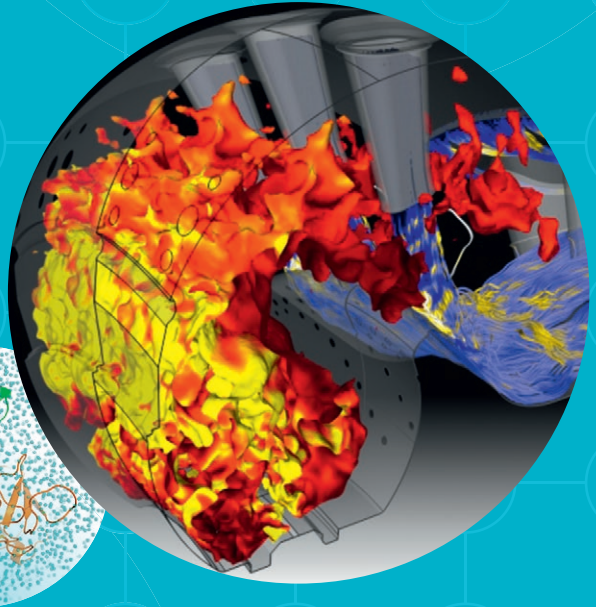
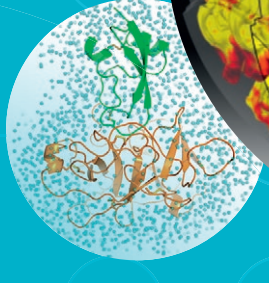
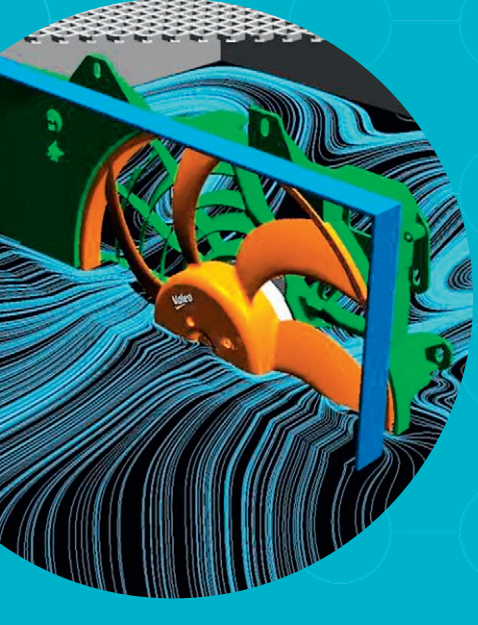
CCRT

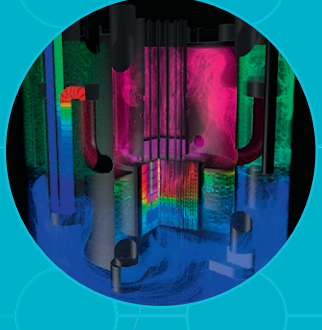
COMPUTING CENTRE FOR RESEARCH AND TECHNOLOGY

WORKING FOR RESEARCH AND INDUSTRY SINCE 2003









ccrt
Centre de calcul recherche et technologie

DE LA RECHERCHE À L'INDUSTRIE
cea

The Computing Centre for Research and Technology (CCRT) was born in October 2003 in the CEA DAM Île-de-France. The reason behind the decision to build and share a pooled computing and services platform was two-fold. The aim for CEA was to remain faithful to its motto "from research to industry", by enabling French industry to benefit from its work and competencies in intensive computing and the management of large volumes of data. This decision was also underpinned by the conviction that, in return, its teams would be able to benefit from the dissemination and reinforcement of the simulation approach in all industrial sectors in the country.

The CCRT offers more than just access to world-class computing, storage and display resources and its role is also to help its partners assimilate new technologies and prepare the simulation tools of tomorrow. Thematic seminars and training sessions are organised for this purpose.

Since 2003, the CCRT has seen four generations of supercomputers and a corresponding growth in its computing power, which has been multiplied by a factor of more than 600. New services have been developed. Computing is now supplemented by data management, remote visualization services and, more recently by the infrastructure put into place for the France Génomique consortium, offering processing of large masses of data, – an example and use case of so-called case "Big Data".

