European Commission

# Joint Research Centre

The European Commission's science and knowledge service

# 60 stories for the 60th anniversary

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# 60 stories, 60 years of scientific advice for Europe

**Who needs experts?**

Well, we all do. In these increasingly complex times, we rely more than ever on the knowledge of scientific experts — to make sure our food is safe, our environment is clean, our economies are working, or our electricity is always on.

Providing that kind of expert scientific advice has long been a key role of the Joint Research Centre, the European Commission's science and knowledge service. This year, the JRC's 60th anniversary, is a reminder of the importance of the EU providing science-based evidence for policy, of having in-house technical expertise in many domains.

The JRC's expertise ranges across virtually all technical aspects of society today. In times of economic turmoil, it assists EU leaders in financial modelling and bank 'stress tests.' As concerns of climate change mount, it helps gather, analyse and model data — assisting the EU in formulating climate policy. Its experts support food safety, health, energy, transport, nuclear safety and more. They have helped track food prices in Africa, studied drought from Italy to Mongolia, and compiled comprehensive maps of soil and water quality in Europe. They have even studied child-safety questions raised by an "Internet of Toys."

"I think you can see that the JRC is in demand!" is how Tibor Navracsics, the European Commissioner for Education, Culture, Youth and Sport, put it in a 2016 session at the European Parliament. "As policymakers, we are all increasingly facing an information overload. We need authoritative voices helping us to separate important signals from the surrounding noise." The JRC fills that role, he said.

Its evolution over 60 years, from a specialised nuclear research centre to a wide-ranging policy-advice service, is woven into the fabric of European history.

On 25 March 1957, six countries (Belgium, France, Germany, Italy, Luxembourg and the Netherlands) signed in Rome the Treaty on the European Economic Community and the Treaty on the European Atomic Energy Community. The latter established a Joint Nuclear Research Centre and gave it its first 5-year work plan.

In the following years, the JNRC was a multi-site organisation, bringing national nuclear research centres under the EURATOM umbrella. Scientific work started swiftly but laboratories and research reactors needed some time before they became operational in Ispra in Italy, Petten in the Netherlands, Geel in Belgium, and Karlsruhe in Germany.

In scientific terms the JNRC started as a nuclear research organisation, working on non-military nuclear technology. In the 1970's the "N" was dropped from its name when it officially started to work in non-nuclear fields: environment, remote sensing, and renewable energies (photovoltaic) were among the many scientific topics already addressed in that period — and they are still part of today's work. In the 1980s and 1990s the JRC increasingly oriented its work towards policy support. Its aim today: "As the science and knowledge service of the European Commission, our mission is to support EU policies with independent evidence throughout the whole policy cycle".

But over the years, the range of topics the JRC has covered is vast. From the 1970s, the first energy crisis and a growing awareness of the limits of growth required new policy responses, for which EU leaders needed reliable and trustworthy science. Many alternative energy scenarios began appearing, including hydrogen. The JRC's work on photovoltaics started in those years.

Remote sensing — often from satellites — is another important field. As early as the 1960s the JRC printed maps of the agricultural areas of the then-Soviet Union from NASA satellite data records. By the late 1980s, the Commission's agricultural policy was looking for a cost-effective way to survey agricultural land in the EU; the JRC was ready to apply its expertise.

As the JRC evolved, so too did its approach to what it studied. In the beginning, technological research and development was its focus. Then it shifted to work on understanding, mastering, and developing technologies for a range of uses, such as remote sensing or measuring of chemicals in the environment.

In 1998 the Baveno manifesto changed this paradigm when it called for developing a European space programme starting from the intended uses, rather than from the available technologies. That has become the JRC's aim in many domains: new work starts because an answer is needed to a policy question, not because we have a new technology at hand. The JRC Strategy 2030, unveiled in 2016, reflects this. In it, the JRC is "to play a central role in creating, managing and making sense of collective scientific knowledge for better EU policies."

Today, the JRC has 2850 staff at six sites in five countries: Italy, Spain, the Netherlands, Belgium and Germany. With headquarters in Brussels, it is the only Commission service that carries out research and scientific activities in-house. It supports the entire Commission in its functions, from initiating EU policies to implementing them. It covers the entire policy cycle, from identifying a need for action, to testing policy options, providing scientific evidence for the design of policy and its implementation, and finally monitoring and evaluating the implementation.

Drawing on its wealth of expertise and more than 50 world-class research facilities, the JRC adds value to the EU because its science is excellent, multi-disciplinary and independent of Member States, industry or other interests. Serving the whole Commission, it provides holistic, cross-silo policy support.  But the JRC also shares its know-how with the Member States, the scientific community, international partners and the EU citizen, to whom this book is directed.

This publication celebrates the JRC's 60 years in 60 short stories. They are non-technical summaries of work, past and present, suggested by JRC staff; more detailed information on each one can be found on the JRC's web sites.  Taken together, they highlight the breadth and depth of the JRC's work through the decades, delivering excellent science to serve society.

# Climate and environment

When it comes to climate change, is that all “fake news”? Obviously not, if you look at the scientific data. No surprise, then, that the JRC’s brief to supply trustworthy and correct scientific knowledge to EU policy making has given it an important role in the areas of climate change and the environment.

In the early years of the European project, these topics were further down the world’s agenda. Nuclear power was the coming thing; and the JRC work on environment was exclusively in that context.  Then, since the early 1970s, the JRC’s environmental and climate research grew in importance, always including extensive monitoring and modelling, and increasingly also socio-economic impacts. This work is since long underscored by the need to present complex information to European policy maker and the public in a digestible form.

# What's the EU's climate score? Good, yet could do better

*Europe's greenhouse gas emissions are falling, but tougher targets are planned*


*The JRC routinely models the impact and policy implications of climate change.*

There's good news from the frontline of the battle against greenhouse gas emissions.

According to a 2016 evaluation performed by the PBL Netherlands Environmental Assessment Agency and the JRC, the EU is on track to overachieve its commitment to cut emissions in 2020 by 20% from 1990 levels. This is confirmed by the official EU greenhouse gas inventory, for which the JRC has the responsibility for the quality of estimates in the agriculture and land use and forestry sectors. In 2015, EU greenhouse gas emissions were 22% below the 1990 level.

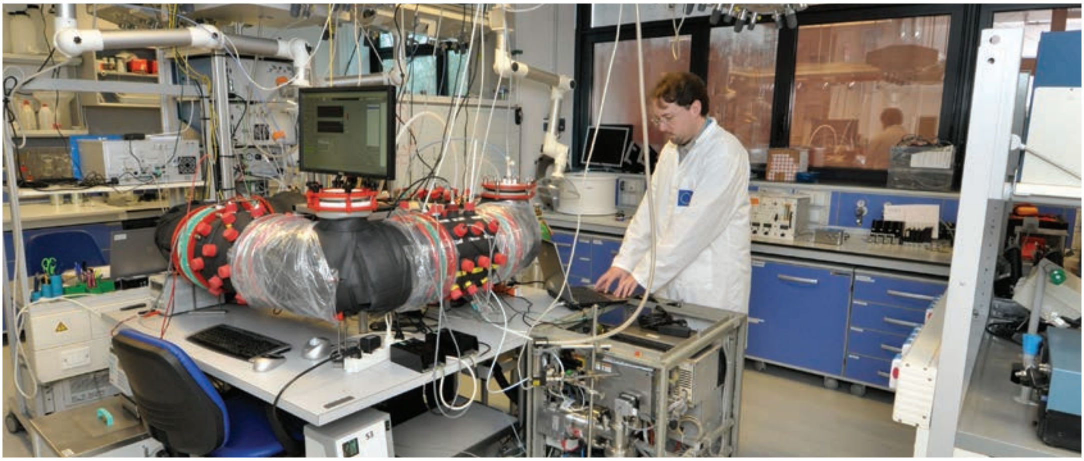
Although this progress is significant, the EU still has work to do. For starters, while 22% is good, the magic number is now 40%: that's what the EU agreed to hit by 2040, under the Paris Agreement. And according to another JRC report, the EU share of carbon dioxide emissions remained at 9.6% of the global total in 2015, with emissions in Germany and the United Kingdom alone making up a third of that. Also Portugal, Spain and Bulgaria reported relatively large increases, between 5% and 8% from 2014 to 2015. To balance the burden, higher income Member States are set more ambitious goals, while lower income countries are given easier goals.

All these policy actions need solid scientific evidence behind them, such as that provided by the JRC in the form of data and models. The approach of balancing the burden among the Member States, for example, was developed with the help of JRC models that allow calculating EU emissions from different scenarios of what's economically feasible at Member State level. In particular, the JRC helped establish how to include the forestry sector in the overall EU 2030 targets; it provided a technical proposal detailing how to account for the capacity of forests to absorb carbon dioxide, and performed modelling of different scenarios.

Finally, the constant monitoring of EU emissions is essential. The JRC provides reliable tools and standardised methods for trusted data. In addition to national compliance checks made every five years, the Commission is planning further in-depth and EU-wide compliance checks in 2027 and 2032. The JRC will be involved by checking data and providing analyses — in line with its mission to make sense of the rapidly increasing knowledge that policy makers need.

# How much will climate change cost?

*Putting a price tag on a range of climate change futures aids decision making*



*Validation of sensors to measure atmospheric particulate matter at the JRC-European Reference Laboratory for Air Pollution (ERLAP).*

The warmth of the rising sun, a cool breeze of mountain air, the shade of a mature oak tree… Priceless.

The benefits of such things cannot be measured. But perhaps the *lack* of these and other natural resources should be. And if it is measured, then policies to preserve them can be properly designed. The JRC is looking into this question and more with a series of projects trying to assess the potential physical and economic impacts of climate change in Europe through the 21st century.

What has it found? The models tell us that, under one 'business as usual' scenario, the EU-wide household welfare losses could amount to around €190 billion, almost 2% of EU GDP. The impact would be mostly in the southern EU Member States. More than half of these losses would be due to many people dying earlier than necessary. Moving to a world where the global temperature rise is pegged to 2 degrees Celsius above pre-industrial levels — the goal agreed in the Paris climate accord — would reduce the damage, but it would still cost as much as €120 billion.

Clearly such figures cannot be taken as predictions. Rather, they describe a series of possible futures based on complex sets of scientifically sound assumptions.

But these are among the findings from the first two phases of a major JRC effort in the field, called PESETA, to project the physical and economic impact of climate change in Europe. Initially the project considered five areas — agriculture, coastal systems, river floods, tourism and human health — and how they responded to four climate change scenarios. The findings were released in 2009. Some were striking, in particular the potential for increases in heat-related deaths and severe river flooding if nothing was done to slow rising temperatures.

The second phase of the project went further, extending the coverage to nine areas, adding energy, transport infrastructure, forest fires, and habitat suitability and up to 15 different climate change scenarios. Using this sophisticated modelling means that it is possible to compare climate change impact on factors such as household welfare (measured as consumption) and general economic activity (GDP). Phase three of the project is now well under way, with its sectoral reports due later this year, and these will be published at **https://ec.europa.eu/jrc/en/peseta.**

# Are droughts becoming the new normal?

*Severe droughts are hitting southern Europe — remedial actions are required*


*Statistical analyses of drought data lead forecasting at the JRC-European Drought Observatory.*

Summer 2017 was punishing. Severe water shortages hit Italy and parts of Spain and Portugal. Drought also led to many forest fires, worst of all in Portugal, where a state of emergency was declared in parts of the country after a single fire killed more than 60 people in July.

What's going on? Whether frequent droughts are caused by climate change or natural variations, we need to become better at coping with them.

This is where the European Drought Observatory comes in, a Web-based information system that helps monitor and predict forthcoming droughts, and estimate the severity and impact. At **http://edo.jrc.ec.europa.eu**, the system is run by the JRC and monitors a range of indices. For instance, it tracks how the actual rainfall deviates from the average precipitation, a measure closely related to the drought risk. Soil moisture, state and density of vegetation, and low water levels in rivers are also important. Based on these and other measures, JRC staff can describe the current drought situation.

In the case of severe drought, the EDO produces special reports, not only for Europe but also worldwide through its Global Drought Observatory, tailored for humanitarian aid (**http://edo.jrc.ec.europa.eu/gdo**). It issued two reports in 2017, for Italy in July and Mongolia in August.

The Italian report showed that up to two-thirds of the country was suffering severe drought, causing major agricultural losses, water restrictions in urban areas and higher fire hazard and intensity in forests. A consistent lack of rain since December 2016, including one of the country's driest springs in 60 years, is cited as the main cause, exacerbated by heatwave. Some regions received 80% less total rainfall than normal. The long-term statistics indicate little chance of recovery before autumn, which is usually the wettest period of the year.

Two questions arise: what can we do to limit the damage of future droughts? And do we have to get used to more frequent severe droughts?

Work continues on these, but priorities so far for drought-mitigation is a search for more drought-resistant crops and better management of the water we have. As for drought frequency, the news isn't good. Climatologists warn us to expect increasing extreme weather events in a warming climate.

# No longer treating soil like dirt

*Soil maps illuminate the hidden, vital world under our feet*


*JRC experts show several issues of the Soil Atlases series, edited by the European Commission, to the Swedish University of Agricultural Sciences, 2014.*

Soil: little mentioned but home to almost one-third of all living organisms. As a natural living system, it needs to be carefully managed to stay healthy. The task is a matter of some urgency: in 2014, Maria Helena Semedo, Deputy Director of the UN Food and Agriculture Organization, declared that if soil degradation continued at its then rate, the world had only 60 years' worth of arable topsoil left. That's 60 years of farming.

Without healthy soil, the world's food supply would be in trouble. Topsoil is the uppermost, nutrient-rich few centimetres of soil that supports plant growth and filters and cleans much of the water we drink. But it is at risk from erosion, pollution and urbanisation, as well as from poor agricultural and forestry practices. And once degraded, soil takes decades, sometimes centuries, to regenerate.

Thankfully, the topic is finally getting the attention it needs. Today, the state of soils across Europe and beyond can be tracked in a series of soil atlases developed by the JRC. The maps in these atlases are outputs from collaborations with organisations across the globe. The first ever *Soil Atlas of Europe* was created by the European Soil Bureau Network, an expert group of soil scientists from more than 40 institutions across the continent, set up and run by the JRC. Covering the EU and neighbouring countries, the atlas was published in 2005 to increase public awareness of the importance of healthy soil life. Soil atlases of Africa, Latin America and the Caribbean, and of the North Polar Region have followed, with an Asian atlas in development.

Key to healthy topsoil is the thriving collection of microorganisms living in it. Any square metre of soil may contain more than 10 000 species, all involved in complex interrelationships that convert organic matter into valuable soil components that plants need for their growth. To increase our knowledge of this teeming, hidden world, the JRC and the Global Soil Biodiversity Initiative published the first-ever Global Soil Biodiversity Atlas in May 2016. This atlas shows that in many parts of the world soil life is endangered. The atlas also proposes solutions.

Because they pinpoint areas where soil is under threat from climate change, contamination, erosion, salinisation and urbanisation, these atlases have allowed the EU to develop clear plans to protect soil, while demonstrating its value to the public.

The digital version is available for free download (**http://esdac.jrc.ec.europa.eu/content/global-soil-biodiversity-atlas**).

# Water of life: keeping Europe's lakes and rivers healthy

*Because pollution doesn't stop at the border...*


*Alan Belward presented the Global Surface Water Explorer, a joint project by the JRC and Google Earth Outreach, at a TED Talk in 2017.*

Eutrophication: a big word for a big problem. Many of Europe's rivers and lakes are shared by neighbouring countries; and by the 1970s, many of these waters have been prone to eutrophication — a dense growth of plant life caused by excess nutrients, usually nitrogen and phosphorus from agriculture and wastewaters.

At its worst, eutrophication due to algal overgrowth can starve fish and other aquatic organisms of oxygen, creating dead zones were no fish can live. Toxic algal blooms — and other sources of pollution — can pose risks to water quality, wildlife and human health. "Less than one in ten thousand litres of water in the world sits in the lakes and the rivers and wetlands on the land where we live: that makes it incredibly important," says Alan Belward of the JRC (to be precise: lakes and rivers form 0,013% of the Earth water resources).

Against this background, the European Commission set out to improve the ecosystem health of Europe's waters. The JRC plays a major role in implementing this objective through cross-border water research. Its work has led to the creation of a map of every strip of water on the planet going back 32 years; to tools for the management of the data about those rivers and lakes; and to technical guidance for cleaning polluted waters, and keeping those waters clean. If you like to play with maps, check out the water portal at: **http://water.jrc.ec.europa.eu**. There you can see, at a scale down to 5 square kilometres, the state of the waterways in every EU Member-State.

JRC researchers also participate in a giant research expedition, the Joint Danube Survey, coordinated by the International Commission for the Protection of the Danube River (ICPDR). JRC scientists provide analyses of a wide range of pollutants, nutrients and microbiology in the river, Europe's longest. The verdict: Certain points of the Danube still experience significant pollution (nitrogen, phosphorus).

"All of the assessments we make improve our ability as scientists to forecast possible changes. It's not our job to come up with solutions, but we can help policymakers to understand what they should be looking at," says Giovanni Bidoglio of the JRC.

# An import consumed, a scrap of environmental footprint exported

*A closer look at the environmental cost of international trade*

*Measuring organic pollutants associated with cross-border trade.*

One click. That's all it takes today to buy whatever you want. But there are hidden costs.

A hand-embroidered blouse from Italy? Easy. The latest tablet imported from China? No problem. A few bottles of one of Belgium's finest beers straight from the brewery in bulk? Available with two-day shipping at no extra charge. Surrounded by internationally traded products, we seldom think about the environmental footprint they leave in their country of origin.

The JRC has looked into this problem at the level of the EU, its individual Member States, Brazil, China, India, Japan, Russia, the USA, and the rest of the world. The approach was simple: every product needs inputs to be produced. That uses resources, and leaves an environmental footprint — for example, in terms of water use, land use, emission of greenhouse gases or other pollution. If a country's consumption takes more resources than its production, it is a net importer of goods and services.

But you can also call it a net 'exporter' of its environmental footprint: That is, its consumption is having an environmental impact on the countries from which it imports the goods. The JRC's report 'Global Resources Use and Pollution' shows that the EU, and other developed countries, are "exporting" part of their environmental footprints in this way to supplier-countries like Brazil.

We know that the world has become increasingly more global and economically interdependent over the years, so the outcome of this study seems to be logical, and there are few surprises. Its value lies in the detail. It's based on carefully collected, documented, and analysed input-output data, so that the results are detailed and coherent enough to be used in international discussions in the climate change and environment context.

For the individual citizen, the report also provides a clear message: if we consume more imported products, we contribute more to the resource use and the emission in the country of origin. In other words, we export a part of our environmental footprint and resource use by importing goods and services.

# Economy

Economy and finance shape our society, so understanding them is critical.

Over the past two decades the JRC has built up expertise and a complex toolbox for monitoring and analysing the financial and economic systems in the EU and around the world.

With its numerical models, the JRC is able to run scenarios and to help policymakers answer “What would happen if…” questions before policy decisions are taken. And through its monitoring activities, the JRC provides the means and the dependable facts necessary for the proper implementation and management of policies. Especially in a financial crisis, this kind of quick and expert advice is essential.

# How to build crash protection into the banking system

*Can better numerical models and safety-net legislation keep your money safe?*


*The JRC contributes to fiscal sustainability reports with estimates of the potential impact of banking losses on public finances.*

For many, the autumn of 2008 may never be forgotten. What had been, until that point, a slow-moving American financial storm caused by bad mortgage debt suddenly became an international crisis. On one day, 29 September 2008, nearly $5 trillion was wiped off the value of publicly traded stocks around the world as investors panicked. Failing banks in many countries, including the US, Britain, Iceland, The Netherlands and elsewhere, needed government bailouts. Suddenly, the man and woman in the street began to worry: was their money safe in the bank?

Action at European level was needed. The public had to be reassured. The JRC was among many institutions that contributed timely economic and financial analysis to help policy makers make the right choices.

The JRC quickly assessed what would happen if governments increased protection for depositors. It could show that a rise in the minimum amount of coverage of individual depositors from €20 000 to €50 000 and even €100 000 would increase the number of accounts covered by around 40%, assuring protection to more than 90% of European deposits. This evidence allowed the European Commission to propose increasing the coverage. This, as part of a multi-faceted programme of economic and fiscal support internationally, was a factor in calming jittery savers.

But the crisis clearly pointed to an urgent need to stabilise Europe's banking industry. Many approaches were discussed, and each needed expert assessment. For instance, one policy option was found to have undesirable effects: the perception that governments would have to bail out the largest banks in case of trouble could distort the market to the extent of implicit and unintended taxpayer-funded subsidies of up to €95 billion per year.

Another question concerned the banks' balance sheets. Simulations using the JRC's SYMBOL financial-modelling system showed, for example, that new EU rules requiring banks to hold more and better capital, together with a resolution mechanism for failing banks, would reduce the potential costs of a crisis to the public finances by more than 85%, compared to a scenario without these financial rules in place.

Of course, the story of the 2008 crash isn't over yet: Eurozone economies have only recently returned to robust growth. So research continues. SYMBOL, short-hand for Systemic Model of Banking Originated Losses, is among the tools that the JRC uses to estimate the effectiveness of alternative regulation scenarios in banking crises of varying severities. Forewarned is fore-armed.

