Building Grids for Europe

A crucial technology for science and industry

Information Society

European Commission

What is a Grid?

In a Grid your PC suddenly becomes a gateway to supercomputing and knowledge power, but you only pay for what you need, when you need it.

Everyone understands that electricity is generated using everything from nuclear plants to windmills. We also know it is stored, transmitted, distributed, sold and re-sold in complex commercial and technical arrangements.

But we don't need to know any of these details — electricity is just something that comes out of the plug. It's available, affordable and dependable. Every now and then we pay a bill, but we control how much or how little we use, and can choose the best supplier for our needs. Most of us don't even know what electricity really is — it's just there, making things work.

In the knowledge-based economy that Europe must become if it is to prosper in the 21st century, we need a second Grid: one that supplies enormous computing power and knowledge without forcing us to worry about where and how.

A new computing paradigm

This new sort of Grid works by connecting together huge varieties of computers, data repositories, software programs, scientific instruments and more.

Connecting such resources together, in itself, is not revolutionary — after all, every time you look up a page on the Web you are connecting your PC to a computer somewhere else in the world.

A Grid, however, allows you to tap that computer's processing power, rather than simply look at some of its files. Now add the power of a thousand other computers spread across the globe. You choose how much power you want to use — your Computational Grid parcels the job and shares it out to computers connected to it. Suddenly your PC has become a gateway to a supercomputer, but you only pay for the power you need, when you need it.

But you have much more than that — you can also access massive amounts of data, whether it is stored in dedicated data storage devices or flowing from scientific instruments and sensors. They are all attached to your Data Grid which — thanks to the computing power available — can both process and store this data easily, using a whole range of software designed to make the most of the Grid's computing power and distributed data.

And more still — Grid computing power enables new sorts of software to become possible. Instead of data coming out of that plug in the wall you now get access to knowledge, represented by semantic analysis software running on your Knowledge Grid. Your PC can understand and manipulate this knowledge, providing you with instant access to answers to queries from across the world.

Finally, you are not alone on this Grid — through it you work with your project team, composed of members located on different continents, working for different organisations. This Service Grid dynamically creates a virtual organisation, working in a virtual laboratory. Sensors and experiments are controlled remotely, data is stored, shared and processed instantly, results are analysed online, and relevant knowledge from the world's databases found and combined with it.

It doesn't matter if your team is modelling the Earth's atmosphere, designing cars, creating animated films or finding new medicines, the basic principle is the same: your Grid supplies all the computing power, software, data and knowledge you need in one integrated package, and helps project teams work more closely together.

The Grid provides immense computing and knowledge power on demand in the same way as the electricity Grid provides electricity.

Grids: crucial technologies and applications for Europe

Grids are going to revolutionise computing as profoundly as e-mail and the Web revolutionised communications and publishing — it is perhaps not surprising that the first Grids were developed for the European Organisation for Nuclear Research (CERN), the particle physics laboratory that gave us the World Wide Web.

Grids are now moving out of the laboratories, following the route taken by e-mail and the Web. As with these two previous e-revolutions, Grids look set to change the way business is structured and how people work, learn and indeed live.

By providing everyone with the immense computing power and knowledge previously available only to the largest corporations and laboratories, Grids will both improve the competitiveness of existing industries and help usher in new markets and services previously thought impossible. Their impact on our quality of life will be profound, allowing us to better monitor and model everything from global climate change to the way cars behave in collisions.

Grids will enable Europe's researchers and businesses to better share knowledge and resources across the continent. Grids will therefore help underpin a truly European research area, a space in which all of Europe's world-class scientific and technological capital can be combined to improve European competitiveness and quality of life.

Grids are therefore a crucial enabling technology for reaching the 'Lisbon strategy', set in spring 2000, of transforming the European Union into the most competitive, knowledge-based economy in the world by the year 2010.

Grid technologies are a 'strategic objective' within information society technologies (ISTs) research, funded under the EU's sixth framework programme (FP6) (2002–06) for research and technological development.

This brochure outlines why and how FP6 is helping Europe take Grids out of the research labs and into industry — a critical step in ensuring Europe realises the benefits of the information society.

Building a commanding position in Grid computing is crucial for Europe. By allowing anyone, anywhere, anytime to easily access supercomputer-level processing power and knowledge resources, Grids will underpin progress in European science, engineering and business. Their impact on European society may be just as profound.

