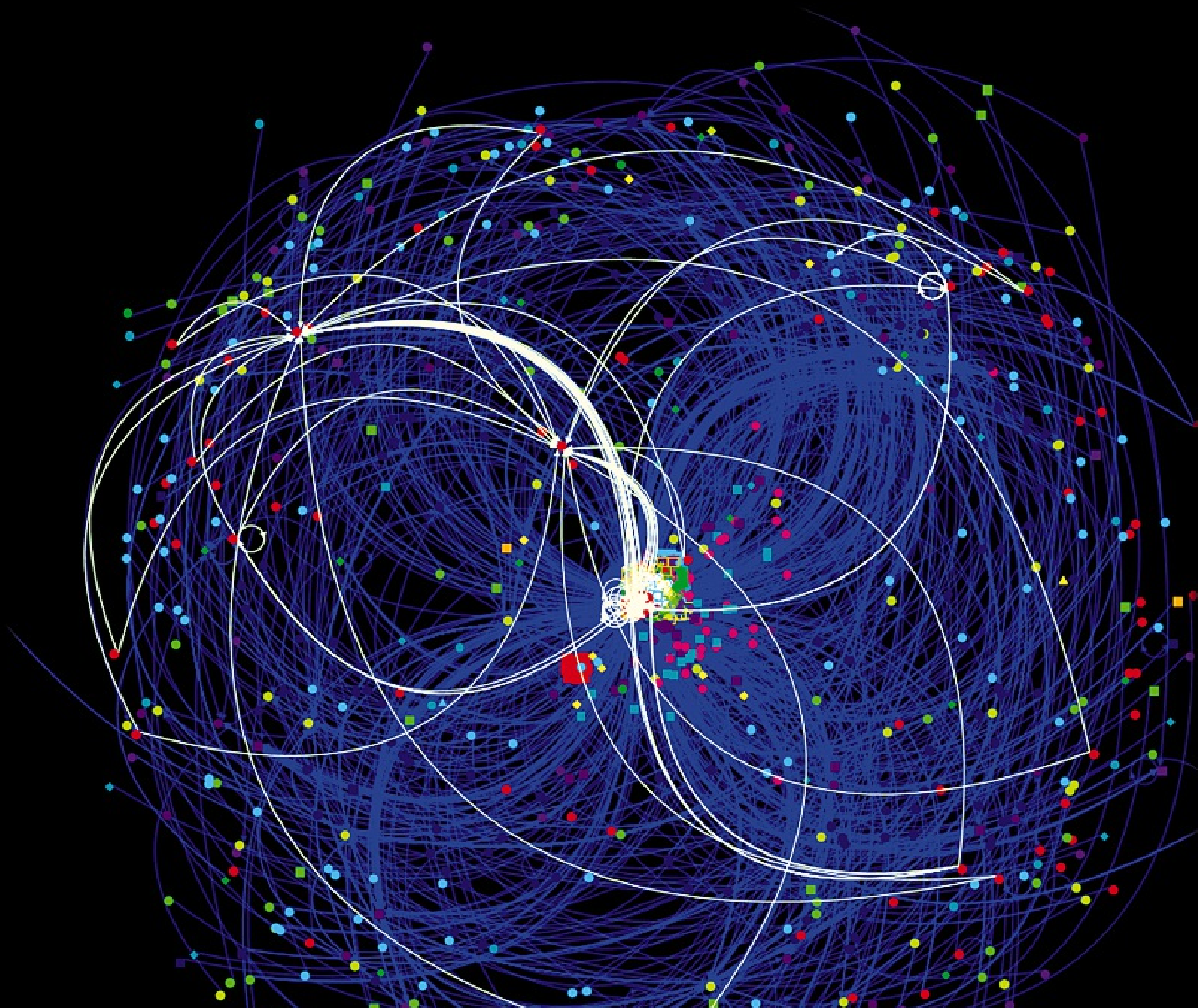
www.usinenouvelle.com
L'USINE NOUVELLE
IT INDUSTRIE & TECHNOLOGIES
www.industrie-techno.com
SUPPLEMENT TO 3418 . APRIL 9 2015 . NOT TO BE SOLD SEPARATELY



SIMULATION

BIG DATA'S BIG BANG

Contents

Président-directeur général : Christophe Czajka
Directeur général délégué : Julien Elmaleh
Directeur du pôle industrie : Pierre-Dominique Lucas
Directeur de la rédaction : Thibaut De Jaegher
Directrice adjointe de la rédaction : Anne Debray
Coordinatrice éditoriale : Aurélie Barbaux
Chef d'édition : Guillaume Dessaix
Direction artistique : Eudes Bulard
Ont participé à ce numéro : Dorothée Coelho, Rebecca Lecauchois (secrétariat de rédaction) ; Charlotte Calament (maquette) ; Jean-François Prevéraud (rédacteur) et la rédaction de « L'Usine Nouvelle »
Supplément de « L'Usine Nouvelle » n° 3418 du 9 avril 2015 (commission paritaire n° 0712T81903)
Ne peut être vendu séparément.
Une publication du groupe Gisi, Antony Parc II - 10 place du Général-de-Gaulle - BP 20156 - 92186 Antony Cedex.
Directeur de publication : Christophe Czajka
Impression : Roto France Impression 77185 Lognes
Photo de couverture : Nodexl

WAITING FOR SIMULATION SERVICES

According to analysts, 2015 will be the year of big data experiments. This is confirmed by our 'Big Data's Big Bang' inquiry. Companies have realized that this new approach to data analysis is not limited to marketing. Without necessarily waiting for solutions to all organizational and data ownership problems, they are launching more and more projects, just like Airbus. Although there is enormous potential – for preventative maintenance, fault detection, anticipating complex systems' behavior, etc. – drawing out what this avalanche of data has to tell us is not without risks. Finding correlations in data batches to establish virtuous behavior rules for systems is certainly nothing new. This has long been possible using business intelligence. But big data's '3 Vs' (high volume, high variety, and up to real-time velocity) only complicate the task of IT departments and statisticians. To successfully carry out big data projects, companies need to decompartmentalize, break down silos, and open up to the outside world. There is no future for IT departments hidden away in ivory towers! Big data exists to find new hypotheses rather than validate existing ones. It is forcing us to accept that what we discover may be counter-intuitive or even completely challenge current practices. Lastly, big data could turn hierarchies upside down. "Big data is challenging the expertise of many self-proclaimed experts since its perspectives and forecasts are proving far more accurate," warns Professor Viktor Mayer-Schönberger of the Oxford Internet Institute. Big data will certainly not replace or even threaten numerical simulation. But by placing data at the heart of new business models, big data will inevitably change service products as well as everyone's work. It is thus opening up new fields in simulation services.

"By putting data at the heart of new business models, big data will change service products."

AURÉLIE BARBAUX

Interview

"DATA OWNERSHIP HAS BECOME AN ISSUE"

For **Yann Barbaux,** chief innovation officer at Airbus, simulating every interaction in aircraft and exploiting big data are essential to create new services.

INTERVIEWED BY OLIVIER JAMES

What do you expect from numerical simulation?

Aircraft are physically and technically complicated machines. They are also developing in a changing environment. We know how to simulate some interactions between various aircraft systems - the cockpit, engines, or landing gear - but not yet every scenario our designers ask us for.

Are your computing tools developing?

Until now, we used to build a "zero" plane, called an «iron bird, in a hangar after designing the equipment but before assembling the first aircraft. This was done for the A 350 XWB. An iron bird includes all an aircraft's systems but not its structural components. It enabled us to check everything was in good working order before assembling the first aircraft. One of our main development priorities today is what we call a "virtual iron bird". In other words, we want to simulate every interaction between an aircraft's various systems.

Surely this is the role of digital mock-ups?

No, a digital mock-up is only an aircraft's geometric definition. You don't know how French people behave just because you have a map of France. Likewise, you don't know how an aircraft's various systems interact just because you have its geometric definition. There are various types of simulation. I've just described simulation used in the aircraft development phase.

What other type of simulation do you need?

Simulation further upstream helps with aircraft design, immediately after drawing up the initial specifications. Simulation must also gradually go into the details, as far as simulating even the tiniest part and taking account of aerodynamics, fluid flow, and many physical parameters. We're aiming to develop a functional digital mock-up to run interaction loops checking that aircraft comply with their initial specifications. Due to the great diversity and complexity of physical phenomena, this mock-up does not yet exist.

Are you aiming to simulate an entire aircraft?

I'm not sure it would really be worth it. Although we must develop numerical simulation of entire aircraft, this needs to be by sections. There too big a difference in scale between an overall model simulating an aircraft's aerodynamics and another describing how a wing panel behaves. We need a multi-scale mock-up that can switch from local to overall scale, just as physicists are trying to find a model to switch from microscopic to macroscopic scale. It we really get down to it, this dream may become a reality within the next five years.

How much time do you hope to save?

For a completely new aircraft, we could reduce the development time by ten months. A complete cycle, from deciding to manufacture to coming into service, takes sixty months on average. But we're not just expecting to save time. The quality of parts is also involved. Common sense tells us that physical tests are more reliable than simulation. Except that each of these tests corresponds to an operating point. Simulation means we can introduce a spread of data. In other words, we can simulate many tests in various scenarios. This gives us a statistical-based approach to assess performance.

Can simulation be used to certify parts?

Certifying parts on the basis of numerical simulation alone is our dream. We're already preparing computer-based certification. For the A 318, we used numerical simulation to certify antenna positioning. This is a complex example. Antennas are disrupted by the aircraft structure and by one another. We proved to the certification authorities that a numerical simulation-based approach was possible by highlighting the similarities and differences with already certified aircraft.

Could this principle be extended to other parts?

Numerical simulation could help reduce less useful tests and help carry out necessary tests, and these only, "better". We want to do more physical tests in the preliminary phase, to increase the amount of data available. But we want to reduce tests in the more advanced development phase, which is long, expensive and doesn't always tell us more than other phases!

Is 100% numerical certification something we can envisage?

A cultural shift is emerging. But for numerical certification to be acceptable, we first need to establish rules on the

"One of our main development priorities today is what we call a «virtual iron bird». In other words, we want to simulate every interaction between an aircraft's various systems."

PASCAL GUITTET

basis of already acquired data, robust numerical models, and individual responsibilities. One of our current projects is uncertainty management.

What do you mean by uncertainty management?

Uncertainty in numerical simulation comes from test data and from software. Numerical simulation clearly isn't deterministic. We need to check how this uncertainty is propagated in various models. We may be able to do this analytically via mathematics. Or adopt a direct approach, running an example several times using a statistical approach similar to a series of physical tests.

Big data management is therefore an issue that lies ahead of you.

Yes, we've centralized our supercomputer resources in Toulouse and Hamburg in Germany. Big data technology has already enabled us to reduce how long we spend analyzing flight data for certification. Data mining is also helping us devise services with airlines. Putting this data together with aircraft data means we can optimize its exploitation and reduce fuel consumption, for example. By synthesizing data on the in-flight state of an aircraft fleet, we can optimize air traffic and develop aircraft predictive maintenance. We're reflecting on how to reorganize ourselves to take this issue further.

How do you organize data sharing?

Since data is given many values, no one wants to exchange it. Data ownership has become an issue. The appearance of chief data officers proves that it is an increasingly sensitive topic. For predictive maintenance, airlines own some of the data while Airbus or its sub-contractors own the rest. But to exploit this data, we need all of it. The economic models are unclear. And once the data has been collected, we need to know how to exploit it! We're tackling this fundamental technical issue very seriously since, in the future, big data may enable us to identify values where we were least expecting to find them.

EVENT

Immanent launch of the Supercomputers' plan

New Industrial France's supercomputers' plan is under way. Several major announcements are expected in 2015. These should give shape to the goals in this TERATEC-run program, both for supercomputer technology and numerical simulation use. But the industry sectors targeted by the plan are not all showing the same dynamism. For materials – whose entire life cycle is involved – a shared laboratory is being set up by major French manufacturers in this sector (metals, polymers, etc.). This will enable them to share problems and ways to resolve them. An announcement is expected by summer 2015. More of a surprise is the crop sector (agriculture and food processing), which has also picked up on numerical simulation. A crop technology park, which will bring together companies (John Deere, Limagrain, etc.), laboratories (INRA [French National Institute of Agronomic Research], BRGM [French Geological Survey], etc.), and modeling experts (CybeleTech, TERATEC), is to be built near Orléans (Loiret). Both these sectors, like others targeted by the plan (healthcare, urban systems, manufacturing industry, energy, and multimedia) are the focus of a project call launched under the 'Investment for the Future' plan. "Healthcare is potentially a heavy consumer of high-performance computing, but we're finding it hard to find the energy needed to make progress," admits Hervé Mouren, Teratec's director. Things are looking better for technology. A 150-petaflop supercomputer based on Bull architecture and much more energy efficient than current supercomputers is announced for 2016.

A 150-petaflop supercomputer, based on Bull architecture, is announced for 2016.

This is the first stage towards exaflop power (1,000 petaflops), which should be achieved by 2020. "We're ahead of the roadmap schedule," confirms Gérard Roucairol, who is managing the project. In addition, big data supercomputers will be developed in a laboratory bringing together major foreign manufacturers present in France.
Here too an announcement is expected by summer. **THIERRY LUCAS**

D.R.

Astrophysics

SPACE FLIGHT IN A CHAMBER

Erios, a space-flight simulation chamber.

The Marseille Astrophysics Laboratory (LAM, CNRS [French National Center for Scientific Research] – University of Aix-Marseille) has built a 90 m^3-vacuum chamber (45 m^3 usable) called ERIOS. It will be used to test the NISP (Near-Infrared Spectrometer and Photometer) instrument that will be sent into space in 2020 to scan the universe. It reproduces space-flight conditions, with a high vacuum (10-6 mbar) and a temperature of – 196 °C. The chamber is cooled to this temperature by an inner shell containing 500 liters of liquid nitrogen. To ensure stability, and hence accurate measurements, the instrument's supporting table is connected to a 100-tonne concrete block under the floor and rests on pillars via spring boxes. The NSIP project is managed by the LAM. This is one of two instruments for the Euclid mission launched by the European Space Agency. **THIERRY LUCAS**

Open Source

KWANT DESCRIBES QUANTUM SYSTEMS

The CEA-INAC (French Atomic Energy and Alternative Energies Commission-Institute for Nanoscience and Cryogenics), in collaboration with the universities of Leiden and Delft has designed Kwant. This online, open-source simulation platform for physicists enables them to study systems in quantum physics. The software works in a theoretical framework known as 'tight binding' and simulates samples or simplified models of systems. "It integrates core concepts. Physicists can use it to describe their quantum system by writing out their equations on the computer just like on a blackboard," explains Christoph Groth of the CEA. Kwant is the basis of the software codes t-Kwant, which calculates radio frequency time-resolved quantum transport, and ee-Kwant, which resolves N-body correlations. **J.-F. P.**

Aeronautics

A SKY SIMULATOR FOR COCKPITS

It took eighteen months to design the sky simulator.

The Chinese aircraft manufacturer Avic turned to Optis to develop cockpits operational in any light conditions. In a world first, Optis developed the sky simulator center, which can reproduce any flight condition for virtual validation of cockpits. The spherical-shaped solution covers all ambient light conditions, especially the worst, encountered during flights (effects of the sun and moon, clouds, dawn light, etc.). The tool combines real, calibrated sky luminance values for measurement tests with virtual reality applications run by SPEOS software photometric algorithms. The software recreates in-flight environments and is used to validate numerical models of cockpits at the start of the development process and real cockpits at the end of it. **J.-F. P.**

Computers

AN EXAFLOP SUPERCOMPUTER BY 2020

Japan launched its exaflop supercomputer project in 2014. It aims to have by the year 2020, a huge supercomputer with 1 exaflop power, i.e. 1018 or 1 billion billion floating-point operations per second. The construction has been entrusted to Fujitsu, developer of the K computer, currently Japan's most powerful supercomputer, with 10.5 petaflops (1 petaflop is equivalent to 1015 or 1 thousand trillion floating point operations per second). The investment amounts to 130 billion yen, i.e. 1.01 billion Euros. The future supercomputer, whose design should be completed this year, will be installed in the Riken advanced institute for computational science in Kobe, which houses the K computer. ■ **R. L.**

A huge supercomputer is being built in Kobe.

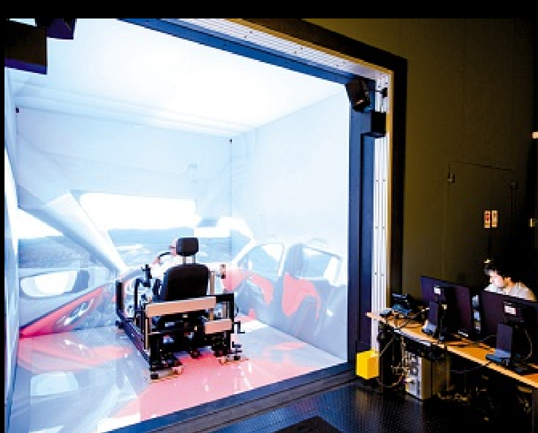
Marie-Paule Cani is a professor at the University of Grenoble INP – Ensimag.

Collège de France

MARIE-PAULE CANI CHAMPIONS 3D

Marie-Paule Cani, a computer graphics researcher, has taken up the 2015 annual chair of informatics and computational sciences at the Collège de France. She wants to share her vision of what 3D creation and numerical simulation can provide. Her sights are even set on designing a new intuitive 3D digital medium to create and gradually refine 3D static or animated objects. This could become a tool as easy to use as a pencil. "By using tablets to design, manipulate and animate 3D content, this tool could really revolutionize working methods in many fields," she says. ■ **J.-F. P.**

70 million 3D pixels for full-scale simulation



D.R.

Renault has equipped itself with IRIS (Immersive Room and Interactive System), a very high-definition immersive 3D visualization system. This 3 x 3 x 3 meter simulator made by Mechdyne has five active panels and a definition of 70 million 3D pixels. Operating at 60 Hz, IRIS calculates 19 new images every 16 milliseconds. This represents one image for each very high-definition Sony projector behind the screens. This real-time processing is provided by 20 or so HP computers, which develop the equivalent of about 20 teraflops. It is used to do a real-time detailed analysis of a vehicle viewed in a full scale, 3D embossed scene. ■ JEAN-FRANÇOIS PREVÉRAUD

Research

A CHAIR IN SMART GRIDS

RTE and the École Centrale de Nantes have created a research and teaching chair dedicated to the analysis and control of smart grids. Research will focus on the scale of smart-grid representation since real-time exploitation is impossible using current simulation models. The five-year goal is to provide solutions for running smart grids, which are incorporating more renewable, intermittent, and decentralized energy sources.