# Get together to get smart — a recipe for regional prosperity

*The secret of local economic success? Make the most of what you've got*


*A JRC conference on strategies for regional development, at Seville in 2015.*

Play your strongest suit. That's smart for a card player — and for a regional government.

That kind of smart thinking now goes into how EU support for regional development is handled. When choosing which projects to back, policy makers often try to focus the money on what the region does best, or can most quickly build into a job-creating engine — whether it's building ships or growing grapes. To help, they often turn to a JRC tool to help with ideas and encouragement to support the local ambitions.

Using this Smart Specialisation Strategy Platform starts with a spot of stocktaking. The locality needs to ask: where are we, where do we want to go? What are we good at here, and what are the most important things to make better? The platform supports policy priority-setting through a broad involvement of local businesses, knowledge institutions, research organisations and civil society. It can help provide methodological advice, share good practice and knowledge, support collaboration between local partners, and develop tools to monitor progress. For instance, the platform has facilitated peer reviews of over 70 strategies, allowing regions to share their concerns and to learn from one another's experience.

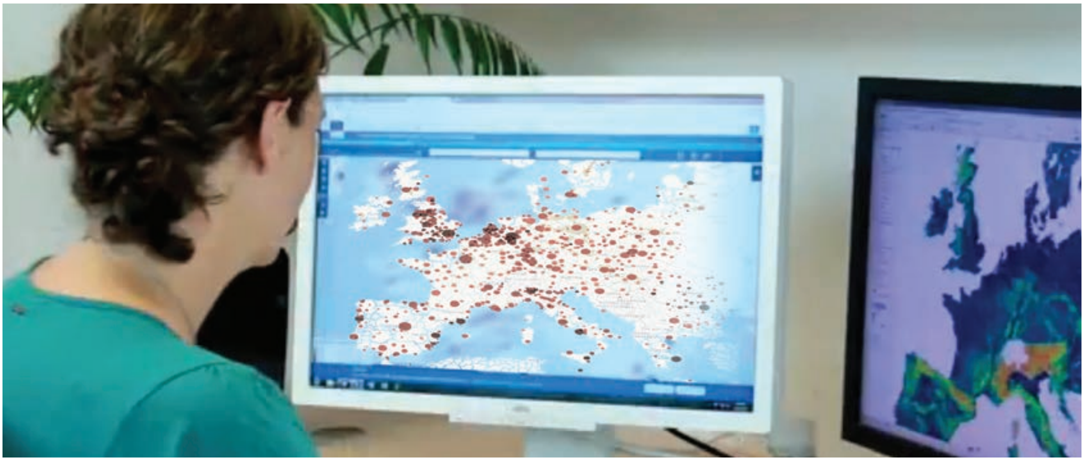
To date more than 120 strategies have been developed; and by 2020, projects already underway are expected to create more than 100 000 new start-up firms and more than 300 000 new jobs. These projects are funded from the more than €60 billion that have been earmarked in the 2014-2020 period for investment in innovation under the European Regional Development Fund.

Since its inception, the smart specialisation initiative has expanded. As common priorities for investment emerged across regions, cooperation across borders is now being promoted, for example through thematic platforms, hosted by the JRC. Thematic areas include agri-food, bio-energy, energy, and industrial modernisation. Also, new Member-States can use JRC tools to optimally combine the different forms of EU funding. This will ultimately help these countries to become more competitive on the global marketplace.

All EU regions have set their priorities for smart growth under this approach. They show that in fact, the potential for innovation is not limited to high-tech industries or manufacturing. It includes as well revisiting and upgrading traditional sectors. For example, Finland has focused their smart specialisation on the development of smart cities — EU-funded pilot projects include electric buses operating in Helsinki. In Extremadura, Spain, local producers received support for modernising the production of a distinctive local cheese.

# What does it take to revive an economy? Good data, for starters

*Modelling, forecasting, analysing — a wide range of JRC tools help steer EU recovery efforts*



*Measuring the urban population density with the JRC platform LUISA (Land Use-based Integrated Sustainability Assessment).*

How to get more jobs in Europe? Greater prosperity?

That's the goal of Europe 2020, a long-term EU strategy for smart, sustainable and inclusive growth. It's a difficult task: as even a glance in the newspapers shows, progress is slow and disparities between regions in terms of growth and employment continue. In response, the Commission has intensified its focus on 'territorial' policies, underpinned by greater coordination and cooperation among different levels of government.

All of this requires data and analysis — lots of it. For this, the JRC has contributed several tools. For instance, a monitoring platform tracks implementation of the Europe 2020 strategy at different territorial levels. And the Europe 2020 Index is a composite of economic, social and environmental indicators measuring progress towards the Europe 2020 objectives.

LUISA, another JRC tool, tracks current and future trends in European cities and regions. The name stands for Land Use-based Integrated Sustainability Assessment, and is used by local and regional governments to evaluate the strengths and weaknesses of their territories. It also helps define new policies or investment strategies. With its help, officials can assess the impact of possible infrastructure investments, for example in a transport hub or energy network. They can also look at the impact of regional subsidies and other factors, such as climate extremes. These evaluations are projected far into the future — typically to 2030 or 2050. Results can be presented at national, regional or local levels.

You can look at some data yourself. For instance, the Urban Data Platform (**http://urban.jrc.ec.europa.eu**) pulls together a ream of numbers describing the entire EU on an interactive map. Which is Europe's richest metropolitan region? Based on the data available for 2015, and measured in GDP per capita: It's the capital of Luxembourg, at €72 000. By comparison, London is at €42 000. The EU average: €27 000.

Try another: which is Europe's most inventive metropolitan area? If you measure it by number of patents per million inhabitants, the most productive in the database is Eindhoven, in the Netherlands — the Philips headquarters that is also home to a major technical university.

Another JRC tool serves primarily to assess the economic impact of investment policies and proposed reforms. Unlike macro-economic models, RHOMOLO zooms into the sub-national territories and delivers results that assess the real impact (on wealth and employment, for example) of the hundreds of thousands of projects across Europe that receive money from the EU Structural and Investment Funds. A new use: assessing the impact of the so-called 'Juncker Fund', a €315 billion initiative — proposed to hit half a trillion — that's key to the EU's current recovery efforts.

# Big companies, big R&D budgets — and big impact

*R&D scoreboard shows EU and US companies invest differently in R&D*

*The JRC, from its Seville site, produces annually scoreboards of EU business enterprise R&D expenditure.*

You often hear it said that EU industries are lagging behind the US and other competitors in terms of investment in research and development. It's said, but is it true? The Industrial R&D Investment Scoreboard, developed and run by the JRC, tells a more nuanced story.

The annual scoreboard (**http://iri.jrc.ec.europa.eu/scoreboard.html**) was created in 2004 to monitor business R&D investment within an EU action plan aiming to raise the level of public and private R&D spending to 3% of EU gross domestic product (GDP). Japan spends around 3.6%, USA 2.8%, and the EU-28 around 2%, which is about the same as China.
At the outset the scoreboard compared the top 500 EU-based companies ranked by research investment against an equal number of counterparts outside the EU. By 2016, the scoreboard had expanded to encompass 2 500 companies that account for roughly 90% of total R&D expenditure by the business sector worldwide.

In 2015/16, research investment by EU firms in JRC's scoreboard reached €188 billion, up 7.5% from the previous year and outpacing growth rates of both the US and Japan. The total figures, however, remain below the 3% of GDP objective. Accordingly, policymakers often fear that EU companies aren't investing enough to keep pace with rivals in the US and Japan, but the scoreboard has shown that the structure of European industry is a bigger hurdle.

Globally operating EU companies are concentrated in medium-tech industries — from automobiles and parts to chemicals, oil and gas, mining and banks. Major US R&D investors, however, are found mainly in high-tech sectors such as pharmaceuticals, biotechnology, software and technology hardware. The sheer size of the R&D investments of these large global players makes a structural difference: the US companies invested almost twice as much of their scoreboard R&D in high-tech sectors compared to the EU, whereas EU companies invested twice as much as the US in medium tech sectors.

"These structural issues weren't widely recognised back in 2004 but are now accepted" says Alexander Tübke from the JRC. "Understanding this side of the 3% target has led us far beyond monitoring R&D of large global players into a new discussion — how these companies trigger innovation and industrial change in the networked economy."

These global players, he says, "have huge indirect market and innovation power. They control supply and distribution chains, help smaller firms grow and internationalise, own participations in start-ups, provide work experience for future entrepreneurs, spin-off technologies, and collaborate with universities and public research institutions for knowledge." As a result, he says, the policy focus moves towards how to create more of these global players.

# Grasping the nettle of corporate taxation — in the name of fairness

*International companies are outfoxing national taxation authorities, but could change be on the way?*


*Calibrating CORTAX, a computable model for simulating corporate tax reforms.*

It's widely believed that the rules governing corporate taxation in the EU today are out of step with the modern economy. Uncoordinated national tax systems are being exploited by international companies to escape taxation, leading to significant revenue losses for countries and unfair competitive distortions for businesses that pay their share. Profit shifting by multinational firms, such as through transfer pricing, allows firms to reduce their tax liability by declaring profits in lower tax countries. Small and medium-sized enterprises are generally unable to engage in such practices.

In 2016 the Commission unveiled the most ambitious corporate tax reform plan yet. The Common Consolidated Corporate Tax Base package (CCCTB) is a two-step plan designed to enable businesses to use a single set of rules to calculate EU-wide taxable profits, reducing both red tape and costs of compliance. It is also a potentially powerful instrument against tax avoidance, which would largely prevent profit shifting between Member States, and help to level the playing field between multinationals and SMEs.

The Commission first raised the idea in 2011, but progress stalled due to opposition from some Member States to the so-called consolidation step, which would share out a company's taxable profits among the Member States in which the company is active.

The JRC has assessed the impact of the CCCTB proposal and compared the Commission's reform plan with and without the consolidation step. The results confirmed that a fairer and more efficient tax system could be introduced while maintaining, and perhaps even improving, gross domestic product and welfare in the EU. This would help to ensure a fairer burden-sharing between multinational firms, domestic firms and individuals.

This simulation is ongoing but "this is still a proposal and changes are usually made in legislation before it is adopted" says Daniel Daco of the JRC. "We are looking for the combination of features that would provide the most benefits to citizens and would find strong support across Member States".

Fairness is a key objective, meaning that profits should be taxed where they are generated — and not where the taxation is lowest. "At the level of the European Union it is a zero-sum game in terms of tax collection. But there would be winners and losers among Member States under the proposal. We are looking at various refinements that would allow more equal burden sharing — avoiding too many divergences and making tax collection and revenue more neutral for Member States," Daco adds.

Promoting investment is another objective of the reform plan and JRC is assessing 'patent boxes', arrangements in which countries grant preferential tax treatment to corporate revenue from intellectual property. "Financing research and development is an important feature of taxation to promote investment," says Daco.

# Untangling the twisted web of exports, jobs and incomes

*To develop a successful trade policy, first you must understand trade*

*SDFA JRC-Ispra.*

The European Commission has identified trade policy as a cornerstone of its strategy to boost jobs and growth. But the links between trade, employment and income have become increasingly difficult to map in today's globalised economy, not least because of the often complex cross-border production chains. Addressing that challenge, the JRC and the Directorate General for Trade have compiled a unique set of indicators to support evidence-based trade policymaking.

First, what's the overall impact of trade on jobs? In 2011 EU exports to the rest of the world supported 31.1 million jobs or 14% of total employment in Member States. That's an increase of 67%, or 12.5 million jobs, since 1995 when jobs supported by export were 9% of total EU employment.

Second, who benefits from the trade? According to these studies, all Member States gain from exports to the rest of the world, either directly through exporting companies or through a 'single market' effect. In 2011, for example, exports from Germany supported about 6.2 million jobs inside that country, but also 1.3 million jobs in other Member States. This is because, besides Germany, other countries are also involved in the production of the goods that Germany exports to extra-EU countries.

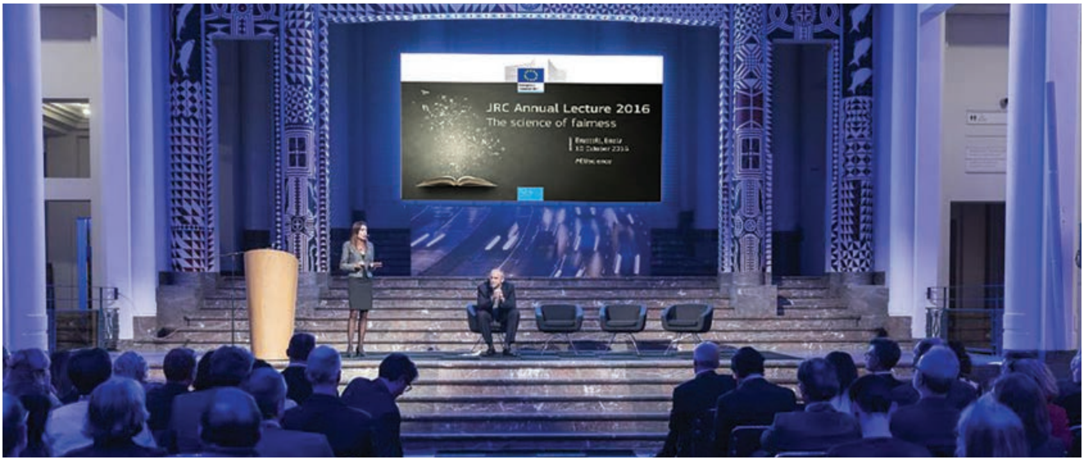
Other indicators compiled by the JRC highlight the growing number of jobs beyond EU borders, which are sustained by the EU exports. "In the past, products were manufactured by value chains in a single country. The more exports, the better, since the same country kept all the value-added," says José M. Rueda-Cantuche from the JRC. "That's no longer the case and value-added is spread around the world. The question of who gets what out of trade is the main concern in trade policy today."

Reshaping and complementing data available through the EU-funded World Input-Output Database, JRC scientists have produced an accessible, essential reference work. "We felt it was necessary to go beyond just a collection of data, of numbers," Rueda-Cantuche continues. "Policy officers across the EU need a resource like this set of indicators to help them identify and monitor how Europe evolved as a result of globalisation in the past decade."

JRC is working with other EU agencies to update its *EU Exports to the World* pocketbook that currently covers 2000-2011 with additional statistics for 2012-2014. Eurostat will take on responsibility for future updating beyond 2014, but JRC scientists will remain deeply involved in the field, for example as participants in a working group with Eurostat, the OECD and the UN Statistical Division aiming for further refinements in analysis of the trade/employment/income nexus.

# Can the data revolution help to make Europe a fairer place?

*How fair is the EU? Science can help us answer such questions*




*'The Science of Fairness' was the 2016 lecture the JRC held at the Bozar in Brussels.*

Who says life should be fair? Well, for starters, the European Union. Primary aims of the European project include peace, prosperity, human rights, freedom, security, justice — in short, a fair society.

But of course, we're a long way from achieving that. In 2016, at the JRC's Annual Lecture, two researchers, Francesca Campolongo and Sven Langedijk, posed the question, "How far is the EU from being a 'fair' society?"

They offer some disturbing facts. Children from wealthy backgrounds with poor cognitive ability go on to outperform brighter children from deprived homes by the age of six. Individuals with a poor family background are more likely to report poor health than those from better-off families. Individuals with a privileged family background are less likely to be overweight or obese than their counterparts with a poorer background. And those with a poor family background are more likely to have been victims of a burglary or assault.

In other words, your family and social background determines to a large extent your fate and future. Is that fair?

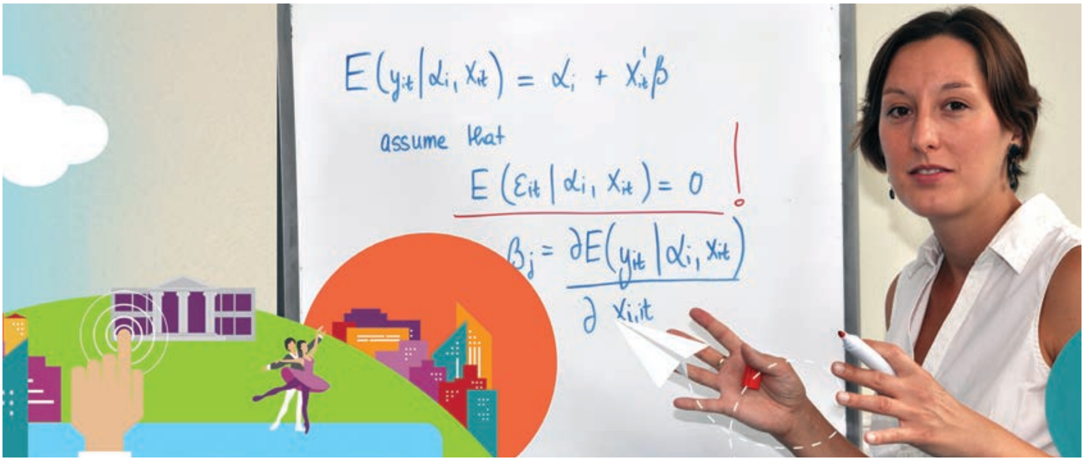
Says Langedijk: "I was surprised by the large differences within all EU countries in life opportunities and healthy life expectancy at birth depending on parental education levels. Many children are born with large disadvantages. Compared to their peers in better educated families, they have less chance of achieving a wide variety of key socio-economic outcomes. I thought the EU was more of an equal-opportunities society than it is".

Can the scientific approach make a difference? Campolongo and Langedijk conclude that fairness needs to be studied in a multidimensional context if we are to understand how inequalities of opportunities interact and cumulate. Combining geographical data with public and survey data on living conditions, together with proper econometric analysis, can help identify the drivers of inequality. And collecting quality controlled facts and figures will help identify the true causes of inequality.

"Now we need to understand better the facts that we found, identify the drivers and consequences of inequality of opportunity in the EU. And we should learn from good practices that apparently exist where the situation is better", says Langedijk. "There is much to learn and the data revolution provides new opportunities for us to understand our society from a citizen perspective. The aim is to contribute to enhancing prospects for a good life in good health for all citizens."

# Let the creative and cultural industries lift city economies

*Modern cities have their problems — can cultural vibrancy help solving them?*




*Econometricians at the JRC Competence Centre on Composite Indicators and Scoreboards have developed the Cultural and Creative Cities Monitor.*

“The man ain’t got no culture”, sang Nobel laureate Bob Dylan.

Well, Europe has culture, and plans to make the most of it. One of the European Union’s missions is to “contribute to the flowering of the cultures of the Member States”, and major innovation in that area came in 1985 with the introduction of European Capitals of Culture, an idea promoted by Melina Mercouri, the famous actress, singer and then-minister for culture in Greece. By 2007 the economic importance of culture and the creative industries was well appreciated, resulting in the Commission adopting the first European Agenda for Culture in a Globalising World.

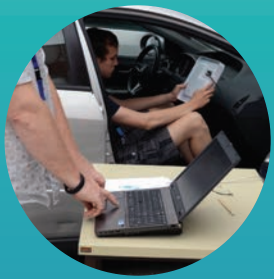
Figures from Eurostat, the EU statistical office, show that in 2014 there were 6.3 million people in the EU working in culture and the creative sectors — including the media and entertainment industries. That is 2.9% of all people in employment in the EU. Cultural and creative industries are responsible for 3.5% of all EU products and services annually — for comparison, the automotive sector is about 4%. And the cultural sector showed some resilience to the 2008 financial crisis, as employment in the sector grew from 2008 to 2011 (+0.7%) whilst it slowed in the general economy (-1.4%): a reminder that diversity in the economy is a strength.

Arts and science are sometimes seen as polar opposites, but the JRC’s scientific work has been effectively used to understand better the economic value of the former. The results appear in the Cultural and Creative Cities Monitor, released in July 2017.

The monitor compares cities against three leading indices: cultural vibrancy, creative economy and enabling environment. To do so, it brings together data from many public sources and the likes of TripAdvisor. The first edition features 168 cities in 30 European countries.

Success stories? Compared to other cities with similar populations, Paris, Copenhagen, Edinburgh and Eindhoven perform better than their counterparts as cultural and creative cities. Various small and medium-sized cities perform particularly well, such as Cork or Linz. And national capitals do well, but are outperformed by other cities in Austria, Belgium, Italy, Germany, Poland, Spain, the Netherlands and the United Kingdom.

A general conclusion that can be drawn is that cities that strive culturally also perform better economically. In short, investing in culture seems to be a useful strategy.



# Energy and transport

The European Union's energy bill is huge. It imports more than €1 billion per day. Despite a push to renewables, it remains highly dependent on oil and natural gas.

Increasing the efficiency of energy usage and finding alternatives that will reduce imports of fossil fuels are critical tasks. One of the biggest users of fossil fuel is the transport sector and e-mobility is one of the avenues to reduce the environmental footprint, at least of the urban transport systems. Safety also matters in transport, and new developments like the self-driving car promise major changes.

Many ideas that are currently in discussion seem to be science fiction, but at the JRC, groundwork is being laid for developing the new technologies we need, making sure that they are as safe as the existing ones.

# Keeping the lights on: the hard work of securing Europe's energy

*Recent scares have emphasised the importance of reliable supplies of energy*


*Energy distribution system simulated in real time at the Smart Grids laboratory in the JRC, Ispra.*

Europe imports more than half of all the energy it consumes — including over 90% of its oil. The cost of these imports is now over €1 billion per day. With future prosperity at stake, the EU is under huge pressure to ensure that energy supplies remain stable, reliable and secure.

