CSTJF
Delivering Tomorrow’s Energy
The Jean Féger Scientific and Technical Center (CSTJF), located in Pau, France, is a great asset and a source of particular pride for Total’s Exploration-Production (EP) business. Its state-of-the-art laboratories and the power of its high-performance supercomputer make it a world-class center of technical expertise, and research and development in the oil and gas world.

With 2,900 employees from 65 nations, the CSTJF is a genuine “melting pot” bringing together all the businesses in the value chain of exploration and production. The close proximity campus facilitates exchanges between geoscientists and specialists in drilling and reservoir development, as well as with experts in advanced production techniques. The successful integration of these different areas is critical in maintaining our ability to innovate and meet the new challenges faced by the oil and gas sector.

As a true center of excellence supporting our subsidiaries around the world, the CSTJF is serving them daily helping to improve performance in terms of safety, operational proficiency, cost reduction, and project start-ups meeting deadlines and budgets.

This large site is the heart of a world-class scientific and technical network that ensures a cost-effective and resilient E&P in a volatile environment. It is at the CSTJF that we demonstrate our capabilities as an operator and a responsible partner, providing clean, safe and low-cost energy.
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2,900 employees
65 nationalities

Some 27 hectares dedicated to engineering and research

High-performance computing able to perform 25 million billion operations per second

48,000 business visitors a year

70 official delegations from around the world a year

60 gigabits per second: the powerful telecommunications network is like a global superhighway

An impressive platform of high-tech laboratories spread over 5,000 sq.m
Internationally recognized experts, world class facilities

The Centre Scientifique et Technique Jean Féger pushes the boundaries of technology, enabling Total to develop new production techniques, helping to ensure responsible and sustainable production.

Located in Pau in southwestern France, and named after the geologist who discovered France’s giant Lacq gas field just a few miles away, the Centre Scientifique et Technique Jean Féger (CSTJF), covers some 27 hectares, 5,000 m² of laboratories, 30,000 m² of offices, and houses 2,900 employees of 65 nationalities. Home to internationally recognized engineers and researchers, passionate in their pursuit of excellence, they are connected via 53 video-conferencing rooms and a telecommunications network tuned into 1,250 affiliates and operational sites around the world. The site attracts some 4,000 visitors every month. The extended facility includes off campus specialist R&D sites; the Lacq Research Center, or PERL, the Lacq Pilot Platform (PPL), plus the TEP-ASD Physical Measurements Center.

As the main R&D hub for Total E&P, the CSTJF is dedicated to overcoming technical barriers and helping to access frontier resources. To this end, Total specializes in spearheading technological innovation, a pre-requisite to opening up new oil and gas provinces, and promoting new solutions for responsible and sustainable production. The CSTJF is currently engaged in over 300 R&D academic and industrial partnerships worldwide. Research topics span a host of oil and gas industry challenges, such as petroleum exploration, appraisal of discoveries, designing complex borehole trajectories and deploying innovative solutions to boost recovery factors and manage industrial impacts.

The center is the home to Pangea, a high performance computer with a computing power of 25 petaflops – 25 million billion operations per second – of one of the most powerful commercial supercomputers in the industrial world. This is a game changer in enhanced reservoir imaging and simulation and makes Total a global leader in this area of processing capacity.

The CSTJF boasts a full suite of state of the art oil & gas industry laboratories with class leading equipment and facilities. All fully ISO 9001 and 14001 certified for quality and HSE management.

With its global reach, the CSTJF is the ideal training center for employees of many different nationalities. Staff from partner national oil companies and representatives of Total’s host countries for E&P projects also come to the center for highly specialized courses. A wide range of options and internship programs is available to meet the diverse needs of participants from all backgrounds.
Total is fully committed to the highest safety and environmental practices.

At the CSTJF, engineers specializing in Health, Safety and Environment (HSE) provide support across the E&P value chain to minimize the negative impacts of our operations on people, the environment and local communities. Teams are committed to planning, acting and continually improving performance towards attaining Total’s ambitious targets.

Smart rooms centered here at the CSTJF enhance safety by providing 24 hour support to operations around the globe, from the southern tip of South America to the northern North Sea. Our technicians remotely monitor critical equipment parameters in real time and can predict and prevent machine failures. Operational data is centralized for cross referencing between facilities, all serving to help maintain the safety of people and assets.

In Murchison Falls National Park, Uganda’s largest protected area, minimizing the impact of operations on the park’s diverse wildlife was a prerequisite. A clear and well defined strategy, to protect against environmental impact, was required. Our innovative technicians were able to develop a novel approach; Total E&P Uganda used a series of wireless seismic receivers to reduce the huge vegetation clearance normally associated with cable use. This also prevented injury or death to animals getting tangled in wires. This strategy is now a model for any future activity in sensitive areas.

At Murchison Falls National Park in Uganda, the use of innovative wireless technology has avoided vegetation clearance and the laying of cables that could easily harm grassland animals and the delicate ecosystem.
Pangea: computing power for researchers, geoscientists & engineers

Pangea is one of the most powerful supercomputers in the world.

