over the length of the channel; measuring the length of the DNA sample will allow for its characterization. The process by which they’ve formulated the nanochannels, known as nano-imprinting, can, Tekniker researchers say, be easily reproduced for high-throughput manufacturing, and could be used for disease diagnostics and for determining appropriate treatments.

SURGICAL CLOSURES

After many grueling hours of brain surgery, it’s finally time for a surgeon to close up the skull. This is no simple matter. The metal products today on the market require surgeons either to position a clamp carefully and exert pressure on it without damaging the brain, or manipulate tiny screws into a metal plate. Both methods present challenges: a clamp’s rough edges can injure the brain, while tiny screws may test the patience of a surgeon finally reaching the end of a long process. And the metal in either product may interfere with future tumor diagnostics and treatments.

In response, a team of neurosurgeons, materials scientists, and manufacturing engineers have teamed up to create new close-up products, and formed a new spinoff company—Neos Surgery—from two research centers, Ascamm and Inasmet.

Neos Surgery’s first product is a device to clamp two pieces of a skull back together, using a shape-changing nickel-titanium



Ascamm’s robot (above) can take a 3-D image and create a model of it. While such a model can be used to sculpt virtually any object, obviating the need for single-use molds, Ascamm, in partnership with the Orthopedic Technical Institute in Barcelona, has also developed a robot-assisted process for building a prosthesis. First the patient’s leg is scanned, then that image is transformed into a 3-D model using CAD. The CAD model is passed to the robot, which then builds a completely custom-designed prosthesis.

Many research centers are working on robots and the parts they need, such as sensors for artificial vision. Tekniker has created a robot complete with x-rays and artificial vision to evaluate defects in seat belts. And AIN is taking part in a project to develop the mechanics and flight controls for unmanned helicopters to monitor power lines; this requires building a system that can overcome and cancel out interference from electrical fields.

alloy that responds to heat—in this case, body heat. The device is kept cold in a refrigerator. When the surgeon is ready to close, she can position the clamp at the section of the skull to be attached. Immediately the coil begins to tighten, the clamp to close.

The success of this first product led to the development of a second, the Cranial Loop, made entirely of polymers. Two pieces of skull are fastened together by inserting the tiny device and applying the necessary pressure until the fit is snug; no plates, screws, or other instruments necessary.

“Instead of pushing on the skull, you just cut off the edges [of the Loop],” says Lluís Chico, Neos’ general manager, and the

entire process takes only seconds to complete. The polymer fits smoothly against the skull and creates a surface with no sharp edges. This is the only such product on the market made totally of polymers, therefore causing no interference with future CT scans or MRIs.

The Cranial Loop was met with enthusiasm at the World Congress of Neurological Surgeons in Boston in September, 2009, says Chico: “Surgeons said, ‘Finally, there’s a new fix to help make cranial-neurosurgery easier.’”

Ascamm worked closely with the product developers to create the appropriate manufacturing conditions necessary for a polymer device of such a small size, with miniscule edges for closure. “We were limited by manufacturing,” says Chico. “[Ascamm] engineers studied the mold, the process for injection, and the plastic itself. With their help, we were able to convince manufacturers that it was possible.”

That microinjection process will find a major market, notes Ascamm Director of Corporate Development Myriam Garcia-Berro: “There’s a tendency towards miniaturization that those in the medical field are demanding, and in electronics as well ... and there isn’t a great deal of knowledge or technology yet on microinjection.”

According to Chico, these two products have applications for additional cranial and spinal surgeries. Shape-changing material could be used, for instance, in minimally invasive spinal surgery, where the product could be implanted while tightly coiled, then expand, warmed by the patient’s body heat, to a degree specified to decompress an area of the spine.

Neos Surgery is already selling its products in nine countries in Europe, and it plans to expand internationally.

FUTURE OF FOOD

In a stark white building, with light flooding the windows and through glass walls into the offices and labs, Ainia scientists are investigating several aspects of food production and monitoring and applying lessons learned from food research to other sectors. Says Miguel Blasco, Director of Research and Development, “The design of the building represents our center’s philosophy: clarity, transparency, and integration.”

Ainia’s scientists have been working with food companies in the Valencia region and around Spain for decades, undertaking projects like helping vintners ensure more consistently high-quality wine production, and improving packaging to prevent spoilage of lettuce greens. The center today operates on an international scale, offering its services and research expertise on topics related to food quality and safety.

Ainia has developed a test for microorganisms that can yield results in only 10 hours instead of three weeks. It is working on methods of identifying contamination using biosensors, and is also cooperating in the development of cameras with multispectral

vision to classify agricultural products and identify defects or contamination in them. The nearby research center Aido, meanwhile, is providing the optical technology expertise for machine vision.