This incredible evolution has been accompanied by an expansion in the applications handled by the industrial partners, who now cover a wide variety of fields: aeronautics, space, energy, land transport, security, environment, health, cosmetics, etc. This diversity is an asset which can be profitable to all CCRT stakeholders and partners. It is up to us to ensure that expertise and feedback cross-pollinate and mutually nourish each other.

With the agreement of its partners, the CCRT is preparing to open the door to new usages via virtualised access to resources. It is also preparing for new uses of the high-performance computing systems for machine learning.

We therefore wish to thank our CCRT partners – and those who could join them – for their confidence, which is driving this dynamic growth at the CCRT, to the benefit of us all.

Pierre Leca
Head of the Simulation and Information Sciences Department

Christine Ménaché
Head of the CCRT

CEA DAM Île-de-France

CLOSE-UP ON THE CCRT

The CCRT, located in Bruyères-le-Châtel (Essonne) under the responsibility of the teams at CEA DAM Île-de-France, is one of the rare computing centres in Europe open to industry. Its role is to support industrial innovation and promote industry-research partnerships in the field of high-performance numerical simulation and data processing. It proposes a diverse offering of high-performance computing (HPC) skills, matching the growing needs of the partners and combining security and flexibility in the use of its resources.

COMPUTING RESOURCES

The computing resources at the CCRT benefit from the exceptional infrastructures of **CEA's Very Large Computing Centre** (TGCC) and offer its partners a comprehensive, secure working environment.
The core element is the **Cobalt supercomputer**, a cluster built and installed by Atos-Bull in 2016. With an initial computing power of 1.5 petaflops[1] distributed over 40,000 cores, it is designed to be able to meet the growing needs of the partners thanks to its scalable architecture.
The CCRT benefits from the shared storage infrastructure of the TGCC which can accommodate large volumes of data over the very long term.
Post-processing and remote visualization resources complete the range of services proposed to the users.
Access to the CCRT is ensured by secure links via the national telecommunications network for technology, teaching and research (Renater).

1/ 1 petaflop: 1 million billion operations per second.

KNOW-HOW AND EXPERTISE

Backed by the expertise developed under CEA's Simulation programme, the personnel at the Simulation and Information Sciences Department of the CEA DAM Île-de-France place their know-how at the disposal of the CCRT. From energy optimisation of the computing centre to the development of Opensource components (Lustre, Slurm, WI4MPI, Selfie, Robinhood, etc.) through the implementation of a high-performance, secure production and data management environment, all the skills necessary for the design and implementation of very large computing infrastructures can be found here.

COBALT

BULLX B700 PLATFORM with Direct Liquid Cooling (DLC)

39,816 INTEL® XEON® E5 2680 V4 (BROADWELL) COMPUTING AND PROCESSING CORES, running at 2.4 GHz (28 cores/node - 128 GB of memory/node)

4 LARGE CAPACITY MEMORY NODES of 3 TB/node devoted to France Génomique

18 HYBRID NODES (Intel Broadwell - Nvidia GPU Pascal) with 256 GB of memory/node

InfiniBand EDR **HIGH-PERFORMANCE INTERCONNECTION NETWORK**

PRIVATE STORAGE SYSTEM with a capacity of 2.5 PB for a rate of 60 GB/s (Lustre file system)

Bullx supercomputer suite (SCS5) **OPTIMISED HPC SOFTWARE PLATFORM**

Slurm® **BATCH AND RESOURCES MANAGER**

Data storage robot (left) and the Cobalt supercomputer (right).

TESTIMONIALS...

from representatives of the companies on the CCRT Steering Committee.

THE CCRT PARTNERS

The CCRT partners have access to the computing power they need for their simulations and can draw on the expertise of the CEA teams in all scientific disciplines involved in numerical simulation. From research to industry, the numerical simulations performed at the CCRT deal with a wide variety of fields: electrical powerplant lifetime studies, the design and safety of nuclear reactors, aircraft and helicopter engine development, optimisation of ventilation and air-conditioning systems for cars, the design of radar and satellite systems, environmental risk assessments, the study of proteins and decoding of the genome, prediction of cosmetic product performance, or the search for new materials...