After concern about stability of supply during disputes between Russia and the Ukraine, the EU in 2014 launched its EU Energy Security Strategy. Priorities are to increase energy efficiency, expand EU energy sources, and improve infrastructure links so that energy can be redirected to where it is most needed during a crisis. As part of this strategy, the European Commission also performed gas 'stress tests' to find out what would happen if gas supplies were interrupted during the winter. JRC's models were used to simulate scenarios of Russian gas import disruptions on EU countries. Member States received reliable information on the security of gas supply and on the risks for their gas systems.

It's hard to overestimate the importance of security of electricity supply, as today we rely more and more on electricity and the Internet. The Baltic States, for instance, are still synchronously interconnected with the Unified Power System (UPS) of Russia. To help assess the weaknesses and vulnerabilities of their power supply, and the potential impact of new connectors, the Baltic states used JRC's integrated model of these systems.

"Right now, we're expecting the solidarity principle to take much more concrete shape in a new extension to the EU Energy Security Strategy," says Marcelo Masera of the JRC. "There will be more emphasis on the regional theme, the idea that neighbouring regions should work together on a common approach for their energy systems for both electricity and gas."

Renewables can of course play a key role in improving Europe's energy self-sufficiency. For electricity production, the leading sources are hydropower and wind, with solar power gaining ground. In heating, bioenergy contributes most. An online JRC tool, the PhotoVoltaic Geographical Information System, allows anyone interested in installing photovoltaic systems to estimate likely energy outputs at almost any location worldwide. To promote the wider introduction of renewables the EU made €1.72 billion available for funding projects of common interest. The JRC helped in identifying the first and second list of these projects.

Smart grids are an area that directly affects the consumer, allowing him or her to become a 'pro-sumer', producing and consuming electricity, and offering any surplus to the market. In 2011 the JRC performed a cost — benefit analysis of smart grids in Europe, the first Europe-wide inventory. The results illustrated the promise they hold: better integration of dispersed renewable electricity sources, supporting electric vehicles, giving more control over consumption to consumers, helping avoid blackouts and restoring power more rapidly when outages occur.

# The too-cool data centres that waste energy and money

*Helping server-farms saving power and keeping data flowing 24/7*

*The JRC opened a data centre in 2015 with over 90 racks of data storage for its European Centre for Scientific Information.*

Online shopping is now. Smart meters in the household are happening. Communicating cars are down the road. And the Internet of Things and toys is over the horizon.

This is the connected society. Always on, always available. And it relies on data — terabytes of it — served up instantaneously by powerful servers running around the clock.

If this society is to function, those servers need to be absolutely reliable, which usually means they need to be kept cool. This requirement has driven the phenomenon of large data centres, where clusters of high-performance computers operate in a closely controlled, perfect (for silicon chips) microclimate. These facilities are estimated to consume a remarkable 50 terawatt-hours (about the gross electricity generation of Greece) of electricity annually in the European Union alone, and this figure is expected to double by 2020. Yet recent studies have shown that about half of that energy is used to cool building interiors to a temperature that is unnecessarily cool. Many servers are in fact 'idling', generating little heat.

With improving efficiency as a central theme of EU energy policy, the JRC produced a set of agreed best-practice guidelines for data centres that could help operators save energy. And so was born, in 2008, the EU Code of Conduct for Data Centres. Its aim? To improve energy efficiency for the whole sector.

The Code is an independent scheme and a voluntary initiative that sets ambitious standards for the companies taking part, helping data-centre operators reduce energy consumption in a cost-effective manner and without hampering the mission-critical function of these installations. Organisations that sign up are expected to follow the Code, and commit to a set of agreed improvements. The JRC updates its guidelines regularly; version 8.1.0 was published in January 2017.

The results? Paolo Bertoldi of the JRC says: "We have 350 data centres and around 150 companies across the EU signed up to the Code. All the big names are there, including Facebook, Google, IBM, and the major European telecoms companies." In addition there are 248 endorsers of the Code — vendors, consultants or industry associations — plus many smaller companies.

Bertoldi adds: "What all these companies like is that the Code is a pan-European approach, a common set of standards, from an organisation that has a solid technological reputation. It is by far the most important energy policy initiative for this sector."

# On a charge: batteries will drive electric vehicles to market

*What will it take for electric and hydrogen-powered vehicles to become the new norm?*


*Battery testing at the European Interoperability Centre for Electric Vehicles and Smart Grids, opened 29 October 2015 at the JRC Ispra.*

Electric cars are exciting — but really, how many of them are actually on the road today? Is it all hype?

Here are the facts. According to a JRC report, the number of full electric and plug-in hybrid electric vehicles sold in the EU has been rising: from just 760 in 2010 to more than 70 000 in 2014 and almost 160 000 in 2016. The choice of models rose from three to nearly 30 in 2014. Today some 550 000 electric and plug-in hybrid electric vehicles are being driven on European roads. Sales of these cars are projected to increase to about 800 000 per year in 2020, and between 1.65 and 1.9 million per year in 2025, possibly including a growing number of hydrogen powered cars — that also need powerful batteries.

To become reality, this development will require batteries that are high performing, safe, durable, and with an ever-larger capacity, all at a reduced cost. The JRC contributes to developing this technology and bringing it to the market through comprehensive research and testing of batteries for vehicle use. That includes performance and safety assessment under a variety of conditions and in second-use applications, and degradation evaluations. In a specially equipped battery-abuse lab battery cells will be exposed to conditions that go beyond normal operating conditions.

This work is critical to ensure that electric vehicles attain the same level of safety for vehicle occupants as conventionally powered vehicles. Since 2012 the JRC has been part of an international working group at the United Nations Economic Commission for Europe, tasked with developing a global technical regulation on the safety of electric vehicles. The international group involved in this effort includes regulators, research institutes and car manufacturers from the EU, the US, China, Japan, Korea and Canada.

As part of the Integrated Strategic Energy Technology-Plan, aiming to support EU competitiveness in the global battery sector, the JRC helps identifying how achieving ambitious battery performance and manufacturing, while meeting cost targets, can be best promoted by Member States, industry members and research organisations.

So if in the future, you are enjoying a long-distance trip in your electric vehicle, driving to your holiday destination with no concerns about your battery power running out or your safety, don't forget JRC's work that will have helped make your journey a safe and routine reality.

# The future's bright: setting standards for the booming solar industry

*A European lab in sunny Italy is a focus for a global industry*

*Class AAA solar simulator at the JRC-European Solar Test Installation (ESTI), devoted to the development of standards for electrical performance of photovoltaic products.*

In its 35 years of existence, photovoltaic (PV) technology — the most common form of solar energy — has changed beyond recognition. From a niche technology, annual sales have grown to over €50 billion globally. Many of the more than 70 standards for photovoltaics set by the International Electrotechnical Commission derive from JRC specifications or research data. These standards ensure that today, a photovoltaic module manufactured in any country can be sold unchanged in any other country, without a new technical approval.

Photovoltaic solar cells are an important source of electricity. Efficiency increases and large-scale production in a global market have meant that installation costs have fallen to the point where solar power is affordable even for ordinary households. But what does the consumer look for in solar cells? Durability and reliability of course - but most of all, lots of power production from a given area of cells. That helps to keep installation and running costs to a minimum.

The EU has a lead position in deployment, technology development and photovoltaic power measurement, especially when new materials are involved, thanks to ESTI, the European Solar Test Installation at JRC's lab in Ispra, Italy. ESTI is one of four recognised World Photovoltaic Scale Laboratories for output measurement, and one of three that can cover the entire product chain from materials to complete energy systems. And the way it measures a solar cell's output power is considered a gold standard in the industry. Says Ewan Dunlop of the JRC: "There are only two other centres in the world with that capability, one in the US and one in Japan. All other labs rely on our measurements for calibration — because we go back to the source."

ESTI started work on solar cells in 1978. Its facilities were complemented in 1996 by cladding the 780-square-metre south facade of its building with photovoltaic solar panels. The panels produced a peak power output of 25 kW and a yearly electricity production of some 15 MWh; at that time it was Europe's largest building-integrated photovoltaic facade. The installation was renovated in 2013 with the introduction of new large area solar simulators. Thanks to continued investment in state-of-the art technologies, ESTI is keeping pace with the rapidly evolving market so it can handle new global standardisation issues as they emerge.

# Safer transport involves hidden technologies as well as fancy driver aids

*There's more to road safety than what goes on behind the steering wheel*

*Looking for hidden tags in car equipment, as part of the JRC research on digital tachographs.*

Anyone who attends a demonstration of Volvo Truck's automated emergency braking (AEB) system cannot fail to be impressed. In a giant articulated truck, you hurl towards a tiny VW Polo, begging the driver to brake. An alarm sounds, and the vehicle judders to a stop centimetres away from the car. The driver has done nothing.

The latest collision avoidance and accident reduction technologies are hugely impressive. Yet much of the critical work in accident reduction over the years has been carried out much further back in the chain of causation, like the digital tachograph, ensuring that drivers do not fall asleep at the wheel in the first place. "The digital tachograph is a fundamental element in enforcing European social legislation for professional truck drivers; it is deployed in more than 50 countries via a UN-ECE Agreement" said JRC Senior Scientist Jean-Pierre Nordvik. "That legislation is there to improve road safety, to ensure fair conditions of work for drivers, and a level playing field for the market."

The JRC ensures the interoperability of the various tachograph components (vehicle units and smart cards) and manages the cryptographic infrastructure that ensures the integrity of the digital contents. The next-generation 'smart tachograph', mandatory from 2019, will also incorporate external data communication and satellite-positioning data, enabling authorities to better detect potential offenders.

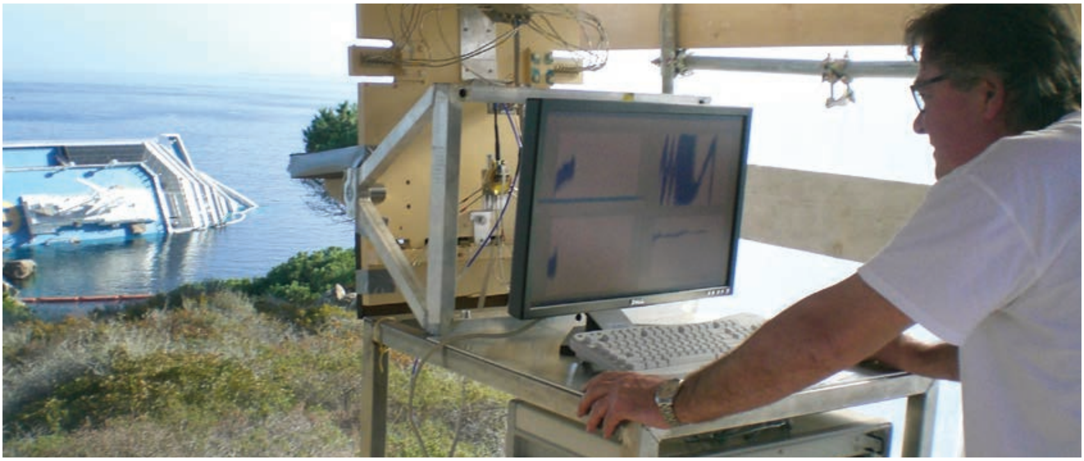
Even further up the causation chain lie the European transport policy. T-NET/TRANSTOOLS is a family of transport models, unique in representing transport infrastructure at EU level and combining demand data for passenger and goods transport. It helps to understand the role of transport infrastructure for connecting European regions and the effect transport policy has on it. It was used, for example, to assess in quantitative terms the impact on transport activity, trade and the environment of a treaty between the Western Balkan countries and the EU on land transport, running through various possible scenarios.

And EU transport statistics apply in skies too. ECCAIRS, the European Co-ordination Centre for Accident and Incident Reporting Systems, was co-developed by the JRC back in 2003. After years of successful use in the aviation industry, maritime and rail authorities are showing interest in the system that supports learning from the reported events.

After a joint study with the JRC, and testing of a suitable prototype, the European Maritime Safety Agency has decided to implement their European Marine Casualty Information Platform on top of ECCAIRS and the European Railways Agency is also considering ECCAIRS for their accident and incident database. A first prototype has been delivered, and after some development, ECCAIRS has been redesigned as a 'Common Framework', upon which specific extensions, depending on transport mode, can be deployed.

# The Costa Concordia disaster: How do you keep track of a ship wreck?

*A maritime surveillance radar system helped rescue teams work safely in the tragic shipwreck*



*JRC researchers were monitoring the Costa Concordia shipwreck, thanks to the radar MELISSA (MIMO Enhanced LInear Short SAR), for more than two years.*

On 13 January 2012, the cruise ship Costa Concordia capsized and sank after striking an underwater rock off Giglio Island, Italy, in the Mediterranean Sea. Emergency rescue organisations scrambled first to rescue survivors, then to locate the bodies of those who lost their lives in the disaster.

An additional problem quickly emerged. The ship was half above water, half below, and perched on an unstable underwater reef. Storms or high seas could move the ship at any time, making the search for further bodies highly dangerous, and hindering efforts to pump fuel from the ships tanks before it polluted the coastline.

“The problem for the emergency divers was that it could take them an hour or more to penetrate the inner parts of the Costa Concordia each dive,” said Dario Tarchi, Senior Scientist at the JRC. “If the ship were to move or capsize further during that time, they could be trapped.”

The JRC liaised with the Italian Coast Guard to quickly deploy its advanced ground-radar system on the coast close to the wreck. The compact and portable system, called MELISSA, can detect movements of objects with very high accuracy. Installed within line of sight of the wreck, it could operate day and night in any weather, and was able to closely monitor the position and stability of the ship, providing instantaneous warnings of any perceptible movements. The continuous stream of data it provided was fundamental to the success of the Italian search and rescue operation.

On Giglio Island, the system was taking two pictures a second, monitoring more than 100 points of the ship. In fact, it is capable of taking measurements up to 140 times a second to detect minute movements.

The experience gained from using the system for the Costa Concordia shipwreck was valuable. The research team is now looking at new surveillance applications to improve maritime security and border management. As an example, it could be used in combination with other sensors and platforms, to improve detection and tracking of small boats.

And, says Tarchi, “the system has improved its capacity for application in other disaster scenarios, involving land movements, volcano measurement, and monitoring of the stability of bridges and other major pieces of infrastructure.”

# Breathe easy: plotting a route to reduced road-traffic air pollution

*Cleaner air for Europe's cities is coming — but we'll have to wait*


*JRC technician at the Vehicle Emissions Laboratories sets up measurement devices.*

Air pollution from vehicles troubles many these days. Growing numbers of diesel vehicles, and the 'dieselgate' emissions control scandal, have brought a realisation that drastic measures are needed to tackle the still too-high levels of nitrogen dioxide and particulate pollution. Both France and the UK recently announced that no petrol- or diesel-powered cars will be allowed on the market after 2040. They may disappear sooner: Volvo has already announced plans to manufacture only fully electric and hybrid cars from 2019.

The JRC has tested vehicle exhaust for many years as a basis for European emissions standards. Analysis at the Vehicle Emissions Laboratory is backed up by research into real-driving emissions. The use of portable emission measurement systems, for example, has become the basis of an on-road testing procedure that is compulsory for all new passenger cars from September 2017. The main expected benefit is the reduction of pollutant emissions to very low levels under the vast majority of normal conditions of vehicle use.

An important European research project, led by the JRC, is developing air-pollution control strategies to improve air quality in 'city canyons'. One of its studies, led by the University of Surrey's Prashant Kumar, has found, for example, that low hedges planted alongside busy city roads can reduce pollution levels. Says Kumar, "we focus on how to reduce people's exposure to pollutants from traffic, and it's clear that the green boundaries, or hedges, are very important for this".

In recent years the emphasis on reducing pollution from road traffic has shifted towards alternative fuels and decarbonisation of transport. A 2014 analysis of the evolution of the EU electric-vehicle market found that further development remains highly dependent on future support policies, especially those based on reducing pollutant emissions and support infrastructures for electric vehicles. Large-scale deployment of electric vehicles in cities will play a key role in reducing local air pollution, but where can they be charged? In a pilot project, the JRC identified the optimum allocations of charging stations for the city area of Bolzano/Bozen and for the region Alto Adige/Südtirol in northern Italy. Local authorities now know how to build a good charging infrastructure.

The recharging infrastructure will also need to be interoperable globally. The JRC is working towards this goal, together with its partner facility at the US Department of Energy Argonne National Laboratories. In October 2015 it inaugurated a new state-of-the-art facility to harmonise technology standards. EC Vice-President Maroš Šefčovič said at the inauguration, "Smart grids and electric vehicles are rapidly evolving, but we have not yet harnessed their full potential. Developing harmonised standards across the Atlantic will minimise trade barriers and increase the global market for innovative products and services for EU and US producers and consumers alike".

# Can smarter road networks make you a smarter driver?

*Going for a drive? Let the car take the strain.*

*Fixing a circularly polarized antenna, designed for GNSS / Galileo applications, at the JRC-European Microwave Signature Laboratory.*

Within a few years, your car might tell you, before you start a journey, “Don’t bother, there’s an hour’s delay on this route. Drink a cup of coffee.” Far-fetched? Not at all; most of the necessary technologies already exist.

Such are the possibilities of Intelligent Transport Systems (ITS), which lie at the heart of the innovative communication services becoming available to travellers and vehicles. The aim is to keep transport users better informed and able to make safer and ‘smarter’ use of transport networks.

The critical element in such systems is how to link them together. And here the JRC is playing a lead role, bringing together public research and major transport businesses to make the disparate systems and services interoperable, and thus genuinely attractive to global markets.

One example is the JRC-led Transport Pilot that began operating in Norway and Sweden in 2015, and has since extended to other countries. The pilot has already given commercial map-providers (for example, TomTom and Here) the ability to update their customers’ vehicle navigation systems almost as soon as the roads change.

Another key effort is enabling vehicles to communicate with one another and with the road infrastructure. Thus equipped, future vehicles will transmit their exact position, speed and direction of travel almost in real time. Picture a motorcycle and a car approaching a T-junction at the same time. The most common accident for motorcyclists is a vehicle pulling out in front of them at a junction (“I’m sorry I didn’t see you”). However, future ITS-equipped vehicles will, even if each driver is unaware of the other, inform the other vehicle of the risk of a collision, and adjust relative speeds to avoid it.

ITS has the potential to vastly reduce severe traffic accidents, thereby saving lives, millions of euros a year, and reducing air pollution caused by queues of stationary traffic. When you add other potential future services to the mix, such as self-driving cars, automated emergency braking, the convoy (follow-me) facility and automated parking, ITS is likely to make future travel unrecognisable compared to what we know today.

Many of these capabilities have been developed with the help of JRC basic research. Standardised formats for vehicle-data exchange, standard communication protocols, built-in vehicle sensors (radar and lidar), automatic control of engine power, pan-European cloud platforms, web services, transport policy and legal and regulatory issues, the JRC has been involved.

So, when your car’s advice is, “time for a coffee”, just go along with it.

# Food

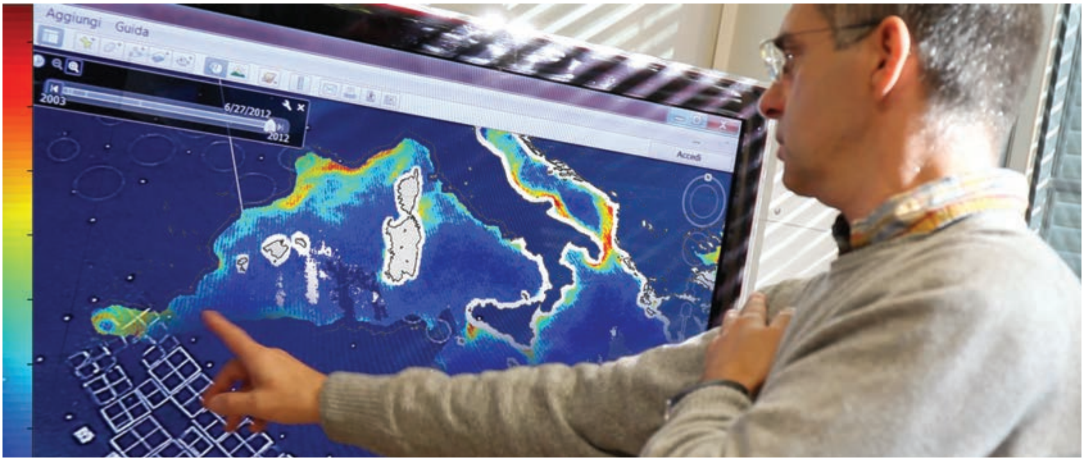
Food scares shake away the complacency surrounding the safety of the things we eat. In the 1990s, it was the BSE crisis in beef. This year it was eggs tainted by the insecticide fipronil.

These scares remind us that vigilance is needed — along with solid science. Threats to the food chain come in various shapes and sizes: whether it is lingering questions over genetically modified crops, the quality of feed for our animals, or the possibility that unhealthy chemicals creep from our packaging into our food or drink.