The Exploration & Production teams at Total collect huge amounts of data every day. This data has to be processed effectively and efficiently, making High-Performance Computing (HPC) the strategic choice. Total has been using supercomputers for several decades, and continues to invest in this technology to process and analyze data, in particular for seismic imaging and reservoir simulation.

When upgraded to 25 petaflops in 2019, Pangea became the most powerful industrial supercomputer in the world with a processing power equivalent to about 130,000 high powered laptops. Energy efficiency is always key, and alongside a more than 300% increase in computing power, the 2019 update also delivered a 66% reduction in energy consumption, a saving of over 3 megawatts, making it one of the most efficient as well, all helping to reduce the CSTJF site environmental footprint.

Pangea also benefits reservoir simulation. When an oil and gas field is discovered, engineers build a reservoir model from which flow simulations can be run. Because they integrate seismic, geological, fluid, well and surface data, reservoir simulations can be used to forecast the production rate of a field throughout its life. The high power of Pangea coupled with cutting edge in-house developed algorithms enable simulation, at an unprecedented level, of complex fluid flows by using a very accurate and detailed representation of the reservoir. Several simulations can be generated based on different geological scenarios, for a much better understanding when facing geoscientific uncertainties.

Pangea has allowed Total to make exceptional gains in terms of performance, simulations that once took a week can now be done in a few hours. These simulation runs help identify the best development scenario and help save millions of dollars to maximize profitability.

Pangea and our Next Generation Reservoir Simulator INTERSECT™, boost study accuracy without data deterioration, and save time by accelerating calculations, allowing us to undertake comprehensive multi-scenario studies and integrated subsurface & surface modeling.

Supercomputing and cutting edge algorithm development

In seismic imaging, algorithms running on Pangea deliver real added value, from acquisition feasibility to the imaging of data acquired from increasingly complex environments around the world. Pangea enables: faster turnaround, better imagery of hydrocarbon traps, enhanced positioning accuracy and delivers greater precision along the entire processing and seismic imaging chain giving better control over production lead times.
Geoscience & reservoir engineering
an integrated platform

At the CSTJF, our geoscience chain spans many disciplines from geoinformation or geomatic engineering to geology, reservoir engineering and geophysics.

The CSTJF has a team tasked with locating and identifying recoverable hydrocarbon reservoirs anywhere in the world. Its members have a unique in-house technological platform offering exceptional data interpretation. At their disposal, Pangea, one of the world’s most powerful supercomputers, dedicates over 90% of its output to supporting this endeavour, all specialist activities are combined and geological expertise is prevalent at every stage of the exploration and production chain, from acquisition of acreage to production of reserves. Our GIS (Geo-Information Science) team engineers are involved throughout, from capture, qualification and mapping to processing, classification and storage. They build integrated reservoir models from seismic, geological and well data.

Reservoir geologists focus on understanding and predicting the behavior of oil and gas basins over time and within their reservoir space. Their job is to characterize the elements that make up a petroleum system — the source rock, the reservoirs in which the oil is trapped, and the cap rock that seals in the oil deep below.

The next link in the chain of geosciences expertise is geophysics, a discipline that has emerged as one of the CSTJF’s areas of excellence. Applying seismic technology, reflecting acoustic waves from deep below the ground, our geophysicists reveal the invisible, “the reservoir” for the first time. The geophysical data obtained are then used to build a three-dimensional (3D) model of the contours and internal architecture of the oil traps. The center’s team builds increasingly complex seismic images using innovative in-house processing algorithms that require the extensive computing power provided by Pangea.

Our reservoir engineers then estimate the productivity of discoveries by modeling fluid movement during production. They help reservoir architects optimize the development plan for individual fields.

Aimed at supporting affiliates, this fully integrated “sismage-CIG chain” is centered at the CSTJF. Armed with a unique set of constantly evolving tools the team can optimize well locations, select best field development scenarios, altogether maximizing E&P asset profitability.
The Sismage-CIG team are able to generate high resolution seismic images. Using these detailed images, experts in GIS can then locate and evaluate petroleum prospects.

Using “time lapse”, or “repetitive” seismic, “4D” anomalies can be interpreted as geobodies and displayed against reservoir flow simulation results. The objective is to monitor production effects observed on 4D seismic anomalies, and verify that pressures and saturations simulated in the reservoir model have similar shapes. This is a key aspect of history matching. GIS teams are then able to track hydrocarbon movement within the reservoir and pinpoint where best to place injection or recovery wells.
Located offsite near to the CSTJF, the Total E&P-ASD (Alternative Subsurface Data) physical measurements center provides the first link in the calibration chain for borehole data logging. It offers a calibration and certification service to industry and academia, not only the oil and gas sector but wherever the need exists in similar areas, such as in geothermal, mining and hydrogeological activities.

The heart of the site is an experimental analytical platform housing silos, that contain rock, fluid and metal standards that serve to calibrate logging probes used in the evaluation of oil & gas reservoirs. These accurately characterized rocks and predetermined standards are located in columns 9 m high. The facility covers a very wide range of borehole conditions and rock types, porosity, cement and casing architectures. Logging probes of any type can be calibrated and certified against a variety of known conditions. This facility is the first of its kind among the oil majors and unique in that it is commercially open and available to all interested users.