CNRS

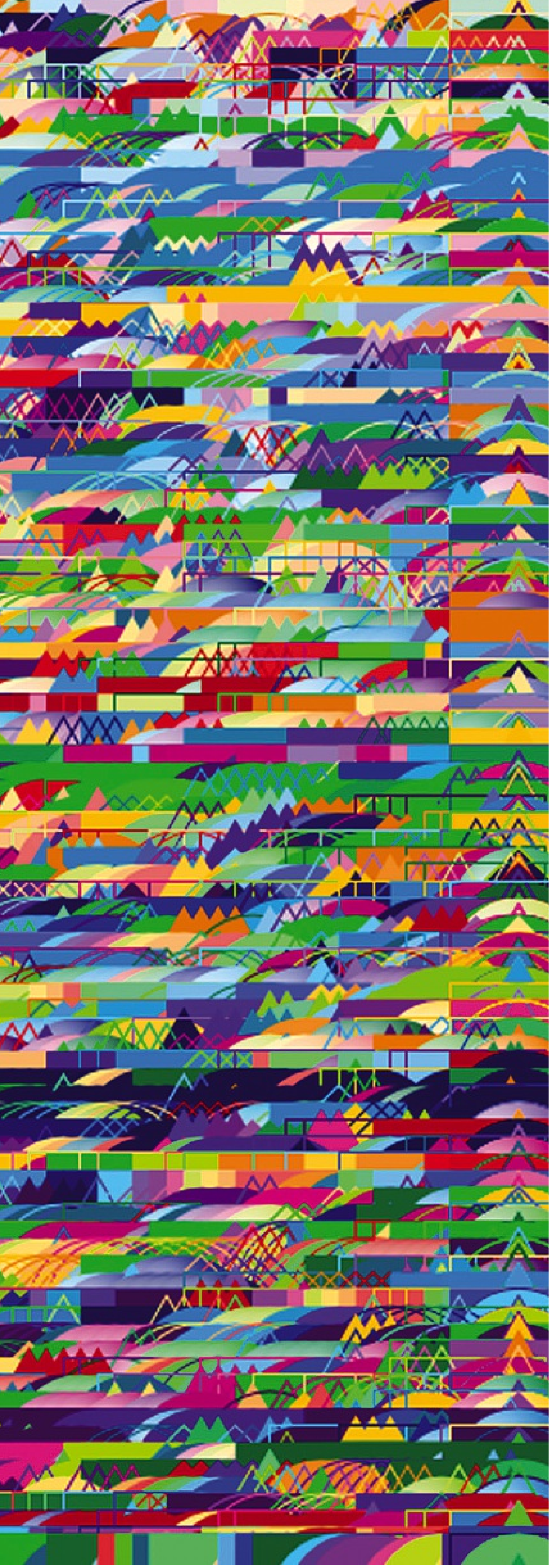
MEDAL AWARDED FOR CRACK SIMULATION

The 2014 CNRS silver medal has been awarded to Professor Nicolas Moës of the École Centrale de Nantes. Moës is a computational mechanics expert and is known for co-inventing the X-FEM method, which is based on extended finite elements. It enables 2D- and 3D-modeling of crack propagation without changing the mesh size during propagation. It is useful in the fields of composite materials, geology, and image processing.

Algorithms

THE INSTITUTE FOR TECHNOLOGICAL RESEARCH SYSTEMX IS ADAPTING TO THE CLOUD

The Institute for Technological Research SystemX's APA (parallel algorithms and remote-access technology) project aims to characterize high-performance, robust, asynchronous algorithms. These will be integrated into numerical simulation environments and tools (structural mechanics, fluid dynamics, and electromagnetism) exploiting the parallelism of supercomputers with hundreds of thousands of cores or distributed across the cloud.



Graphic illustration of Twitter data, using the NodeXL data visualization software.

Predictive Analysis

BIG DATA'S BIG BANG

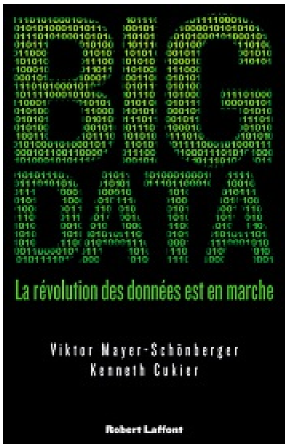
Big data is much more than technology for exploiting large volumes of data and predicting systems' behavior. It is a new culture shaking up our organizations

BY AURÉLIE BARBAUX

Numerical simulation will not be abandoned for big data. Although managing ever larger volumes of data is forcing us to rethink how we understand reality, there is a future for modeling systems from their components and changing input parameters to run these models. This is especially true for speeding up R&D, even though big data is shaking up everything. Big data first appeared at Google to exploit the avalanche of query data. For some people, it embodies new technology whereas for others it is a new culture. But it is still mainly perceived in terms of technology. Although there is no formal definition of big data, the American information technology research and advisory firm Gartner has described it using 3 Vs: "high volume, high velocity, and high variety." These three parameters have resulted in new storage and distributed computing tools.

But this technological change is only the tip of the big data revolution iceberg. "We now know how to measure every aspect of reality. But our relationship with data is changing

BIRTH OF A REVOLUTION



Professor Viktor Mayer-Schönberger of Oxford University's Internet Institute is a world authority on big data. Published in 2013, his book Big Data, co-authored with 'The Economist' journalist Kenneth Cukier, is a standard reference. All reports and books now refer to it or take up its examples of how this not so new data exploitation method is used. As early as the 19th century, the American cartographer Matthew Fontaine Maury systematized how navigation data for drawing nautical charts was collected. He took into account sailors' experiences related via messages in bottles cast into the sea! The digitalization of the world has systematized this approach, which is enabling us to work on complete, albeit imperfect, data sets from various sources rather than on samples. But as in Steven Spielberg's film 'Minority Report', Mayer-Schönberger and Cukier recommend having algorithms checked by 'algorithmists' to guard against a priori judgements. An avenue worth exploring.

since generating it now costs practically nothing," says Henri Verdier, France's chief data officer, in an interview for the collectively authored book 'Big, fast & open data' published by Epita et Fyp Éditions. This ability to generate the world's data from all types of sensors for almost nothing is overturning how scientists understand and simulate complex systems in both the hard and social sciences. This is first because scientists, who are used to relevant data being scarce and to sampling, can now work on complete data sets. Big data means reality can be perceived on a life-size scale. It even means we can be less demanding about the accuracy of this data, which is often disorganized, of variable quality, and from many different sources. In particular, working on complete, albeit imperfect, data sets may help us step back from causality, which is often a source of error and mistaken interpretation, explains Viktor Mayer-Schönberger in the book Big data [see above].

Big data deals with what rather than why

Big data works on the principle of discovering correlations that reveal trends, without explaining their cause. A correlation merely quantifies a statistical relationship between two values. There is a strong correlation if the second value is very likely to change when the first value is modified. Correlations merely indicate probability rather than certainty. They do not explain why something happens; only that it happens. Big data deals with 'what' rather than 'why'. And it does so very accurately. This means we no longer need to put forward and check hypotheses. We simply need to let data speak for itself and observe its interconnections, some of which we would never have imagined.

The strength of this approach is borne out in preventing mechanical and structural faults, forecasting biological reactions to chemical compounds, detecting faults in cars and instances of fraud, etc. "Predictive analysis enables us to obtain models we would never have thought of," says Charles Parat, director of innovation at the digital services company Micropole. This is apparently nothing really new for some companies. "Big data is simply a development of business intelligence. We've been doing it for ages. All of HP's simulation is already done using big data," explains Didier Kirszenberg, director of big data massive architecture at HP France. Except that the transition to 'n = everything' scale and real time is turning everything upside down. "We discovered that models learn faster with huge amounts of imperfect, incomplete data than with small amounts of efficient data," says Verdier. Furthermore, most big data developments center on machine learning.

Big data will have to bring about an organizational revolution to deliver its promised results. "An interdisciplinary approach, with mathematicians, statisticians, robotics engineers, business experts, etc., is required for big data" explains Stéphan Clémençon, an associate professor at Télécom ParisTech who holds the chair of Machine Learning for Big Data.

Asking the right questions

Data management is proving difficult. "Especially since data scientists no longer make do with internal data but are looking for external data to predict systems' behavior," observes Marc Batty, commercial manager at Dataiku. Launching big data projects therefore forces companies not only to break down internal silos and mix expertise but also to ask new questions. "The biggest difficulty for companies is daring to question how they do things," observes Laurent Letourmy, co-founder of the consultancy agency Ysance, in an interview with EPITA (French graduate school of computer science). "Daring to come up with questions is not particularly easy or natural." This is how a group such as PSA, which was thinking about using big data from car sensors for predictive maintenance, ended up asking questions about how cars are used.

Our relationship with risk has also changed completely. Enormous databases now exist to discover new hypotheses rather than validate existing ones. What we obtain from these databases may be counter-intuitive or even completely challenge existing practices. Companies must accept abandoning or suddenly refocusing a project, just like the most agile digital technology champions. "Big data behaves rather like venture capital. Perhaps only one out of five projects will be worthwhile," says Parat. Lastly, big data is shaking up hierarchies. "Decision-making in the workplace is becoming more democratic and big data is challenging the expertise of many self-proclaimed experts since its perspectives and forecasts are proving far more accurate," notes Mayer-Schönberger. It is better to be aware of this.

D.R.

THE DATA SCIENTISTS' TOOLBOX

Data scientists use infrastructure tools, which collect, store and prepare data from any source and in any format (structured, semi-structured, or unstructured), to draw out what big data can tell us. They then use machine learning's analysis and visualization tools to make this data understandable and exploitable.

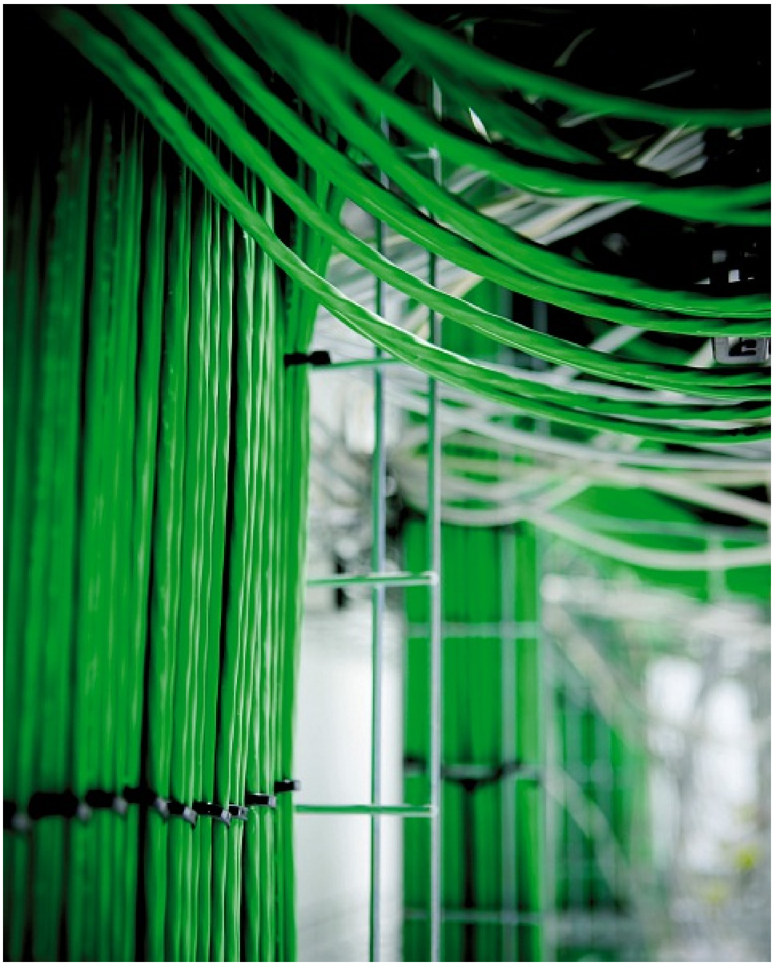
INFRASTRUCTURE TOOLS

NoSQL (Not Only Structured Query Language) databases store and manage large volumes of structured and unstructured data. The main open-source databases are MongoDB, Apache Cassandra, HBase, and Amazon DynamoDB. Software vendors' databases are called Vertica (HP), NoSQL Database (Oracle), and Document DB (Microsoft). Distributed computing frameworks separate algorithm queries, distribute them to parallel nodes (clusters), and reduce the results. The most well known is the Apache Software Foundation's open-source solution Hadoop, which was initially developed by Yahoo. It integrates tools such as MapReduce, GoogleFS, and BigTable developed by Google. A replacement - Spark - is now on the market.

ANALYSIS TOOLS

The two main open-source languages for writing algorithms are R and Pithon. There are also pre-programed modules, such as Apache Mahout for machine learning in Hadoop. Lastly, visualization tools developed by the software vendor Tableau are especially noteworthy.

Data scientists also use market tools inherited from data mining technology, such as SAS software and IBM's SPSS. IBM also offers an online tool called Watson Analytics. This is a natural language-based cognitive service, which loads cloud-based data sets to find ways of exploiting them. Some data scientists are also starting to share specialized algorithms, such as PredPol, which is used to identify and map crime hotspots. Not to mention start-ups that are developing specific algorithms to provide turnkey services [see page 12].



Big data analysis, a French speciality.

French tech

GIFTED FOR DATA

French start-ups are adept at drawing out what big data has to tell us. We present the top ten specialists helping companies with their big data projects.

BY RIDHA LOUKIL

With its exemplary mathematical training and high-quality engineering courses, France obviously has a role to play in big data. Although data collection, storage and processing tools remain the preserve of big American groups such as IBM, Oracle, SAS, Informatica and Teradata (or the open source community, with data platforms such as Hadoop), France gives added value by simplifying these tools and above all by analyzing big data to help business managers exploit it. This is currently small-scale work and can only be done by a few specialist data scientists. French start-ups are devoting their best resources to this still unexplored field. Some of them, such as PredicSis, Spikenet Technology and Quinten, are standing out with data mining algorithms, adapted to each business sector or type of problem. Others, such as Captain Dash, Dataiku, Hurence, Nexedi and OpenDataSoft, are developing online solutions for easier access to data storage, calculation, and exploitation tools. These solutions are accessible using simple web browsers. Still others, such as Data & Data and Perfect Memory, specialize in services. Originality is the trademark common to them all.

CAPTAIN DASH CROSS-REFERENCES INTERNAL AND EXTERNAL DATA

Service	
Date set up	December 2009
Place	Paris
Workforce	40 people
T/O	10 million Euros in 2017 (forecast)
Funds raised	1,5 million Euros

The company provides a data aggregation, correlation, and exploration service. It cross-references companies' business data with external data (open source, social networks, Internet, etc.) to determine, for example, how weather impacts on consumer purchasing behavior. The results are displayed as dashboard indicators on mobile devices and help manage sales and marketing campaigns. Almost everything is in real time. This solution is the result of three years' R&D and can process several billion data lines. It has been rolled out in 24 countries and is offered as a cloud-based subscription service for 80,000-500,000 Euros a year. It is used by a quarter of CAC 40 companies. Captain Dash plans to expand into North America this year.

CLIENTS BPCE, Axa, Danone, L'Oréal, SNCF, etc.

SPIKENET TECHNOLOGY INTERPRETS VIDEO IMAGES

Technology	
Date set up	August 1999
Place	Balma (Haute-Garonne)
Workforce	14 people
T/O	1,4 million Euros in 2014
Funds raised	None

Set up by CERCO (French Center for Brain and Cognitive Research) neuroscience researchers at the CNRS (French National Center for Scientific Research) in Toulouse, Spikenet has developed an artificial vision system inspired by the biology of human vision. The algorithm functions as an electronic eye, scouring and analyzing large volumes of video images. Its first application was for measuring

JÉRÔME GALLAND / GETTY IMAGES

brand visibility on TV. It has also been used by the police and security services to quickly decrypt video surveillance camera images, by transport services to monitor road traffic, and by casinos to optimize how they operate. Spikenet, which has 30 clients, sells the software on license or on royalty agreements for products using it. The company expects to generate turnover of 3 million Euros in 2015 and 10 million Euros within five years.

CLIENTS **French Ministry of the Interior, Aria Resort & Casino, Airbus, Aéroport de Bordeaux-Mérignac, Cofely Ineo, etc.**

DATA & DATA TRACKS DOWN ONLINE COUNTERFEITS

Service
Date set up September 2012
Place Paris
Workforce 10 people
T/O 3 millions Euros in 2015 (forecast)
Funds raised None

Data & Data provides a platform for monitoring and detecting counterfeits sold on the Internet and social networks. It has combined two in-house technology engines: one searching the Internet and social networks in 12 languages and detecting suspicious-looking accounts, and another using machine learning to sort genuine accounts from fakes. A counterfeit account can be detected within five minutes of being set up. Brands can therefore retaliate almost in real time by asking social networks to close down counterfeit accounts or by alerting customs. The service is currently available for luxury goods and cosmetics brands and will be extended to pharmaceuticals and car spare parts. Developing these algorithms was an investment of over 1 million Euros. To support its growth, Data & Data plans to recruit another 20 staff and raise 500,000-1 million Euros.

CLIENTS **Ten of the biggest French and Italian cosmetics and luxury goods brands.**

QUINTEN PROVIDES DETAILED ANALYSIS OF CLINICAL DATA

Service
Date set up November 2008
Place Paris
Workforce 25 people
T/O 2 millions Euros in 2014
Funds raised None

Quinten provides a detailed data analysis service, using an algorithm unique on the market. The system, called Q-Finder, is inspired by financial models. It identifies specific profiles and their opposites rather than trends. Its first application was for analyzing clinical-trial data sets, finding the patient category in which a given medicine had been effective and without major side effects. Over the past year and half, it has been used for more diverse applications: in finance (to forecast factors causing securities to rise or fall), in insurance (to detect customers about to switch to a competitor), in construction (to build passenger routes in airports), etc. Neurone network and machine learning functions have been added to this algorithm. Quinten plans to sell this algorithm as a software program in 2016.

CLIENTS **Covéa, Danone, L'Oréal, Aéroports de Paris, Sanofi, Roche, etc.**

PERFECT MEMORY MANAGES YOUR DATA

Services	
Date set up July 2008	
Place Chamalières (Puy-de-Dôme)	
Workforce 10 people	
T/O Not disclosed	
Funds raised 600,000 Euros	

Perfect Memory defines itself as a repository for companies' digital memory. Its web platform consists of 50 modules for collecting, processing, enriching, indexing, and increasing the value of data. This gives companies access to reliable, structured internal data (supplemented by additional data collected on the internet) to improve their marketing or how their customers understand them. The service combines an artificial intelligence and semantic web engine with a device saving and increasing the value of audiovisual content. Developing this service was a 2 million-Euro investment.

CLIENTS **Radio France, Belgian Ministry of Culture, Viacom, etc.**

HURENCE PUTS BIG DATA WITHIN REACH OF BUSINESS

Technology	
Date set up April 2011	
Place Grenoble (Isère)	
Workforce 10 people	
T/O Not disclosed	
Funds raised None	

Hurence was set up by former employees of IBM, HP, Xerox, and Capgemini. It aims to give marketing, sales, and other business managers access to data analysis. By using Docker image technology, its software platform can be easily installed on top of a Hadoop distribution, without specialist advice and support. With its interface, dashboard, etc., Hurence is two years' ahead of SAP and Oracle. There is no charge for a single data processor, but a fee is payable for machine clusters.

CLIENTS **EDF, Orange, Veolia, etc.**

DATAIKU, THE BIG DATA 'PLUMBER'

Services	
Date de création February 2013	
Place Paris	
Workforce 23 people	
T/O 1 million Euros in 2014	
Funds raised 3 millions Euros	

The data science studio platform provided by this Paris-based start-up makes big data more accessible by automating technical tasks requiring data scientist skills: preparation, cleaning and cross-referencing data, connecting to open source databases, testing analysis models, checking forecasts, etc. Released from all this 'plumbing' work, analysts can develop predictive business applications more quickly. The interface is inspired by video games, making it easier to gradually appropriate this tool. The software is free for less than 100,000 data lines. Beyond this volume, it is sold on a subscription basis, starting at 20,000 Euros a year. About twenty clients have already been won over. The company made a profit in its first year (2014), which is quite rare.