The JRC keeps a watchful eye over these issues, and passes on its knowledge to the European Commission so it can make better laws to safeguard food standards and make sure they are implemented equally throughout the EU. Ensuring food is not only safe, but plentiful, is another area of concern for the JRC, which is why it has also developed modern technology to monitor difficult food markets in Africa and cares about overfishing

# Ensuring there are plenty more fish in the sea

*Too many fish fingers? Researchers try to tackle overfishing in European waters*



*Exploring the multi-annual mean occurrence of bluefin tuna feeding habitat in the Mediterranean, as part of the Fisheries and Aquaculture research at the JRC.*

The eminent 19th century biologist Thomas Huxley, also known as "Darwin's bulldog", stated in 1883: "I believe that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea-fisheries are inexhaustible; that is to say, nothing we can do seriously affects the number of fish". In the following decades, the collapse of multiple fish stock has proved him wrong.

A growing appetite for seafood is pushing fisheries to the brink. The average European eats about 25 kilograms of fish per year, six kilograms more than the worldwide average. People living by Europe's coastline put away 50 kilograms each per year. The EU fishing industry may be the fourth largest in the world, providing some 6.4 million tonnes of fish, but even this is not enough to meet demand, with the result that many of the fish reaching our restaurants and supermarkets come from foreign waters. One factor that helps explain a growing volume of imported fish is a slow take-up of the latest techniques for aquaculture, or fish farming, across Europe. Compared to the rest of the world, where farmed fish is increasing, European fish farming has flat-lined.

This puzzle has caught the attention of JRC scientists, who want to help fill anglers' nets, while guiding them away from unsustainable practices. Using fisheries data collected from Member States, the JRC has developed cutting-edge ways to model the capacity of fisheries. This sort of data is essential to inform work to maintain and restore fish stocks, and improve aquaculture and fishing practices.

Better knowledge on fisheries and fish stocks is particularly important for the Mediterranean region, an area where fish always was an important component of the diet but where overfishing is abundant. Reinvigorating Mediterranean fishing could provide more food, exports and jobs, says Jann Martinsohn, a JRC scientist. "When it comes to the Mediterranean, one of the main issues is the lack of knowledge on the status of commercially exploited fish stocks," says Martinsohn, whose research has found that 93 per cent of stocks in the region have been overfished.

To help limit the catch where overfishing is occurring, the JRC works with local scientists to collect data on fish stocks, leading to better forecasts and management strategies. JRC scientists also use DNA data to monitor fish health, looking mainly at how genetics affects breeding and biodiversity. The combination of these two approaches, scientists say, is the best chance for Europe to ensure there is enough fish for everyone.

# Test then test again: keeping track of GMOs in the food chain

*All citizens have a right to know if there are GMOs in their food*

*Working in the incubator within the GMO laboratory at the JRC.*

Genetically modified organisms, or GMOs, are a politically hot topic. But they also pose many technical challenges.

In the EU, genetically modified plants may only be cultivated or used in food or feed after a careful risk assessment, and if a method is available for detecting their presence. The principle of 'no method — no market' counts for all GMOs. No market, too, if the European Food Safety Agency has not assessed a GMO's risk.

But tests must be tested, and validation is a JRC responsibility. Validated tests must detect the presence or absence of GMOs in food or feed; and for GMOs that are allowed onto the EU market, the tests must also determine the amount of any GMO that is present. This is done by comparing results against test data from reference materials with precisely known GMO content — and the JRC is one of the two producers of GMO reference materials in the world.

Having validated tests is not enough; the national food control laboratories in Member States must be able to use these methods in their routine controls. The European Network of GMO Laboratories, run by the JRC, ensures that validated methods are fit for purpose and can be run in all Member States. The network brings together the practical experience of more than 100 laboratories, and also deals with challenges posed by new GMOs that are not authorised in the EU but which might be found in imported products. Together, the the JRC and the network provide a full range of tools for controlling and monitoring the presence of GMOs in food or feed.

So what's the impact of this work for the public? First, clearer labelling; within the EU any food or feed product containing GMO material in traces of more than 0.9% of the mass of the authorised GMO ingredient must clearly identify on its label what this substance is. The consumer knows what he or she is getting because the public authorities are able to control it.

The second benefit is peace of mind for the consumer; any product containing even a tiny trace of an unauthorised GMO, a potential safety risk, will immediately be taken off the market.

And finally, as this work has led to test methods that can be applied in any modern molecular biology laboratory, the European-developed standards are widely used in many countries to control and monitor GMOs in their territories. For more than a decade, the JRC has been helping these countries to build-up their capacity, not least through supporting regional networks of GMO labs around the world. A global network has emerged, exchanging experience and good practice between exporting and importing countries, and helping to avoid the export of GMOs to a country where they would be unwelcome.

# It's a wrap: do you know what's been in touch with your food?

*Food packaging has to be tough enough to protect the food — but harmless for the eater*

*The EU Reference Laboratory for Food Contact Materials offers scientific support to the fight against counterfeiting.*

Unless you are a prolific gardener, it's likely that most of the food you eat has travelled some distance before arriving in your hands, and during that time it has been processed, wrapped, bagged, boxed and stored in a series of warehouses, commercial kitchens and shops. It's easy to assume that as long as the packaging material of the food hasn't been damaged and the content exposed to the environment, it is safe to eat. But how do we know that our foods are not being affected by the packaging they are surrounded by, or the plates and glasses we use to serve it?

The answer lies in careful testing and authorisation of food contact materials. That's not just the cardboard, plastic, metal or glass used in food packaging or presentation materials, but also the adhesives, inks and coatings that bring them together. The European Reference Laboratory for Food Contact Materials, which is operated by the JRC, provides the reference materials, testing methods and other tools needed to authorise the packaging materials used by food producers, processors and vendors. Tests are made available to examine substances released by packaging or food processing machinery, to ensure they do not contaminate your food above tolerated levels.

Monitoring these substances isn't easy. As recently as 2016, the JRC found that lack of compatibility between testing protocols and reporting in the Member States meant that national standards and lists of authorised substances varied widely from country to country, making it nearly impossible for legislation to be effectively enforced.

This issue is important to all of us; after all, we want to know what we are putting into our mouths. But it becomes particularly important when considering the impact on children and babies who, because of their lower bodyweights, would be more vulnerable to contaminating food contact materials.

One telling example is the material used to make baby bottles. Following a ban on the use of bisphenol A in baby bottles in the EU in 2011, JRC scientists sought to ensure that plastic substitutes used for manufacturing baby bottles were up to standard. Through their studies, they were able to develop methods to measure a number of substances migrating from the material into the contents of the bottles, methods which could then be used to check the compliance of any bottle marketed in the European Union.

# Mad cow disease: a scandal that changed food safety policies

*Validated diagnostic tests were crucial for solving a major food crisis*

*Preparation of BSE samples in the Reference Materials building, processing hall, at JRC-Geel site.*

It is easy to ignore the complex chain of production that goes into our food, particularly meat. With an ever-increasing global population, meat production on a large-enough scale is possible only through a combination of careful management of animal health and welfare, and high-performance production. The feed used for such animals is an essential part of this process, and is necessarily governed by strict quality and safety standards.

These standards came under the spotlight during the BSE (bovine spongiform encephalopathy) crisis that started in the late 1980s when increasing numbers of cattle in the UK developed symptoms of what is commonly known as mad cow disease. It hit the headlines when UK scientists announced the likely transmission of BSE to humans, causing a debilitating new variant of the Creutzfeldt-Jakob neurodegenerative disease. The new variant's alarming novelty was to affect young people; the non-BSE related forms most commonly hit older adults.

It became clear that inadequately processed meat and bone meal, an important part of cattle feed at that time, was the vector that infected cattle, and that one sick animal could infect hundreds more. Ruminant protein was therefore banned from cattle feed (in 1994) and from the diet of all animals (in 2001).

To further reduce the risk of infected animals entering the food and feed chain, there was a need for a rapid test for use on fallen stock (animals dying before slaughter), slaughtered cattle and if possible, in living animals. Several biotechnology companies soon offered tests — but did they work?

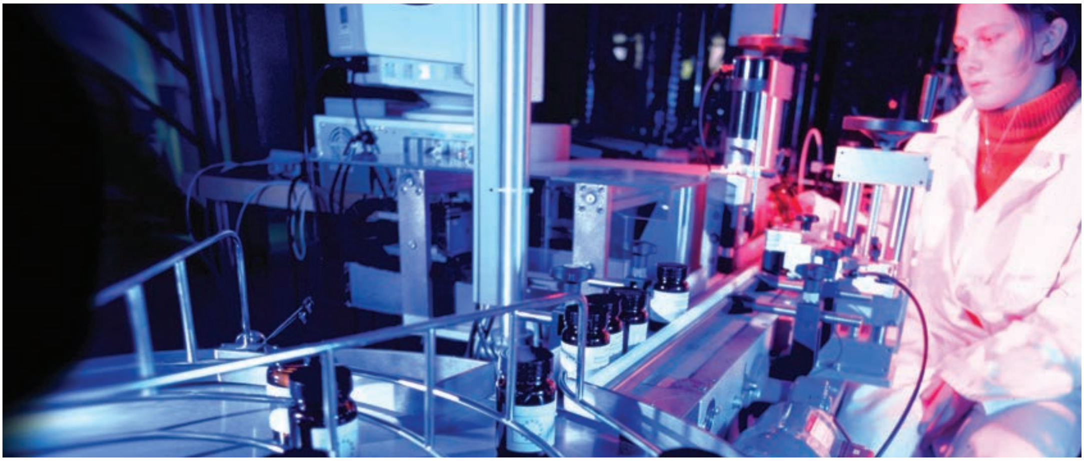
The Commission asked the JRC to validate the tests, designed for use on brain samples. In 1999 three tests were found capable of identifying BSE in dead cattle, and approved for mandatory screening across the EU. In later years (until 2005) the JRC evaluated another 15 rapid BSE tests, several proving suitable for used in official BSE surveillance programmes. This systematic BSE testing has led to the efficient removal of infected animals from the food and feed chains and helped to restore consumer confidence.

Also, a meat and bone meal ban was crucial for containing the BSE crisis. But what could be done to prevent future outbreaks? The JRC was again called upon, this time to evaluate methods of testing animal feedstuff for the presence of mammalian protein, the feed component assumed to transfer the disease.

The story does not end there. Processed animal proteins, a by-product of slaughtering healthy animals, have a high nutritional value and are used in pig and poultry production. It is important that these proteins are not contaminated with potentially infectious meat and bone meal. To this end the JRC developed a test to determine the origin of feed ingredients. This test is now obligatory, and an important contribution to the possible safe reintroduction of animal proteins in animal nutrition.

# You are what you read: why food labelling is so important

*There's a lot of science behind those impressive ingredients lists*



*Bottle labelling at the JRC-Reference Materials processing hall.*

As food production techniques advance, knowing what your favourite snack is really made of gets trickier. Food labelling is an increasingly important part of consumer protection, providing information not just on product composition, but also on nutritional value and where the product comes from. It's important for health reasons too, as the label warns allergen sufferers what ingredients have been used in its preparation. Consumers have a right to know what is in the products they are buying, and work done by the JRC helps make sure that's possible.

The composition of chocolate, for example, may vary from producer to producer, each bringing together different ratios of the core ingredients of cocoa solids, cocoa fat and sugar, although certain minimum compositional standards have to be respected throughout the EU. The only way to know what is really under the wrapper is to look at the ingredients list.

In the case of chocolate, better labelling ended a dispute that had lasted nearly 30 years, when in 2003 the European Court of Justice ruled that Spain and Italy could no longer ban the sale of UK chocolate, in which part of the cocoa butter, the ingredient considered essential for making chocolate, is replaced by other vegetable fats. Despite the claim by some countries that the UK product should not even be called 'chocolate', as it does not contain cocoa butter only, the court ruled that the product could be sold throughout Europe as long as the labelling made clear that it included vegetable fats, as well as meeting the legal minimum requirements for cocoa solid and fat content.

For this sort of legislation to work, simple tools are needed for ease of monitoring. That is a fit description for 'CoCal', a series of toolboxes created by scientists at the JRC, which provides the appropriate methods and calculations needed to prove the authenticity of milk and dark chocolate. CoCal is used by national testing labs in Member States to ensure the quality of the produce on sale in their country. With these tests in place, we can rest assured that we really are getting the treat that we deserve — anywhere in the EU. But to be sure- read the label.

# How crowdsourcing can improve Africa’s food supply

*What’s the price of bread? Testing a new way to get accurate food pricing information*

*JRC staff explaining the Africa Food Prices Collection initiative.*

In countries experiencing food crises, real-time information about location, availability and cost of food supplies makes a dramatic difference in decision making and the provision of aid. As a leading agent for global food security the EU needs reliable and timely information for modelling and monitoring food security management, particularly in those areas most at risk. Yet too often the data available suffer from being out of date, having gaps in their geographical coverage or lack of continuity.

Enter crowdsourcing. Today in Africa, the widespread usage of mobile phones make crowdsourcing, the collection of data through citizens, a realistic option for better food security information. But how effective is the method and how reliable are such data, collected by people that are not trained in data collection?

To answer these questions the JRC, alongside the African Development Bank and a data visualisation company called Knoema, developed a crowdsourcing data platform and tried it out. The JRC studied different technologies and methods with networks of both professional data collectors and amateurs. These trials ran until the end of 2016 and results were made publicly available on **http://africafoodprices.io**. A pilot looking for contributions of multiple volunteers ran in three cities: Nairobi, Kampala and Freetown.

The specific data are fascinating. How much, for instance, does it cost to buy a 450 gram loaf of white bread? Depends on the country. The most expensive loaf among the African countries for which data was gathered at the end of December 2016: not surprisingly, war-torn South Sudan at $4.56. But more typical of the continent is Mali, at 45 US cents, or Sierra Leone at 36 cents. Among the cheapest, by government policy, was Algeria at 9 cents. A similar pattern emerges for a litre of pasteurised unskimmed milk, ranging from $4.25 in South Sudan to 23 cents in Algeria.

The conclusion from JRC scientists: a crowdsourcing approach proved suitable for collecting and disseminating data in a timely fashion but quality and reliability of the data and the long-term sustainability of the crowdsourcing networks remained a challenge. Testing is needed for any data collection method but is of particular importance for crowdsourcing approaches.

Typical problems encountered include that for the public (the “crowd”) to actively send in data they need to be rewarded, e.g. by small financial benefits or mobile phone credits, and they need to be able to use their current technology, be it a mobile phone or smart phone. The study also showed that richer data are better collected through apps on smartphones, and that paying out financial rewards can increase the quality of data (quantity and accuracy) but could render crowdsourcing less cost effective.

# Is it the right vintage? To find out, drink it — or take it to the lab

*The EU Wine Databank helps keep tabs on what's genuine, and what isn't*

*Testing wine samples in a nuclear magnetic resonance machine, at a JRC lab.*

Wine is a quintessential part of European culture and an important export. Ensuring the quality of the product is essential to customer satisfaction, the protection of regional wine-growing practices and traditions — and to make sure it's European wines that take that market share.

Yet wine is a product that, sadly, is often tampered with; the JRC regularly reports examples of wine that has been watered down or beefed up by undeclared addition of sugar and other illegal additives, as well as examples of counterfeit products being passed off as well-known brands or deliberately mislabelled.

The way to combat this is to develop reliable measurements of quality, such as those provided by the European Reference Centre for Control in the Wine Sector, which is run by the JRC. Work on this began in 1991 with the creation of the EU Wine Databank, designed to support EU wine legislation by collecting the compositional data of authentic wines produced by hand picking grapes from vineyards across Europe and turning them into wine without the addition of anything other than yeast to start the fermentation.

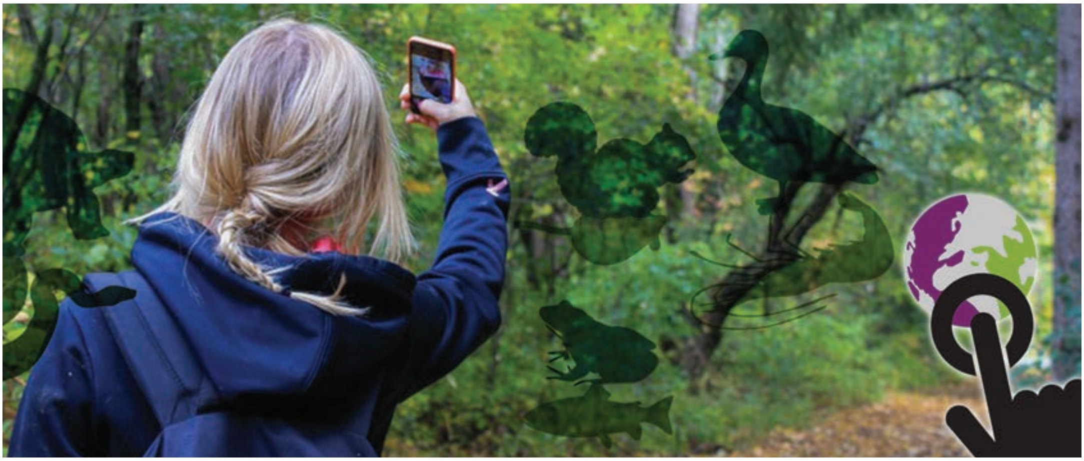
Working with such an extensive database has enabled the JRC and the Member States to develop tests that can establish whether wine has been tampered with, and can determine the origin of the wine. These findings become the reference materials that are needed to ensure the comparability of tests results obtained in different labs. The EU Wine Databank became the European Office for Wine, Alcohol and Spirit Drinks in 1993, took on responsibility for supporting clear identification of wine by geographical and varietal origin as well as vintage, all essential parts of marking the quality of European wines.

More change, when the office became the European Reference Centre for Control in the Wine Sector in 2013 as a response to growing interest in this area. Having such a rich source of data enables the JRC to push forward research, and standards, in this sector. It helps make sure that what you drink is what you bought.

For more on food fraud and wine, pour a glass and visit **https://ec.europa.eu/jrc/en/research-topic/food-authenticity-and-quality**.

# See how they grow: local crop-growth models go global

*The latest agricultural monitoring techniques take the broad view*



*The JRC, through the European Alien Species Information Network (EASIN), proposes an innovative use of global Earth observation data.*

Keeping the world's growing population fed, now and in the future, is a challenge. Local knowledge is paramount. No two regions, farms or even fields are exactly alike, with each having a particular combination of soils, agricultural practice and local climate, whilst population, consumption, diet and economy issues also vary. These differences mean that local-level analysis can't help us plan food supply on a large-scale, and that's where global monitoring and modelling comes in.

Agricultural monitoring, combining space-based Earth observation, meteorological data, crop-growth modelling and statistical analysis, is a capability developed by the JRC and its collaborators over many years. The systems follow current-year development of agricultural crops on a large scale, and combined with data sets from previous years (back to the late 1970s), enable the forecasting of the harvest with some precision. The forecasts are used to help manage European food stocks within the EU's Common Agricultural Policy, and also by many managers in the food supply industry whose markets and suppliers operate globally.

Global satellite networks,analytical algorithms, and the JRC's models, are being taken up globally. This makes it possible to monitor the development of pasture and food crops in Africa, for example, helping aid agencies react timely to upcoming food shortages. Global monitoring allows 'hot spots' of concern to be identified for investigation. The JRC works with partners, including aid agencies and charities, to provide a common system for categorising food shortages so that aid can be targeted quickly to where it is most needed.

Beyond informing us about the current food supply, the use of these data to model what can happen in the future is a powerful warning system. It means it is possible to preview the impact of certain actions, such as changing food crops to non-food crops, or to predict the impact of changing climatic conditions on individual crops. This knowledge can be used to develop food supply scenarios and to see how possible measures, like switching to drought-resistant crops, could influence food security under climate-change scenarios.

The JRC is also involved in other work to do with securing our food supply. Did you know that some imported or migrant plants and animals could endanger the ecosystems on which our agriculture depends? The JRC has published an inventory of these invasive alien species, and an *Invasive Alien Species Europe* smartphone app to go with it, available from Apple iTunes and GooglePlay.

The app is true 'citizen science' in action; when you send in your findings the JRC feeds the data into a map, so you will be helping to monitor the success or otherwise of interfering species.

# Health

The JRC has amassed a wealth of health data, which is used by the European Commission and elsewhere to watch out for looming threats of new epidemics, improve breast cancer care quality throughout the EU, and tackling rare diseases.

It uses its nuclear expertise and machinery for producing radioisotopes that save lives, and digital technologies to promote healthier eating. It also helps prepare our health care systems for an ageing population.

Particular emphasis is put on public health issues that are most efficiently handled at European level, and where the JRC's contribution most obviously generates direct benefits for the EU citizens and patients."

# The text-mining watchdog with a nose for a public health threat

*JRC's medical intelligence system is on the lookout for the next pandemic*


*Preparing the automatic system for highly radioactive drug dispensing in the JRC radio-pharmaceutical laboratory.*

The Ebola epidemic in West Africa in 2014-2016, which claimed more than 11 000 lives, was a wake-up call for public health authorities across the world. The struggle to control the outbreak exposed weaknesses in the global health security system, but also demonstrated its capabilities. Although it is impossible to predict where or when the next major epidemic or pandemic will strike, strengthening public health authorities' preparedness is an imperative. It is a complex agenda, but timely global access to actionable information is one vital dimension.