The center offers a lower cost but technically accurate data logging alternative by using tools that are simpler and more versatile that could potentially generate savings of tens of millions of dollars, helping to keep project costs down.
Well design & drilling

Drilling is a high-tech undertaking in which physics, geomechanics, chemistry, data processing, real-time analysis of downhole data logging and sophisticated well-steering tools are all vital to managing today’s increasingly complex well trajectories.

The era of easy-to-extract conventional resources is surely coming to an end. Newly found reservoirs are likely to be buried deeply in complicated and difficult geology, or at great water depths. As a result wells today are deeper, longer and more complex, they will encounter challenging rock formations, and higher temperature and pressure environments than before. This means that drilling has become a high-tech undertaking in which physics, geomechanics, chemistry, data processing, real-time downhole data analysis (recorded during drilling) and sophisticated well-steering tools are now vital to managing increasingly complex well trajectories. As a result, drilling costs can be as high as $1 million or more per day.

Total understands these challenges and is working tirelessly to introduce more efficient technologies to save time and reduce potentially high costs.

Over the last ten years, Total has drilled more than 3,000 wells around the globe, encountering all types of geology: foothills, abrupt margins, pre-salt basins, carbonate reservoirs, plus shale and unconventional reservoirs, the list goes on.

Drilling costs for the more complex wells can exceed $1 million per day

Total has long been at the forefront of world firsts and technological breakthroughs, such as Measurement While Drilling (MWD), the technology that made it possible to industrialize horizontal drilling. In 2016 we commissioned the world’s first all electric subsea well in the North Sea. With more than 400 subsea wells operated, we are a pioneer and leader in deepwater drilling technologies, such as lighter risers, robust connectivity, control of cement temperatures, simplification of architectures and maintenance, and using all-electric equipment. In partnership with our contractors, we are continually developing technologies tailored to subsea pressures and high load conditions.
Our ability to design and drill high pressure/high temperature wells is acknowledged industry-wide. Well configuration is critical in such environments. Controlling pore pressure and fracture gradient differentials is crucial, with a very narrow mud weight window using such techniques as managed pressure drilling (MPD), even in deepwater wells. Our expertise includes controlling the stability of well walls during drilling, drilling infill wells in highly depleted reservoirs, cement rheology, predicting pore pressure, and strengthening wells with stress caging.

At the CSTJF, our specialist drilling teams have a full suite of high-performance integrated research laboratories specialized in drilling fluids and cements, rock mechanics, reservoir to wellbore interface, and well productivity. They work closely with field personnel and are able to test, model and validate solutions that enhance well integrity and productivity. Their complex modeling allows them to create and customize designer muds to prevent well fracture while drilling. In-house software enables them to simulate the behavior of wells and cements over their lifetime, helping to prevent failures during drilling, completion and production.

Via our Real Time Support Centre (RTSC), a smart room based at the CSTJF, we remotely monitor the drilling parameters of complex wells around the world, to optimize performance, provide real time access to expertise and further reduce exposure to major risks. Operational performance can be tracked economically and is compared instantly to reference drilling conditions.

Our drilling capabilities also extend to well productivity. We develop advanced fracture stimulation, injection or acidizing techniques to improve flow rate, fluidity and productivity in all types of formations. Our wellbore interface laboratory has developed innovative systems and treatments for gravel packing, sand consolidation, deposit prevention, and more. Adjusted to reservoir conditions and production objectives, these solutions optimize the control of sand ingress at the reservoir-to-wellbore interface with the support of point-and-shoot simulation and monitoring software.

2016: Offshore Uruguay in the ultra-deep waters of the south west Atlantic and against difficult ocean currents Total drills Raya-1. In 3,405 meters of water, at the time it was the world’s deepest subsea well.
Being lowered into the Dutch North Sea in 2016, the K5F-3 module was the world’s first all-electric subsea well. The addition of an electric Downhole Safety Valve (eDHSV) previously unavailable commercially made this project a reality. With an eye for the future, all components were designed and certified for deepwater use (up to 3,000 m).
Hydrocarbon production is a complex, dynamic process lasting many years, involving enormous volumes of fluids of varying viscosity and corrosiveness. Maximizing this production is fundamental to the profitability of a field. At CSTJF, scientists and engineers work to determine the most effective reservoir recovery mechanisms, calculating well trajectories that will optimize drainage and estimating the quantities of oil, gas and water that a field will yield over its lifetime. Experts use their understanding of geology to predict for each type of reservoir how hydrocarbons will behave during production, especially their ability to flow towards the wells. They also carefully evaluate and mitigate factors liable to impact production, such as pipe clogging or corrosion.

Oilfield operations engineers focus on key themes such as forestalling production decline, preventing deterioration of production facilities and adapting extraction processes to specific reservoirs, and the physical and chemical changes that well fluids undergo over the producing life of a field.