CLIENTS **Cdiscount, PagesJaunes, Vente-privée, BlaBlaCar, Chronopost, etc.**

NEXEDI, THE FRENCH ALTERNATIVE TO HADOOP

Technology	
Date set up December 2001	
Place Marcq-en-Barœul (Nord)	
Workforce 30 people	
T/O 2 millions Euros in 2014	
Funds raised None	

This open source software vendor has launched Wendelin, an open source platform it presents as the French alternative to open source technology developed by the American giant Hadoop. Their solution combines Neo - its NoSQL database - and INRIA's (French Institute for Research in Computer Science and Automation) Scikit-Learn machine learning engine. The specific feature of this solution is in overcoming the limitations of memories in large data processors. The current version, which can be downloaded free, is suitable for 10 GB of data. An 'Investment for the Future' project aims to extend its capacity to 10 TB within three years. This solution is for processing data from industrial connected objects.

CLIENTS **Sanef, Infoterra, Mitsubishi Motors, etc.**

OPENDATASOFT POOLS DATA

Services	
Date set up December 2011	
Place Paris	
Workforce 10 people	
T/O 600 000 Euros in 2014	
Funds raised None	

This software vendor has produced a cloud-based platform for publishing, sharing, and reusing data. It transforms data so that it can be used in business applications and is easily accessible in real time, including on mobile devices. Users can cross-reference their own data with other sources (socio-economic, customers, weather, etc.), thus creating innovative big data uses. Several clients can share their data to broaden the analysis base and improve the quality of results. New features are added to the platform every week.

CLIENTS **Axa, Veolia, SNCF, RATP, Keolis, La Poste, etc.**

PREDICSIS DETECTS FRAGILE CUSTOMERS

Services	
Date set up July 2013	
Place Lannion (Côtes-d'Armor)	
Workforce 18 people	
T/O 300 000 Euros in 2014	
Funds raised 1 million Euros	

With its solution for predicting customer behavior and internet users, PredicSis helps companies reduce their rate of attrition, i.e. the number of customers lost. This software is based on a machine learning engine and draws on ten years of R&D at Orange Labs. It aims to improve customer retention by analyzing customer-operator interaction data. Almost 750,000 behavior-related variables are scrutinized to identify fragile customers. After inputting all their customer interactions (e-mails, web logs, etc.), companies obtain a list of consumers that are on the point of leaving them, together with their reasons. This is an online subscription-based service, starting at 100 Euros a month.

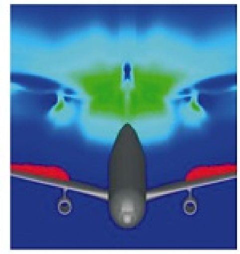
CLIENTS **Renault, Orange, Sodexo, EDF, 1000 Mercis, etc.**

SIMULATION PROCESS INTEGRATION IS KEY FOR SUCCESSFUL INDUSTRIAL PROJECTS

As we move forward in the product development cycle, costs associated with a system or a design change increase significantly. The continuous search for competitiveness and reactivity compels our customers to detect non-compliances in the product lifecycle as early as possible. Thanks to Digital Simulation combined with Virtual Testing, the product could be physically prototyped at the early phases for real tests. Beyond relevant benefits on tests costs – a car crash simulation is cheaper than a real crash test -, Virtual Testing mainly allows the optimisation of efficiency and numbers of necessary real tests. Indeed, simulation enables the definition of sizing-tests and key measure indicators, and the checking of bench capacity protocol to support these ultimate cases.

Moreover, an anticipated identification of gaps limits the necessary iterations on product design, and reduces all at once the development cycle.

Likewise, in complex systems design, availability of subsystems is staggered over time. The use of a simulator as a test tool all over the product lifecycle, allows the emulation of non-available subsystems at a given time to reveal the whole final system's behaviour. Subsystem models are then replaced by real equipments as soon as they are available. This other Virtual Testing application makes every unitary subsystem test easier as well as its integration to the remaining subsystems, while maintaining an overview of the potential impact on the final system.



Sogeti High Tech simulation department addresses sectors such as Aeronautics, Space, Energy, and Railway, with a wide range of simulation services covering simultaneously the simulation of physical phenomena, complex systems and flows.

Therefore, Sogeti High Tech offers a unique expertise in integrating and creating enterprise-wide simulation solutions.
Sogeti High Tech simulation department provides you with consulting, studies, development and training services, throughout your entire simulation process, combining both Engineering and IT skills.

Simulation benefits strongly depend on the use of appropriate technologies. Hence, Sogeti High Tech attaches great importance on:

- Advanced materials (composite, elastomer) and complex phenomena (rapid dynamic, fatigue, breach...);

- The definition of efficient modelisation methods (macro-elements, response surface) and efficient specific computation codes development (HPC);

- The automation of the CAD/meshing/computation chain in order to optimise multi-physical concepts;

- Taking into account Hardware in the Loop and co-simulation in real-time simulators;

- The implementation of effective Simulation Data Management (SDM) enabling rapid access to data as well as sharing enterprise-wide.

Contact :

Caroline Martins Petitjean
Simulation & Scientific Software Director
Sogeti High Tech
Caroline.martins@sogeti.com

www.sogeti-hightech.fr

Sogeti High Tech

2-10 rue Marceau - CS 70400
92136 Issy-les-Moulineaux Cedex

Tel. : +33 (0)1 40 93 73 00
E-mail: infohightech@sogeti.com

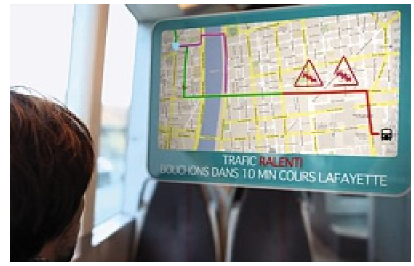
Big data
8 TEXTBOOK EXAMPLES

"Big data is in fashion. According to certain studies, half of companies are interested in big data but don't necessarily know how to benefit from it," says Ghislaine Doukhan, who has just been appointed head of Safran Analytics. The division, set up in early 2015, is responsible for developing services based on data exploitation. Safran is a forerunner, but it is not the only manufacturer to take advantage of big data. Although the most successful projects tend to be in the service sector, as proved by Accor, M6 and Adictiz, initiatives at Airbus, PSA, BMW and Santen seem off to a good start. We review the state of play.

BY RIDHA LOUKIL

QUICKER PLANE TESTING AT AIRBUS

Before delivering its planes, Airbus checks that their in-flight performance complies with design-phase specifications. Aircraft are fitted with sensors for these tests: 6,000 on the first flight and 200 on subsequent flights. Test sensor data is cross-referenced with on-board sensors after each test flight. Any difference detected indicates a problem that needs fixing. "Data analysis tasks and incident detection requiring corrections are performed by human brain power," reminds Jean-Marc Wattecant, who is in charge of big data at Airbus. The problem is that the volume of data generated per day of test flights doubles with each generation of plane: it has risen to 2 terabytes for Airbus's latest model, the A 350. Not to mention the fact that 400-600 users need simultaneous access to this data. It was inevitable that Airbus would make the transition to big data. "Our initial goal is to provide simultaneous access to data via Google-type technology," explains Wattecant. "But we're also going to set up a statistical analysis engine for automatic data correlation. This will enable us to detect and correct issues more quickly." The first phase has been up and running since the beginning of this year. The second phase will follow in the second quarter. This solution is based on an Oracle big data engine, supplemented by technology developed in-house and at Sopra. In all, the A 350's test campaign will last four months and generate dozens of terabytes of data. "Instead of analyzing data flight by flight, we will be able to use multi-flight analysis in the future. This will improve incident detection, find the causes of problems more quickly, and reduce the number of test flights," predicts Wattecant. **R. L.**



IMPROVING URBAN TRAFFIC FLOW IN LYON

The Optimod'Lyon R&D project aims to improve urban mobility and traffic flow in Greater Lyon. Launched in 2011 with 12 partners, including IBM, Orange, Renault Trucks and Cityway, it has developed two innovations based on big data technology. The first is a navigator for mobile devices providing real-time urban mobility data. The application developed by Cityway helps users modify their journeys according to real traffic levels. The second, created by IBM, is a 1-hour traffic forecast system. It took centralizing data from various types of transportation and the installation of over 350 traffic sensors in the city. "Real-time traffic forecasts were used on motorways, but never in heavy traffic settings such as Greater Lyon," points out Philippe Sajhau, vice-president of IBM France's Smarter Cities program. Since not all roads are equipped with sensors, IBM created an algorithm that assesses traffic levels on roads without sensors by interpolating and modeling data from connected roads. Traffic forecasts are updated every six minutes to take account of any unexpected events, such as accidents. Lyon's central traffic control and regulation center sends these forecasts to three levels: mobile-device navigators, freight transporters (to optimize delivery rounds), and soon to the traffic light control system. Forecasts are improved by integrating the impact of incidents and response plan outcomes. Lyon is expected to make the transition from the test phase to rollout this year **R. L.**

D.R.

SANTEN OPTIMIZES ITS R & D

For the past two years, Santen has been using Quinten's big data service in galenic studies and clinical trials for its ophthalmic drugs. "Our profession generates a lot of data," says Jean-Sébastien Garrigue, general manager of this innovation center that employs 80 people. "We exploit data to make our R&D more effective." The former Novagali Pharma, acquired by the Japanese firm Santen in 2011, has a database comprising several hundred thousand pieces of data on the physico-chemical composition of its drugs. "We use about thirty excipients with different concentrations. We had to test thousands of compositions to find one with the desired effectiveness, stability, and innocuousness," explains Garrigue. "We find suitable virtual formulations by analyzing this data using Quinten's Q-finder algorithm." Tests on patients during clinical trials generate over a million pieces of objective data. Santen, which is based in Évry (Essonne), also uses the Q-Finder engine to explore data and identify patient categories in which medicines are most effective and have the least side effects. "This is how we zeroed in on our eyewash for treating ocular dryness in patients with severe keratitis," says Garrigue. Using traditional statistical methods requested by health agencies would have involved a long, tedious iterative process with no guaranteed result. "We're in a profession prone to setbacks. Big data helps us reduce risks, become more competitive and invest more money in later clinical phases, which are very expensive." **R. L.**

BMW USES BIG DATA ON ITS VEHICLES

Many car recalls are due to faults that went undetected during tests. BMW wants to reduce if not completely eradicate these recalls. Its magic formula is big data: specifically, a big data predictive analysis solution supplied by IBM. BMW has collected enormous amounts of data from its development, testing, production, after-sales, and repair departments. No less than 15,000 faults were recorded for prototype tests alone. Predictive analysis of this data will help BMW detect and correct faults before new models are launched into production. BMW will thus be able to optimize its entire industrial line, from vehicle design to maintenance. Until now, it took several months to analyze this quantity of data. But big data technology means it now only takes a few days. The results can thus be integrated into design and production processes in time. Detecting and correcting faults quickly avoid breakdowns after vehicles go on the market. The solution rolled out by BMW is based on SPSS statistical analysis software. It provides the benefit of automating certain recurrent analyses for BMW's divisions and subsidiaries. Over 500 users at BMW have access to around 250 analysis applications. **R. L.**

PSA DRAWS OUT WHAT CONNECTED VEHICLES CAN TELL US

PSA is speeding up its big data projects. "In the future, we want to be able to capture and analyze data from our connected cars so that we can offer drivers customized services," states Brigitte Courtehoux, PSA's director of cars and connected services. The group currently has a pool of 1.5 million cars, each one of which can potentially provide thousands of pieces of data from a hundred or so in-car sensors. PSA plans to extend data collection to other sources, such as the internet, social networks, and mobile devices. The first applications aim to improve overall vehicle design. Which is why all the relevant business units (development, production, quality, etc.) are involved. "Analyzing the data collected will give us detailed understanding of vehicle faults and drivers' behavior," says Courtehoux. "We'll know which features they use most frequently, those they never use, how many times a year they open their car roof, etc. This will help us adapt our vehicle design to user needs and adjust prices accordingly." Around fifty people are working on this project in PSA's technical center in Poissy (Yvelines). This workforce can increase to as many as 100 people according to requirements. The group, led by CEO Carlos Tavares encourages experiments to identify priority rollout projects. PSA Peugeot Citroën relies on IBM's big data tools. "But the real expertise is human intelligence: our data scientists' ability to model the application and identify the values to extract from huge masses of data," concludes Courtehoux. **R. L.**

D.R.

ADICTIZ ANTICIPATES PLAYER BEHAVIOR

Adictiz's web-based and mobile social games change every week. They are adapted to take account of players' behavior while they are getting used to a game. The goal is to keep players for as long as possible, develop virality (recommendation) and encourage monetization (purchase of virtual goods). For the past two years, this Lille-based SME employing 40 people has been using big data to optimize its games. The company provides entertainment for 40 million players worldwide, 4 million of whom are active each month. "We used to adapt our games using general data and by intuitive choices," says Alexis de Charentenay, its director of business development. "We now have a structured approach based on analyzing players' behavior." To achieve this result, the company recruited a data scientist and used Microsoft's cloud-based big data solutions. Up to 5,000 players are monitored in real time every day. "The data collected provides information about where games are abandoned, how long sessions last, how much players spend on virtual assets, whether or not the game is at the right level and has enough virality," explains de Charentenay. This weekly analysis helps developers improve the game. The goal is to keep players by creating a feeling of frustration that makes them purchase virtual goods to carry on playing. "One month after a game is launched, it is 60% different from its initial version," says de Charentenay. This approach has generated a 30% increase in monetization. **R. L.**

M6 UNCOVERS THE SECRETS OF TV COMMERCIALS

What is the real impact of TV commercials on purchasing? How can we explain their effectiveness? M6 has been using big data to answer these questions since 2011. Shopping data is measured on a panel of shoppers and cross-referenced with their media consumption data. M6 has built up a database of 1,200 commercials for this purpose, representing over 100,000 data lines: campaign budgets, TV channels chosen, time slots when commercials are broadcast, brands, products involved, etc. "It's impossible to exploit this database with the naked eye," says Carine Groz, director of M6's research group. Especially as new variables, such as the weather, are added to it every year. M6 analyzes this data using Quinten's big data service. Data is presented in Excel file format and processed by the Q-Finder algorithm. The reconstructed results then just have to be explored to identify the keys to effective commercials by brand, product, etc. This analysis has confirmed the traditional factors in making a strong impact, such as powerful campaigns, using celebrities, and choosing evening slots for chocolate commercials. "Although we already knew this from experience or intuitively, it had never been measured," says Croz. This work has also uncovered some unknown principles, which even go against the trend of received ideas. "We discovered that summer and weekend slots, which had hitherto been neglected periods, were good times for advertising, especially for small- and medium-sized brands," explains Groz. M6 aims to help advertizers optimize their campaigns beyond established advertizing criteria and make them more effective. In this way, M6 hopes to develop their loyalty. **R. L.**

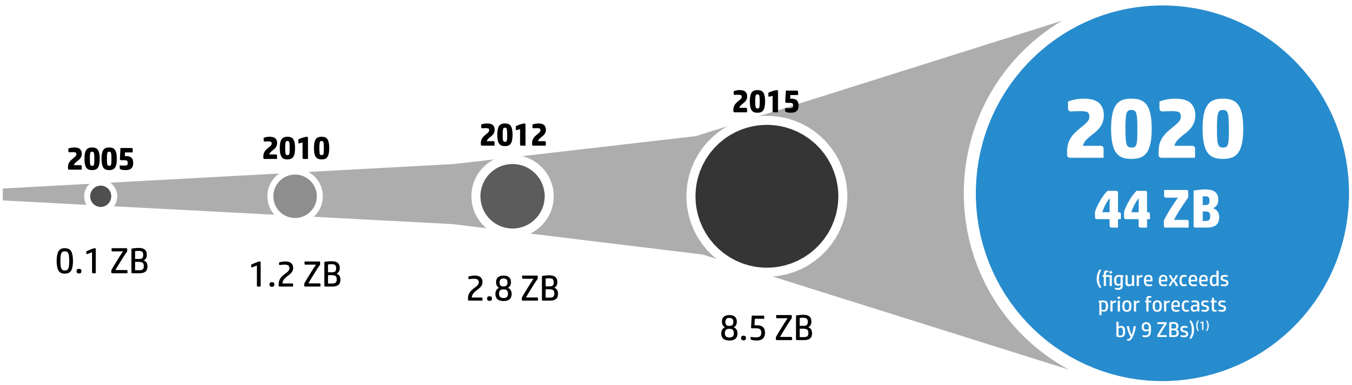
ACCOR CUSTOMIZES ITS SERVICES

Accor is customizing its offers to boost sales and develop customer loyalty. It started by centralizing data into a database of 50 million customers. "It was a complex operation since we had to reconcile various sources in database management systems for the group's call centers, websites, and 3,600 hotels," explains Hervé Mignot, a partner in the consultancy firm Equancy that supported Accor throughout the process. The database is segmented into 17 groups (frequent customers, foreign customers, business customers, etc.). The goal is to improve conversion rates during customer interactions via call centers or websites. When already listed customers make contact, they are identified automatically. Based on their profile, history, service consumption habits and preferences, a recommendation engine selects suitable offers, calculates their probability of being accepted, and presents customers with its highest scored offers. All this is done in real time. The algorithm, based on an Oracle solution, improves as and when it is used. According to Amélie Hameau, head of CRM projects at Accor, this system generated over 140 million recommendations in 2014. These increased the website click-through rate by 50%, nights purchased by 100%, and customized banner ad turnover by 200%. Nevertheless, the group has chosen not to rely on this automatic engine alone. "The system allows for human intervention to keep control of marketing strategy, especially for new offers," points out Mignot. Developments to the engine should enable it to recommend complementary services, such as airport transfers, visits to cultural sites, and reservations for shows **R. L.**

D.R.

The Machine:
A new kind of computer

Data explosion outpacing technology



Next-generation competitive advantage delivered through:

- **Business insight at real-life speeds**
- **Personalized content that follows you**
- **Questions that arise automatically from data**

(1) IDC "The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things" April 2014

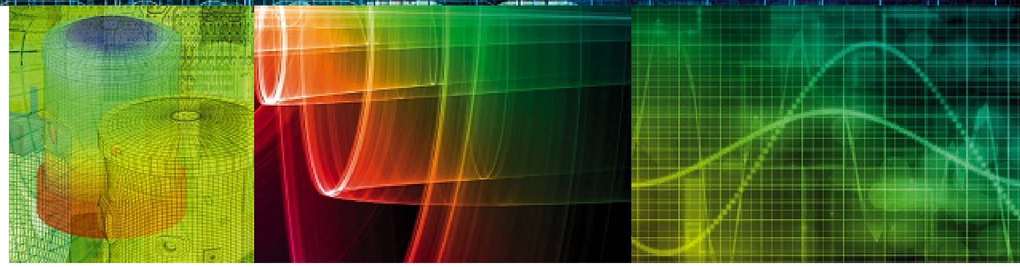
By 2020, 30 billion connected devices will generate unprecedented amounts of data. The infrastructure required to collect, process, store, and analyze this data requires transformational changes in the foundations of computing.

Learn more

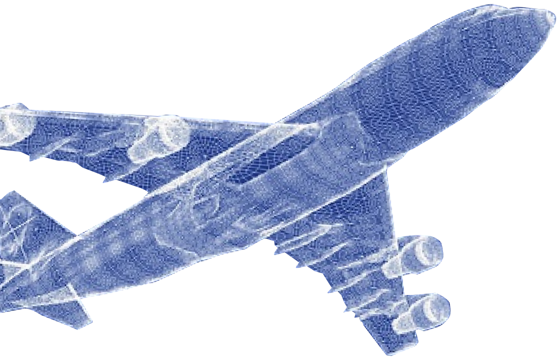
http://www.hpl.hp.com/research/systems-research/themachine/

DESIGNER, INTEGRATOR & OPERATOR OF MISSION-CRITICAL SYSTEMS

The power of innovation



How can we optimize the added value of Big Data, simulation, and HPC?