The packaging and logistics center Itene has employed its nanoparticles division to investigate improved food packaging, leading an EU project to develop materials that will include a microbial agent to extend shelf life. Itene researchers are also developing an intelligent packaging system, which in the future may include radio frequency tags for a shipment’s location and conductive inks to communicate the temperature of a container, helping to prevent a shipment of produce from getting too warm and spoiling. “So far, this new system is expensive, but I think it will get to the market in a few years,” says Carmen Sanchez, Itene’s associate director, “because it’s expensive for companies now to solve these problems when they occur.”

Active packages like these are also a prime research focus of the National Center for Food Technology and Safety (CNTA). Originally born of an association of companies devoted to vegetables, the center has since expanded to work with companies across all aspects of food production.

The food industry hopes to use more food-derived antioxidants, such as resveratrol from grapes, both for their health benefits and to prevent spoilage. So CNTA researchers have been working to develop ways to stabilize these compounds by micro- and nano-encapsulation. The resulting process could either protect the compounds during the transportation phase, until they are integrated into the food, or encapsulate them until their coating is destroyed in the stomach. These processes are currently being patented, and CNTA is spinning off a company to market the results.

ENVIRONMENTAL IMPROVEMENTS

As focus on renewable energy and reducing greenhouse gases continues to grow worldwide, Cidaut has turned its attention to a technology that already has reached a wide international market: the solar-powered water heater. The basic technology consists of collecting the sun’s rays to heat water, then using that hot water for the building’s needs. Cidaut’s Merino says there are many improvements in efficiency to be made, which could provide significant savings by heating more water in a smaller space at a lower cost. After five years of research, Cidaut has patented a new system with an improved heat-absorbing material, embedded with nanoparticles that allow for advanced absorption. Cidaut has also tweaked the fluid dynamics, the heat transfer system, and the panel’s heat-retaining ability. The company that commissioned this research—which, because the panels are not yet on the market, does not wish to be named—already has the capacity to produce more than 100,000 panels a year.

This improvement of existing technology also propelled Cidaut’s biomass project. Such waste-to-energy systems are

Supercritical CO₂ extraction tanks.

SUPERCritical CARBON DIOXIDE

A faint herbal aroma wafts among the gargantuan metal tanks and clanking machinery. The scent comes from an Indian seed, neem, whose extracts are used as a biocide. And Altex, S.A., a company near Valencia, Spain, is using supercritical carbon dioxide to extract the oil from the seed.

Extracting compounds from agricultural products is common practice; decaffeinated coffee and cocoa butter from cocoa powder are two of the most familiar examples. But many solvents used to catalyze these separations contain harsh chemicals and may taint part of the original product, preventing its future use in food applications.

One promising solution to this problem is the use of supercritical carbon dioxide, which has been subjected to high pressure and temperatures such that its density becomes that of a liquid, while it retains the mobility of a gas. That flow, tweaked by temperature, pressure, and the addition of small amounts of other materials such as water, can be directed to latch onto specific types of molecules, pull them away from the rest of the material, and then deposit them elsewhere following a decrease in pressure. The use of supercritical carbon dioxide can, for instance, separate out cocoa butter and leave behind a pure cocoa powder residue. The carbon dioxide is then recovered and reused.

Engineers at the research center Ainia developed a system for optimizing supercritical carbon dioxide for food and developed methods for specific food products. The center has also spun this technology off and created the company (Altex, S.A.), which operates one of the largest facilities for supercritical carbon dioxide extraction in the world. Altex works with customers around the world, including France, the UK, and Australia, to develop systems to extract plant-based compounds, including cocoa powder, valerian root extract, and neem. One project involved developing a proprietary technique for a company interested in eliminating a chemical component in cork, to prevent cork from contaminating wine.

“Our flexibility means that we can offer these services to food and beverage companies, and also for cosmetics and pharmaceuticals,” says Antonio Tornero, Altex general manager. “There is nothing we can do to damage the original materials.”

not widely used today, says Merino, because the feedstocks—such as wood chips or agricultural waste—“have to be brought long distances to a [large] biomass facility, and so waste a lot of energy in the transportation.” The biomass concept involves gassifying or burning the biomass and using the heat to generate steam for electricity. But there hasn’t yet been an efficient, inexpensive small-scale model of a biomass facility available on the market.

So Cidaut engineers took advantage of their expertise in engines, and developed an efficient small-scale system that can make use of waste where it’s generated and provide on-site power. Cidaut developed a combustion process that produces carbon monoxide, then coupled that with combustion motors adapted to the gas. “The resulting system is small and easy to transport—any type of trailer can be used—and it can be placed anywhere there’s organic waste. It works at the efficiency and cost comparable to much larger systems,” says Merino. They’re in the process of finalizing this product for a wider market.