In the drive to improve the productivity of Total’s assets, the CSTJF has the resources to improve existing methodologies and even devise new ones that will benefit Total’s E&P subsidiaries. For example, new software applications have been developed and implemented into oil field process control systems that perform well production optimization in real time, 24 h/7, systematically and simultaneously across all wells. With forward thinking and planning we can install customized pumps during deep offshore field development. For example, we can anticipate future well pressure loss by installing electric submersible pumps (ESP) or accommodate increased produced water and gas by installing multiphase pumps (MPP).

These innovations have ushered in a new era of remote monitoring of field performance, with data accessible in subsidiary offices as well as at the CSTJF.

By combining all their expertise, the engineers at the center accelerate field development and help producing sites to achieve a best-in-class production efficiency for the full life of a field.
Conventional production methods rarely achieve recovery factors above 35%. Enhanced Oil Recovery (EOR) can increase this by as much as 15%, a considerable financial gain for an existing installation. Total has extensive experience in many EOR technologies in different geological matrices using various fluid types. Traditionally, water and gas are injected to “sweep” the maximum possible amount of oil or gas in the right direction, but we also employ more sophisticated techniques. Analytical chemistry makes it possible to formulate additives tailored to the properties of individual reservoirs. One such method, the in-house developed “SWIM” (Smart Water Injection Methodology) fine tunes the composition of injection water (salinity, ionic content etc.) for individual reservoirs. The CSTJF also examines the feasibility of injecting polymer, air, steam, foam or solvent (hydrocarbons and/or carbon dioxide) in an effort to devise new solutions and raise final recovery factors even further.

One of two multiphase pumps installed on the see floor at Moho-Nord off the Congolese coast. These enormous pumps, the most powerful in the world when commissioned will prolong field life by adapting to the phase shift from oil to oil-water and gas as the field matures.
Managing produced water

Most oil companies are now producing more water than oil, and this water cut inevitably rises as a field matures. Much of the water can be reinjected into the reservoir for pressure maintenance. Produced water must undergo fine filtration to mitigate the risk of formation damage or well plugging. Given the scale of an oilfield, the chosen technology must be both highly efficient and economic. The engineers at the CSTJF are developing solutions to meet the challenge. One example is a ceramic membrane ultrafiltration process, an innovative technology that outperforms conventional systems. It removes suspended solids as tiny as a few hundredths of a micron, as well as droplets of non-soluble hydrocarbons. This is the first time the technique has been applied to oilfield produced water—another pioneering achievement for Total and a new milestone for the E&P industry in general.
World class laboratories combined with expert technical support

Pushing exploration success and recovery factors ever higher.

At its heart, the CSTJF boasts a suite of around a dozen highly sophisticated and integrated laboratories across all core disciplines. They are all fully certified to ISO 9001 and ISO 14001 standards. These class leading laboratories offer more than just analysis, they also provide full backup and technical support to our E&P affiliates and their partners operating in 50 countries on 6 continents. Providing expert analysis of potential problems, proposing integrated solutions and minimizing downtime all help to maximize profitability, throughout the value chain.

Sedimentology and Structural Interpretation

A range of interpretational laboratories focusing on sedimentology, structural geology, biostratigraphy and mineral chemistry. These laboratories are fully equipped with the most advanced equipment including; Scanning Electron Microscope (SEM), CT scan and X-ray florescence. From core analysis these laboratories can help assess critical characteristics such as; reservoir quality, carbonate diagenesis, connectivity & water rock interactions, clay, mineral and shale formations. The biostratigraphy laboratory can undertake age dating based on expert fossil knowledge and interpretation.

A CT scanner is just one of the many high-tech instruments used in the sedimentology and structural interpretation laboratories. It is being used here to generate 3D images of core samples to determine hydrocarbon content, a key parameter in reservoir characterization.
The Fluids and Organic Geochemistry Department, offers an end-to-end service, providing not only high precision analyses, but also a full and comprehensive interpretation of the results. Its unique laboratory was designed in house and uses advanced technologies alongside original and patented equipment. It has developed and improved the quality and diversity of its measurement techniques to better assess fluid properties and source rock potential. Ideally positioned and equipped to address some of the principal technical challenges facing the oil and gas upstream sector, our laboratory is managed and staffed by highly trained expert and experienced personnel, operating to the strictest safety and quality standards.

Our competencies span five core activities:

• Onsite hydrocarbon fluid sampling;
• Compositional and isotope analysis of oil, gas and source rock extracts;
• Rock and source rock characterization (Rock-Eval pyrolysis, vitrinite reflectance);
• Characterization of reservoir fluid behavior and the thermophysical properties of oil and gas samples;
• Onsite analysis in remote locations with specialized mobile lab equipment: PVT (pressure-volume-temperature); production allocation; gas chromatography.

In the U.K. sector of the North Sea, Total drilled one of the very first step-out wells in a high-pressure/high temperature environment. The 7,300-meter-long Glenelg well reached its target 5,600 meters beneath the seabed, with a reservoir temperature of 200°C and pressure of 1,150 bar. This feat was made possible by the complex studies performed at the CSTJF’s laboratories. Seen here, the Pressure Volume Temperature (PVT) analyzer cell.
New developments mean ever more challenging fluids (corrosive, waxy or asphaltic crudes, etc.) along with more complex field architectures (ultra-deep, long tie-back, high pressure, high temperature, operating in hydrate zones, subsea processing, etc.).