Digital simulation represents a major opportunity for improving the performance of companies. The emergence of Big Data with the development of smart connected objects is also a challenge that has both economic and social implications. The exponential growth of calculating power allows increasingly rich simulations and makes it possible to process and analyze large volumes of data.
But to take full advantage of the development of these technologies, it is more and more vital to be able to leverage their potential and to make them accessible to operational users.

INDUSTRIAL BIG DATA PROVIDING SOLUTIONS FOR PREDICTIVE MAINTENANCE

With the increasingly widespread use of often interconnected sensors (accelerometers, RFID chips, GPS, etc.), the volume and complexity of the data produced is growing. However, currently available data analysis algorithms in Machine Learning and Data Mining are poorly suited to processing the large numbers of time series produced by these sensors. Moreover, the various tools that make it possible to mine this data are often unconnected, making it necessary to set up time-consuming processing chains with no real added value for the end user.

In response to this problem, CS has launched the **IKATS** project (Innovative ToolKit for Analysing Time Series). This initiative, run in collaboration with the Laboratoire Informatique de Grenoble (LIG) and supported by Airbus and EDF R&D, aims to provide a ready-to-use toolkit that will give the user all the necessary software for handling, exploring/analyzing and visualizing large numbers of time series within a single framework. Analysis of this data will make it possible to determine essential predictive models, for example in the field of predictive maintenance. There are countless potential applications. For manufacturing industries, where sensors are used to monitor and maintain large-scale operating systems (aeronautics, energy, rail), IKATS will make it possible to model and monitor manufacturing lines and processes. It will also to be possible to use it as part of industrial operating systems based on hi-tech products and requiring high-performance supervision by networks of sensors: in particular, energy optimization. Not to mention areas that include connected and monitored objects: smart buildings, quantified self, telecommunications, the military, and so on. The IKATS project comes in addition to PLM solutions offered by CS, as well as digital simulation and high-performance computing solutions.

DIGITAL SIMULATION: A DIFFERENT APPROACH TO MULTI-PHYSICS CFD

Simulation is essential to the competitiveness of companies. It makes it possible not only to design products that are relevant to clients' needs more rapidly, but also to understand complex phenomena. In this field, CS facilitates cost-effective access to technology and shares its expertise in high-performance calculation and studying physical phenomena.
CS has, working with Renault, Airbus and other partners, developed **LaBS,** a digital simulation tool for fluid mechanics, based on the Lattice Boltzmann method networked and optimized for High performance computing. This solution makes it possible to simulate poorly compressible fluid flows around and inside complex shapes. Thanks to its accuracy and outstanding performance, at optimum cost, LaBS is already being used in the automobile and aeronautics sectors for aerodynamic and aero-acoustic applications.

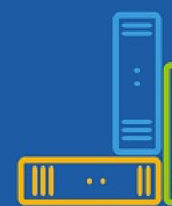
CS: a major player in digital simulation and industrial Big Data

Combined CS expertise in multi-physics simulation, high-performance calculation, PLM, and processing and analyzing large volumes of data allows us to help our clients to speed up their production and cost optimization processes throughout the life cycle of a product or system.

communication.cs@c-s.fr

DATA CENTER 2.0

Our mission:
Accelerate the digital service economy by removing the limitations inherent in today's datacenter infrastructure



1. PREPARE TO GOBBLE UP IMMENSE AMOUNTS OF DATA.

More Internet users ...

2012	2018
2.3 BILLION	3.9 BILLION [1]

Our lives are increasingly digital. Is your data center up to the task?

... are generating more data

2013	2020
4.4 ZETTABYTES	44 ZETTABYTES [2]

1 "Cisco Visual Networking Index: 2014 VNI Complete Forecast Introduction." Cisco (June 10, 2014).
2 The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet. EMC (April 2014).

2. AVOID THE PITFALLS OF AN AGING INFRASTRUCTURE.

Inefficient server performance and utilization

Shrinking storage capacity

Increasing network latency

3. LEVEL UP TO STRENGTHEN YOUR DATACENTER.

Master cloud computing.

Build your cloud on a highly virtualized environment for substantial efficiency gains and cost savings.

9

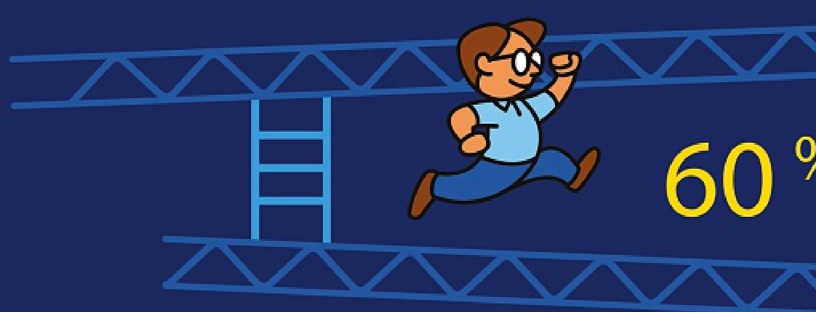
Increased ne
when Intel IT upgrad
Ethernet (GbE)

LEVEL 2:

Capture more valuable data.

Optimize storage systems. Start with advanced capabilities: data deduplication, thin provisioning, and compression. Add solid-state drives.

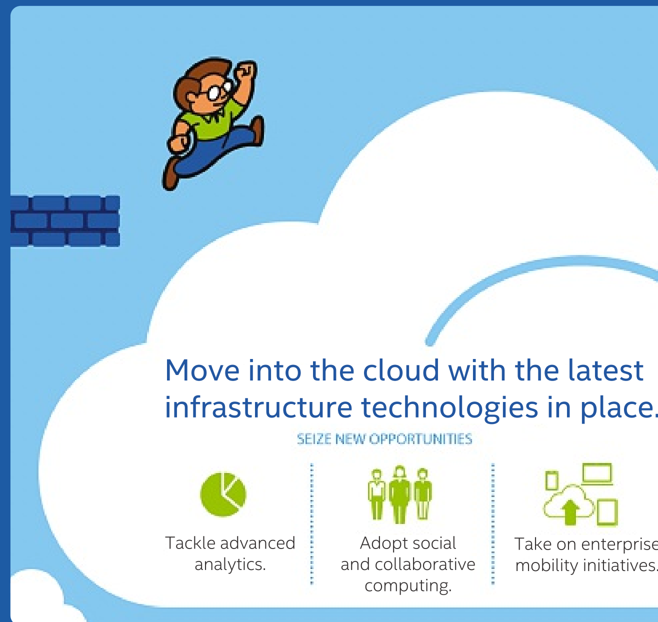
$33M



60 %

3 Intel IT's Data Center Strategy for Business Transformation. Intel (January 2014).

by intel®



4. EXPLORE WHAT YOUR ENTERPRISE CAN DO.

Workload custom optimized silicon: Intel leadership delivering 3 generations of SoCs

0 days to 3 hours: reduced provisioning time achieved by Intel IT [3]

$9M Intel IT's net savings during five years, with $20 million anticipated total program net present value (NPV) [3]

LEVEL 3:

Earn 10x, 40x, and 100x network speed bonuses.

twork bandwidth ded to 10 gigabit (over three years)

400 %

Upgrade 100 Mbps and 1 GbE connections with 10, 40, and 100 GbE connections.

Intel IT's cost avoidance from new capabilities, accelerated refresh, and increased utilization [3]

27 % Intel IT's increase in server capacity when Intel® Solid-State Drives deployed as "fast swap" drives [3]

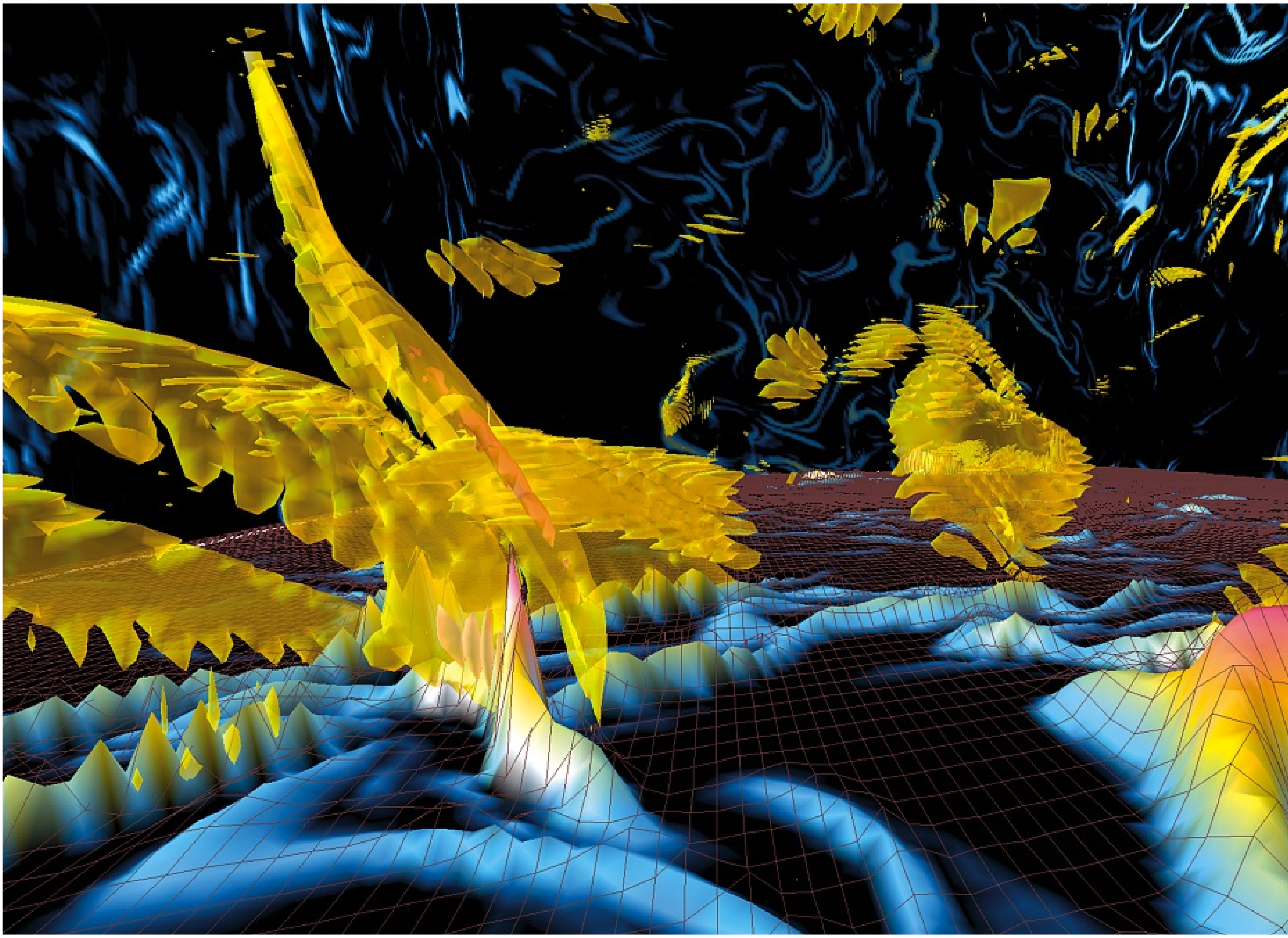
LEVEL 1:

Get more compute and virtualization power.

Consolidate servers and boost efficiency, performance, and security.

% server virtualization across Intel's Office and Enterprise environments [3]

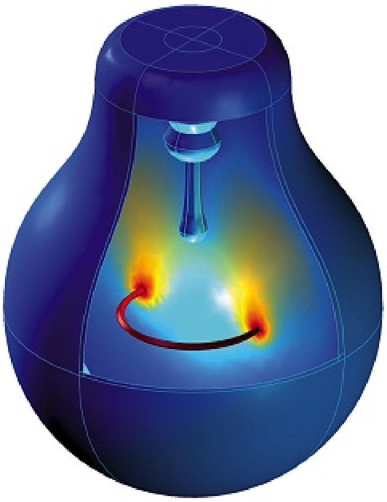
35:1 Virtualization ratios achieved by Intel IT using the latest Intel Xeon® processor-based servers



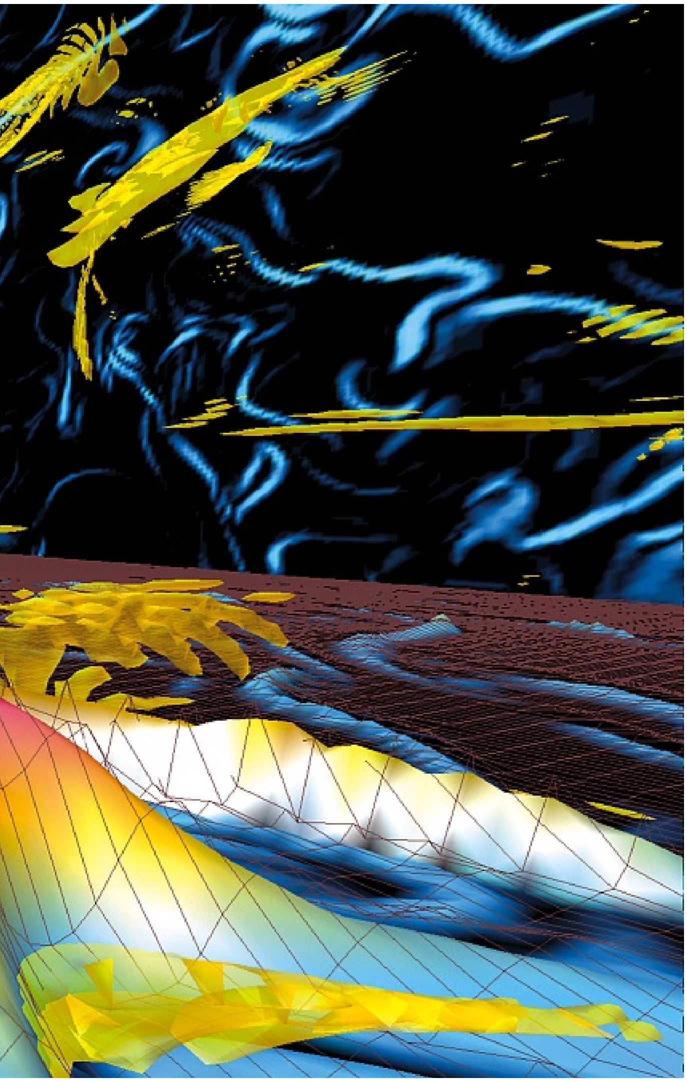
Portfolio
BEYOND REALITY

Visualization and simulation software leads us to see what we do not see, three dimensionally and in color. Projecting the observer into a fourth dimension.

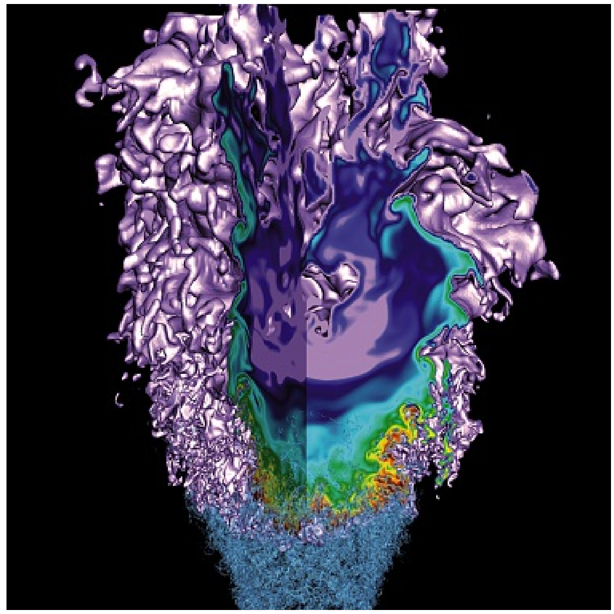
BY THIERRY LUCAS



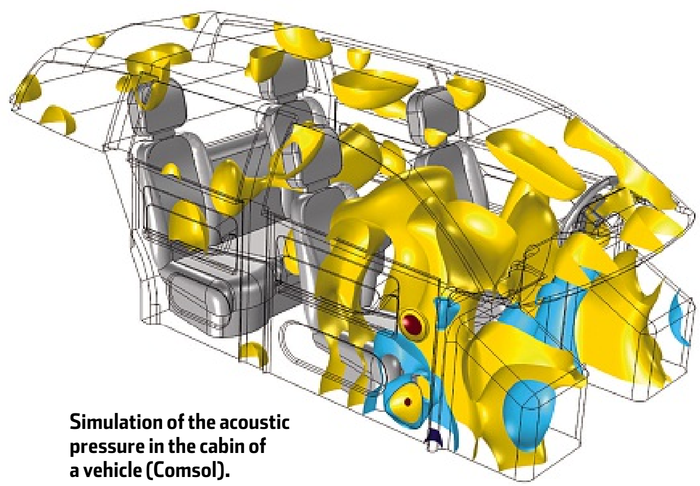
Temperature distribution in a light bulb (Comsol).



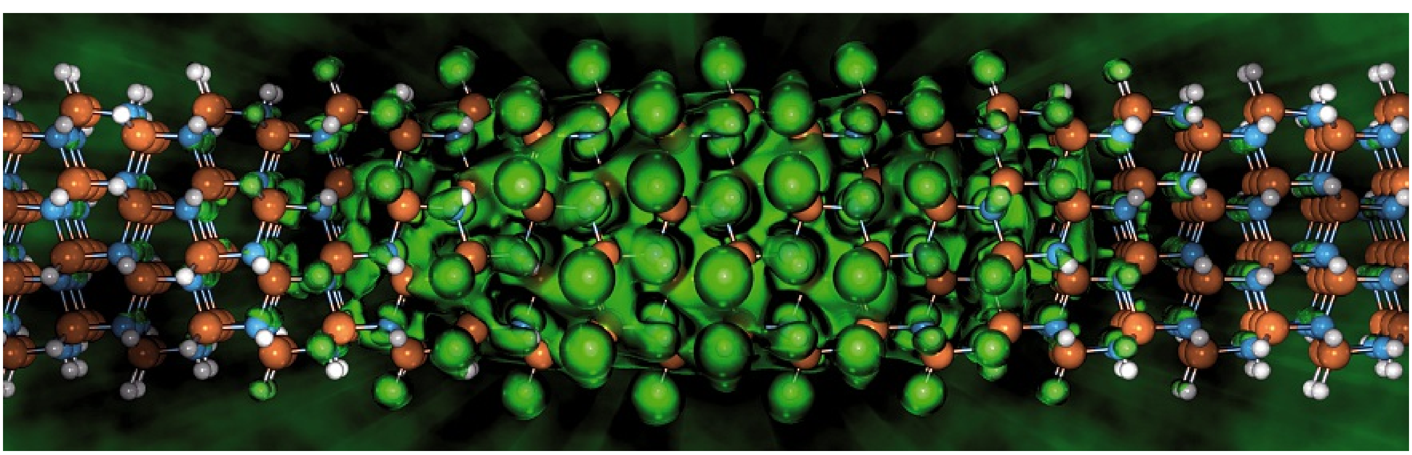
3D view of fluid turbulence (NERSC).



Turbulence in a flame (NERCS).