During the past decade the Medical Information System, or Medisys, developed by the JRC, has become a key line of defence in the international system for protecting public health. Processing information from the JRC's Europe Media Monitor, the Medical Information System is a complement to — not a replacement for — traditional surveillance based on official notifications. It senses alterations in patterns of reporting that can pinpoint an emerging threat. Its reach is planet-wide: every week, the system processes over two million articles and announcements published in 50 languages by commercial news providers and official sources, as well as substantial Twitter traffic.

With just a few clicks, users can call up current reports on any pathogen or zoom in on specific countries for local public health updates. MedISys also collects information on chemical, biological and nuclear weapons, on incidents involving hazardous chemicals, and on plant and animal health. It even includes reports of adverse events involving medical devices. As well as following links to the original reports, the system automatically tabulates recent disease incidents from around the globe.

You can check it yourself at **http://medisys.newsbrief.eu**. It is widely used by public health authorities in the EU, including the European Centre for Disease Prevention and Control, the European Food Safety Authority and the European Monitoring Centre for Drugs and Drug Addiction. The World Health Organisation employs the system as part of its Hazard Detection and Risk Assessment System, also developed by the JRC, and it became a vital source of intelligence during the Ebola epidemic in Guinea, Liberia and Sierra Leona.

At the height of the crisis in West Africa, traffic on MedISys peaked at 6505 news items on Ebola in a single day, 16 October 2014. MedISys is currently responsible for identifying more than 30% of the incidents the who investigates. Its continued refinement will further bolster its capabilities, particularly as broadband access in low-income countries grows and media coverage of under-reported communities improves.

# Evidence-based improvements in breast cancer care

*A level playing field for breast cancer patients in the EU*


*International workshop on Quality Assessment, in the frame of the EC Initiative on Breast Cancer (ECIB), held in JRC-Ispra, 2015.*

Breast cancer remains the most common type of cancer and the most frequent cause of death from a specific cancer among women in Europe. Across the EU, about 92 500 women died from the condition in 2013, according to Eurostat data. Inevitably, incidence rates vary between Member States, reflecting variations in environmental, genetic, and lifestyle factors. Less acceptable is the fact that the survival rate also vary, due mainly to differing approaches to diagnosis and treatment.

With regard to diagnosis, the JRC has uncovered disparities between Member States in the organisation and the operation of breast-cancer screening programmes and revealed a wide variation in the standards of quality-assurance schemes for breast cancer healthcare — as well as a plethora of different quality-management approaches.

The JRC is now steering an ambitious undertaking, the European Commission Initiative on Breast Cancer, which aims to put in place a minimum set of harmonised quality standards by developing new evidence-based recommendations for breast cancer screening and diagnosis, and by coordinating the development of a 'platform of guidelines' spanning treatment, rehabilitation and follow-up. The result of this work will be freely available online and will include different versions of the guidelines tailored for different audiences — patients and other non-experts, healthcare professionals, and policymakers.

The first steps have been taken. The Europe-wide team of experts developing the new guidelines has published the first ten recommendations, of an anticipated 90. Each takes the form of a direct answer to a precise query. For example, in response to the question, "Should organised mammography screening, or no mammography screening, be used for early detection of breast cancer in women aged 50 to 69?" the recommendation is that "women between 50 and 69 years old should have mammography screening for breast cancer, even if they are not at high risk of breast cancer and do not have symptoms".

The guidance is graded in terms of the quality of the recommendation. A 'strong' recommendation is based on clear-cut evidence and should be followed, whereas a 'conditional' recommendation (based on more ambiguous evidence), should prompt a visit to the doctor. Each recommendation is explained by accompanying data and an extensive bibliography of the research on which the recommendation rests. Users can also download 'evidence profiles', which summarise the relevant clinical research; try it out at **http://ecibc.jrc.ec.europa.eu/recommendations**.

# Pooling knowledge and making connections to ease the burden of rare disease

*Over 6 000 diseases are called 'rare' but knowledge about them doesn't have to be*

*X-ray examination by JRC medical staff.*

Rare diseases pose a significant problem for the sufferers and also for society, both in scale and complexity.

In the EU about 30 million people, or 6% of all citizens, suffer from some type of rare disease. A rare disease is technically defined as a life-threatening or chronically debilitating condition with a maximum prevalence of 5 in 10 000, but the enormous diversity of such conditions (between 6 000 and 8 000) complicates matters. Some of the rare diseases, such as cystic fibrosis, haemophilia, and muscular dystrophy, are relatively well known; but most affect tiny populations and are often familiar only to those affected, their families, and some specialised medical teams. The majority of rare diseases have a genetic cause, but some result from bacterial or viral infections.

The reality of living with a rare disease can be stark. Many patients and their parents — 75% of rare diseases affect children — face long and gruelling delays before receiving a diagnosis, about 25% die before the age of five. Of the others, many suffer from progressive or degenerative conditions, leading to significant levels of physical, cognitive, and sensory problems and disability. In addition, many patients and their care-givers suffer from isolation and a lack of support, due to the limited knowledge about their conditions in healthcare systems as well as in society as a whole.

Moreover, the small scale and the wide geographical distribution of patient populations make epidemiological and clinical research challenging. There are over 600 disease-specific patient registries in the EU, each of which records the medical histories, clinical care and treatment outcomes of individual patients — often in proprietary systems making sharing of data difficult. The JRC is tackling this fragmentation by spearheading an initiative to create an EU-wide platform for rare disease registries.

The initiative has four main objectives: (1) to promote interoperability across stand-alone data silos (registries) by developing an agreed set of data standards and IT tools; (2) to support the development of new registries based on uniform standards; (3) to act as a rare-disease data hub; and (4) to encourage the collaborative involvement of all stakeholders, including patients, healthcare professionals, policy makers, and industry.

In addition, in this general domain, the JRC manages two specific registries with long-standing data: EUROCAT (the European Surveillance of Congenital Anomalies) collects data from across Europe on birth defects, and SCPE (Surveillance of Cerebral Palsy in Europe).

This is only the beginning. Integrating knowledge sources at a pan-European level will help to boost the awareness and knowledge of individual rare diseases and encourage and enable further scientific, epidemiological and clinical research. Over time this will help more patients to receive a timely diagnosis and better treatment.

# The 'other' nuclear industry: sourcing the radioisotopes that save lives

*A JRC lab in the Netherlands is a key supplier of diagnostic and therapeutic radioisotopes*

*Preparation of a sample for isotope analysis.*

It is a little-known fact that the JRC plays a pivotal role in the global supply of radioactive isotopes used in medical diagnosis and therapies. Every year, these isotopes touch the lives of about 9 million people across the world. Nestled in the sand dunes at Petten, on the north-western coast of the Netherlands, JRC's High Flux Reactor (HFR) is Europe's largest producer of medical radioisotopes for use in a wide range of conditions, including many types of cancer, cancer pain, arthritis, and hyperthyroidism.

The HFR facility that the Dutch Nuclear Research and Consultancy Group operates on behalf of the JRC, has a history in nuclear research that dates back to 1954 when design work on the HFR began, and 1961 when the reactor went critical for the first time. Thereafter the reactor was used for irradiation experiments and since 1989, when the JRC included nuclear medicine into its portfolio, the HFR also produces about a dozen different radioisotopes. Each is deployed in different settings, but the unifying principle is that the interaction between the radiation energy emitted by a decaying isotope and a patient's tissues can be exploited for diagnostic or therapeutic purposes.

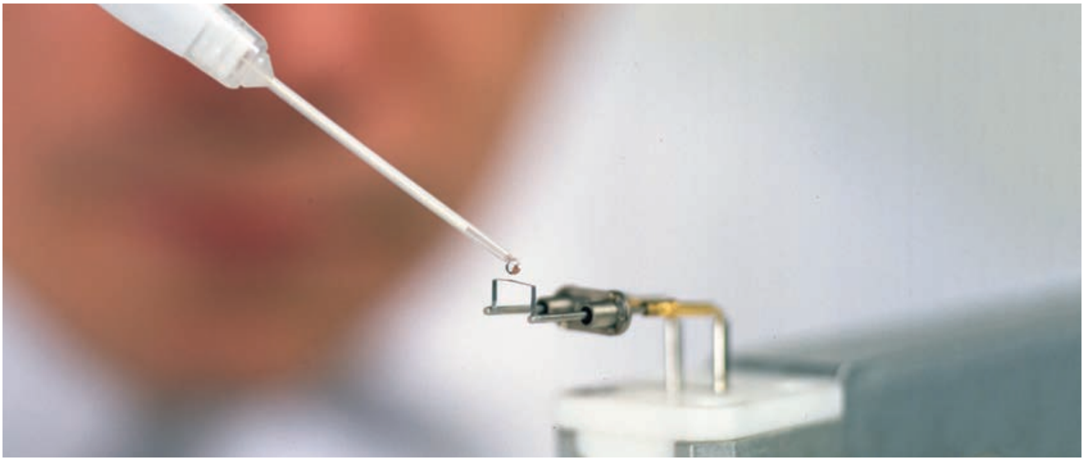
In volume terms, molybdenum-99 (99Mo) is the HFR's most significant product. It spontaneously decays to form technetium-99m (99mTc), often called the workhorse of nuclear medicine because of its versatility and ease of use. It can be readily coupled to a broad range of chemical compounds, each of which has a characteristic distribution profile within the body. This enables the investigation of many tissues and organs, including the brain, heart, liver, kidneys and bone. Radioactive tracers containing technetium-99m are used in about 85% of all diagnostic imaging procedures in nuclear medicine, it emits gamma-rays, which are captured by gamma cameras. The resulting images provide radiologists with insights into the structure and function of soft tissues, which would be unobtainable with X-rays.

Therapeutic applications of nuclear medicine require more intense levels of radiation energy, in order to kill rapidly-growing cancer cells. Therapeutic radioisotopes produced at the HFR include iodine-131 for treating thyroid cancer, yttrium-90 for liver cancer, and iridium-192 for brachytherapy, a form of localized cancer therapy in which the radioactive isotope is placed inside miniature 'seeds' inserted in the patient's body close to the tumour. Treating cancer pain, particularly metastatic bone pain, is another important application of nuclear medicine. Radioisotopes, such as strontium-89 or samarium-153, which selectively localise to bone tissues, have proven to be very effective in reducing this form of highly debilitating pain.

The continuous delivery of an extensive catalogue of radioisotopes, at the right time with the right specifications, requires a tightly controlled, just-in-time production process operating to rigorous technical and safety standards. The connection between the JRC's Petten facility and the patients it serves is largely invisible, but it represents one of the most compelling relationships between the JRC and the people of Europe.

# Eat to live: let's make diet count in cancer prevention

*Presented well, and distributed widely, dietary advice can help save lives*



*The objective of the Osteodiet project ( 2000-2003) was to investigate the impact of diet and gene-nutrient interactions on calcium and bone metabolism: optimal nutrition towards osteoporosis prevention.*

The old adage 'you are what you eat' is generally attributed to the celebrated French epicure and gourmand Jean Anthelme Brillat-Savarin. In his classic work, *Physiologie du goût* (*The Physiology of Taste*), published in December 1825 and still in print today, he wrote "tell me what you eat, and I will tell you what you are".

It was a pretty good guess, given the embryonic state of nutrition science at that time. Empirical knowledge guided our dietary habits then, rather than any theoretical understanding of the chemical constituents of food and of their various roles in the biological processes that sustain life. Since then, of course, our understanding of the links between diet and health has increased enormously, even if isolating the individual health effects of particular foodstuffs over long time scales can be methodologically challenging. Nevertheless, it is widely accepted that eating a balanced diet, high in fibre, fruit, and vegetables can help to reduce cancer risk, as can minimising the consumption of red meat, processed meat, and salt.

Today, many of us consume far too much food — and we are bombarded by torrents of advertising and advice about food as well. Commercial interests drive much of this agenda, but the JRC, which is free from any such ties, is promoting awareness of the value of diet in cancer prevention. As part of this, it has mapped in detail the efforts of Member States to include diet as a cancer prevention measure.

The resulting report, '*Mapping dietary prevention of cancer in the EU28*' JRC, 2014, found that many Member States tend to rely on awareness-raising campaigns rather than more concrete interventions, such as ensuring the availability of healthy food options in schools or encouraging citizens to adopt healthier dietary habits.

Also targeting dietary risk factors varies. Several national cancer programmes propose measures to reduce consumption of high-calorie foods and sugar-laden drinks, but — as the authors of the report note — "despite scientific evidence linking salt or red- and processed meat consumption with an increased risk of specific cancers", few programmes explicitly address these well-recognised risk factors.

In a related initiative, the JRC has teamed up with the Network of European Cancer Registries to publish a series of concise, authoritative factsheets that summarise current data on incidence and mortality rates, risk factors, diagnosis, screening, and prevention for different types of cancers across the EU. Eleven have been published in the series so far, check them out at: **http://www.encr.eu/index.php/publications/factsheets**.

# Live long and prosper: adapting society to an ageing population

*If we live longer, soaring healthcare costs could become a real headache*


*Prevention campaign on cardio-vascular disease, JRC-Ispra.*

The European population is ageing rapidly. The number of Europeans aged over 65 is expected to double in the next 50 years, and the number over 80 to almost triple. But living longer does not always mean a healthier, more active and independent third age.

Responding to this situation, in 2011, the European Commission launched the European Innovation Partnership on Active and Healthy Ageing. The aim was to seek ways of closing the gap between the increasing life expectancy and the number of years of life spent in good health. JRC researchers reviewed the evidence on the key determinants of active and healthy ageing, including economic and social factors and how they relate to diet. Their report focused on the effects of micronutrients and the prevention and treatment of age-related diseases. Results collected from intervention studies pointed to only limited benefits from the use of micronutrient supplements. Rather, the report stressed the potential of the whole diet, and the idea that diets like the Mediterranean diet, containing vitamins, minerals and bioactive compounds from natural food sources, can promote a healthier old age was once more reconfirmed.

Better diets notwithstanding, as the population ages, the number of people needing long-term care will increase. Based partly on previous research, the JRC joined forces with Eurocarers, the European network representing informal caretakers and their organisations, to launch CarICT, a database of digital services for caretakers of the elderly. This online tool offers access to scores of examples of good practice applied to digital services for older care at home, including telecare, e-learning, and care-tasks coordination apps. CarICT is accessible online **http://www.eurocarers.org/carICT-Project**.

However, an ageing population has political and economic implications beyond the immediate concerns of health and social care. The 2015 Ageing Report, produced by the European Commission, provides economic and budgetary projections for EU Member States for the years 2013-2060, covering the period when the average age of the population is increasing significantly. The long-term projections provide a timescale for the difficult policy decisions that must be made in the coming decades as, for instance, the proportion of working-age adults in the population falls.

Another report from JRC, Long-term Care Challenges in an Ageing Society: The Role of ICT and Migrants 2010, highlights another aspect of the complexity of these issues. While focusing on the role that information and communication technology plays and will play for an ageing population it also addresses the importance of migrant population as caretakers to the EU ageing population.

# Information and communication technology

One of the most dramatic achievements in the past 60 years has been a massive expansion in computing and connectivity. Today, almost every European citizen carries around with them far more processing power than NASA used to put a man on the Moon in 1969.

The JRC tries to help Europe make the best possible use of the on-going digital revolution. Its researchers have been using massive computing power for processing research data from early on. Beside crunching data from its experiments and measurements, it explored its early mainframe computers for machine translation and processed, over time, increasing volumes of satellite and other research data.

Recent work in has turned towards digital services and their efficiency and safety. The JRC helps provide policy makers and the public with reliable and on-time data about the environment, climate, health, the economy, disaster risk management, and, as described in this chapter, migration.

# The always connected childhood — is it safe?

*As the Internet infiltrates every aspect of our daily lives, the young need special protection*

*JRC researchers test toys that can record a child's location or other data.*

From teddy bears to model cars, today's toys are getting online. How will the Internet of Toys change childhood? Will it change the way children's brains develop? What happens if toys that record and share information about their young owners fall into the wrong hands and are used as surveillance tools?

After researching these thorny questions, a team of JRC scientists and international experts concluded that robotic toys can both help and hinder children's cognitive, emotional, social and behavioural development. For example, social robots can help children learn a foreign language in the absence of native speakers, by removing the peer pressure of the classroom. Children with developmental problems, such as autism or learning difficulties, may also find it easier to interact with robots than with humans.

At the same time, there is a danger that the growing use of algorithms to personalise a child's education could create 'educational bubbles', where children receive only information that fits their pre-existing knowledge and interests. The researchers also fretted about the long-term impact of growing up in a culture where the tracking, recording and analysis of everyday choices is the norm.

In a report outlining their findings, the researchers called for industry and policymakers to create a connected toys usage framework as a guide for their design and for their use. "Locking [connected toys] up in a cupboard is not the way to go," says Stéphane Chaudron, the lead researcher at the JRC. "We as adults have to understand how they work — what are the possibilities they offer and how they might 'misbehave' — so that we can provide the right tools and the right opportunities for our children to grow up happy in a secure digital world."

The JRC's work on the 'Internet of Toys' followed a pilot study conducted in 2015 that explored how children under the age of eight and their families engage with digital technologies. After uncovering a lack of awareness of the risks of cyberbullying and viewing inappropriate content, the report argued that parents and teachers need practical tools to empower them to help children become smarter, more responsible, and respectful digital citizens.

The authors called for the development of technologies specifically tailored or tailorable for children, with clear child-friendly warnings and quality labels. To help parents and teachers, the JRC has developed a game and toolkit, called Happy Onlife, which includes a quiz and other educational activities for children. Following the release of the source code in February 2017, organisations and communities can now tailor Happy Onlife to their own needs, and even translate it into different languages. Happy Onlife is also available for iOS, Android and Windows smartphones. Try the app on **https://web.jrc.ec.europa.eu/happyonlife/**.

# High-tech news monitoring sorts the (real) wheat from the (fake) chaff

*JRC has developed a tool for monitoring the world's news — and you can use it too*


*The JRC's European Media Monitor analyses news across 70 languages every day.*

In the battle against fake news and social media echo chambers, the champions of plurality have at least one sophisticated weapon.

Europe Media Monitor (EMM) automatically sifts through 300 000 news items per day in up to 70 languages, allocating articles to more than 1 000 categories, so that users can discover complementary information and compare viewpoints. Launched in 2002, EMM extracts the names of persons, organisations and locations, tracks quotes by and about people, produces statistics and shows trends. It is now used extensively by the European Commission and many other organisations, including United Nations bodies, the African Union, and the Organization of American States. Its pages are also visited by thousands of journalists, professionals and interested private users every day.

The first prototype for EMM was developed at the JRC in 2000, following a request from the European Parliament for a search for news on cases of Internet abuse when legislation in that area was being prepared. When the trilingual prototype matched the performance of a manual news clipping system, the European Commission pushed for a general tool to monitor many more languages, sources and subject areas.

JRC's development team of 20 scientists and IT specialists had to overcome tricky technical challenges, such as how to automatically extract news text from semi-structured pages on the Internet and making the monitoring system work very rapidly, as well as handling texts in languages as different as German, Portuguese, Greek, Finnish, Latvian, Swahili, Arabic and Russian.

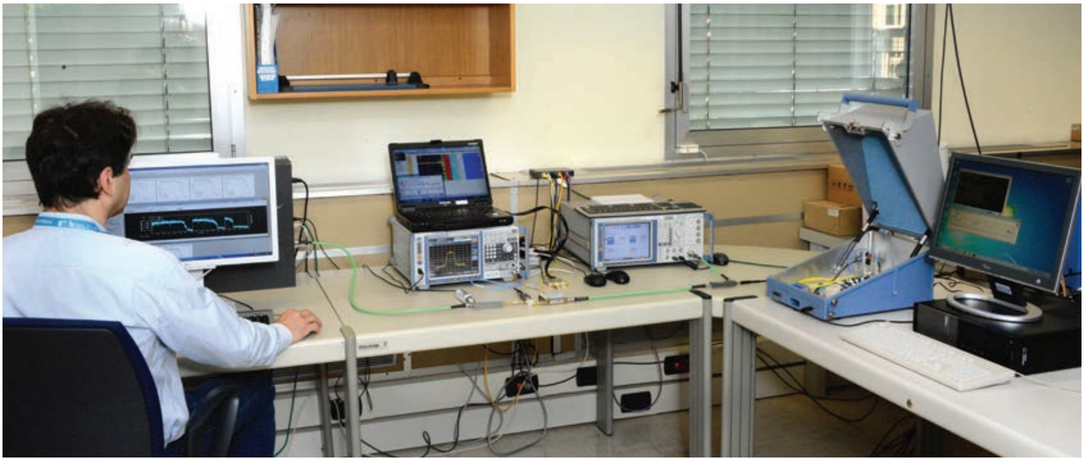
"The biggest challenge is the high number of languages EMM has to analyse," says Ralf Steinberger, a senior JRC scientist and computational linguist who has worked on the project from the beginning. "We tackled the problem by using language-independent rules with lightweight language-specific dictionaries, which were created semi-automatically, using machine learning methods." Over 200 international peer-reviewed publications document the team's related research output.

Responding to user requests, the EMM of today has trend detection capabilities, an early warning function, machine translation services, and the ability to extract specific event information — such as, who did what to whom, where and when. It also monitors social media, supports mobile devices, and has a customisable interface.

EMM's supporters claim that no other fully automatic news monitoring system closely integrates so many different text processing software tools in so many different languages. And it's free, so do take a look, at **http://emm.newsbrief.eu**. From the home page you can also access MedISys, a similar service for medical news, and other products in the EMM family. And why not download an EMM app for your smartphone? Is there any better way to sort real wheat from the fake chaff in your news feed?