Our Physical-Chemistry and Corrosion specialists have at their disposal state of the art in-house facilities to meet these new demands and can recommend optimized solutions to our affiliates and partners all around the world. Our laboratory is fully equipped for fluids and deposits characterization (organic and mineral), corrosion testing, materials and additive selection. Numerous pilots are available to simulate fluid behavior and additive efficiency, hydrate prediction and mitigation, water treatment membrane selection and more.

This facility hosts the laboratories and expertise for petrophysics and complex recovery mechanisms, including EOR. It aims to provide reliable laboratory results, with expert interpretation and guidance. “Customers” include external companies, operating companies (OPCO’s), affiliates, R&D, and exploration. The business model is to provide auditable data and information that external laboratories cannot supply along with exceptional quality control. Proprietary and patented experimental techniques are used to improve the understanding of physico-chemical mechanisms and optimize experimental modeling. These techniques include:

- 2D and 3D X-ray monitoring of three-phase corefloods to assess in-situ saturation;
- NMR (Nuclear Magnetic Resonance) coreflood monitoring;
- Fluid monitoring at both surface & reservoir conditions (650 bars & 150 °C);
- Ultrafast Capillary Pressure & Resistivity index measurements (UFPCRI);
- Permeability measurements in nanoporous rocks (Step Decay);
- Saturation measurements in unconventional rock (MRSat & Thermogravimetry);
- Digital rock physics: Micro-CT and micromodels.

This close knit engagement between specialist competency and laboratory capability ensures:

- R&D outcomes are quickly available to both new developments and ongoing operations;
- Fluid risks are identified rapidly through the flow assurance approach. This facilitates an optimized development concept and accelerates the delivery of new projects while driving down costs;
- The best performing chemicals are always tested and selected to minimize operational issues. Chemical treatment programs are also specified internally meaning no conflict of interest for chemical suppliers;
- The materials selected for new developments are always fit for purpose. The range of materials available is enlarged and new products are qualified in house.

Treatment and laboratory teams in affiliates can rely on our competencies and support for training, onsite measurements, laboratory audits and damage expertise.
Drilling Fluids

Drill fluids (muds) and cements are critical for ensuring optimum drilling with minimum drill failure and downtime. The fluids and cements laboratory is fully focused on developing and selecting the best possible muds and cements. The laboratory has particular expertise in validating fluids and cement slurries for use in ultra deep water and HP/HT environments. Thanks to a wellbore strengthening package this laboratory can design and validate mud systems for plugging induced fractures while maintaining drilling. It is capable of predicting cement sheath integrity using its unique STCA (Slurry to Cement Analyzer) cell, enabling curing and mechanical testing under downhole conditions without returning to atmospheric temperature and pressure. The results can then be used in T-CemiINT modeling software for cement sheath integrity.

Reservoir Wellbore Interface

The reservoir wellbore interface laboratory is a best-in-class facility, boasting state of the art equipment plus a team of experts to deliver test results and supporting engineering studies, covering:

- Damage and compatibility assessment: evaluations between in-situ reservoir fluids and completion, intervention and stimulation products including fracturing and gravel pack gels;
- Returned permeability: evaluation of the impact of fluids and completion / production / injection processes on reservoir permeability, hence determining a well’s productivity and injectivity;
- Sandcontrol: residual sand production; plugging and consolidation tests;
- Shale sensitivity and fines migration: assessment of interactions and the consequences of fluid – formation reaction and potential impact on well productivity. Analysis of fines migration mechanism and impact on well productivity;
- Cake treatment: evaluation of the cake breaking efficiency of proposed service products;
- Carbonate reservoir stimulation: evaluation of the efficiency of acid stimulation in creating wormholes in carbonate reservoirs and the diversion techniques that may be applicable;
- Enhanced oil recovery: evaluation of polymer degradation through completion;
- Injectivity: produced water reinjection evaluation.
The geomechanical services team and laboratory identify and enable the application of best technology to ensure wellbore stability, and maximize asset recovery, using:

- Core testing: triaxial, oedometric, mini-compression, pore pressure transmission, shale hydration and swelling, fracture toughness, fracture permeability, and scratch and micro-indentation tests;
- Determination of rock mechanical parameters: elasticity (Young’s modulus, Poisson’s ratio), Biot’s coefficient, failure, cohesion, friction angle, shale chemical and physical properties;
- Determination of the change of sonic velocity of reservoir rocks as a function of pore pressure evolution under in-situ stress conditions; measuring reservoir rock compressibility, and the threshold of pore collapse.

Wellbore stability can be maintained by offering optimally tailored technical solutions. Scratch testing can determine and quantify sand production risks.

The assessment of reservoir geomechanical risks in terms of cap rock integrity, fault slipping, subsidence and casing integrity can be undertaken. Numerical modeling with validated data from lab tests can be carried out to optimize reservoir stimulation and predict production performance.

To limit the ever-increasing costs of drilling as much as possible, perfection is the key—and the secret to optimizing drilling efficiency. Attaining this high standard requires in-depth knowledge of the rock encountered and its “response” to drilling. This is one of the fundamental objectives of the Geomechanics Laboratory.
Digital innovation

Digital remote support and monitoring of operations improves safety, cost control and operational efficiency thus maximizing performance and profitability.