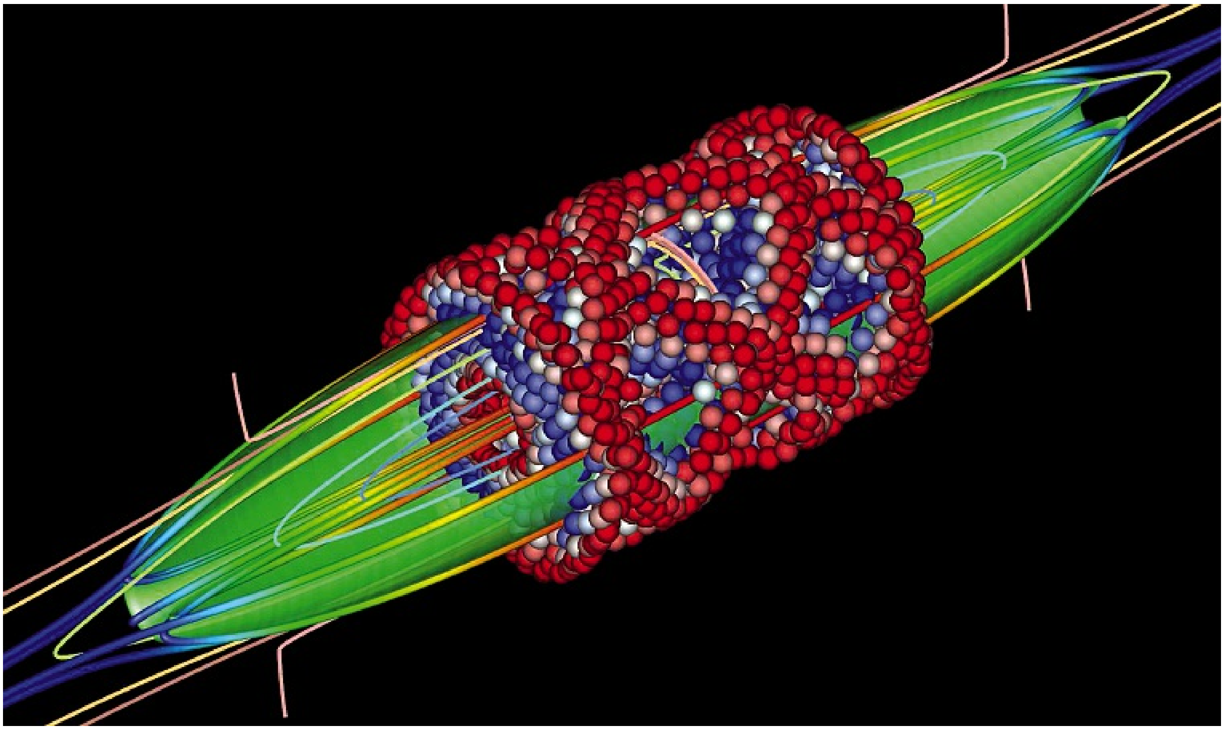


Simulation of the acoustic pressure in the cabin of a vehicle (Comsol).

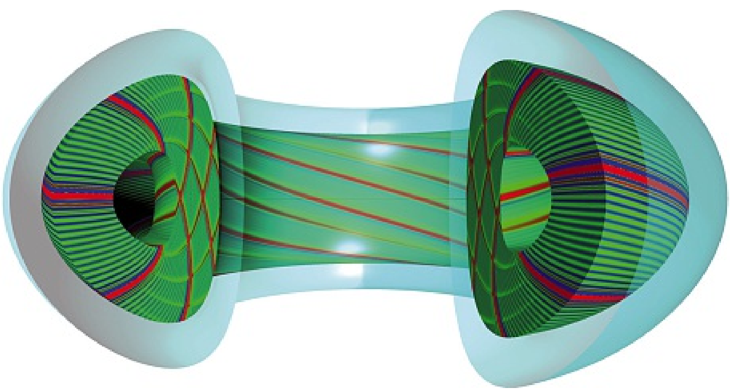


D.R.

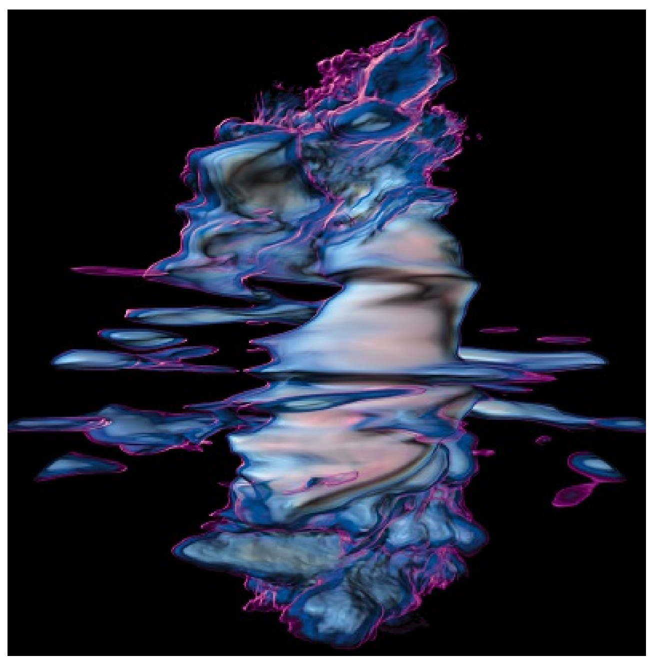
Molecular modeling of LED materials (NERSC).



Trajectory of an energetic ion in a magnetic field (Nimrod).



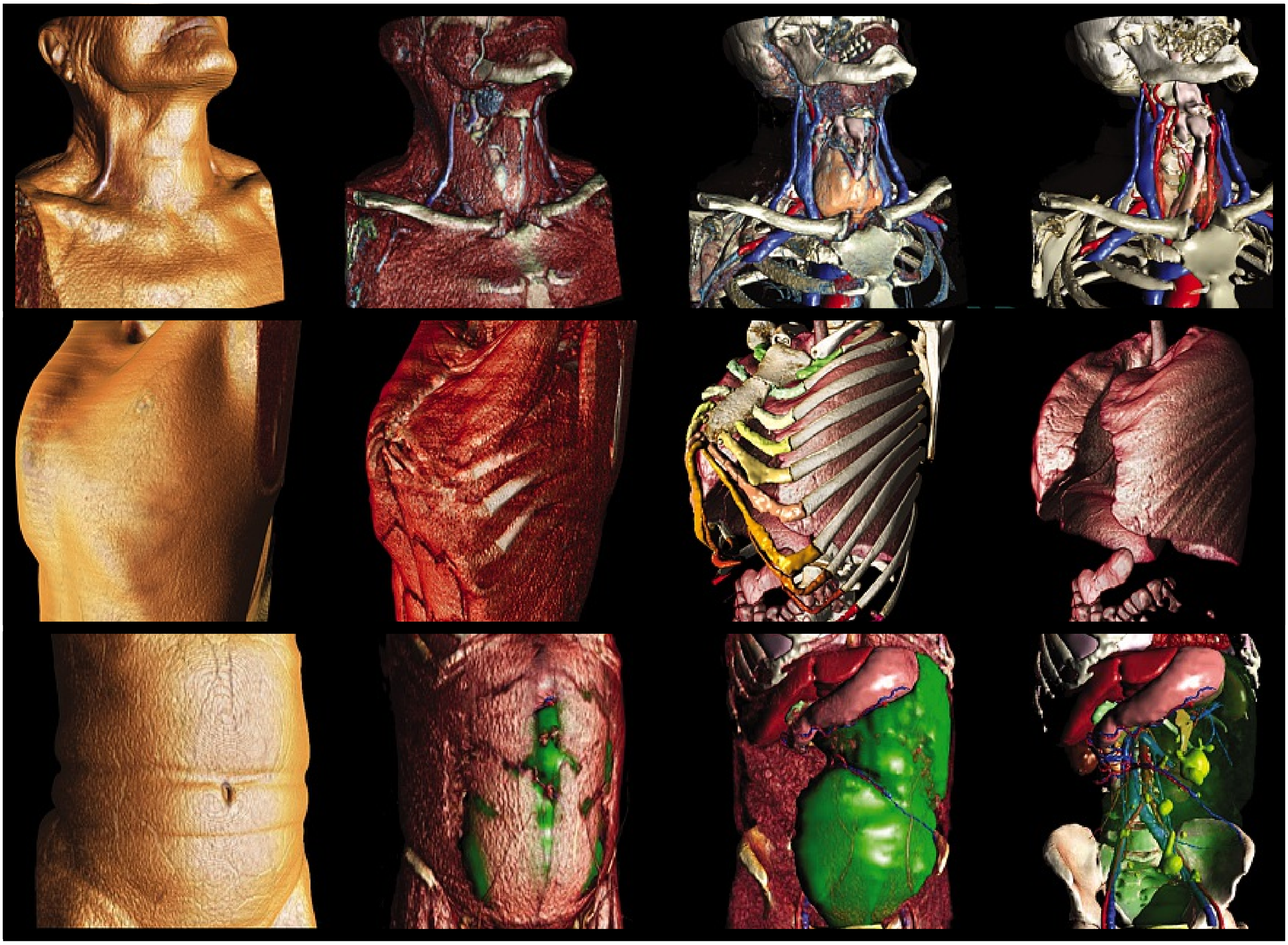
Plasma of a tokamak (nuclear fusion) simulated with the software GaCode from General Atomics.



Vortex in solar plasma (University of Texas, Austin).

Urban traffic simulation (Sumo).

D.R.



Visible Patient is a start-up that helps surgeons prepare for operations with 3D modelization.

Research

MODELING THE HUMAN BODY

Simulating the body's main organs is giving rise to new diagnostic aids and a choice of therapies.

BY THIERRY LUCAS

TECHNOLOGY FOR...

- **Predicting** the risk of developing an illness or its progression
- **Optimizing** a patient's drug or surgical treatment
- **Selecting** new medicines
- **Designing** patient-specific implants

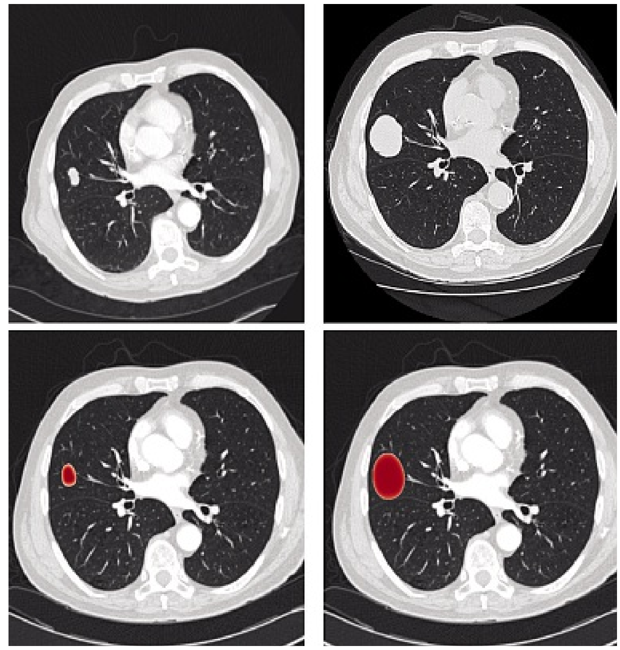
The problem with human beings is that they are all different. Although it could be an essay question on a philosophy exam, for engineers it becomes a crucial practical problem when it comes to simulating a human heart, liver or brain rather than mechanical components or an electronic circuit. Simulation for treating patients only really makes sense if it is patient-specific. In order to meet surgeons' expectations, simulation of the human body must also represent how it operates at every level, from molecules, cells, tissues and organs to the entire body. Vast international research programs, such as the Physiome Project and the Virtual Physiological Human Project, are attempting to encompass this complex reality. Laboratories involved in this project are using mathematical models and medical images to construct anatomical and physiological 'organ simulator' software. They also aim to use this software in combination for more realistic simulation. This objective has taken a new direction. Combined use of software programs, which is currently impossible, is less of a concern. New projects aim first and foremost to validate models and progress to medical applications. These projects focus on vital organs (brains, liver, heart, etc.) and pathologies that are public health issues in developed countries (cardiovascular disease, Alzheimer's disease, cancer, repetitive strain injury, etc.).

The brain holds a special place. It is at the center of large-scale projects with budgets of several million Euros or dollars: the Human Brain Project (HBP) in Europe and the Brain Initiative in the USA. The HBP, run by the EPFL (Switzerland) and the University of Heidelberg (Germany) is thinking big: it hopes to improve understanding of how the brain works, create new diagnostic instruments, and invent computers inspired by neurone networks. This could be over-ambitious since some neurobiologists dispute its relevance. Nevertheless, the project started at the end of 2013 and involves thousands of researchers. Many research teams throughout the world are also working on heart simulation, which is yielding results for prevention and therapy [see article on page 30].

Invaluable aid to surgeons

Although the liver receives less media attention, it is nevertheless essential. Apart from its role in metabolizing and storing many different substances, this largest of the body's organs plays a key anti-toxic role in eliminating potentially dangerous products for the body. It also helps assimilate medicines. The Virtual Liver Network, a consortium of German laboratories, intends to construct a virtual liver model, with several applications in sight. The goal in pharmacology is improved understanding of how the liver breaks down active molecules. Patients' tomographic images are used to construct an anatomical model. In combination with data about patients' genome, this should enable scientists to predict how a particular person assimilates a given medicine so that treatment can be made patient-specific. Some illnesses could be caused by lipid accumulation in the liver. Simulation is making it easier to understand this phenomenon so that it can be anticipated. Lastly, the liver has a well known if poorly understood ability to regenerate after inflammation or an operation. Simulation may help identify methods to encourage this regeneration (diet, healthcare, etc.).

British scientists at the University of Leicester are using medical images and genomic data to create patient-specific models of respiratory tracts. This work, carried out in partnership with the AirProm project, aims to predict the development of illnesses such as asthma so that treatment can be adapted to each patient. 'Simple' anatomical modeling is already proving an invaluable aid to surgeons. Teams from the French National Digestive System Cancer Research Institute (IRCAD) in Strasbourg have successfully automated the generation of 3D visual models from medical images (scans, MRIs, etc.). The online service offered by Visible Patient, a spin-off company from the institute, is currently used by around fifteen hospitals and has already helped over 2,500 patients. Surgeons supply images of their patients and receive back a 3D model enabling them to prepare operations: setting up instruments, anticipating difficulties, and choosing the best strategy. "Modeling means we can operate on patients initially judged inoperable," says Luc Soler, IRCAD's director of R&D. Currently, the main limitation is that some images (especially MRIs) are not very sharp. In addition, this procedure is not reimbursed by the French social security system. The IRCAD is actively working on simulation to help surgeons during operations. In other words, guiding surgeons' hands by



The Inria in Bordeaux has perfected models of tumeral growth. Here the evolution of a pulmonary tumor.

D.R.

Beating cancer

Modeling tumour growth is a way to predict the development of an illness. This helps choose the best time for an operation or for changing to chemo- or radiotherapy. The INRIA (French National Institute for Research in Computer Science and Automation) in Bordeaux has developed generic and patient-specific models of tumour growth for this very purpose. The most advanced model, which simulates the formation of pulmonary metastases, was validated using data from 30 patients. «We're aiming to design software as a service that doctors can test in real-life situations,» says Thierry Colin, director of this Bordeaux research team. Large-scale clinical trials will then be required. The team has extended its approach to other pathologies with specific models (brain tumours, for example). It also aims to use simulation to predict when a particular course of treatment will no longer be effective on a patient.

superimposing a virtual model of patient organs on a surgeon's real but nevertheless restricted vision. There is still the problem of complex automatic realignment of these two images since patients breathe and their organs move during operations. The Strasbourg team hopes to offer the first application in 2016: virtual 'transparent' positioning of organs beneath the skin to make incisions as safe and accurate as possible. A real-time guiding system for entire operations is not expected before 2017 and will be limited to just one organ: the liver.

IMPROVED PREVENTION OF BONE DISEASE

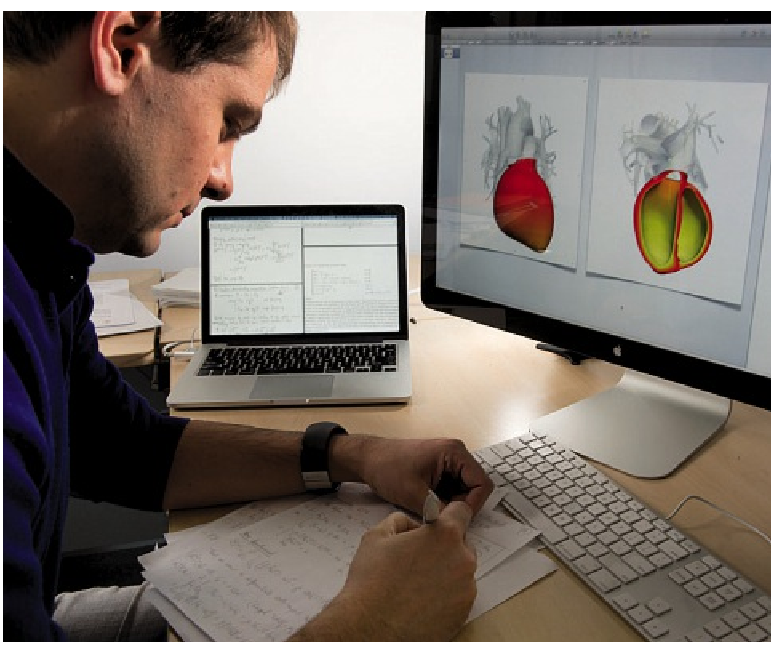
As with organs, simulation may be beneficial to the skeleton. Major public health issues are at stake. For example, osteoporosis (brittle bones) causes millions of bone fractures in Europe every year. Musculoskeletal simulation, which models how bones behave and the strain to which they are subjected, may improve prevention and treatment of this pathology and other bone diseases. This is the realm of biomechanics, whose practitioners are often trained mechanical engineers who subsequently took up biology. Special issues are involved: specific bone behavior laws and other more complex viscoelasticity laws for soft tissue and ligaments. "The problem is obtaining materials' mechanical properties to feed into simulation models. We can get bone rigidity from tomographic images, but it's more difficult for soft tissue," explains Damien Lacroix, Professor of Mechanobiology at the University of Sheffield (UK). Models of the femur, with muscles and ligaments, have been developed for a hundred or so patients.

Designing patient-specific implants is another use of this type of simulation. Such software may be useful to clinicians. "It may enable the risk of fracture to be detected, and also monitor the effect of a course of treatment," says Lacroix. Industrial funding, for example from implant manufacturers, is still needed for genuine clinical trials. Another application is treating chronic lumbar pain. In this case, simulation assesses the consequences of operations. The same team is also working on modeling interactions between various parts of the body. Although it is easier to create a model of an isolated body part or organ, this is never how the body works.

NUMERICAL SIMULATION OF HEARTBEATS

Joint efforts by engineers and clinicians to simulate the heart are paving the way to new methods of prevention and treatment.

BY THIERRY LUCAS



H. RAGUET/INRIA

Simulation combines a numerical anatomical model with a system of equations describing heart behavior.

How long is a heartbeat? On a fairly powerful desktop computer, it is about two hours. In other words, the time required to simulate a cardiac cycle by calculating various physical phenomena: electrical activity (triggering heart-muscle contraction), mechanics (heart-wall movement), and fluid dynamics (blood flow).

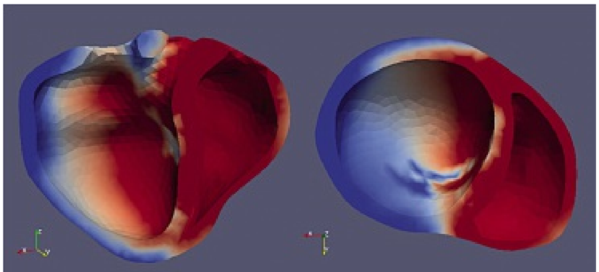
Carrying out this simulation requires a numerical model of human heart anatomy, which is constructed from scans and magnetic resonance images (MRI). Heart behavior is described by systems of equations. By using the equations and numerical model in combination, an entire cardiac cycle can be simulated. What is a patient's risk of atherosclerosis or arrhythmia? Does a pacemaker need to be fitted? What are the best sites for electrodes on the heart? Which tissue should be operated on if an intervention is required and what are the consequences? Simulation is the least invasive way to answer all these questions since everything is done on computers via a numerical model. Various manufacturers are involved in constructing a numerical heart model. Philips (medical imaging) is a partner in the European VP2HF project, which is focused on therapies. Medtronic (heart implants) is involved in the Living Heart project launched by Dassault Systèmes. Their engineering expertise is essential to make progress for numerical heart models.