Another method of converting waste to energy relies on biogas, the production of methane from fermenting organic materials. Ainia, with extensive research capabilities in the food sector, set to improving the fuel side of the equation.

Agricultural centers have expressed interest and are starting to utilize methane, primarily from the decomposition of animal waste, to fuel electricity generation. But, as Ainia’s research director Miguel Blasco points out, research on the appropriate recipes can lead to significantly higher production of methane from the same feedstocks. Scientists are evaluating the mix of feedstocks and simultaneously determining methods to control odor and produce an added-value compost.

In the laboratory, various blends of agricultural products are capped by bags to trap and evaluate the gasses emitted. “We’re optimizing the product by taking cow manure, and adding other materials with higher levels of sugars, fats, and polysaccharides, that together generate more methane,” says Blasco. They’ve tested the addition of not only other agricultural materials, but also urban food residue, and worked on pretreatments that could increase methane production. The system, Blasco explains, creates no waste, since the residue can be used as compost. Ainia has developed a bioreactor and generator pilot plant that is currently being tested in a nearby farm, in the town of Requena.

To prolong the life of wind power turbines, and to increase the environmental sustainability of the parts involved, Tekniker is developing new biolubricants while it creates monitoring systems to evaluate the quality and degradation of lubricants in the systems. “This will become increasingly important as systems move off-shore, or in new wave and current systems,” explains Javier Laucirica, Tekniker’s scientific director. “There are significant amounts of oils in these systems, and strong seas increase the risk of oil spillage. So developing bio-oils that can withstand salt and other ambient conditions is a key point for these systems.”

“You need to know what is going to happen when the product enters the waste stream, and what we can do with it.”

Tekniker is also leveraging its decades of experience in precision manufacturing to work with solar power customers to increase the geometric accuracy of the mirrors that concentrate the sun’s rays to a focal point. The efficiency of the system also depends on how well the tube at the focal point absorbs and contains the sun’s heat, says Laucirica, so Tekniker is also working on projects to increase the capabilities of the tubes.

The Gaiker center builds on its plastics manufacturing expertise to develop new machinery and robotics for plastics separation and recycling. Gaiker has continued along the recycling and waste stream analysis research path, identifying and analyzing the components of ordinary household waste, electronics, and vehicle waste for potential separation and reuse; Gaiker researchers have created tools to help facilitate the waste separation process. As technology has hurtled along with the integration of new gadgets and materials, Gaiker has stayed one step ahead of the market in identifying the trends and the materials involved.

Now the center is working on recycling OLEDs (organic light-emitting diodes), which are thus far used in the screens of only a handful of products. “In Europe, as you develop new products, there is also horizontal research on recycling,” says Salas. “You need to know what is going to happen when the product enters the waste stream, and what we can do with it.”

ENTERTAINMENT

Toni Mateos, director of Barcelona Media’s audio research line, sits down at a computer. With a few clicks, he pulls up a scene on a huge screen at the front of the room. An image of a lizard fills the screen. Sounds of minute movements, including the faint crackling of a twig, emanate from the two dozen speakers in the test facility. Suddenly, it begins to rain on screen. In the room, the sound emanates not from the screen, not from around the room, but from directly overhead, above the listen-



3-D virtual representation of section of Barcelona

ers' heads. This is no movie theater surround-sound: this sound transports viewers to the center of a tropical downpour.

This 3-D audio programming is a product of research at Barcelona Media, located in the heart of the city. 3-D sound has not yet reached anywhere near the penetration of 3-D visual imagery, in part because of challenges in both recording and broadcasting it, and in part because standardization of speakers and algorithms to translate signals to the speakers is lacking. So far, there are multiple systems for recording and broadcasting three-dimensional sound, and they need to match exactly.

To overcome this challenge, engineers at Barcelona Media are approaching the problem by recording not just the acoustic pressure of the sound waves, but other parameters, including the speed of the waves. They're simultaneously developing computer programs that can translate these signals into 3-D recordings for a variety of speaker systems, without knowing the configuration of the end broadcast.

The sound research team has also modified these 3-D sound systems to allow for a realistic sound experience within a virtual environment. For instance, a viewer may move among flamenco musicians on a screen; as the viewer moves past a guitar player, the trills of the guitar suddenly emanate from behind.

The center has also developed a 3-D virtual representation of the city of Barcelona for urban planners. Its users can navigate through the city and evaluate planned projects and their impact on the city, right down to noise and shadow impacts. They can also leave behind the public face of the city and descend beneath the buildings to travel among the cable fibers and gas conduits.

"This is a sector that's based on creativity," says Marta Ysern, director of special projects. "And in order to survive, you have to be successful—and that means that we must be constantly innovating."

Resources

ICEX (Spanish Institute for Foreign Trade)
www.spainbusiness.com

Fedit
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For a complete company listing and to find out more about New Technologies in Spain, visit:
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