# Smart spectrum sharing for next-generation broadband and mobile networks

*Helping the digital superhighway get even more super*



*Testbed for conducted measurements in the Radio Spectrum Lab at the JRC.*

Radio, television, mobile phones and Wi-Fi: all are part of our daily lives, entertain us, and keep us connected to work and to the world. These services are carried on invisible digital highways of radio waves — the radio spectrum, each service using its own separate fixed frequency channel. The evolution of this pattern can be traced back a hundred years or more to the invention of wireless telegraphy. But it is not the most efficient way of using radio waves.

Imagine city roads with a lane for every different type of vehicle. The cost would be prohibitive, and there would not be enough land for such roads. Instead, roads have just a few lanes, and traffic rules allow different types of user to share them. Like land, radio frequency channels are a precious and finite natural resource that must be harnessed as efficiently as possible. And to meet the growth of the connected society, a new way of sharing the radio spectrum will be needed.

Since the arrival of second-generation mobile telephone technology (GSM) in the early 1990s, Europe has been a leader in mobile communications. Today over 80% of the European population has access to the modern standard, 4G (for fourth generation), and the new 4.5G systems in cities now offer speeds of up to 300 megabits per second. However, the speed achieved by users depends not only on the network but also on the number of users accessing it. At busy times the networks seem slow.

The number of users, devices, and digital services can only increase, and the next generation of mobile technology is eagerly awaited. As part of the push to 5G and beyond, the JRC is developing new ways of sharing radio spectrum.

In 2016, a joint pilot project between the Italian government and the JRC, carried out in Rome, tested spectrum-sharing in the 2.3-2.4 GHz frequency channels between existing wireless services and a new 4G mobile network. Since existing users do not use their allocated frequency channels all the time, those frequencies could be shared with a 4G network operator to offer additional mobile broadband service, under pre-defined sharing rules that ensured that there was no interference from the new service.

The pilot project was a success: the simple sharing system could provide mobile broadband users with an additional capacity of up to 70 megabits of data per second. This kind of solution has the potential to ease bottlenecks at peak hours for mobile broadband users in the future.

The JRC has also developed a mobile app, netBravo, that monitors the quality of mobile network coverage and broadband connections. Data from millions of measurements by users on various networks across Europe are aggregated and displayed on a map on the netbravo.eu website. Anyone with a recent smartphone can use the app, so why not try it?

# Rating the runners and riders in the race to a digital future

*The Commission's Innovation Radar tracks the impact of EU-funded research*


*The JRC organised in Brussels, 2015, a conference on Innovation in the European Digital Single Market, analysing the role of patents as a policy tool.*

Digital technologies and services are transforming the way we live, work, spend our free time, shop, bank, plan our holidays, and communicate with friends and family. Yet we are only at the beginning of this digital revolution. We need to better understand and prepare for what's next.

Does Europe have a problem? Many of the digital tools we use are developed and sold by US companies. To be sure, there are some well-known European players: Spotify, the music streaming company, was created in Stockholm. Skype began in Estonia; though owned today by Microsoft, its headquarters are in Luxembourg. Europe also has other world-class companies in the field, such as Vodafone, BT, Orange, Telefonica and Telecom. Still, many of the giants that dominate our markets, like Google, Apple, Facebook, Microsoft and Amazon, are all from the US.

All in all, it's widely felt that Europe should be more competitive in digital technologies. One step in this direction is the Commission's plan to create a true 'Digital Single Market' for Europe. An early success in this area was the abolition of roaming charges within the EU, enforced by the European Commission in 2017. Less well known are a number of research and innovation programmes in ICT that are funded by the EU to promote new developments and to bring them to our home markets first. EU policy can also help by ending the coexistence of different national rules and by making it in general easier for start-ups and other companies to convert research results to successful commercial products.

For that to happen, policymakers need detailed information on ICT innovation. The ICT 'Innovation Radar' of the European Commission provides exactly that. It started by analysing 280 relevant EU-funded research and innovation projects and found, for example, that small and medium enterprises (SMEs) are the best innovators. They delivered 41% of the high potential innovations generated in these projects, despite accounting for a mere 14% of the total funding. But the Radar also found that one quarter of these innovations were not yet being exploited commercially.

"By assessing the impact of their work, the Innovation Radar has changed the mind-set of the participants in EU-funded research and innovation programmes," says Daniel Nepelski, of the JRC. "They became more entrepreneurial and think about the social and economic impact of their targeted product or service, from the start."

Nepelski says the Radar, which has now been used to analyse more than 1 200 ICT research projects, is now being scaled up for use across all scientific research domains funded by the EU. This will help us better understand how the brilliant research done in the EU can be translated more efficiently into practical — and marketable — products and services.

# Not lost in translation: a new language for environmental data sharing

*A mission to make cross-border misunderstandings a thing of the past*

*The JRC acts as the overall technical co-ordinator of the INSPIRE project so geographical data can be shared and analysed more easily.*

Neither natural disasters nor those resulting from human activities, respect national borders. When the Eyjafjallajökull volcano erupted in Iceland in 2010, a cloud of volcanic ash spread across Northern Europe, causing the worst disruption to air travel since the Second World War.

To help European countries mount a coordinated response to such events, and tackle more routine challenges such as cross-border river pollution and energy shortages, the European Commission is developing a common infrastructure for geospatial data. Coordinated by the JRC, hundreds of experts from across Europe have been working together for 15 years to agree on common definitions in important policy areas, such as energy, climate change, biodiversity, the marine environment, and human health.

The result is an Infrastructure for Spatial Information in Europe, (or just INSPIRE; **http://inspire.ec.europa.eu**), a series of standards and data specifications that defines everything from how to measure groundwater to population density, altitude and air temperatures. It involves tens of thousands of organisations at all levels in public administrations in the EU.

Why is such an infrastructure needed? For many centuries, European nations tried to hide their strategic assets from potential enemies by using different reference systems, making foreign maps and measurements difficult to interpret. This has had some unfortunate results, for instance some bridges and tunnels built across two sides of a national border have failed to meet in the middle. Now enshrined in EU law, INSPIRE cuts costs and improves the basis for decision making. By 2021, once it is fully implemented, Member States will be using a consistent approach to collecting and sharing 34 types of spatial data.

"Nobody has undertaken such a complex endeavour before," says Massimo Craglia, who has been involved in the initiative from its early stages, i.e. preparing the assessment of its likely impacts in 2003. "In the beginning, it was both politically and technically challenging. Politically, because many public sector agencies in Europe asked for a fee for using their data and saw the common infrastructure as a challenge to their business model; technically, because of the lack of standards and the complexity of operating across 34 data themes in 24 languages." The team at the JRC made it work by adopting a strongly participative model, involving stakeholder organisations across the EU in the development of legislation and technical specifications. "In the end, the project succeeded because it built upon a strong multi-disciplinary network of recognised experts in each domain-specific theme, who volunteered with the support of their public or private organisation as INSPIRE stakeholders," concludes Vanda Lima who has led the INSPIRE data specifications team in the JRC.

# Machine translation, from IBM mainframe to the phone in your pocket

*Pioneering JRC research made computers multilingual back in the 1960s*


*The JRC's Competence Centre on Text Mining and Analysis contributes to the European Commission's support to multilingualism, language diversity.*

Today's slick online translation tools are the product of half a century of hard work and painstaking research. In fact, the JRC has been wrestling with machine translation since the 1960s. It was a case of needs must. From 1963, researchers at JRC's Euratom Centre in Ispra, Italy, were using a Russian-English machine translation system, developed at Georgetown University, to help cope with a shortage of qualified translators. "Late 1961 we made contact with the Euratom Centre," recalls Antony Brown, a linguist at Georgetown at the time, in the book Early Years in Machine Translation: Memoirs and biographies of pioneers. "We were told they had a new 7090 [an IBM mainframe computer], very much under-utilised, and that someone had rashly promised to develop MT (machine translation), soon, for what were then the four languages of the Common Market. Today the story sounds ridiculous, but at any rate Euratom was willing to give us all the 7090 time we wanted, in exchange for our expertise."

The usefulness of the Georgetown system prompted the European Scientific Data Processing Centre (CETIS) at JRC/Ispra and the ETC (European Translations Centre) in Delft to jointly work on their own system. In the era of punch cards and room-sized computers, they developed a rule-based system splitting the translation process into separate manageable steps. Progress was slow, but the JRC was convinced that machine translation was the future. The pilot project influenced the large-scale EUROTRA project, which started in 1982. EUROTRA involved up to 150 scientists and engineers in 12 Member States, developing MT for nine languages and 72 language pairs, under the general direction of Sergei Perschke. The project proved too ambitious, but its insights laid the foundation for future work.

With computers getting faster, and massive amounts of documents available on the Internet, new approaches to machine translation emerged: the new generation of statistical translation systems teach themselves how to translate by analysing documents and their human-produced translations. In the early 2000s, Ispra focused on analysing large multilingual news collections. However, in 2006, they contributed to the first freely available machine translation system covering 462 language pairs; this required processing more than one hundred million sentences and their translations.

In 2012, the JRC announced its own statistical machine translation system ONTS (Optima News Translation System). Based on the freely available MOSES software from Edinburgh University, it was trained on publicly available texts and optimised for news, putting a special focus on translating names and headlines correctly. As part of the European Media Monitor system, it continuously translates headlines and the first sentences of the news from many languages into English. "Computers are still far from reaching human translation quality, but users much appreciate understanding the main contents of foreign language news, even if the translations are not perfect," says Steinberger. Perschke himself has admitted that machine translation remains rather poor — but good enough to decide if a text was worth being sent to (expensive) human translation.

# Better data and detailed analysis reveal the facts about migration

*With a migrant population of 405 million predicted for 2050, the EU needs to be prepared*


*The JRC Knowledge Centre on Migration and Demography focuses on migration developments at global scale and their demographic impact on the EU*

Migration — or in a wider sense, human mobility — is changing the world we live in. Due to globalisation, economic trends, demography, war, instability and climate change, Europe will remain an attractive destination for people in search of safety, a better life, or to be reunited with their families. With estimates showing that by 2050 the population of Africa will double, and that the number of international migrants worldwide will reach 405 million, migration will remain high on the agenda.

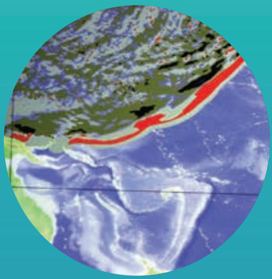
To better understand the root causes and impact of migration on EU economies and societies, and to anticipate future migration flows and population trends, the European Commission's Knowledge Centre on Migration and Demography was established in June 2016. Its daily activities are run by the JRC, and it provides EU policymakers with evidence-based analysis and knowledge tailored to their needs. Even better, this information is publicly available and can be used by anybody: **https://ec.europa.eu/jrc/en/migration-and-demography**.

The knowledge centre has created tools that, for instance, use interactive mapping based on regularly updated datasets to report on migration flows, residence permits, forced displacements and children in migration, etc. Based on the best available facts and figures, such analyses can help separate fact from myth and rumor.

To better understand why people migrate, the JRC is developing Migration Inclination Indexes. These will measure the extent to which economic, demographic, geographical and policy factors in the countries of origin and in destination countries influence migratory patterns. They will give insight into the drivers of future migration to Europe and will allow assessing the effects of migration related policies.

Another product is Migration Profiles for priority countries of origin and transit, such as Mali and Niger. These profiles provide up-to-date and context-specific information in the form of quality controlled datasets and infographics. The migration profiles are designed to support the dialogue with these countries and the development of coordinated EU interventions for improving the situation where necessary and possible. They are also helpful for identifying the geo-political forces that trigger migration flows.

Finally, there are maps of migrant communities in EU cities. These visualise the distribution of migrant populations in cities by nationality or country of birth in several EU Member States. This detailed information will help local and city authorities to design better integration policies for education, social services, housing, work and transport systems.



# Natural disasters

Accuracy in predicting natural disasters is often the difference between life and death.

Flooding in the Danube and Elbe rivers in 2002 was a spur for the EU to step up its action on disaster preparedness and management, as were devastating tsunamis in the Pacific in 2004.

In the time since, the JRC has developed a strong record of bringing science to bear on the often-fickle discipline of weather forecasting, and has built up a network of people and systems to track tsunamis, earthquakes, fires and floods.

Scientists have developed sensors for detecting disasters in their early stages; flood prediction models on continental and river-basin scales; fire danger forecasts; and building codes to ensure that homes can withstand wind, flooding and earthquakes.

When a disaster does strike, this same data is used by the EU's Emergency Response Coordination Centre to help Member States pool resources for clean-up and rebuilding.

# Summer in the forest: taking the fight to the wildfires

*Ten-day forecast maps help focus efforts to control fires*


*JRC researchers explaining the work developed by the European Forest Fire Information System (EFFIS) on the occasion of the Student Days, 2014.*

Summer brings fire to Europe's parched lands. Each year, flames devour on average half a million hectares of forest and natural lands. Five Mediterranean countries — Portugal, Spain, France, Italy and Greece — endure the most destruction.

This year Portugal suffered one of the most devastating forest fires Europe has experienced. Burning for six days, a massive blaze killed 64 people, forced mass evacuations and laid waste to huge areas of forest. The fire spread rapidly, sometimes changing its direction of spread and trapping the local population that was trying to flee. What can be done in the face of such forces?

Despite extensive research, wildfires remain notoriously unpredictable. In most cases, humans unwittingly light the spark, although lightning also plays a role. Add a variable forest terrain and the capacity of a large fire to create its own local weather system, and the outcome is difficult to predict. The JRC has taken on the challenge. Using a combination of satellite imagery from NASA and the European Space Agency, and extensive ground data sets, it is now able to produce real-time information on fire activity and its impact in Europe, and soon globally. This includes 10-day forecasts of meteorological fire danger, daily updated maps of hot spots (active fires), and burnt-area perimeters. Fire authorities in Member States and other countries get this information through the European Forest Fire Information System (EFFIS) run by the JRC. They use it to prepare for, and where possible, to prevent wildfires. It also warns local inhabitants in critical areas. This information is not only available to specialised services, but also to journalists and the public through EFFIS (**http://effis.jrc.ec.europa.eu**).

The JRC also estimates how severe a fire will be once it starts, factoring in the many aspects that influence fire intensity, including availability of materials to burn, dryness of these fuels, projected wind speeds and topography. "If someone throws a cigarette out of a car in Scotland, the chances are it will not be dangerous. The same event in Portugal after a drought may have a totally different outcome," says Tracy Durrant, who logs Internet news of individual fire events in EFFIS each morning.

The data generated at JRC is available through EFFIS to a network covering over 40 countries. Since 1998 this network has also provided a platform for exchange of good fire prevention practices and experience. "The data we provide to the network, and the experience shared within, makes national authorities and firefighters better prepared," says Durrant. "Participating countries and regions can better allocate fire-fighting resources in their territory and the 10-day fire danger forecasts help them to move resources in place in advance of a fire. This often makes the difference between a small, quickly controlled fire and a huge blaze. The good news is that as more countries join the network, more data are available to strengthen our prediction models."

# Alerting Europe to looming floods

*Timely forecasting of floods gives authorities a chance to warn the people at risk*


*Communication event of the European Flood Awareness System (EFAS).*

Flooding is a growing problem for emergency authorities; insurance pay-out figures tell us that the number of devastating floods has more than doubled in Europe since 1980.

This trend looks set to accelerate as warming temperatures drive up atmospheric moisture levels. JRC scientists estimate that at least half a million Europeans could be affected by floods every year by 2050, under a 4ºC temperature-rise scenario for global warming.

Faced with a rising flood threat, politicians called on scientists to provide better flood predictions. “Member States came to us and said they could predict when a flood was coming 24 hours in advance. They wanted to know if we could do better,” says Ad de Roo from the JRC.

Challenge accepted: Using a range of weather predictions, from several weather services, de Roo and his colleagues came up with a system to forecast floods in Europe up to 10 days in advance. Called the European Flood Awareness System (EFAS), it uses hydrological and statistical models to predict floods with a precision previously unimaginable and to inform all relevant authorities.

“Before we developed this system, flood management was extremely complicated and often not coordinated between administrations, and in particular not between different countries. Everyone knew something about the part of the river under their authority but nobody had the whole picture,” says Jutta Thielen-Del-Pozo from JRC. “Downstream regions did not know what was coming because they did not know what was happening upstream.”

The extent of this problem was laid bare in 2002, when the Elbe and Danube, two major rivers that snake through several countries, broke their banks but Europe was not prepared. Each country dealt with the flooding with their own systems. There was no coordination on EU level. Early warning and exchange of information between countries was limited and not structured.

During the floods back in 2002, de Roo and his team were called upon while on holidays to immediately start work on what would eventually evolve into EFAS. “Over the years, through EFAS, we made authorities talk to each other and to share information and best practices, and this is a big achievement by itself - not to speak of the improved flood management this eventually results in,” says Thielen-Del-Pozo. “In future, in addition to forecasting floods, EFAS could be used to predict water availability in general, i.e. forecasting whether there is enough water for agricultural lands or for cooling of power plants”, De Roo suggests.

For now, the success of EFAS has elevated the status of flood forecasting in Europe. “I don’t think we have missed a big flood, and we have been able to flag a few floods before they were captured by the national flood warning systems,” said Thielen-Del-Pozo. “Many people said you’d never do this. But we did.” And if you are worried about your flood risk, check it out at **https://www.efas.eu**

# Tsunami watch: listen out for the big waves before they hit

*A JRC-developed ultrasound device gives crucial extra minutes of warning to coastal cities*


*Monitoring the earthquake and tsunami which hit Japan in 2011, within the European Crisis Management Laboratory at the JRC.*

To date, it has been impossible to pinpoint when a tsunami — an unusually large sea wave caused by a seaquake or undersea volcanic eruption — will develop. But it is possible to provide early warning of an increased likelihood of large waves, if there is enough distance between the seismic source and the coast.

Tsunami warnings normally involve sea level measurement devices installed in ports. These are expensive to install and maintain, so are not widely distributed. To reduce costs the JRC has developed a new type of detection system, the Inexpensive Device for Sea Level measurement (IDSL), which uses an ultrasound sensor to measure water height every five seconds and transmits the data in real time to a JRC server. These devices, if distributed in large numbers along the Mediterranean coast, would allow rapid detection of a developing tsunami.

A related development from the JRC is the Tsunami Alerting Device (TAD), a patented system that can receive a triggering signal by manual activation, or direct from a sea level measurement device; the TAD then shows an alert on its display panel, sounds a siren and activates a flashing light. A prototype was tested in 2014. As part of the experiment, an evacuation warning flashed on a screen near the beach, and a siren sounded four or five minutes before the 'wave' was due. That does not leave much time for hesitation, but gives a crucial extra few minutes warning for coastal cities, says Alessandro Annunziato, a JRC scientist.

"Best that people are prepared," Annunziato says. "It's a non-frequent but very serious event." The devastating tsunami in 2004 in the Indian Ocean, which killed or displaced nearly 230 000 people, raised the urgency of early warnings, he says. The vast majority of waves falling on Europe's beaches are harmless, but two tsunamis were recorded in Greece and Turkey, in June and July 2017. In the second event, a 1.5-metre wave destroyed a number of boats off the Greek island of Kos and in Gumbet Bay in Turkey. Before this, the last recorded big wave in Europe had been in 2015.

"When there's a big one, it's just about one of the most destructive natural hazard there is," Annunziato says. He points to 1908, when the combination of an earthquake and a wave between 8 and 12 metres high hit the Straits of Messina, destroying the cities of Messina in Sicily and Reggio di Calabria on the Italian mainland. Between 75 000 and 200 000 people were killed in what was the most destructive earthquake in recorded European history.

One barrier to better tsunami warnings is cost. As the 2011 Fukushima nuclear disaster made tragically clear, the Japanese coast is vulnerable to tsunamis, so it is not surprising that the country has some of the best tsunami detection instruments. "At the moment, only the very rich countries, like Japan, can pay for and maintain these systems," says Annunziato. The next challenge is to create a cheaper floating measurement device; those installed in Japan cost around €2 million. "We have to reduce this to somewhere around €50 000 to €60 000, by using commercial components and low-cost devices, as we did for the IDSLs", says Annunziato.

# On shaky ground: earthquake-proof buildings by design

*New ideas put to the test, in a wall-shaking simulator*

*Setup of a large-scale building test at the European Laboratory for Structural Assessment (ELSA).*

To varying degrees, seismic rumbling between Earth's tectonic plates can put Europe's most densely populated countries at risk. But for the most part, it's not the earthquakes themselves that pose the greatest risk: it's collapsing buildings. So it is important that building materials don't crumble when subjected to seismic stress.

To ensure this doesn't happen, an EU building standard, called Eurocodes, covers concrete, steel, composites, timber, masonry and aluminum produced in Europe, It requires materials to be strong and flexible, so that they can absorb and distribute the energy of earthquakes.

The first building to comply with Eurocodes was constructed and tested in 1994 at JRC's European Laboratory for Structural Assessment (ELSA) in Ispra, Italy. Since then, more than 20 reference tests have been carried out to calibrate and develop the codes. Structures built to Eurocodes guidelines include the Millau Viaduct in France, the roof of the Liège railway station in Belgium and the roof of Hall M at Charles de Gaulle airport in Paris.