D.R.

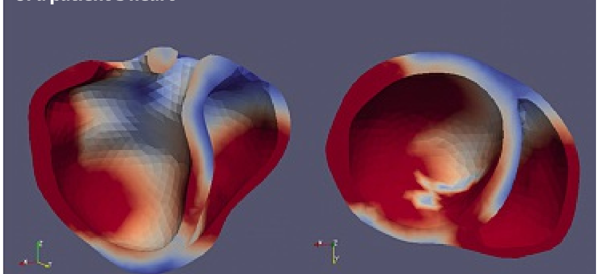
Designing patient-specific medical equipment

Many heart patients live with medical equipment in their body: pacemakers, replacement valves, stents, etc. The manufacturers that design them often use modeling and calculation software to develop these devices. But the success of an operation depends on finding the right implant for each patient's body. The Living Heart project, launched by Dassault Systèmes in 2014, is aiming to adapt implantable equipment to each patient. This specialist digital design software vendor is applying its 3D modeling expertise to heart simulation to achieve industrial goals. The medical equipment manufacturers Medtronic and Sorin are partners in this project, as is Insilicomed, a spin-off from the University of California (USA) that has developed heart models for medical-equipment design engineers. Dassault Systèmes also wants to attract leading heart modeling research institutes to its project: Stanford University and University College, London are already involved.

"I started with work on structural calculations for mechanical and civil engineering," recalls Dominique Chapelle, director of the French National Institute for Research in Computer Science and Automation (INRIA). The team is working on heart modeling and is involved in the VP2HF project. Heart modeling experts at American universities often belong to mechanical or aerospace engineering departments. When dealing with an organ as complex as the heart, expertise in structural mechanics or fluid dynamics is not enough. To simulate the heart, it is essential to combine modeling of various phenomena.



BEFORE Modeling of electrical activation of a patient's heart



AFTER Modeling of the heart after treatment via cardiac resynchronization therapy

Risk prevention

Many tests and analyses can be carried out on patient-specific numerical heart models, thus avoiding risks and saving money. HeartFlow, an American start-up that is a spin-off from a laboratory at Stanford University, has developed a non-invasive test to assess the risk of heart disease. Scan images are used to construct a heart model and calculations provide the fractional flow reserve (FFR), a factor in assessing the effect of narrowing the coronary artery on blood flow. Numerical testing is replacing invasive and sometimes unnecessary tests. HeartFlow, which is at an advanced stage of clinical trials, is awaiting authorization from the Food and Drug Administration, the American regulatory agency for food products and medicines. In Europe, around twenty partners are involved in the ARTreat project on preventing atherosclerosis [Ed. note: hardening of the arteries]. Numerical models that simulate the initialization and development of cholesterol plaques on artery walls are detecting risk areas. The initial results correlate well with patient data. Further clinical trials will be required before it can actually be used, which is expected for 2018. Modeling may also be used to detect the risk of arrhythmia, which is being attempted by the Computational Cardiology Lab at John Hopkins University (USA). Although calculation is generally limited to one cardiac cycle, INRIA researchers are aiming to model heart behavior from one hour to up to a year to simulate the development of certain pathologies.

Choosing and optimizing therapies

Cardiac resynchronization therapy (CRT) by fitting a pacemaker is ineffective in 30% of cases. Virtual tests on patient-specific heart models may detect this 30% and help choose the best sites for electrodes before operations. An INRIA team is working on this application of patient-specific models. Comparative tests with data from many patients are due to be carried out with St Thomas' Hospital, London as part of the European VP2HF project. "We're aiming to prove that this model is predictive," says Chapelle, INRIA's director of research. Numerical modeling may also be beneficial to preparing radiofrequency ablation, another treatment for heart rhythm problems that involves 'burning' certain tissues. To this end, CardioSolv, a start-up that is a spin-off from laboratories at John Hopkins University, wants to use patient-specific modeling to identify areas that need to be treated. Treatment optimization is another research goal: researchers at University College, London are trying to establish the most suitable stent for each patient. Researchers at the University of California are attempting to understand why coronary artery bypasses sometimes fail. Numerical simulation is also being used for emerging therapies: Stanford University's Living Matter Lab is using simulation to predict the best stem cell injection sites for treating acute myocardial infarction. Finally, patient-specific models may enable virtual adaptation of heart patients' drug therapy.

Patient-specific models

"Combining mechanical and electrical phenomena is quite effective and is already enabling us to model pathologies. We're making progress on the link with fluid mechanics - blood flow -, which means we are able to refine our modeling," explains Hervé Delingette, an INRIA researcher who used to work in medical imaging. But the crux of the problem for clinical applications is obtaining a patient-specific model. This alone will help doctors and patients make decisions. But it isn't easy. Unlike artificial systems (car components, mechanisms, etc.) the input parameters - for example tissues' mechanical properties - are poorly understood. Constructing patient-specific models presupposes using a generic heart model together with data measured on patients (MRIs, scans, ECGs, etc.) to find parameters needed for calculations to reconstitute this very same data. Again, using engineering to solve this 'inverse problem' makes sense. "We've developed inverse methods inspired by methods used in automation," says Chapelle. Inverse methods are at the core of the VP2HF project. Patient-specific models are being developed by all American laboratories and start-ups focused on preventative and therapeutic applications.

But things are far from fully resolved. Progress is still needed on combining various phenomena and on models' various scales, from heart cells to tissues and the whole heart. Another difficulty is designing tests to validate heart models. Procedures need to be specified and funding found for clinical trials. Neither pharmaceuticals laboratories nor medical equipment manufacturers are heading up projects. Calculation time is another essential factor that needs to be taken into account. In the short-term, optimized computing and parallel computing architecture could make it ten times faster. Then it will perform sufficiently well for numerical modeling to become another piece of equipment used in hospitals.

JOHN MOTTERN/FEATURE PHOTO

Nuclear

SIMULATING NUCLEAR FUSION TO REPLACE TESTS

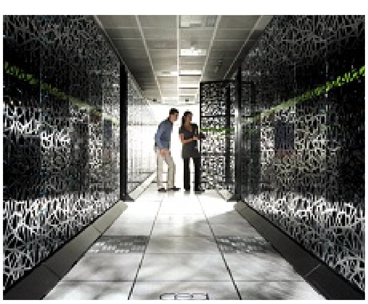
Ever since nuclear testing ended, America and France have been developing simulation methods to ensure the continued reliability of their nuclear weapons.

BY THIERRY LUCAS

The laser chamber at Megajoule is reinforced with 20 cm boron-doped concrete to absorb neutrons.

Experts at the CEA (French Atomic Energy and Alternative Energies Commission) speak of maintaining a nuclear deterrent. This raises a major issue: how can the safety, reliability and efficiency of nuclear weapons be ensured without carrying out tests? France has not conducted open-air tests of its nuclear bombs since 1996. French research has instead invested in complex simulation methods to continue assessing their reliability. Calculation-based numerical simulation uses the world's most powerful computers. They are also used in physical simulation: half of the French simulation program's budget – i.e. 3 billion Euros – has been allocated to building the Laser Megajoule (LMJ) facility. This installation is for very small-scale reproduction and study of fusion reactions triggered in nuclear weapons.
Both France and America are gradually installing remarkable facilities for both these aspects of nuclear simulation. The CEA-DAM (Military Applications Division) computing center in France, and the Lawrence Livermore National Laboratory in the USA, are home to the world's most powerful supercomputers, which are used exclusively for nuclear deterrent work (see box). Physical simulation using the LMJ facility near Bordeaux began in October 2014. America has been using its NIF (National Ignition Facility) laser for the past five years. The principle underlying both installations is to amplify and focus a large number of laser beams – 192 in the NIF and 176 in the Laser Megajoule facility once it is finished – onto a target a few millimetres in size. The intense heat and pressure – 100 million °C and 10,000 times

AN EXAFLOPS SUPERCOMPUTER



CEA; D.R.

The Tera 100 supercomputer calculates the effects of nuclear weapons.

Following the transition to simulation tests, nuclear deterrents now require enormous computing capacity. Several weeks of calculations are sometimes needed to simulate physical phenomena occurring in nuclear weapons with the CEA-DAM's current Tera 100 (1 petaflops = 1015 calculations per second) designed by Bull. From 2015 on, the CEA and Bull are to have the supercomputer used exclusively for nuclear deterrent work upgraded to 20-30 petaflops power. The architecture of this Tera 1000 supercomputer will foreshadow the future Exa 1 supercomputer, planned for 2020 and expected to achieve exaflops (1000 petaflops) power. Bull announced the broad outlines of its exaflops program last November. In the USA, the National Nuclear Security Administration (NNSA), which is responsible for ensuring that America's nuclear weapons are reliable, is also on the way to achieving exaflops capacity.
IBM will be delivering its Sierra supercomputer (120-150 petaflops) to the Lawrence Livermore National Laboratory in 2017. The Sierra supercomputer is also expected to perform calculations for the NIF superlaser, used for physical simulation of nuclear weapons.

atmospheric pressure – trigger a very small-scale nuclear fusion reaction, which is nevertheless representative of what happens in nuclear weapons. After various ups and downs, American scientists obtained results showing the fusion reaction pathway in 2013. France, which started with eight laser beams (ramp-up will take several years), will first be conducting experiments on the resistance of materials under extreme conditions.

X-ray photos

Nuclear-weapons' simulation on both sides of the Atlantic is based on a combination of computer calculations and measurements made in physical experiments. Numerical simulation involves a software string simulating the complex physics at work in nuclear weapons: behaviour of materials, interactions with photons and neutrons, plasma turbulence caused by the explosion, etc. These calculation-based simulation models must be validated by the results of physical measurements, which will be provided by experiments with NIF lasers in the USA and the Laser Megajoule facility in France. Physical simulation also uses X-ray machines: the DARHT (Dual-Axis Radiographic Hydrodynamic Test) facility in the USA, and Epure (Expérience de Physique Utilisant la Radiographie Éclair; Physics Experiment Using Flash Radiography) in France (equipment is shared with British scientists). These take X-ray 'photographs' of ultrafast phenomena occurring in nuclear weapons just before nuclear reactions. Other experimental research conducted at the Sandia National Laboratories (USA) has simulated aging of stored nuclear-warhead electronic components. This research is also intended to help maintain a nuclear deterrent.

The French Laser Megajoule facility is far from complete and it will take several years to finish building its amplification chains (250 industrial partners are involved in the project). Other countries are following suit; Russia plans to install a simulation laser for nuclear deterrents in Nizhny Novgorod, and is looking for industrial partners to build it. China expects to commission its Divine Light project in 2020.

EXCEPTIONAL TECHNOLOGY FOR THE LASER MEGAJOULE FACILITY

Some 250 industrial partners have contributed to the innovative technology and production methods for making this facility's components.

BY THIERRY LUCAS

On 29 January 1996, the French President, Jacques Chirac, announced the end of French nuclear tests. On 23 October 2014, the French Prime Minister, Manuel Valls, opened the Laser Megajoule (LMJ) facility in Le Barp (Gironde). The LMJ will recreate reactions occurring in nuclear weapons and, together with numerical simulation, will replace tests as a means of ensuring the reliability of France's nuclear deterrent. Almost two decades' worth of R&D, which extended the boundaries of optical, electronic, mechanical, etc. technology, was carried out between these two dates. Innovative manufacturing methods were developed by the project's industrial partners. Factories were specially set up to manufacture LMJ components in optimum conditions. From the initial laser impulse to the millimetre-sized target on which a nuclear fusion reaction is triggered, practically everything had to be invented.

A PURE SOURCE

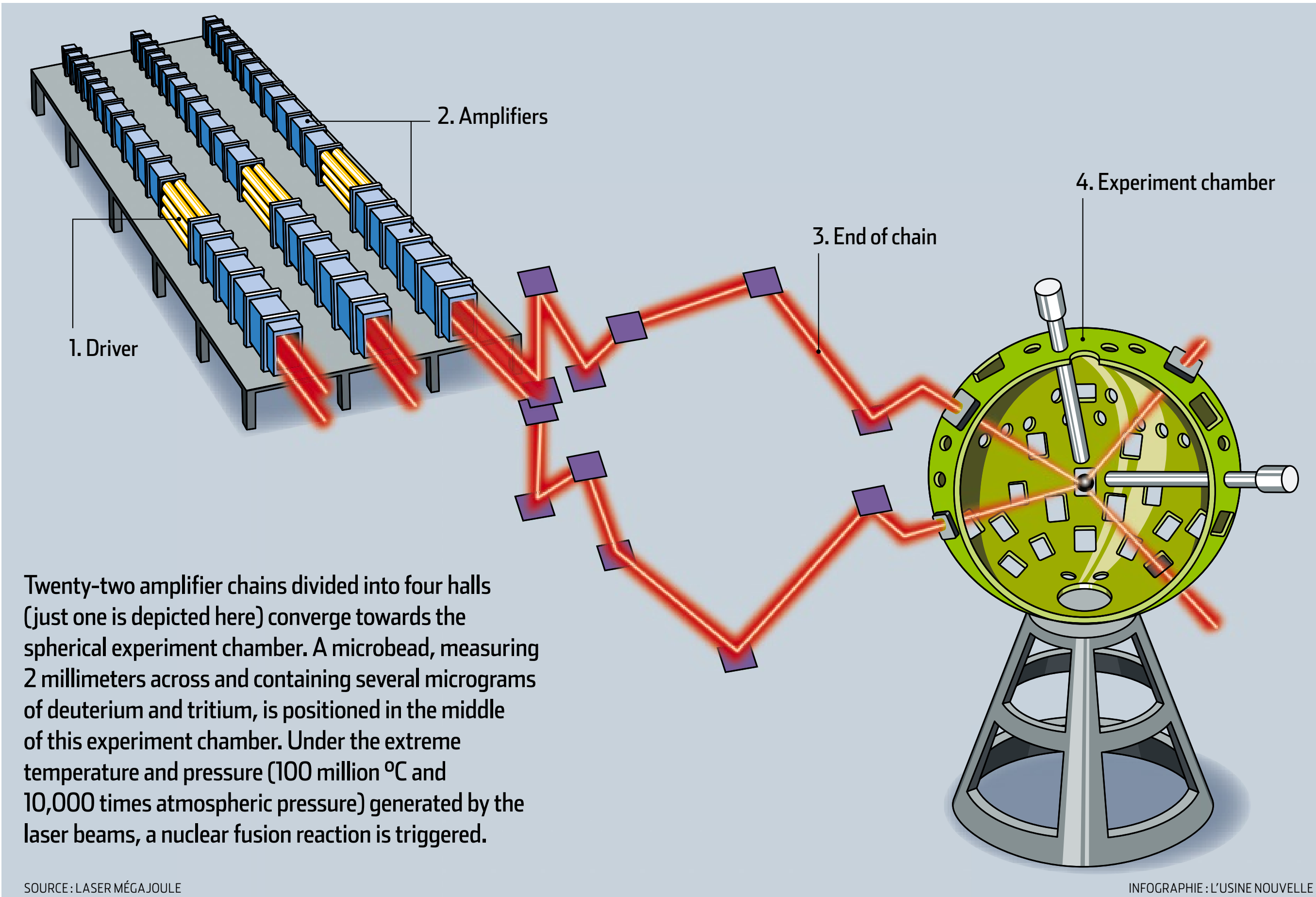
Laser beams triggering nuclear fusion begin with... a source. In other words, a small laser producing very low-energy impulses (1 billionth of a joule) with extremely controlled properties. This laser has a very precise wavelength (1 053 nm) and all its properties (beam shape, impulse duration, etc.) are established and calculated in anticipation of beam distortion along amplifier chains. This ensures that the intended performance is achieved on the target. "The laser source is fitted with a diagnostic system, which guarantees a beam's properties before an impulse passes through an amplifier chain, thus avoiding any risk of damage," explains Patrice Le Boudec, CEO of Idil, which supplied the LMJ's four laser sources. These sources generate 176 beams, which are immediately pre-amplified using a module supplied by Quantel. Idil, an SME employing 28 people, found it a challenge to integrate into the LMJ industrial project. It had to ensure its laser sources interacted with monitoring and control software supplied by Codra (over a million variables will be monitored), and provide follow-up and documentation in a project run according to aeronautics-industry standards. But it was worth it: the LMJ represents 15% of Idil's business and the expertise acquired has opened the door to major scientific instrument projects, such as the European X-Ray Free-Electron Laser (European XFEL), an X-ray laser facility under construction near Hamburg.

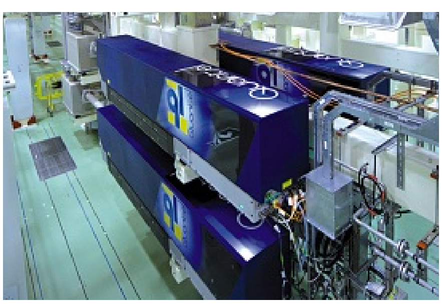
ENERGY AMPLIFIED 20,000-FOLD

It takes three essential ingredients to amplify the 176 laser beams generating energy needed for experiments: gigantic size, advanced technology, and cleanliness. Each laser chain (22 chains of eight beams each are planned) passes four times through an amplification 'tunnel' (amplifier) manufactured by Cilas. This ensures that as much energy as possible is generated. Each 'tunnel' contains a series of neodymium-doped laser glass slabs illuminated by flash

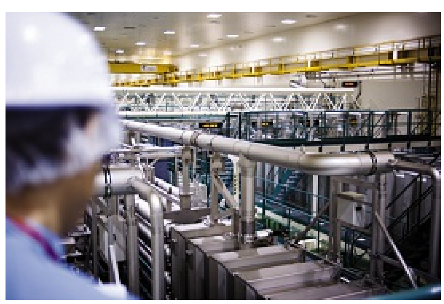
STÉPHANIE JAYET

THE PRINCIPLE OF THE LASER MEGAJOULE FACILITY





A very low-energy laser source is pre-amplified to 1 joule.



One of four halls housing the laser amplifier chains.

The experiment chamber, towards which 176 laser beams converge.

lamps. Powerful electronic systems supplied by Thales are used to control these lamps in a fraction of a millisecond. The LMJ's 3,000 laser glass slabs were manufactured in a specialist factory in the USA that was involved in a similar American project: the National Ignition Facility (NIF). Although there is nothing standard about laser beam-lines, it is worth dwelling on two components at least, which ensure the quality of laser beams generated by amplification.

A mirror supplied by Alsyom (Alcen Group) is positioned at one end of the 'tunnels'. This enables laser beams to circulate and corrects wavefront deformations.

It is an adaptive mirror, which deforms using micro-actuators designed by ISP System. "We began drawing up a catalogue during preliminary studies for the LMJ and now deliver products for big lasers throughout the world," says a delighted Paul Sauvageot. He is the CEO of ISP System,

STÉPHANIE JAYET ; CEA

a Hautes-Pyrénées-based SME that has also supplied most of the LMJ's precision actuators. Another sophisticated component – the Pockels cell – is positioned next to the mirror. "It's a safety system," sums up Franck Poirier, CEO of Sodern the Airbus subsidiary that manufactures these cells. A Pockels cell is a sort of 'switch' – operating at nanosecond speed – that turns off part of a wave when it is likely to damage optical components. Its key component is a large crystal controlled by high-voltage electricity synchronized with the laser. It took around a year to manufacture the first cell, which gives some idea of its complexity.
Cleanliness is easy to understand: it applies to everything.