Digital technology is radically redefining the way we design, build and operate our facilities. Here at the CSTJF, evolution is not just novel, it is groundbreaking. We have harnessed one of the world’s most powerful supercomputers, and with our geoscientists and engineers we map subterranean landscapes many kilometers beneath the surface. We are embracing the future, piloting innovative technologies such as autonomous robots for site inspection and response with ARGOS (Autonomous Robots for Oil and Gas Sites). We are pioneering air-borne drone technology with the METIS™ project (Multiphysics Exploration Technology Integrated System) using flights of automated drones to safely deploy seismic sensors in difficult to access or dangerous terrains. Subsea, we are industrializing Autonomous Underwater Vehicles (AUV) that will be able to work more safely, faster and more cheaply.

Beyond these next generation innovations, real-time industrial support is already essential for ongoing safe and efficient operations, and today, using digital connectivity, smart rooms centralized at E&P’s headquarters here at the CSTJF bring specific industry expertise to remote locations, anywhere in the world, using applications such as RAID (Remote Assistance Intervention and Diagnosis) a 24/7 diagnostic service for rotating machines, geoscientific support with RTSC (Real Time Support Centre) for drilling operations, and Remote Metering Monitoring (RMM) tracking and analyzing production parameters from wells above ground or deep beneath the sea.

The RTSC platform simultaneously supports multiple drilling rigs around the world. Data (mud logging, directional drilling, LWD, rig settings, etc.) is collected from rigs and then transferred and stored in a data center. Being real time, instant 24 hour, 7 days per week assistance and advice can be offered. However the real added value lies in the interpretation and analysis of this data by the RTSC in Pau, made possible through a software suite and a number of specially developed algorithms. This highly efficient mode of value engineering allows us to provide assistance to subsidiaries and make recommendations on ongoing drilling operations leveraging the areas of dedicated expertise – Geomechanics, Fluids, Reservoir-Borehole Interface, Directional Drilling, and more – found at the CSTJF. It also means that operational safety is enhanced through real time 24/7 support.

Production monitoring to boost performance or balance flowrates as required. RMM, originally designed for the remote monitoring of subsea multi-phase pumps, is now used to boost the performance of any production site around the globe. Standard monitoring can be used for flowrates, temperature, pressure, emissions or for fiscal purposes, and advanced monitoring can detect failures, fluid types, or ingress of sand. All controlled via the smart metering room centered at the CSTJF with instant access to and input from experts in all disciplines bringing faster response times, and greater efficiencies to our affiliates worldwide.

Asset management is key in ensuring economically sustainable production. RAID uses SmartSignal technology to remotely monitor operational parameters of rotating machinery anywhere around the world. Potential mechanical problems can be identified and remedied to prevent failure. RAID offers the special benefit of interfacing with existing monitoring sensors without always requiring costly new equipment. Today RAID monitors over 250 rotating shafts, in 550 pieces of equipment using over 30,000 sensors. Since its introduction in 2013 there has been no lost production due to preventable maintenance failures.
Located in the Patagonian desert in southern Argentina, but not isolated from the geoscience teams, the Aguada Pichana wells are fully connected to the CST, JF and receive real-time 24/7 geoscience back-up and input using RTSC.
Thanks to RAID and SmartSignal technology, the rotating machinery on the Yadana platform off the coast of Myanmar in the Bay of Bengal can be monitored continually by the CSTJF engineering teams in France. Such monitoring has meant there have been no preventable system failures since 2013.

The Remote Metering Monitoring team at the CSTJF can see flowrates, temperatures, pressures and emissions from production sites all around the world. The team, comprising a group of wide ranging specialists, use this data to maximize efficiency and performance or even detect failures.
Research & development spearheading innovation

The nerve center of Total’s Exploration & Production Research and Development is the CSTJF.

For Total, technological innovation is the primary means of gaining access to new oil and gas provinces, through the development of new solutions for responsible and sustainable production. When it comes to the future of energy, only innovative thinking can push the limits of feasibility and shift the boundaries of science. R&D is spearheading efforts in reaching its goal of supplying safe, clean, reliable and affordable energy. The nerve centre of Total’s Exploration & Production research and development is located at the CSTJF. Here, over 200 R&D engineers and technicians are dedicated full-time to improving those techniques already available and designing new breakthrough and cost effective technologies. The teams devise and develop innovations that will enable profitable production of frontier resources and optimize production techniques to increase reserves on existing fields. They introduce new technologies to preserve and protect the environment and ensure the safety of people and facilities. The CSTJF is the hub for more than 40 research projects in the areas of frontier exploration, earth imaging, reservoirs, sustainable development, wells, deep offshore, digital, unconventional oil & gas, and gas solutions. In addition to these spheres of expertise, the site is home to 6 R&D specialized laboratories researching emerging fields such as nano-technologies and robotics.