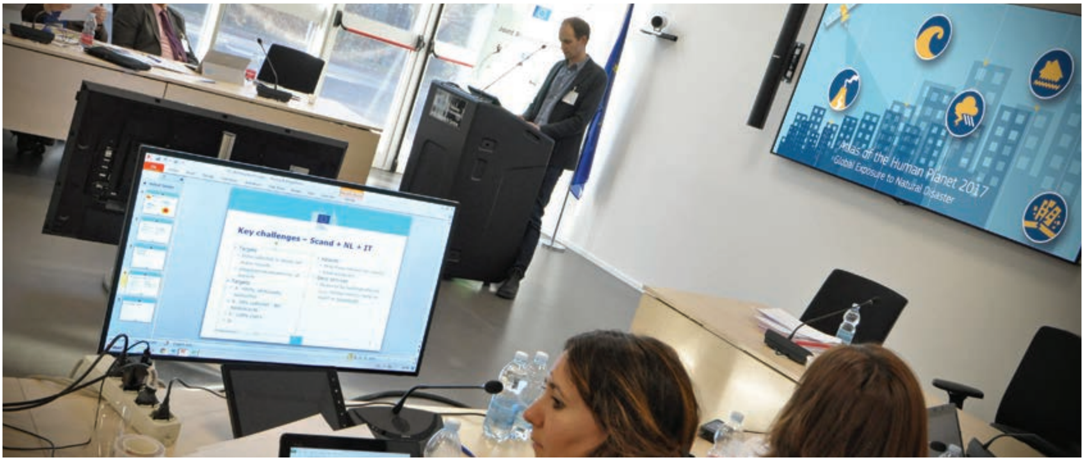
The key facility for this work at ELSA is the reaction wall, the second largest in the world and the largest in Europe; it comprises a reinforced concrete vertical wall rigidly connected to a horizontal floor to test the vulnerability of buildings up to five floors high to earthquakes and other types of stress. Even simple changes to building materials can improve how structures withstand such forces, says Artur Pinto,from JRC. "Knowing that these codes can save lives is the most rewarding part of my job," he adds.

As well as testing new materials and structures, the JRC assesses the earthquake vulnerability of old, unreinforced buildings. Many existing buildings in Europe were not designed to withstand earthquakes; for this reason, the risk of being killed by an earthquake in Europe may be higher than in Japan. These structures are in need of renovation, and the JRC advises on upgrades.

The JRC is now helping to develop a new generation of codes, says Pinto, which should expand to cover glass, new performance requirements and design methods, and the assessment, reuse and retrofitting of existing structures. Back at ELSA, another facility, the 'Hopkinson bar' laboratory, serves a very different but equally vital function. The JRC 'HopLab' is the world's largest Hopkinson pressure bar, a device used to test the resistance of large material samples and structural components to conditions that simulate impacts and explosions — whatever the cause.

# The human factor in natural disasters and what we can do about it

*Science can help us define — and deal with— catastrophes*




*EU Loss Data workshop, held at the JRC, in the context of risk management.*

The JRC's data gathering and analysis have created tools to help countries in the EU and beyond to respond quickly to whatever nature throws at us. Science has made forecasts better, warning us what to expect when and where. What more can it tell us about our vulnerability to natural hazards? The 2017 edition of the 'JRC Atlas of the Human Planet' looks at the exposure of people around the world to six major natural hazards: earthquakes, volcanos, tsunamis, tropical cyclone winds, tropical cyclone storm surge, and floods. The bottom line in a study of four decades is that things have got worse; more and more people are at risk.

Aneta Florczyk, from the JRC, says: "Previously, the global increase of natural hazards has dominated discussions about the impact of disasters on populations and infrastructures. The Atlas of the Human Planet illustrates the human factor: we are increasingly filling the available planetary space with infrastructures and people. If not well managed, this amplifies the risk of natural disasters."

Exposure to natural hazards around the world doubled between 1975 and 2015, mostly due to urbanisation, population growth and socioeconomic development. For instance, the Atlas records that one out of three people in the world are now exposed to earthquakes, a number that has almost doubled in the past 40 years. Also within Europe, over 170 million people are potentially exposed to earthquakes, almost a quarter of the EU population. Earthquake risk is highest in Italy, Romania and Greece.

Does it help to know our exposure to natural hazards? Well yes, because by following risk for decades we can hope to identify what makes risk levels change. We might be able to identify actions to make communities less vulnerable and more resilient, able to bounce back after disaster has struck. Resilience raises the issue of disaster risk management. 'Science for disaster risk management 2017: knowing better and losing less', is the first report from the JRC's Disaster Risk Management Knowledge Centre, with the ambitious aim of integrating science into decision making by making sense of it for the decision maker. JRC's Karmen Poljansek says: "We made every effort to collect the best available knowledge from the various fields of disaster risk management. It is now up to you: citizens, scientists, policymakers and practitioners, to learn from it, to enrich it with your experiences and collaboratively use it. Only then and together, can we make Europe a safer place to live."

A sign of hope? The Internet and the democratisation of science it allows. People can now get access to information previously only available to the experts, and people's knowledge can be shared. Thanks to operations like the Knowledge Centres of the European Commission, the interested citizen can also access the facts behind the decision making, and make informed judgements for themselves. Is there any better antidote to "fake news"?

# Nuclear

The European Atomic Energy Community Treaty, signed on 25 March 1957, is one of the three founding treaties of the European Union. It established the Joint Nuclear Research Centre to undertake research programmes, establish a common nuclear terminology across Europe, and implement a standard system of measurement for radioactivity. From then onward, nuclear science has been a core part of the JRC's portfolio.

Initially, the focus was on developing nuclear energy. But later, it shifted to nuclear safety, security, waste management and decommissioning. It also is deeply involved in standardisation (not only in the nuclear field) of materials and tools. And it collects and makes available information relevant to nuclear safety and security.

It does this working closely with Member States, striving, since the early days of its existence, for optimal Community-wide coordination and cooperation — to make the best use of limited resources.

# For nuclear energy, safety is the first priority

*With a third of the EU's electricity generated by nuclear reactors, ensuring safety is key*

*Technicians at work at the High Flux Reactor at JRC-Petten.*

On 11 March 2011, one of history's most powerful earthquakes unleashed a tsunami of epic proportions on parts of Japan, with waves up to 40.5 metres high. It knocked the Fukashima Dai-ichi nuclear complex off the grid — and ruined the plant's emergency generators. The result: The worst nuclear accident since Chernobyl, with a cost that the World Bank estimated at $235 billion. It was, the then-prime minister said, Japan's worst crisis since World War II.

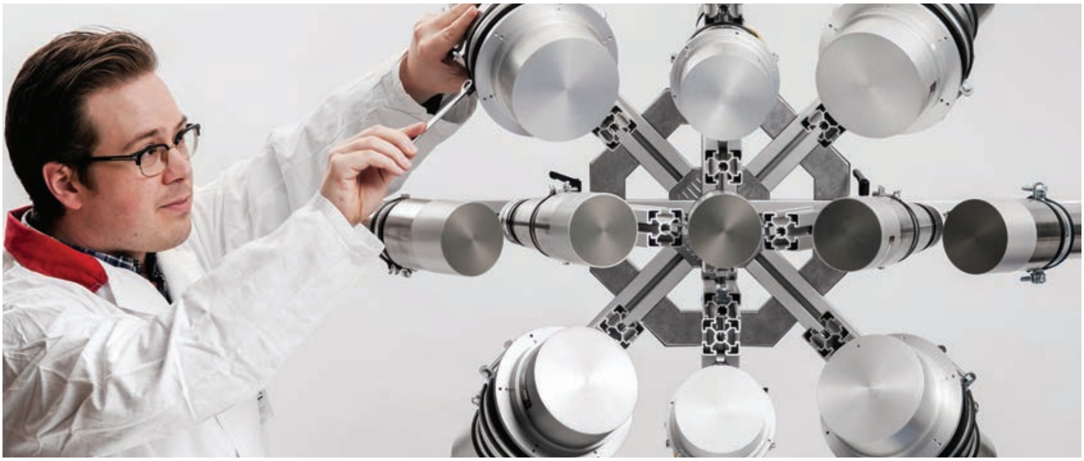
It was also, around the world, a spur for governments to go back to the drawing board and review all their old thinking about nuclear power. It eventually prompted Germany to foreswear nuclear energy entirely. A safety review of all EU nuclear power plants was ordered, and the JRC was involved; about 20 staff worked full time on the EU 'stress test' process. This established whether existing nuclear safety standards were sufficient to cover unexpected extreme events, including severe earthquakes, flooding, terrorist attacks or aircraft collisions. The conclusion: Safety standards of European nuclear power plants were found to be generally high, but further improvements were recommended and national regulators set up action plans to implement the findings.

The Fukushima incident also gave rise to further research on nuclear fuel, focusing on fuel behaviour in extreme accident conditions. To this end, the JRC worked with Japanese research groups on topics such as nuclear fuel corrosion in seawater. It also refined its techniques for analysing molten fuel debris; it can 'fingerprint' materials in an unknown sample and determine the composition. The technique has great potential in nuclear security and nuclear waste management.

Following the safety reviews, nuclear power remains a vital energy source in much of the EU. Today there are some 130 nuclear reactors operating in 14 EU countries. The unique nature of nuclear materials implies that safety is always the priority, so deepening our understanding of the safe operation of nuclear facilities is a key mission for the JRC. Its role includes research on materials and fuels, and technical support for the Member States' nuclear safety authorities. To collect, analyse and disseminate safety-relevant experiences throughout Europe is essential, and to this end a centralised EU 'clearinghouse' was established by the JRC in Petten, in the Netherlands. Today all nuclear safety authorities in EU countries with nuclear power plants have joined this JRC clearinghouse, making information available on their safety-relevant operating experience.

# The nuclear detectives are on the case...

*A highly specialised forensic discipline reveals the history of nuclear material when intercepted*



*A device to detect neutrons, at JRC-Geel.*

What happens if nuclear material ends up in the wrong hands? To prevent that, for more than 40 years the JRC has provided scientific and technical support to the teams of nuclear inspectors that operate within Europe and beyond.

The risk isn't hypothetical. Following the collapse of the Soviet Union, at the beginning of the 1990s, incidents of illicit trafficking of radioactive material generated a deep concern at European and international levels. The first seizures of smuggled radioactive material took place in 1991 in Switzerland and Italy. Similar incidents soon followed in Germany, the Czech Republic, Hungary and other central European countries. Many of the early cases concerned low-enriched uranium fuels. But the most serious incidents involved sizeable quantities of highly enriched uranium, plutonium mixed oxide, and weapons-grade plutonium.

It became urgent to determine the nature of the illicitly trafficked materials, their possible intended use, and where they came from. Effective countermeasures based on 'nuclear forensics' had to be rapidly deployed, and the JRC stepped in, becoming one of the world's top nuclear forensic labs.

This lab can trace the origin of any nuclear sample picked up by the inspectors. Research concentrated first on the analysis of trace elements as indicators of environmental contamination to help locate production sites. The roughness of fuel pellet surfaces was also examined to identify the fabrication process; this provides valuable insights on the producer.

There's more. To identify the production site, the 'age' or date of its last chemical separation is another key characteristic of uranium and plutonium samples. An age determination method for plutonium was developed using mass spectrometry. Today this is done by a new state-of-the-art facility at the JRC.

But the work can go beyond reactors and fuel. In the run-up to Germany's hosting of the FIFA World Cup in 2006, the JRC examined links between nuclear forensics and traditional police forensics, such as fingerprints and DNA analysis. The main concern was how to collect and examine radioactively contaminated evidence, for example, following a possible 'dirty' bomb explosion. Together with the German Federal Criminal Police, a dedicated glove box was designed and set up in Karlsruhe, allowing the safe analysis of evidence following established police protocols. Of course, there was no such attack — but the skills acquired, if they are ever needed in earnest, will serve Europe well.

# What does it take to stop nuclear proliferation? Lots of tools

*European technologies support nuclear safeguards inspections around the world.*

*Scanning electron microscope analysis of a highly-enriched uranium sample as part of a nuclear forensics science investigation.*

It's in the news from time to time: nuclear inspectors visiting reactors or storage depots around the world, to be sure the radioactive materials stay put, and don't get into the wrong hands. That work, led by the International Atomic Energy Agency safeguards inspection teams, requires lots of complex tools — and the JRC is among the regular tool-makers for the inspectors.

For instance, since the 1990s, the JRC has developed a variety of laser scanning techniques for verifying movement of uranium in and out of nuclear facilities, and to identify nuclear containers. Some of these JRC-patented innovations have found commercial non-nuclear application in areas such as construction monitoring. One system creates accurate 3D models of complex infrastructures, both externally and internally, and can detect any changes with millimetre accuracy. Another can identify and track uranium hexafluoride cylinders — reactor fuel — as they move around an enrichment site. And the over the years, the JRC has also developed sealing systems that can warn when a fuel assembly has been tampered with — a nuclear version of the 'don't open if the seal is broken' you find on pickle jars.

Another JRC tool can measure how much uranium and plutonium is in a sample of liquid taken from a fuel reprocessing plant. That's harder than it might sound: the two are often mixed together, and inspectors want a way to check without having to take the sample into a chemistry lab. An X-ray system, developed by the JRC, provides the answer — and the device can be taken directly to the reprocessing plant. That avoids hundreds of radioactive samples moving back and forth between the lab and the reprocessing plants, now at Sellafield in Britain and La Hague in France.

Digital tools also abound. The JRC has made extensive use of so-called Monte Carlo simulations — basically, using a computer to simulate an event and calculate the odds of different outcomes. For instance, one tool enables inspectors to read plant-operator declarations from spreadsheets, and calculate a simulated radiation measurement. Then they can compare it with the real, on-site measurements. If the two don't match, it's a signal something may be wrong.

And then there's the Web. The JRC supports the IAEA in finding and evaluating open-source data on trade. A web-based multilingual news aggregation system automatically collects and filters articles from some 4000 general web sources and more than 150 nuclear-specific websites. Again, they are looking for discrepancies between what they find in the databases, and the official reports from nuclear operators. The watchword for nuclear inspectors: Trust, but verify.

# Wanted: A safe way to get rid of radioactive waste

*Safely disposing of the waste from nuclear reactors is a problem with many technical challenges*

*Handling and storage of highly radioactive elements in JRC-Karlsruhe, 2005.*

How do you handle nuclear waste? Very carefully, of course. Every industrial activity produces waste, in different quantities and levels of toxicity. But nuclear reactors are special, with some radionuclides in the waste fuel having half-lives of 100 000 years or more. There are several long-term disposal plans under investigation, in Sweden, Finland, the US and elsewhere — but all are politically charged. In the meantime, some of the waste sits on-site, near the reactors.

The JRC is among many labs across Europe looking for solutions — or at least techniques to help manage the problem more easily. One under development is transforming the most toxic, long-lived waste into shorter-lived elements that will decay over much faster timeframes. Known as 'transmutation', this process achieves what the alchemists of old sought to do: transforming one element into another.

Knowledge about the long-term behaviour of the waste is also essential to ensure that it can be safely stored and disposed of in a repository, deep underground. How long can the waste containers resist corrosion? How will the local environment in which it's stored affect it? By answering such questions, the goal is to be able to make comprehensive predictions of the expected long-term performance.

Ensuring 'continuity of knowledge' on the disposed waste is also important. This means that, at any time, the complete history of a waste container is known, and available to the authorities, without any gaps. The specific problem is that waste canisters and their contents must be monitored over very long periods, until the waste is considered no longer harmful.

For instance, Swede is considering whether to go ahead with plans for a deep, underground fuel repository in Forsmark, near a nuclear plant a two-hour drive north from Stockholm. The fuel would be sealed inside copper canisters, surrounded by clay and buried deep in the granite bedrock.

Lots of technical questions arise — some, at first glance, trivial. Take an example: with so many identical copper canisters in storage, how do you tell them apart? Each will have a different age and contents. Marking them on the outside won't work: Labels can fall off, and many marking systems can lead to corrosion decades later. The JRC is working on a solution. It turns out that when the canisters are welded shut, the shape of the weld, on a microscopic level, is unique. That's a form of labelling, which can be read with ultrasound sensors. The technology for this is complicated. But it's an example of how, one small technical step at a time, this big problem of waste storage can be solved.

# The worst case happens: Harmonising safety after Chernobyl

*Nuclear safety knows no borders.*

*This lithium fluoride evaporator, for physical vapour deposition, is intended to improve nuclear safety and security. 2013.*

One of the world's worst nuclear accidents happened on 26 April 1986, at a plant deep in the Ukrainian forests near the town of Pripyat.

The operators, in what was then the Soviet Union, were making a safety test — checking that, in the event of a power black-out, the Chernobyl plant reactors would shut down safely as intended. In fact, they set up the test wrong. The reactor went out of control, blowing radioactive steam through the roof. A plume of fall-out spread across northern and western Europe, alarming millions.

The clean-up task was huge - and in Ukraine, continues to this day. But more broadly, the accident prompted renewed scrutiny of reactor safety around the world, and especially at Soviet-designed plants such as Chernobyl. The EU made a significant contribution to this initiative, through two well-known programmes, TACIS (Technical Assistance to the Commonwealth of Independent States) and PHARE (Poland and Hungary Assistance for the Restructuring of the Economy). PHARE was later extended to cover the majority of Eastern Europe.

Part of the problem was that the Chernobyl-type design was uniquely Soviet, using flammable graphite to help control the reactor. These so-called RBMK reactors were more efficient than the most-common Western designs, but, as the accident suggested, also carried special risks. Other Soviet models, though similar to the standard water-moderated reactors in the West, also needed checking.

The JRC was part of this international effort. It helped the Commission in the preparation, tendering, contracting and implementation of safety improvements. Numerous projects, many of which involved the JRC, were implemented in the former Soviet Union — mainly in Russia, Ukraine, Armenia, and Kazakhstan. These projects had a total EU contribution of approximately €900 million.  Thanks to the programme, a level of nuclear safety approaching EU standards was achieved in the Soviet-era nuclear power plants. This considerably raised the level of protection for all European citizens: safety knows no borders.

This cooperation continues to this day, with the JRC providing technical support to the successful implementation of nuclear safety improvement projects across an even wider geographic area.

# How much radiation are you getting? Check out the app

*Near real-time information on the radiation level in your environment is at your fingertips*


*Spectrometers measure radioactivity in cell cultures.*

Radiation is all around us — from granite in the ground, to cosmic rays in the sky. But how much is around you, right now?

If you've ever wondered that, you're in luck: The JRC developed an online mapping tool — that you can use, yourself — to check out the radiation in your area. It's based on the European Radiological Data Exchange Platform, or EURDEP. And it displays radiological monitoring data from most European countries on a single online map, in nearly real time. Data from 37 countries are made available, with hourly updates from some 5 000 radiation monitoring stations and an additional 100 air concentration measurement stations. It's at **http://remon.jrc.ec.europa.eu**.

What does the system say? Well, for the most part it's safe out there. The average hourly dose rate of gamma radiation is quite low all around Europe, well below the safety thresholds that are internationally recommended. There are some slightly hotter spots, such as in parts of Belarus. But if you're in doubt, you can get a daily update from the site. You can see how much radiation you might be getting from specific sources, such as cosmic rays or radon in the foundation stones of your house. And there's even an app you can download to your smartphone.

Of course, this system isn't there for amusement. The 1957 Euratom Treaty requires that Member States continuously monitor radioactivity in the air, water and soil of their territory and report back to the Commission. Radioactivity does not respect national borders; and past nuclear crises, such as the 1986 Chernobyl disaster, highlighted the need for procedures for get data flowing quickly to guide disaster response. To ensure the availability and exchange of information, the JRC developed the EURDEP system along with another, the European Community Urgent Radiological Information Exchange (ECURIE) system. It allows EU Member States to promptly notify everyone when they intend to take counter-measures to protect their population, in case of a radiological or nuclear accident. The ECURIE and EURDEP systems form the basis for the development of a global monitoring system by the International Atomic Energy Agency (IAEA), with which the JRC is also involved.

The accuracy of the radiological environmental data provided is, of course, very important. To this end, the JRC periodically undertakes comparative tests, each time focusing on specific radionuclides, which allows the participating monitoring stations to verify their own performance. When it comes to radiation safety, the rule is: test, and test again.

# Keeping nuclear skills in Europe

*A better supply of skilled nuclear labour is needed to keep up with demand*

*Learning to identify radioactive material from a crime scene at the European Nuclear Security Training Centre.*

Where once the nuclear industry was seen as a hot career choice with excellent pay, today young peoples' interest in nuclear studies has fallen. Some engineering faculties have abandoned nuclear education altogether.

What's going on? A glut of cheap gas, concerns about the energy's safety and the high promise of renewables have conspired against nuclear, with the result that many reactors are heading into early retirement. In the meantime, the current generation of senior nuclear experts is retiring, adding to concerns that expertise may be in decline. And that's a problem.

And nuclear expertise is needed for more than power, alone: nuclear technologies are increasingly used in various industrial and medical applications, raising concerns about the supply of experts in those fields, as well.