And always for the same reason: the slightest speck of dust is dangerous for the facility. This obviously applies to the laser halls, which have a controlled atmosphere. Their air is renewed nine times an hour and the temperature is regulated to within 0.5 °C. But this obsession with cleanliness starts much earlier. In Cilas's specially built factory next to the LMJ facility, all amplifier components, – the 'tunnel's' metal structure that is the size of a bus – from the laser glass slabs to the tiniest screw or washer, are machine-washed before entering the assembly clean rooms. At the neighbouring Alsyom factory, which manufactures large mechanical structures to support components, post-washing integration is done in a 4,000 m²-clean room. Both sites share a clean vehicle for deliveries to their only client. This 'clean room-on-wheels' keeps everything dirt-free up to installation in the LMJ halls.

176 LASER BEAMS FOCUSED ON 1 MM

This is the distribution phase. The 176 amplified laser beams are transported and redirected around the spherical experiment chamber. This is done by sets of mirrors (currently manufactured in the USA), which are supported by extremely stable mechanical structures impervious to any vibrations that might disturb laser chain alignment. It was built by Seiv (Alcen Group), which has since supplied mirror supports for the Romanian ELI super laser.

"The LMJ has enabled us to become an exporter," says Patrice Daste, CEO of Seiv. The motorized optical-component positioning systems – which can move two-tonne weights to within a micron – were manufactured by CNIM. There are two final stages before lasers enter the experiment chamber. First, the laser frequency is converted from infrared to ultraviolet, which interacts better with the target. This is done using a KDP crystal manufactured by Saint-Gobain. Secondly, the lasers are focused, which reduces beams measuring 40 cm across to less than a millimetre when they reach the target.

FUSION EXAMINED IN MINUTE DETAIL

The laser beams converge towards an experiment chamber with a diameter of 10 meters that resembles a time-travel machine. This spherical chamber, and the experiment hall housing it, both contain a great deal of technology. Although the hall is 38 meters high, it is packed. According to Bernard Ponsot, CNIM's director of major projects and the experiment hall's project manager, it is "like a submarine".

3 344

This is how many large optical components are required for the Laser Megajoule (LMJ) facility's first fit. Not every optical components manufacturer knows how to make square lenses measuring 40 cm across! The LMJ, and its counterpart National Ignition Facility in the USA, have been an incentive for a few specialists to develop technology. Thales Seso has designed mass polishing equipment to make at least 2,000 of these large optical components. The slightest surface blemish caused by powerful laser beams can damage a component, and it may even have to be changed. Thales shares this market with two American manufacturers. In addition, a Seiv workshop near the LMJ uses a sol-gel process developed at the CEA to add an anti-reflective coating to thousands of optical components. ∎

This is no randomly chosen image since CNIM, a defense supplier, has worked on submarine missile launch systems. It also expresses the complexity of this facility and of integrating its 10,000 components supplied by 25 partners. Specially designed handling robots were even developed to handle several-tonne loads in this very tight space.

The spherical experiment chamber, manufactured by Cegelec, is located in the middle of the hall. Its wall consists of aluminium (10 cm-thick) and boron-doped concrete (20 cm-thick), which absorbs neutrons. During experiments, a target is positioned in the middle of the chamber. This is a microbead containing a deuterium/tritium mixture, which is placed inside a container with a diameter of two millimeters. The experiment chamber contains an array of mechanical and optical systems to position the target and align the lasers. It also contains observation and measuring instruments for use during experiments. Bertin, a CNIM subsidiary, supplied the target positioning system.

Its telescopic arms are several meters long and accurate to within ten microns. The French Atomic Energy and Alternative Energies Commission, Military Applications Division (CEA - DAM) is responsible for the targets. Dozens of targets, which vary according to the experiments conducted, are planned. They are manufactured at the CEA's Valduc Center (Côte-d'Or), which specializes in nuclear materials. At cruising power, the LMJ is large enough to carry out 50-200 experiments a year (i.e. a maximum of one a day). This complies with the specifications drawn up by the army. Nevertheless, some space will be made at the PETAL facility; a high-power (several petawatts) laser beam installed in one of the LMJ halls that share its experiment chamber. PETAL's ultrashort impulses, which are 100 times more powerful than LMJ cells, are for scientific research. This facility is due to start up at the end of 2015. ∎

Success Story

SPRING, THE LEADER IN MACHINING SIMULATION

French software vendor Spring Technologies has been developing computer-aided design and manufacturing (CAD/CAM) tools for the past twenty years. Today they are global benchmarks.

BY JEAN-FRANÇOIS PREVÉRAUD

A HIDDEN CHAMPION
• 10 million Euros in 2014
• 30% on exports
• 800 clients
• 100 employees, including 26 in R&D
• 1 patent

What do the US Air Force, Toyota, Bosch, Thales, Hyundai Heavy Industries, Swarowski, and Nike have in common? They all simulate their machining using NCSimul software developed by the French software vendor Spring Technologies. A resounding success for an SME set up in 1983 by four renegades from the software vendor Computervision, which was at the time the CAD/CAM market leader. These four founders were specialists in CADDS software services. Their rare skills were valued by all key accounts, especially for designing post-processors to run machine-tool controllers. They were also experts in imaging for architects and developed Iko-Light software.

But self-doubt set in during the 1991-1992 crisis. The spectacular development of UNIX (large-systems OS) led them to believe that CAD/CAM would become commonplace and dilute their expertise. At the same time, imaging was still not being used for architecture - the other aspect of their business - due to a lack of resources. They were ready to throw in the towel. But this was before they realized the tenacity of their sales director, an engineer who had gained experience at SGAO (a Saint-Gobain company devoted to integrating CAD/CAM into the group). "Of course there will be more competition as the market expands, but very few companies have our expertise. If we can extend it to other CAD/CAM systems, such as CATIA, we'll grow again," he explained at the time. Battier suddenly found himself CEO in 1994. It was then that he met Bernard Girard, operations manager at PSA, who was struggling with two CAD/CAM systems for its mechanical engineering and car bodywork subsidiaries. Battier offered to maintain the interfaces between these two systems and develop CAM post-processors. He also realized that clients were spending a lot of time developing tool paths on their machines. This nonsensical situation was taking machines out of action without even eliminating the risk of collision. "Surely we could produce some computer graphics to help them?" thought Battier. NCSimul machining simulation software was created. This

Gilles Battier, a pillar of CAD/CAM

Gilles Battier spent his childhood on the move. His father worked his way up through the ranks at Michelin from factory hand to engineer, holding posts in Vietnam, Brazil, Algeria, and Ivory Coast. Battier returned to France when he was 13, where he acquired his passion for maths from one of his junior high school teachers. But as an outstanding rugby player and keen tennis player and skier, he opted for university rather than 'prépa' (post-secondary school preparing students for entrance examinations to French Grandes Écoles) to have some spare time. He then switched to what was then ENSIMEV engineering school in Valenciennes, where he set up the rugby club and started learning about CAD/CAM at the same time as his lecturers. He trained at Computervision from his first year and set up a CAD/CAM junior enterprise for manufacturers new to this subject. He fine-tuned his understanding of industry via internships at Sambre et Meuse, ANF, and SGAO. Battier did his national service at the Paris fire brigade, where he learnt to manage risks, resources, and people in crisis situations. He joined Spring Technologies at the end of 1988 to launch its consultancy business, and was appointed CEO in 1994. During contact with clients while designing their post-processors, he was alarmed to see machines out of action when machining programs were developed. He drew on all Spring's expertise to develop an offline machining simulator: NCSimul. This has won over machinists throughout the world and established a name for Spring's technology.

HERVÉ BOUTET

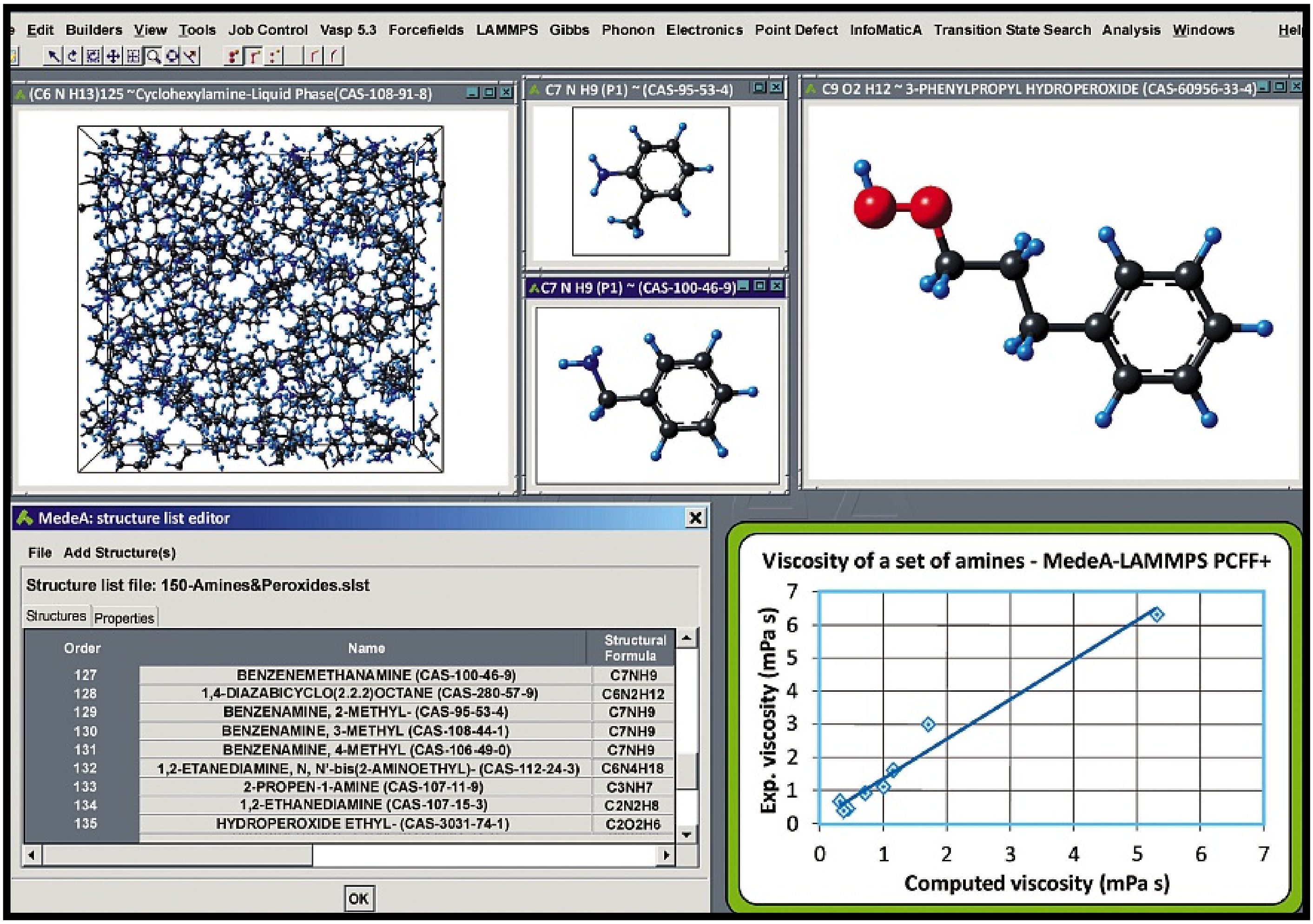
was a real help for offline verification carried out by process planning departments, many of which were still programming their machines manually. Progress in imaging meant realistic renderings could be developed, thus making the software more efficient and easier to use. Its simulations were also easier to understand.

Optimized overall productivity

Unlike CAD/CAM tools, NCSimul integrated workshop realities from the outset: collision detection, tool path optimization, and removal of material. “I guessed that manufacturers would want their machines to carry out increasingly complex operations, with sophisticated kinematics and more axes. Our algorithms anticipated this development,” says Battier. The advent of mill-turn machines, robots, and machines with 5 or more axes was handled serenely at Spring Technologies. The company also expanded its offer to workshop services: managing and monitoring machines, producing working documents, and even tablet-based, real-time monitoring of machining. Spring Technologies, whose expertise is recognized throughout France, has opened offices in Germany, the USA and China to support the international expansion of big industrial groups (PSA, Renault, Alstom, Thales, Airbus, etc.). This approach has helped it entice local sub-contractors and international groups (Toyota, Canon, ZF, etc.), which were won over by its integrated offer.

“Only 5% of CAM users currently simulate their machining paths before giving them to workshops, which means there’s still great potential for improving productivity to be discovered,” says Battier. This is why Spring Technologies focuses on monitoring workshops and machines as well on savings made by optimizing paths and eliminating collisions. This increases overall productivity and detects wear and tear that damages quality. Time saved by machine operators and setters could be put to good use by feeding back expertise and technical events from workshops to process planning departments. This would improve machine programming and identify high-risk areas in tool paths. Research is being carried out with industrial groups and laboratories as part of projects run by the Systematic and ASTech technology and innovation clusters, where Spring Technologies has a strong foothold.

Many manufacturers would also like to change which machine they run a program on without having to reprogram everything. Spring Technologies is therefore working on a tool to feed technical data and simulation features back upstream, for simpler, faster and more flexible CAM tool programming. Spring Technologies is doing everything necessary to remain the leader in its market.



Molecular modelling software produced by Materials Design automates calculations performed using methods developed during the Predimol project.

Chemistry

COMPUTER-AIDED REACH

Computers can evaluate the toxicity, explosibility, and inflammability of chemicals registered under European REACH regulations.

BY THIERRY LUCAS

Molecular modeling calculates rather than measures the properties of substances. But another scope – regulations – lies ahead of molecular modeling. In particular, European REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) regulations, which came into force in 2007. These require manufacturers to register dossiers for potentially toxic or hazardous characteristics of thousands of products. Until now, available software was intended to predict toxic or ecotoxic properties. Mounting pressure against animal testing has speeded up its development.

Computers can now be used to help with the other part of REACH regulations: calculating hazardous physico-chemical properties (explosibility, inflammability, etc.) using models developed during the Predimol project, which ended in May 2014. Run by the French National Institute for Industrial Environment and Risks (INERIS), together with partners such as Arkema, the goal of the Predimol project was to develop software to calculate missing data about commonly used industrial chemicals. "Beyond REACH, we wanted to evaluate how

PASCAL GUITTET

much confidence we could have in these methods to calculate the characteristics of our products," explains David André, process and product safety laboratory manager at Arkema.

The project focused on two families of substances: organic peroxides, used in many polymer synthesis processes, and amines, used to synthesize various fine chemicals and pharmaceuticals. To evaluate the stability of organic peroxides, two models were developed and tested to establish a quantitative relationship between molecular structure and two characteristic thermal properties: heat and decomposition temperature. In 2015, these two QSPR (Quantitative Structure-Property Relationship) models are expected to be integrated into a toolbox (set of software made available to manufacturers) created by the Organization for Economic Cooperation and Development (OCDE). "INERIS has already developed a model to predict the explosive properties of nitro compounds (TNT-type)," points out Patricia Rotureau, manager of this project at INERIS. This is just the beginning since developing QSPR predictive models is a long process (the Predimol project lasted four years).

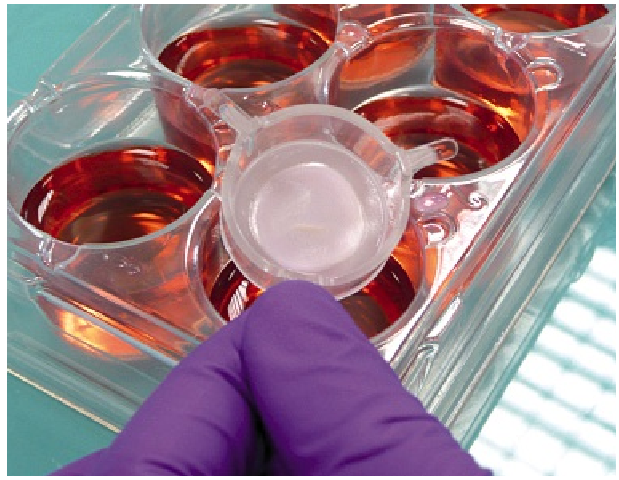
Still Complicated to Use

Developing QSPR models to calculate physico-chemical properties, and QSAR (Quantitative Structure-Activity Relationship) models to predict biological effects, often starts with experiments and measurements. This step is essential to create a database containing enough products with known chemical structures and properties. Equations for predicting the characteristics of other substances in the same family on the basis of their chemical structure can then be deduced from this database.

To construct the peroxides' model, INERIS and Arkema first completed a database covering around forty products in this family. "Two thirds of the products listed were used to construct the model. The rest of them enabled us to validate it by checking that the predictions were correct," says Rotureau. Arkema points out that these results are only the first step. "We're starting to use these models during research to predict the properties of products we're developing. But more effort is needed for these approaches to be recognized and accepted by the authorities before they can be used in regulatory frameworks. INERIS is committed to this process," says André. QSPR models have a fairly limited scope – type of molecules and properties sought – and proving their validity within the framework of regulatory dossiers may be rather tricky. Previous QSAR models used to predict effects on biological organisms suggest that we should be cautious.

THREE POSSIBLE USES

- **In regulatory frameworks** (REACH, transportation of hazardous materials, etc.) to calculate missing data about substances.
- **In R&D,** to identify dangerous molecules upstream of processes.
- **On existing manufacturing processes,** to replace dangerous molecules with safer ones.



Alternative methods include in vitro tests on laboratory-reconstituted tissues.

Alternative Methods

To complete the REACH project, which involves collecting data about tens of thousands of substances to be registered by 1 June 2018, the European Chemicals Agency (ECHA) is encouraging the use of alternative methods that do not involve animal testing. These include in vitro (tests on cells, tissues or organs) and in silico (QSAR) methods, which analyse the chemical structure of molecules to calculate their activity. According to a recent ECPA report, QSAR software is still only used in a minority of cases. Read across methods, which are easier to use and can formulate toxicity hypotheses by comparing a small number of analogous molecules, are much more popular. QSPR software completes the technical paraphernalia at manufacturers' disposal, enabling them to predict hazardous physico-chemical properties (explosibility, inflammability) by means of calculations.

QSAR methods in REACH are still only used in a minority of cases. This is mainly because although many software programs are available, either free or for a charge, they tend to be used in upstream research to screen large numbers of molecules. They are not really suitable for regulatory requirements. "These models are not necessarily accurate enough to determine whether or not a molecule is toxic or carcinogenic," confirms Enrico Mombelli, a specialist in ecotoxicological and toxicological models at INERIS. In addition, QSPR and QSAR models are inevitably complex, meaning that only experts can use them. This is another obstacle preventing in silico methods from becoming commonplace. Materials Design, a company specializing in molecular modelling, was a partner in the Predimol project. It is making this software easier to use by creating interfaces that automatically prepare calculations and exploit their results. With REACH, for example, it automatically generates lists of similarly structured molecules that serve as a basis on which to start calculations.

Design
COMPOSITES, BACK TO SQUARE ONE

While we know how to simulate practically anything on current vehicles, all this will change when they include composite materials. Research is under way to establish the laws governing how composites behave.