INERIS

maîtriser le risque pour un développement durable

As a national expert in the assessment and prevention of environmental and technological risks, Ineris performs calculations in the CCRT for all its modelling activities: air quality forecasting, evaluation of chemical substance hazards, study of accidental phenomena (toxic dispersion, fire, explosion).

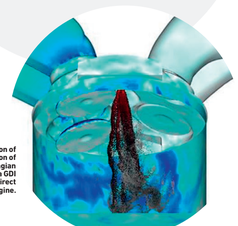
Thanks to the CCRT, Ineris more specifically produces innovative maps for the transport of pollutants and their chemical transformation in the atmosphere. Based on the Chimère chemistry-transport model, the simulations were for example able to forecast air quality over the entire Northern hemisphere with unprecedented spatial resolution.

Simulation of fine particle concentrations in the Northern hemisphere (10 January 2014).

IFP Energies nouvelles

IFPEN has a long-standing tradition of the use of supercomputers for its applied research in the fields of energy, transport and the environment.

The partnership with the CCRT created in September 2016 supplements the HPC resources available in-house and enables the IFPEN researchers to access very high performance for their research work in the fields of fluid mechanics (CFD applied to the design of internal combustion engines, the simulation of flows in porous media, but also inside and outside complex structures), molecular modelling (optimisation of catalysts for refining processes) and structural mechanics (structural calculations: design optimisation, floating structure anchors, etc.).



Visualisation of LES simulation of the Lagrangian spray in a GDI (gasoline direct injection) engine.

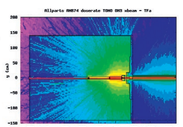
SOLEIL SYNCHROTRON

The Soleil Synchrotron uses large-scale computing resources in various fields: analysis, reduction and post-processing of experimental data, radiation protection calculations, design of mechanical parts and optical elements, electron beam and accelerator simulation.

Access to the CCRT enables it to use the best available resources to improve the performance of:

- future accelerators (these parallel computing means and new genetic algorithms are capable of simulating the dynamics of the electron beam, while optimising its injection efficiency and lifetime),
- design calculations for experimentation booth shielding,
- research on the optimum positioning of the samples to be explored.

Radioactive dose rate for an experimentation booth

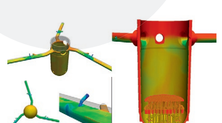


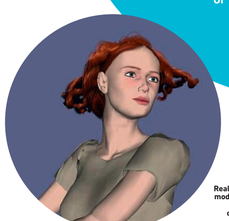
EDF

EDF uses high-performance simulation in numerous fields: fluid mechanics, mechanics, materials, networks, energy management, etc.

Access to the CCRT supplements our own computing resources. It enables us to experiment with new computing environments, to carry out cutting-edge studies and maintain a dynamic dialogue with the leading players in intensive simulation. EDF carried out pressurised water reactor thermohydraulic simulations in the CCRT.

Two-phase cold shock reactor scenarios.



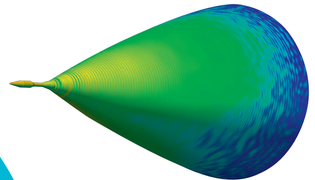


Realistic physical modelling of hair. L'Oréal-Inria collaboration.

L'ORÉAL Recherche & Innovation

For research at L'Oréal, standing at the crossroads of several disciplines, numerical simulation through high-performance computing is in the process of becoming a key element in the success of its main missions: discovering new areas for innovation, prediction in evaluating product effectiveness and safety, simulating to anticipate visible performance.

For us, access to the CCRT is a unique opportunity, not only to be able to use very high computing power, but also because of the network of partners capable of helping us in accelerating the development of our simulation tools. We also hope that this will be a fantastic opportunity to take up new challenges in collaboration with major academic partners.

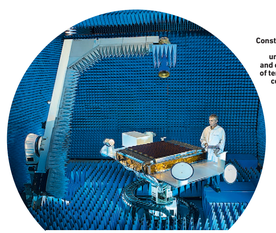


Surface current on a fighter aircraft nosecone radome.