The METIS® (Multiphysics Exploration Technology Integrated System) project will use a flight of intelligent drones to drop a series of sensors. These sensors penetrate the ground by a few cm and become part of a wireless seismic network able to map the subsurface, minimizing the need for people and machinery on the ground above.

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Launched in 2014 and designed for use in areas either difficult to access, or where environmental damage would result, the METIS® (Multiphysics Exploration Technology Integrated System) project will use a flight of intelligent drones to drop a series of sensors. These sensors penetrate the ground by a few cm and become part of a wireless seismic network able to map the subsurface, minimizing the need for people and machinery on the ground above.

The PERL (Pôle d’Études et de Recherche de Lacq) is a nearby sister site and part of the CSTJF R&D organisation. Its innovative use of a former industrial complex means it can replicate real life size and situation without compromise.

The CSTJF R&D department comprises researchers of 25 nationalities, and with PERL some 9,000 m² of laboratory space. It has filed over 1,700 patents around the world.
Total’s R&D also includes an international network of five other research centers in Aberdeen, Houston, Doha, Rio de Janeiro and Stavanger, all coordinated from the CSTJF.

Total is meeting the challenges of deepwater oil and gas production. Our facilities have been recovering reserves under more than 1,500 meters of water for over 15 years. Throughout this period Total has set world firsts for deep sea exploration, both in terms of absolute depth and the ingenuity of its subsea architecture. Yet these bold operations are set to become even more complex, as oil and gas will have to be produced deeper, and transported over longer subsea distances—in some cases more than 100 kilometers. Also ahead is the shift to “all-electric” systems to replace hydraulic controls. This and other innovative and game changing technologies will be the key enablers to descending even deeper, to water depths of 3,500 meters or greater, ensuring that even the most difficult to produce fluids remain cost effective.

Reinventing ourselves, R&D is planning for the future and what next generation facilities (NGF) might actually look like. In the quest for improved safety and lower cost, unattended activities, such as valve operations, monitoring, dredging, etc., may provide a solution. Both onshore and offshore, risk is reduced with humans out of harm’s way. In such a world robotics would play a key role.

The CSTJF is taking us ever closer to artificial intelligence. Exploration and production activities are often carried out in difficult conditions, such as extreme hot or cold, isolation, noise, or risk of dangerous substance exposure. In order to meet these challenges while continuing to make our operations safer and more efficient, in 2014 Total, in partnership with the French National Research Agency (ANR) launched the first robotics challenge in the oil & gas industry; the ARGOS challenge (Autonomous Robot for Gas & Oil Sites). It drew teams from industry and universities from around the world and produced a winning robot in 2017. The next stage will be to further test and develop this robot in autonomous mode on real oil installations.

The high power parallel computing capacity installed at the CSTJF enables more efficient scientific calculation, more realistic modelling, and generates more reliable subsurface modelling. It has allowed R&D to run more complex simulations and to optimize the scalability of algorithms to achieve parallelization and reduce computing times. For example, R&D’s field production history matching prototype based on the “ensemble method” (a tool developed in the Sismage-CIG environment) combined with the INTERSECT flow simulator has been successfully applied to two fields in the Middle East. This has enabled us to enhance the reliability of our predictions for future reservoir production profiling, leading ultimately to increased production.

As part of R&D’s mandate to deliver the technologies that grant us a license to operate in an increasingly regulated industry, the teams at CSTJF have developed a bio-treatment for produced water (BIOMEM project) to ensure that any discharges into the environment are clean enough to meet or exceed regulatory demands. This very compact biological reactor with supported immobilized biomass will remove the residual dissolved hydrocarbon fraction and organic compounds contained in produced water. This field-tested technology is well suited to our offshore platforms and significantly cuts the cost for water treatment.
BIOMEM biological filtration system for cleaner produced water. The compact matrix supports millions of organisms in an immobilized mass, they biologically "consume" the residual hydrocarbon to leave water clean enough for direct discharge into the ocean, as shown here. In fact, detailed chemical analysis shows the treated water to exceed all regulatory requirements for discharge.

Carbon Capture, Utilization and Storage (CCUS) technology plays a vital role in the International Energy Agency’s 2°C climate change scenario. Total shares that view and is preparing a strategy to encourage advances in CCUS technology, both on our own and through partnerships. We have been actively involved in this field for many years and routinely examine any opportunity for storing or reusing our CO₂ emissions. Conducted between 2010 and 2016, the Lacq pilot project involved oxy-fuel combustion and capture of CO₂ followed by its permanent storage in a depleted reservoir. Today, we are stepping up our efforts to treat our own emissions while also developing solutions that can be applied in other sectors, such as power generation, cement manufacturing and steelmaking. Accordingly, our R&D budget for CCUS has tripled in just two years and will account for 10% of our overall R&D budget by 2020.