BY JEAN-FRANÇOIS PREVÉRAUD

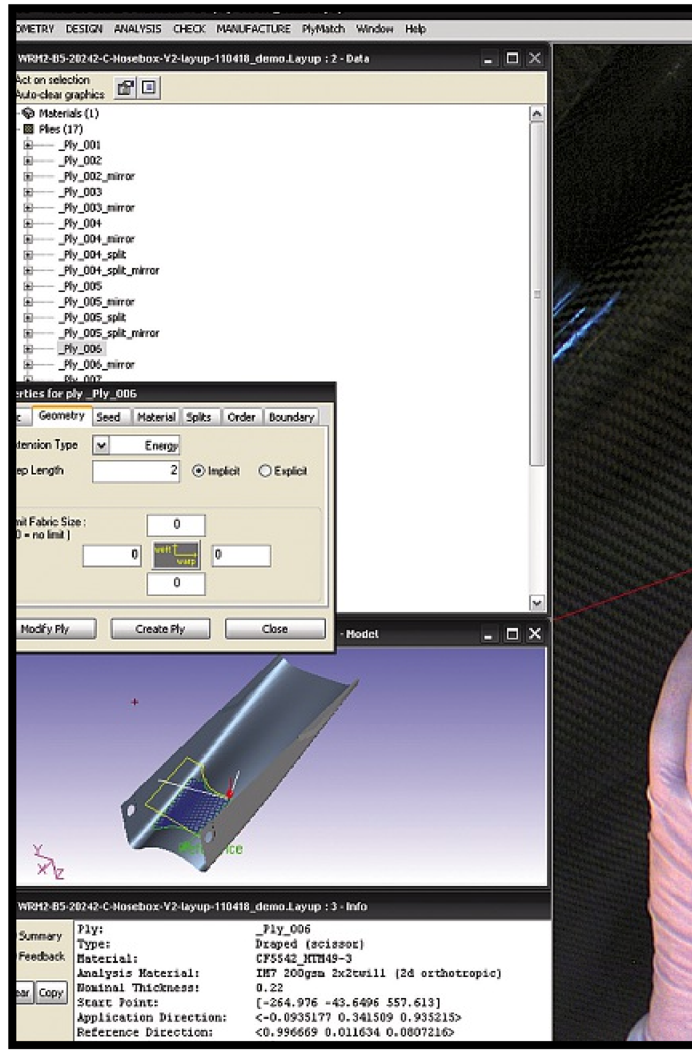
Archimedes said: “Give me a lever and a place to stand and I will move the world.” Simulation experts proclaim: “Give us the right behavioral models and test values and we will simulate every composite in the world.” That is quite the claim. Although calculation codes and solvers used for metals are relevant for composites, we still have a limited understanding of laws governing how composite materials behave. The same problem exists for physical test values, which enable models to be adjusted to give a better depiction of reality. In this field, almost everything still remains to be modeled.

For the time being, we only completely understand metal manufacturing. We now know precisely what metals are made of and hence their physical constants, which have been established by numerous tests. Metals are also isotropic materials: they react the same way to stresses exerted in all observation directions. By contrast, composite materials are much ‘younger’ and change constantly.

A probabilistic approach

Whether short-fiber reinforced resins or sheets of long-fiber material embedded in resin, composite materials have anisotropic behavior that depends, among other things, on the nature, thickness, and direction of their various layers. In addition, depending on the geometry of the part in question, there may be local variations in the relative direction of sheets in a mold, which creates an area that behaves differently.

Formulating equations to describe how metals behave is clearly easy. Things are very different for composite materials, which need to be worked on simultaneously at the macro- and microscopic scale. “Whether we think in terms of a big manufacturing process for car parts (casting,

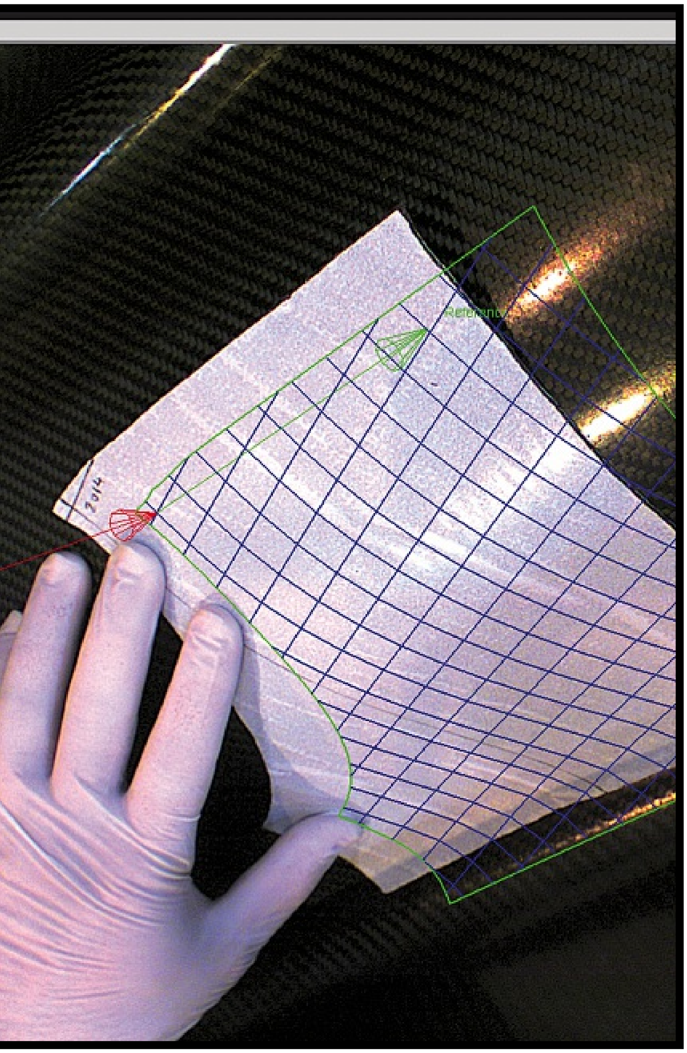


Anaglyph has created a tool for designing structural components made of composite materials.

stamping, metalworking, welding, etc.), parts’ performance (resistance, fatigue, vibration, etc.), or crashes of sub-units or entire cars, we thoroughly understand simulation in the metals sector. This technique enables us to come within a few percent accuracy of real physical behavior,” says Jean-Christophe Allain, business development manager for land transport at ESI Group, a French software vendor. By contrast,

“When we characterize composites, we don’t obtain a curve, as with metals, but rather a scatter of points. We need to move from a deterministic to a probabilistic approach.”

Patricia Millot, composites specialist at Dassault Systèmes



D.R.

the many inherent dispersions in composite materials make this a much tougher issue where they are concerned. "We can't just settle for a few iterations. We need to develop new calculation methods, real experimental designs, which will give an envelope of results with a percentage occurrence of incidents," continues Allain.

Patricia Millot, a composites simulation specialist at Dassault Systèmes, confirms this analysis: "When we characterize composite materials, we don't obtain a curve, as with metals, but rather a scatter of points. We therefore need to move from a deterministic to a probabilistic approach in any envelope of results used for calculations."

And what is true for simulating parts is also true for simulating their manufacturing processes. "As with metals, we can precisely adjust settings for the manufacturing process, amperage, and pressure of a welding gun, for example, to achieve the optimum levels determined by simulation," observes Antoine Langlois, senior technical manager at MSC Software France. But the reproducibility of manufacturing processes for composites and everything involved in making them causes major dispersions." And this behavior cannot always be reproduced. As a result, our understanding of fatigue and durability in composite materials under stress or exposed to sunshine and humidity is poor. "Since composites are not uniform, we obviously can't use the behavioral models we use for metal fatigue," explains Pierre Thieffry, product manager at Ansys.

Modeling composites' aging

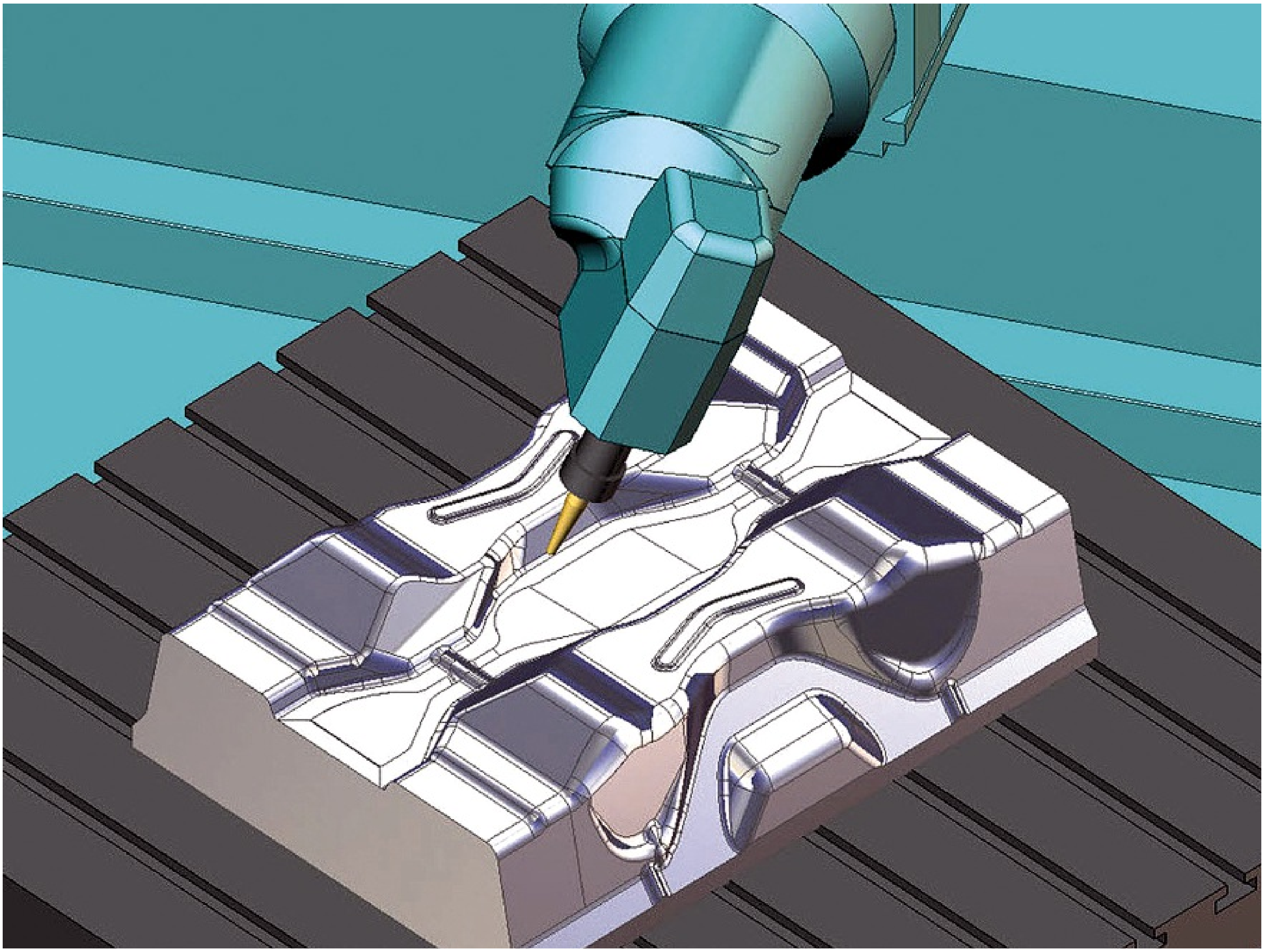
Furthermore, the promising integration of natural fibers (hemp, linen, etc.) into resins is raising the issue of characterizing biomaterials, which are very diverse. For this reason, much testing and research is being carried out at manufacturers, materials suppliers, and simulation software vendors, with support from university laboratories. This expensive, lengthy research does not sit well with the scheduled release by 2020 of vehicles made largely of composites. "Manufacturers will have to draw up a limited standard range of materials and applications to limit the scope of their research. Due to their shorter manufacturing cycle, thermoplastics now seem to have the leading edge," assesses Allain.

Another important point for simulating components made of composite materials is their assembly. Whether for gluing or riveting, much modeling and characterization work still remains to be done, especially on aging and fatigue resistance. Gradually replacing metal parts with composites will require much greater use of simulation during development and optimization of the parts involved.

Fortunately, supercomputers' processing capacity is increasing at the same pace as the size of models. Nevertheless, the not inconsiderable additional cost will be a big factor in the overall economic equation for making vehicles lighter. ∎

Progress needed on virtual test crashes

Virtual test crashes are essential for automobile manufacturers' safety checks. This is because they very accurately depict how vehicles behave in many crash situations. But will what is feasible on current vehicles remain so when they include significant amounts of composites? Nothing could be less certain. Crashes cause high deformation speeds and significant displacements, with wreckage resulting from complex processes. "Although we now have good understanding of these processes for metals, much research is still needed on composites. This is because their layers delaminate at the same time as their fibers and resin break," observes Langlois of MSC Software. "But nothing is insurmountable. We're simply where we were with metals 15 years ago," says Allain, of ESI Group. ∎



D.R.

The increasingly fine dividing line between simulation and CAM software is giving manufacturers complete software chains.

Production

SIMULATING MACHINING AND MUCH MORE...

The world of computer-aided manufacturing is changing with software enriched by new functions.

BY FRÉDÉRIC PARISOT

Computer-aided manufacturing (CAM) software has extended its traditional scope. Since this software emerged in the 1980s, its features had hardly changed. But the advent of simulation software has speeded everything up. So much so that nowadays the dividing line between CAM and machining simulation is becoming blurred. Both approaches involve simulating the removal of material from rough parts to obtain finished parts. CAM involves drawing up machining strategies (tool paths, number of passes, feed rate, etc.), whereas machining simulation provides virtual representations of programs run on machines. CAM software works on the CAO files of the workpiece, without taking account of machine-tool geometry, whereas machining simulators run ISO numerical control programs integrated into machines, where they decompose and distribute each movement over a machine's various axes. But these two features are increasingly found together in the same software suite. The partnership agreed between two French software vendors in early 2014 is evidence of this. From now on, TopSolid, Missler Software's

CAD-CAM software, can be supplied with NCSimul, Spring Technologies' machining simulation module, [see page 38]. This agreement means manufacturers now have a complete software chain, from design to simulation. But simulation is not the only thing CAM has its eye on. Recent innovations include software that can communicate with robots, offer real-time monitoring of manufacturing processes, and integrate 3D printing.

TRAINING ROBOTS

Machine tools have become increasingly complex in recent years. Simple 2- or 3-axis lathes and milling machines are no longer the norm. They have been replaced by hybrid machining centers - integrating turning and milling - with up to 5 axes. CAM software's post-processors, i.e. algorithms decomposing paths into orders that can be understood by a machine's various motors, are increasingly important since they determine the quality of CAM solutions. Software vendors need to provide post-processors for every type of machine, most recently for robots. "Some manufacturers directly machine their parts in robot grippers, meaning that CAM software must be able to generate both robotic and ISO codes," says Christian Arber, CEO of Missler Software (210 employees, 27.5 million Euros turnover).

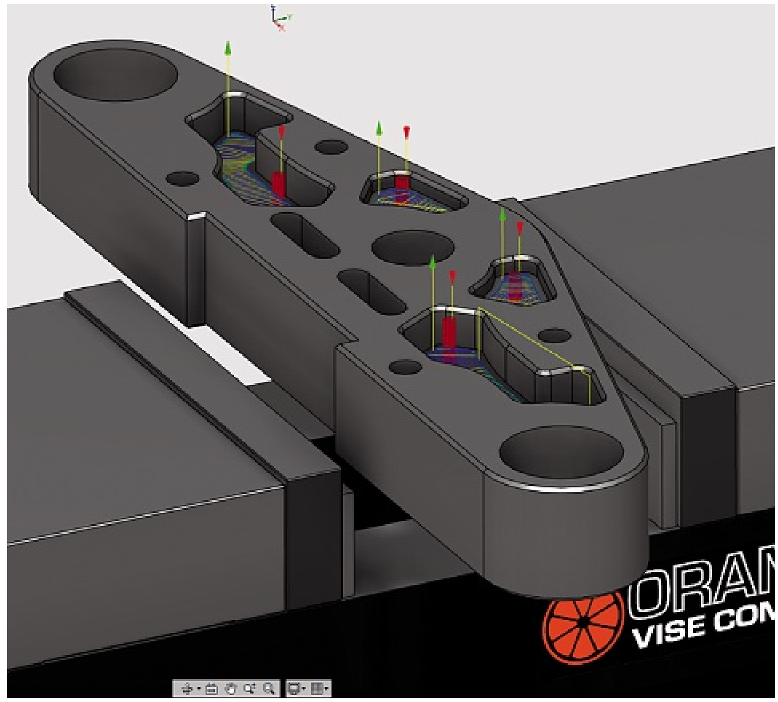
In addition to its increasing complexity, CAM and simulation software is becoming more realistic and no longer settles for displaying transparent cylinders to illustrate tools. "We now represent parts' entire environment, especially tool clamping systems and spindles," says Romain Pitette, Siemens PLM Software's Solid Edge product manager.

OPTIMIZING MACHINISTS' ACTION

CAM is now used in workshops. Although for a long time this software was only used by design and planning engineers, it has recently been targeting machinists. Siemens PLM Software, Spring Technologies and Autodesk all launched collision detection features last year. These prevent any risk of impact between parts and machines when operators are adjusting settings or running programs for the first time. The software guides operators when they move machines manually by showing them how to proceed safely. Spring Technologies has gone even further by offering tablet-based, real-time production monitoring. "Operators always know what's happening on their machines. They can monitor several machines at once and anticipate tool changes, which saves a lot of time," says Olivier Bellaton, CEO of Spring Technologies (100 employees, 10 million Euros turnover).

INTEGRATING 3D PRINTING

DMG Mori's new hybrid machine tool - a 3D printer and 5-axis machining center - has not gone unnoticed. "Our software must be able to generate programs for these new machines. Clients purchasing this state-of-the-art equipment need a software chain to go with it," says Arber. CAM, which by definition was only used for removing material, i.e. subtractive manufacturing, is now very interested in additive manufacturing. Spring Technologies and Altair (2,200 employees, 300 million Euros turnover) are reflecting on a specific model to simulate additive manufacturing processes. "In this field, we've already got design facilitation features, such as topology optimization tools that design parts according to the stresses they must withstand. In the future, we'll be able to simulate what happens to materials during manufacturing processes," says François Weiler, Altair's Southern Europe marketing manager. ■



CAM 360, Autodesk's CAM solution, is available on the cloud.

D.R.

Collaborative manufacturing in the cloud

CAM and machining simulation have always been resource-intensive. To avoid calculations lasting several days, path optimization algorithms and other renderers must be installed on powerful servers. This is what drove the American software vendor Autodesk to take its manufacturing software offer to the cloud, i.e. become web-based. Since calculations are done in remote data centers, users can work on any PC. Above all, the cloud provides a collaborative dimension. "If engineers run into problems on a part they can easily turn to more experienced colleagues, even those on other sites. All they have to do is open a shared work session," explains Anthony Graves, Autodesk's Fusion 360 CAM product manager. These collaborative work sessions can also be shared with design engineers, enabling them to offer real-time input on parts. ■

INNOVATION BY SIMULATION

SIMULER POUR INNOVER

Forum Teratec

le rendez-vous international

The international meeting

HPC BIG DATA SIMULATION

2005 DIX ANS 2015

23 & 24 juin/June 2015

ECOLE POLYTECHNIQUE

PALAISEAU - FRANCE

www.teratec.eu

Ter@tec

Platinum Sponsors : Bull atos technologies, hp, intel

Gold Sponsors : cea, panasas, SEAGATE, sgi

Silver Sponsors : DataDirect NETWORKS, DELL, GENCI, NVIDIA, FUJITSU bullion

bullion server: designed for Big Data

Using the technology developed for the most powerful supercomputers in the world, bullion is the new figurehead server for Bull, the Atos group technology brand. Designed for Big Data and massive ‘in memory’ processing, and equipped with between 2 and 16 Intel® Xeon® E7 processors and up to 24 TB of memory, bullion allows a business’s data to be transformed into value-generating information in real-time.

intel inside™ XEON®

Bull
atos technologies