The prospect of a shortage of skilled professionals has prompted action from the JRC. As well as offering external researchers from the Member States and other non-EU countries the opportunity of study experience at its own nuclear facilities, the JRC has helped collected data on nuclear workforce needs since 2011. Recent assessments have revealed a 30% shortfall in skilled human resources, underlining the urgent need to attract young professionals into the industry through appropriate education and training programmes.

has lead an initiative called ELINDER (short for the European Learning Initiatives for Nuclear Decommissioning and Environmental Remediation) to prepare specialists for the dismantling of nuclear plants as they reach their end-of-life. A complete decommissioning, starting from the end of operation of a reactor until its final release from regulatory control, is a process that can easily take 20 years. This explains why only a few major nuclear sites have been fully decommissioned so far in Europe, while a third of the over 200 nuclear reactors are already in permanent shut down.

Recently, the JRC has also helped train customs officers from 70 countries to detect and manage nuclear trafficking. The International Atomic Energy Agency, which tracks trafficking, thefts, losses and other unauthorised nuclear activities, says there have been almost 3 000 incidents reported in the world between 1993 and 2015. The training, which takes place at the European Nuclear Security Training Centre, a JRC facility, familiarises trainees with radiation detection and hazards. Trainees get to see and experience actual nuclear materials, as the centre is one of the few places in the world where a wide range of samples of plutonium and uranium can be used for training.

# Space

Space research isn't only about distant planets or galaxies; it's also about what we can learn about our own planet, with eyes in the sky.

A steady increase in the number of EU-funded Earth observation satellites in orbit, with launches to space set to double over the next decade, is making more data available as well as bringing down the cost of doing research. The Sentinel constellation, when fully up and running, will be able to sense Earth's every action.

But this data-stream must be channeled and analysed — and the JRC has over 40 years experience in this discipline. Its clever algorithms have enabled the JRC to make sense out of satellite data that initially are only shades of grey. Results include a map of every strip of water on the planet going back 32 years; a much truer estimate of small scale diamond production in Africa; and information that helps tracing pollution, and tackling piracy and smuggling and illegal fishing in our oceans.

# A bird's eye view of polluters and pirates

*Shipping traffic is booming — so here's how satellite technology is keeping track of it all*


*The JRC tracks global shipping. Vessel positions are refreshed every 6 hours and reconstructed every hour.*

One side-effect of globalisation can be seen on the high seas. Over the past few decades, global shipping traffic has soared four-fold. Oil, gas, cars, grain, people — four-fifths of the world's trade now moves by ship. The numbers are staggering. In EU ports alone in 2015, according to Eurostat, there were 2.2 million ships calling. They carried 16.4 billion gross tonnes, with Dutch ports the busiest of all.

So how to keep track of all those ships? With satellites, of course — but it's easier said than done.

Some satellites carry receivers to pick up signals from transponders installed on each vessel, which transmit data about a ship's position, course, speed and cargo (International law mandates that all vessels over 300 gross tonnes must be fitted with these devices). But that doesn't catch everything, particularly if the captain would rather not be seen at all. So other satellites make images of the sea surface that reveal the presence of ships. The data received from the satellites can be used to follow ship traffic, enforce fisheries rules, trace pollution, and help tackle piracy and smuggling.

JRC software can predict where a vessel will most likely be a few days in advance, based on its type and the routes they usually follow. Deviations from these routes may signal something is not right. The satellites have aided cracking down on the illegal fishing industry, tracking ships to witness crimes in real time. Researchers can see if a ship meets another vessel in a strange place, possibly to offload illegal cargo, or is moving in patterns typical for fishing in water where it's not allowed. Satellites have also been used to warn merchant vessels against piracy off East Africa and West Africa, where some years ago attacks and hijackings resulted in million-euro ransoms.

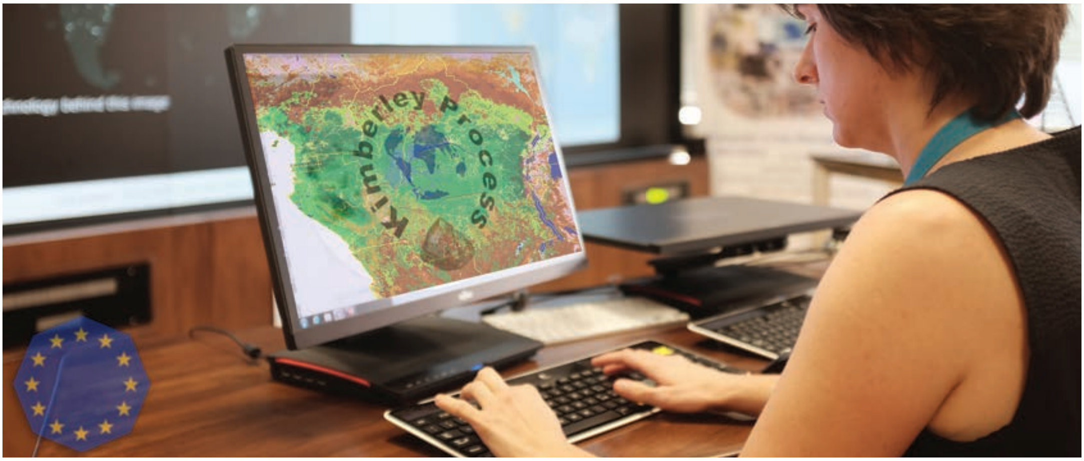
Making sense of the huge amount of data beamed down from space is the job of a team of JRC scientists. Harm Greidanus explains how a dark area in a radar image could indicate an oil spill, for example: "When the operator sees a dark spot where it shouldn't be, he will notify the appropriate national authority, which can fly a plane to sea to check it out," he said.

The JRC will soon make its ocean surveillance tool called SUMO — for Search for Unidentified Maritime Objects — available to everyone via open source. Developed over 15 years, the system can process batches of more than 10 000 satellite images in less than two hours. "We needed to come up with powerful automatic processing tools, because the images from space we are getting these days are too large and too many to analyse by hand," says Greidanus.

Another aspect is cost. Until recently, and before the EU launched its modern fleet of Sentinel satellites under the Copernicus Earth observation programme, it was prohibitively expensive to receive these kinds of satellite data records for those not directly involved in the field. "You'd spend €1 000 or more on a single satellite image before. Thanks to the free and open policy of the Copernicus programme, we don't need to worry about that anymore," says Greidanus. A look at the map on your smartphone confirms it: today, the challenge is to make sense of a data tsunami rather than to worry about getting data in the first place.

# Satellite data shine in the fight to stop the 'blood diamond' trade

*In the search for illegal diamond mines, the words needle and haystack come to mind xxxx*




*Satellite imagery is being used by the JRC to identify active diamond mines in Africa and monitor their activity in time through repeated observations.*

The discovery and exploitation of diamond deposits has been an important economic catalyst for development in many African countries. But diamonds also have a tragic history of fueling wars, with rebel groups selling them to buy arms. Harrowing details of the diamond-financed rebel uprisings in Sierra Leone, Liberia, and Angola in the late 1990s, and an impressive movie about it, shocked the world and spawned the terms 'blood' or 'conflict' diamonds.

Since then, the world — following the lead of the United Nations — has fought to stem the flow of tainted rough diamonds, setting up in 2003 a stringent certification scheme for trading them. Today, this scheme, known as the Kimberley Process, is implemented by 81 countries and covers 99.8% of worldwide rough diamond production and trade. The Kimberley Process is a scheme founded by governments, the diamond industry and NGOs to halt the sale of diamonds from conflict zones. By imposing exacting standards on trade with 'conflict-free' rough diamonds, the member countries ensure that stones are sourced legally and impose transparency throughout the industry.

"Peer reviews, in which member countries inspect each other's Kimberley Process Certification Schemes are essential to the efficient functioning of the Process," says Winfried Ottoy of the JRC. Yet despite the best efforts, collecting information to monitor the rough- diamond industry remains a continuous challenge.

This is where the JRC's contribution comes in. Analysing satellite images, JRC researchers assess the activity level of artisanal diamond mines in African countries such as Ivory Coast and the Central African Republic. Some of these mines are vast, watery pits, but many measure only 10 to 15 metres across, "which is why you need high-resolution shots from space and clever software to evaluate them," says Ottoy. The analysis allows the JRC to compare observed diamond production in selected regions with the official Kimberley Process statistics and with open source information gathered and analysed through other tools developed by the JRC, such as the European Media Monitor. The resulting reports, maps and other visualisations provide decision makers with a clear and understandable base, supporting the implementation of the Kimberley Process.

The JRC has accumulated a wealth of experience searching for and identifying illicit mines, and was asked by EU decision makers to represent the EU in the Kimberley Process peer review teams and in its working group on statistics. "Peer reviews and official meetings allow us to validate and refine our data and findings in the field, which is why I love the work," says Ottoy.

Notwithstanding these efforts, emerging and long-lasting conflicts in the Central African Republic and elsewhere pose new challenges: "During its chairmanship of the Kimberley Process in 2018, the EU will try to address some of these, an effort that will be supported by our work", says Ottoy.

# Follow the Sun: the ever-present threat of extreme space weather

*Extreme solar outbursts are rare, but we need to be prepared*

*Weather and air pollution measurements in the JRC Atmospheric Observatory, a 100m high tower inaugurated in Ispra the 10th of July 2017.*

In March 1989, the Sun emitted a burst of energy so powerful that it knocked out power supplies in the entire province of Quebec, Canada, leaving six million people without electricity for nine hours. According to NASA, the solar incident, which also destroyed a transformer at a nuclear power plant in New Jersey, was "like the energy of thousands of nuclear bombs exploding at the same time". It was a dramatic example of how space weather caused by solar activity can affect us here on Earth, says JRC researcher Elisabeth Krausmann.

There have been similar incidents. After solar storms in 2003, Sweden suffered a power outage for over an hour, and aircraft controllers were forced to re-route aircraft. In fact, these events are quite common: in 2005 the total cost of extra fuel used for rerouting flights from polar routes due to space weather amounted to $186 million (excluding costs to passengers and compensation).

And way back, in 1859, the 'Carrington flare', thought to be the biggest solar eruption on record, produced a display of spectacular green auroras witnessed as far away from the poles as Sub-Saharan Africa, Monterrey and Cuba.

Thankfully, extreme solar outbursts on a par with the Carrington flare are rare. According to the JRC, the likelihood of such major events is between 6% and 12% within the next decade. "But in principle, we could experience one at any time," says Krausmann. "We almost got a bad bout of space weather in 2012, when a coronal mass ejection — a magnetised solar plasma cloud — barely missed Earth. If it had hit, we'd have been in trouble." It could have caused radio blackouts on aircraft, sent satellites haywire, disturbed navigation satellite signals and cause power blackouts of major proportions with damaging ripple effects throughout society.

To better prepare for extreme space weather events, the JRC in 2016 gathered together a meeting of some of the world's major players in the field, including the Swedish Civil Contingencies Agency, the UK Met Office, and the US National Oceanic and Atmospheric Administration's Space Weather Prediction Center.

The goal of the two-day summit was to discuss the state of extreme space-weather preparedness on critical infrastructures in the EU. Researchers and policymakers at the meeting concluded that Europe's electricity grid urgently needed a vulnerability health check. There was also a general call for more cooperation and consistency among countries on space weather preparedness and response.

"A really big event has not yet been felt in Europe," says Krausmann. "But if we are to witness an extreme incident, many countries will be hit,We need to join efforts."

# Home truths: Earth's mosaic of human settlement seen from space

*A map reveals all the places where humans have lived during the past 40 years*

*Mapping human settlements at the JRC on behalf of a globally-consistent, multi-scale and detailed representation of built-up areas.*

We live on a big planet, but we tend to cluster in only small parts of it.

Today the global population exceeds 7.32 billion. But the actual, built-up surface area corresponds to only 0.52% of the global land mass surface. To put it another way, if the built-up areas of the world were one single giant city with no open spaces, in 1975 it would have covered an area the size of Oman. In 1990: the size of France. In 2015: the size of Turkey.

What's more, the way we settle the available land isn't evenly distributed between rich and poor: in 2015 the people living in high-income countries had four times more built-up surface per capita available than medium and low-income countries.

Those are some of the facts that come from a pioneering system developed by the JRC. Some years ago, JRC scientists taught a computer to learn the meaning of satellite data records by comparing them with data relating to known examples, taken from existing maps and texts. Ploughing through all the high-resolution satellite data recorded since the beginning of remote sensing technology, the system now recognises all roofed buildings. JRC scientists can make a map, in a format never seen before.

Called the Global Human Settlement Layer (GHSL), the map is based on a freely available dataset on human settlements from villages to megacities, spanning 40 years of Earth observations. Unlike conventional maps, this one is dynamic. It can be used to check where and how people lived yesterday and live today. It can measure the available built-up area per capita at different points in time, and how this changed over the last 40 years. It allows scientists to calculate the density of cities and analyse how green or how exposed to disasters urban centres were, and are. It also provides a practical tool for monitoring of the implementation of international frameworks, such as the Sustainable Development Goals, disaster risk reduction, biodiversity or world heritage sites.

While maps tend to skew towards places and things that their makers deem most important — probably the most-chronicled example is how maps throughout history have under-represented Africa's true size — the GHSL is truer to reality. Accurate, high-resolution population density maps of this type can allow policymakers to identify the best places to build new schools, hospitals or transport infrastructure. Researchers also see this technology as a tool to allow nations to plan for coping better with natural disasters.

The key findings of the analysis of the GHSL are presented in the first release of the Atlas of the Human Planet, an international collaborative effort within the Group of Earth Observation Human Planet initiative.

# Europe's eyes in space: the rise and rise of Copernicus

*How a coming-together in an Italian village helped spawn space-based Earth monitoring*


*Testing wireless communication systems, in the frame of the Earth Observation Programme Copernicus.*

Echoing the pioneering Polish astronomer and mathematician it was named after, the Copernicus Earth observation programme can be said to have changed the way we see our world — and it is a truly European success story. The programme takes vast amounts of data from a constellation of satellites, including the European Sentinel families, and a global network of ground-based, airborne and seaborne observation systems. This vast amount of information is then processed, providing essential information to service providers, public authorities and international organisations.

Most of the Copernicus information services are provided free and are accessible to all. Everyone, from decision-makers and planners to interested citizens, can improve their understanding of the planet we are living on. Copernicus brings benefits to agriculture and tourism, security and disaster response, urban planning, and to monitoring climate change and its impact.

The story of the Copernicus programme can be traced back to a small village called Baveno in northern Italy. There, In May 1998, the JRC held a conference with European space agencies from Italy, Germany, UK, France and the EU to discuss the future of European space activities.

The JRC's Herbert Allgeier, a pioneer of the Copernicus programme, recalls: "Before Baveno, space applications were driven by specialists, who thought that if an application was interesting enough then we should do it — never mind if the application was actually needed or not!

"We changed this," he says. "The Baveno Manifesto's message is that applications should be driven by users' needs — environment and security policy above all. Replacing technologies, such as 'remote sensing' with a visionary, user-driven concept was the result. And 20 years later we've created applications responding to many policy needs; and we have made Earth observation and remote sensing technologies available to everyone. Who knows what new non-policy driven commercial market of applications will emerge next?"

As a result of the manifesto, European space agencies and organisations committed to developing space-based environmental and security monitoring services, as well as making use of, and further developing, European skills, and technologies. The JRC contributed to this with a portfolio of technologies for remote sensing applications. Today it is responsible for the operational implementation of various aspects of the programme, in particular the global land component.

Facilitating the response of emergency services during natural catastrophes was one of Copernicus's early successes. Thanks to its near real-time information on the situation at ground level, it allows search and rescue operations to be coordinated much more efficiently.

The latest addition to the Copernicus programme is a climate change service. It compiles projections of climate change and impacts on the environment, and thus on economic activities. Interested? Read more on at **http://copernicus.eu/data-access-services**.

# JRC Legal Timeline

The Joint Research Centre has been a key feature of the European Project for 60 years. It is an expert service of men and women advising the Commission — but it is also a legal creation of what is now called the European Union. Its activities have been shaped by a series of treaties, regulations and policies. The following legal timeline provides an overview of those measures.

# Enthusiasm and adventure - the early days

**1957**
- Signature of Euratom treaty.

**1958-1962**
- 1st Euratom research programme.

**1959**
- Signature of the ISPRA site agreement (entered into force on 1/9/1960).

**1960**
- 21/12 signature of the Karlsruhe site agreement (entered into force on 30/10/1962).

**1961**
- 1/3 Inauguration of the Ispra Site.
- 29/5 Signature of the long lease contract between Euratom and SCK/CEN in Geel.
- 25/7 Signature of the Site Agreement in Petten (entered into force on 30/10/1962, after notary deed regarding the transaction Reactor Centrum Nederland — Kingdom of the Netherlands — Euratom granting an emphyteusis right to Euratom on the Petten site).

**1963-1967**
- 2nd Euratom Research Programme.

# Crisis and transformation

**1969**
- Council Resolution of 06/12/1969 (R/2424/69; PV/CONS/R 14 of 27/05/1970).

**1970**
- Creation of COST (European Cooperation in the field of Science and Technical Research).

**1971**
- Commission Decision 71/57/EURATOM of 13/01/1971 on the reorganization of the Joint Nuclear Research Centre (JRC) (amended by Commission Decision 74/578/EURATOM, that moves the Head quarter of the JRC from Ispra to Brussels, Commission Decision 75/241/EURATOM, Commission Decision 82/755/EURATOM of 02/06/1982, Commission Decision 84/339/EURATOM of 24/05/1984).

**1973**
- Council Decision 73/125/EEC, Council Decision 73/126/EEC, Council Decision 73/127/EEC establishing the first multiannual (1973-1976) research programme for the European Economic Community (EEC).

**1977**
- 1977: 3-Years Programme (1977-79).

**1978**
- Community programme FAST (1978-1993, Forecasting and Assessment in the field of Science and Technology).

**1981**
- Fusion between JRC and DG XII.

**1982**
- Council decides (5-years) programme (1983-87) of the JRC.

# Towards the next JRC

**1988**
- Council Resolution of 29/06/1988 concerning the activities to be undertaken by the Joint Research Centre (JRC).
- Council Decision 88/522/Euratom of 14/10/1988 adopting specific research programmes to be implemented by the Joint Research Centre for the European Atomic Energy Community (1988 to 1991).

**1991**
- 3rd Framework Programme RDT (1991-1994).

**1992**
- Council Resolution of 29/04/1992 concerning the activities to be undertaken by the Joint Research Centre.

**1994**
- Council Conclusions of 26/04/1994 on the role of the Joint Research Centre (JRC).

**1995**
- 4th Framework Programme on RDT (1995-1998).

**1996**
- Commission re-establishes JRC as a fully independent DG under J.P. Contzen, implemented on 30.04.1996.
- Commission Decision 96/282/EURATOM of 10/04/1996 on the reorganization of the Joint Research Centre.

**1998**
- 5th Framework Programme on RDT (1999-2002).

**2001**
- JRC reorganisation.
- Commission Communication SEC/2001/1397 of 12/09/2001.

**2002**
- 6th Framework Programme on RDT (2003-2006).

**1983**

- 1st Framework Programme for RDT.
- ESPRIT (European Strategic Programme for Research and Development in Information Technologies).

**1984**

- First Framework Programme for Research, adding indirect community co-funded (indirect) research to the (direct) research carried out by the JRC and funded 100% from the institutional budget. JRC Board of governors was created by Commission Decision.

**1985**

- Commission Decision 85/593/EURATOM of 20/11/1985 on the reorganization of the Joint Research Centre (JRC) (amended by Commission Decision 93/95/EURATOM of 02/02/1993 and Commission Decision 94/809/EURATOM of 16/11/1994).

**1986**

- EEC treaty amended by title IV.

**1987**

- 2nd Framework Programme on RDT (1987-1991).
- New JRC's role: 1) Support to the Commission's sectorial policies, 2) research against partial or total payment by 3rd parties, i.e. countries and private firms.

**2004**

- Communication from the Commission to the Council and the European Parliament SEC/2004/0621 - Decommissioning of nuclear installations and waste management - Nuclear liabilities arising out of the activities of the Joint Research Centre (JRC) carried out under the Euratom Treaty.

**2007**

- After Lisbon Lisbon Treaty the new Treaty of the European Union (ECC becomes EU).
- 7th Framework Programme on RDT (2007-2013).

**2008**

- Communication from the Commission to the Council and the European Parliament COM/2008/0903 - Decommissioning of Nuclear Installations and Management of Radioactive Waste: Management of Nuclear Liabilities arising out of the Activities of the Joint Research Centre (JRC) carried out under the Euratom Treaty.

**2012**

- JRC reorganisation.

**2013**

- Communication from the Commission to the Council and the European Parliament COM/2013/0734 final. Decommissioning of Nuclear Installations and Management of Radioactive Waste: Management of Nuclear Liabilities arising out of the Activities of the Joint Research Centre (JRC) carried out under the Euratom Treaty 2013: Horizon 2020 (research program 2014-2020).

**2016**

- JRC reorganisation; new JRC strategy 2030.

If you would like to learn more about the activities of the JRC, please contact:

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**Joint Research Centre**
**60 stories**
**For the 60th anniversary**

**Abstract**
The publication consists of a general introduction followed by a timeline depicting the 60 years from 1957 (signature of EURATOM Treaty and creation o JRC) to 2017 (One year after the new JRC strategy 2030). The bulk are 6o 1-page stories, grouped in 9 chapters. Each story relates to a specific aspect that is deemed of relevance to the EU citizen.

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## JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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