Taking us closer to artificial intelligence. In 2014 in partnership with the French National Research Agency (ANR), Total launched the first robotics challenge in the oil & gas industry; the ARGOS challenge (Autonomous Robot for Gas & Oil Sites). In 2017 the challenge produced a winning robot, which is now being further developed on a real life installation.
The Platform for Experimental Research in Lacq, or PERL, formerly a large industrial site, is now a CSTJF R&D facility, located only a few miles away. It is internationally renowned for its scientific research into three areas crucial for E&P:

The first is innovative solutions for gas separation and treatment: formulating new solvents to expand our range of absorption processes developed for the treatment of sour gases. Our HySWEET® solvent permits the simultaneous removal of CO₂, H₂S, RHS and COS, and is more economical and energy efficient than conventional amine processes. PERL also develops new processes using membrane separation and adsorption. Case specific approaches are conducted to meet the specific needs of different gas related applications.

The second is the physical chemistry of interfaces: focusing primarily on liquid/liquid interfaces (control of emulsions, deposits, corrosion and formulation of surfactants for chemical EOR, or C-EOR) with further research devoted to solid/liquid and liquid/gas interfaces. The teams develop polymers to increase the viscosity of injection water to optimize sweep efficiency and boost hydrocarbon recovery factors. But the PERL’s physical chemists are not restricted to merely “inventing new molecules”. Their integration with field operations was one of the keys to the success of the C-EOR trial in 2014 at the ABK (Abu al Bukhoosh) field in Abu Dhabi, where surfactants formulated at PERL helped lead to ultimate recovery factors of up to 42%.

The third is managing environmental outcomes with the PERL teams targeting key areas:
• Soil remediation and hydrogeology: management of soil and/or groundwater remediation projects, including diagnostics, monitoring and decontamination techniques offering best performance and cost.
• Water treatment: development of optimized treatment processes (ultra- and nano-filtration membrane processes, oxidation, absorption, adsorption and bio-treatment) for produced water, including waters containing polymer from C-EOR applications. This enables maximum recycling in our industrial processes and even allows the water to be reused for irrigation of non-food crops.
• Impact management: anticipating increasingly stringent legislation such as the “no harmful impact” principle advocated by the OSPAR (Oslo/Paris convention for the protection of the marine environment of the North-East Atlantic) guidelines for discharged effluents, by developing measurement, diagnostic and assessment technologies and methods able to determine actual environmental impacts (or not) caused by our discharges.

Combined with the adjoining Lacq Pilot Platform (PPL) Seveso III-compliant Control of Major Accident Hazards (COMAH) site, the PERL center has a significant competitive advantage by being able to conduct full scale experimental studies using hazardous fluids and gases in a secure environment, something not possible in conventional laboratories.

The PERL center has 4,000 square meters of conventional laboratories and test facilities, plus a further 6 hectares of large-scale R&D pilot study areas.
Water treatment pilot unit at the PERL center. Testing UV/ozonation for removing dissolved organic compounds from produced water.
Operational since 2015, the Lacq Pilot Platform (PPL) comprises nearly 6 hectares of large-scale pilot facilities able to pursue research in a genuine industrial setting. With SEVESO III compliance, its purpose is to host industrial scale pilot trials in conditions similar to actual production sites.

The pilot units at the PPL comply with the safety and environmental procedures in force at major sites subject to specific environmental protection legislation. This means they can handle the volumes of raw materials, chemicals and by-products associated with an industrial site (toxic/flammable gases, including H₂S; oil, produced water and waste etc). The PPL is home to a large number of large R&D installations on a permanent basis, such as a pilot unit to test new solvent processes for acid gas treatment and CO₂ capture.

This latest generation facility is highly modular and a decisive part of our ongoing R&D program, affording an ideal proving ground for the R&D activities of Total’s E&P division.

The River Pilots are a unique and outstanding facility found at the PERL. This outdoor laboratory is unmatched in the oil and gas industry. It comprises 16 artificial watercourses deviated from the Gave de Pau (river). We use it to study how industrial effluent discharges affect freshwater, assess these impacts using biological indicators and evaluate the risks relating to the substances of interest involved in our operations.
To make genuine technical progress, good research relies on discoveries made anywhere and everywhere. Because sharing is essential our R&D teams have forged partnerships with academia and industrial companies of all sizes from large IOC’s to small businesses. Our cooperation with universities includes: Stanford (understanding the physical phenomena of subsurface hydrocarbon generation), Massachusetts Institute of Technology, “MIT” (hydraulic fracture propagation), École Supérieure de Physique et de Chimie Industrielles, Paris (complex oil and water interface phenomena), and the Université Pau et Pays de l’Adour. We also work with research agencies such as ONERA, The French National Aerospace Research Agency (atmospheric imaging for exploration and environmental protection). These all enable us to tap into and network with the world’s smartest research minds.

A greenhouse for research. Evaluating the feasibility of using vegetation, or more precisely, its “hyperspectral signature”, as an indirect indicator of hydrocarbon seepage at the earth’s surface. This is one of the challenging questions being studied by the NAOMI program (New Aerospace Observation Methods Integration) under an exclusive research partnership with ONERA (a leader in remote sensing) on remote detection of hydrocarbons. The PERL center is conducting research on plants grown in controlled greenhouse conditions. Results could prove invaluable in future exploration.
Total is a major energy player that produces and markets fuels, natural gas and low-carbon electricity. Our 100,000 employees are committed to better energy that is safer, more affordable, cleaner and accessible to as many people as possible. Active in more than 130 countries, our ambition is to become the responsible energy major.