THALES

For Thales Systèmes Aéroportés, the detailed electromagnetic simulation of increasingly complex objects required by our radar systems, and easier access to parametric simulation are the pre-requisites for reliable and robust design.

The partnership with the CCRT makes it possible to overcome the limits of our computing resources. The raw power offered and the flexibility of the operating conditions mean that this computing facility is an ideal partner in our process to produce a virtual mock-up of our equipment.



Iridium Constellation: antenna under test and example of terrestrial coverage.

ThalesAlenia Space

A Thales / Finmeccanica Company

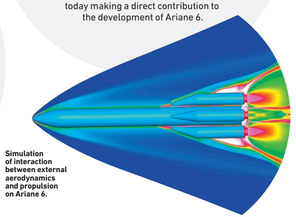
The increased performance demanded by satellite operators means that the electromagnetic interactions between all parts of a satellite's antenna system have to be managed in detail, as of the design phases.

Telecommunication systems based on low-Earth orbit satellite constellations, such as Iridium, require System traffic management involving accurate antenna steering. The computing power offered by the CCRT enabled high-performance numerical simulation to be used to optimise these systems, from object mock-ups to the definition of steering strategies.

AIRBUS SAFRAN LAUNCHERS

Airbus Safran Launchers relies on the CCRT to qualify its launchers. Numerous disciplines are studied using numerical simulation: aerodynamics, electromagnetism, etc.

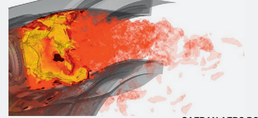
Using the available machines and through information sharing, the partnership with the CCRT enables us to develop the codes of tomorrow more efficiently, to carry out a number of very large simulations and produce extensive parameter configuration plans using numerical simulation. The technological advances obtained are today making a direct contribution to the development of Ariane 6.



Simulation of interaction between external aerodynamics and propulsion on Ariane 6.

SAFRAN

In an environment of fierce competition between aeronautical engine makers, the use of high-performance computing at Safran helps us keep pace with the best in the world. HPC is able to take better account of multiphysical phenomena and accurately reproduce technological effects, while bringing down the time needed to design and build aircraft and helicopter engines. Over the past ten years, the growth in the use of HPC in the company has been exponential. Numerical simulation opens up opportunities by investigating new architectures without having to wait for test results. Four companies in the Safran group are CCRT partners.



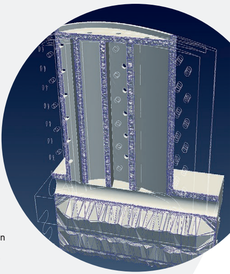
Combustion calculation to predict the temperature profile at the turbine inlet (Safran Aircraft Engines).

SAFRAN AERO BOOSTERS – Numerical simulation has significantly reduced the aerodynamic design time for boosters. Extreme computing is also used to assess the impact of manufacturing tolerances on the performance of the product and to optimise production costs. In the near future, HPC will allow an improvement in the reliability of simulations, ushering in the Big Data era, for performance of multi-scale, multiphysical calculations and making for more robust optimisations.

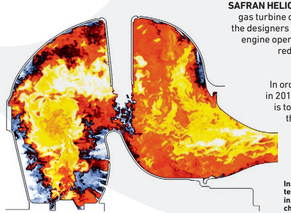
SAFRAN AIRCRAFT ENGINES – The simulations used in the design, development and industrialisation of our products help us attain our ambitious objectives and keep us at the cutting edge (engines for civil and military aircraft and satellites). The partnership with the CCRT has helped with the deployment of industrial scale design methodologies through the systematic use of steady state and unsteady state codes. The gradual increase in computing power has also made 360° modelling increasingly possible and facilitated the use of high-fidelity methods.

SAFRAN HELICOPTER ENGINES uses numerical simulation in the design of helicopter gas turbine compressors and combustion chambers. Access to the CCRT enables the designers to increase technological innovation while safeguarding performance, engine operability in all situations (engine on, engine off, emergency situations), reduction in weight, pollutant emissions and fuel consumption (about 15% reduction in 15 years).

In order to amplify research efforts, Safran created **SAFRAN TECH** in 2015. This is a group-wide research centre, the main aim of which is to develop models, algorithms and computer codes which will then be used in the design offices. Safran Tech thus makes extensive use of the TGCC infrastructures to validate and improve its simulation tools.



HP turbine blade (Safran Tech).



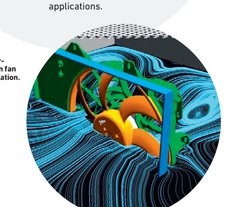
Instantaneous temperature field in a combustion chamber (Safran Helicopter Engines).

Valeo

Virtual prototyping is integrated into the development processes in the automotive industry and enables performance predictions and validation analyses to be provided as of the initial design phases.

After developing calculation and optimisation chains for our products which take full advantage of the CCRT supercomputers, our simulations lend themselves to new high-performance computing themes: unsteady state model for long physical time-frames, multi-scale and reliability or robustness analyses are among the prospects opened up by this new computing power. By taking greater account of physical reality, numerically designed products are better suited to their actual use over the long-term and in a wide variety of automobile applications.

Motor-driven fan simulation.



cea

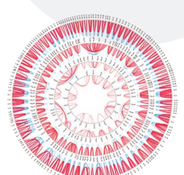
The growth in numerical simulation capacity is a priority and a major challenge for CEA, which is also working on its dissemination, participating in the national and European organisation of infrastructures and developing partnerships with industry.

CEA created the CCRT, which is also a wonderful vehicle for the dissemination of software and fosters the establishment of new scientific collaborations. CEA used the CCRT to characterise the Astrid reactor, a prototype generation IV nuclear reactor. The CCRT also contributed to the development of new enzyme function prediction tools, the development of multi-scale calculations in the field of materials and so on.

Simulation of phase transitions in an iron-nickel alloy (CEA/DAM).

FRANCE GÉNOMIQUE

The France Génomique infrastructure, financed by the "Investing in the Future" programme, aims to keep French research as competitive and effective as possible in the production and analysis of genomic data, at the forefront of the state of the art internationally. The CCRT was chosen as the e-infrastructure for storage and processing of these data. Since 2012, this e-infrastructure has been enabling France Génomique users to benefit from a storage capacity of several petabytes (medium-term storage for scientific projects lasting several years), connected to several thousand processing cores by a high-performance interconnection network.



Duplications of the *Paramecium tetraurelia* genome.

IRSN

INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

ONERA

THE FRENCH AEROSPACE LAB

CCRT FEATURES

A reliable, secure environment

The CCRT operates round-the-clock except for scheduled maintenance periods. On-site support from the manufacturer Atos-Bull, expert administration teams and an on-call duty system, optimise the availability of the computing service. Guaranteeing secure access and data confidentiality is a major concern for the CCRT. A CEA IT security experts unit oversees a supervision system which monitors, detects and analyses alerts, enabling the security managers to react extremely rapidly.

User assistance

• A single point of contact for the users: hotline.tgcc@cea.fr – tel.: +33 1 77 57 42 42. This call centre assists the partners using the computing centre and they can send their requests and incident reports to it.
• A specific website for the users (https://www-ccrt.ccc.cea.fr): "best practices", information and technical news.
• Application support: a team of IT specialists provides its expertise on the porting and optimisation of user codes on the CCRT machines.

Training

• Training is regularly proposed to enable the users to take full advantage of the architectures implemented on the CCRT. This training concerns parallel programming (MPI, OpenMP, vectorisation, etc.), development environments, but also new technologies in advance of their integration into the production machines.
• CCRT "familiarisation" sessions are proposed for the new users.

Dynamic exchanges between partners

In order to share the expertise of its teams with its partners and more generally take advantage of the strategies and skills of each one, the CCRT regularly proposes technological or thematic workshops:
• High Performance Programming in C++,
• Development of new services at the CCRT in order to meet the needs of the users,
• Deep-learning of solutions,
• Provision of virtual machines at the CCRT...
To this list can be added proposals from partners who share common problems. Every year, the CCRT also organises a science day open to all, which is an opportunity for the users to present their scientific results.

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