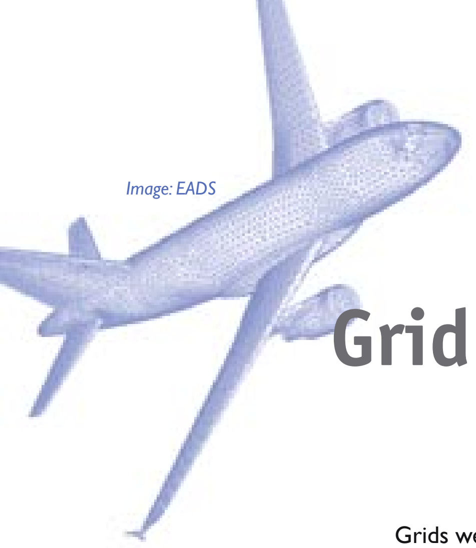


Image: EADS

Grid expectations

Grids allow us to solve complex problems that could not be tackled before by both providing powerful computing and data resources and enhancing global collaboration. While the first applications were in 'big science', Grids are now entering mainstream industry.

Grids help the analysis of data from crash tests

Image: EUROGRID

Grids were originally conceived for tackling problems involving large amounts of data and/or compute-intensive calculations, so it is not surprising that the first Grids were developed for global-scale scientific projects — all deal in vast quantities of data, require supercomputer-scale number crunching and involve technically advanced teams spread throughout the world's universities, research centres and hi-tech companies.

Today, however, Grids are entering completely new waters. Their impact on the world of engineering and business will be massive and is already being felt — but sectors as diverse as medicine, engineering, finance and entertainment are also facing radical changes.

Benefits on tap

Until the Grid, the only organisations which could afford supercomputing were those with large budgets and significant computing needs. Grids, however, could allow 'supercomputing on tap' — organisations pay for the power they need, when they need it, making supercomputing affordable to those who only need this sort of computing power occasionally.

The range of organisations who stand to benefit is surprising. Emergency response teams, for example, could build a Grid to handle data from the thousands of sensors already scattered through river basins, on mountain tops and even in orbit. This Grid could analyse, model and compare this data in real time to predict the risk of emergencies: flooding, avalanches or — when the basic science is ready — earthquakes and volcanic eruptions.

When a disaster strikes, the team could then use the Grid to predict how the danger will spread, and to optimise resource allocation. Grid technologies can provide ad hoc the sort of data storage, processing power and communications required at the prices emergency response teams can afford.

Manufacturing

The Grid is much more than affordable supercomputing. Grid technologies allow users to share data, software, instruments and generally work together more closely, even when in different organisations on different continents. The impact could be profound on Europe's manufacturing industries, where teams in different companies work together on data- and compute-intensive engineering and design projects.

EMERGENCY RESPONSE GRID

In times of crisis — be it a natural disaster, terrorist attack or infrastructure failure — mobile workers need to work together in time-critical and dangerous situations. Real-time access to information and knowledge, powered by Grids, will help save lives.

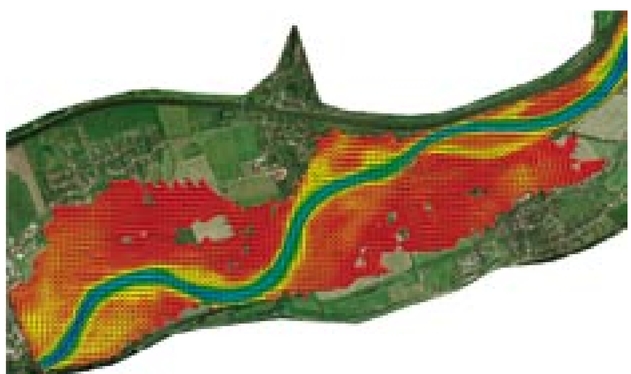
Crises are complex situations, with large numbers and varieties of mobile workers — medical and rescue teams, police, fire fighters and other security personnel — appearing on the spot at short notice. These different teams come from different organisations, and generally have incomplete or even contradictory knowledge of the crisis situation. Finally, many of the sophisticated tools they bring with them — from infra-red cameras to find victims in the rubble to decision-support systems for planning evacuations — will probably not interconnect with anyone else's.

Grid technologies could fill this collaboration gap, helping these workers to work more effectively both as individuals and as members of highly complex teams.

For example, while current mobile equipment has limited computational power, a Grid set up to help handle the disaster could allow workers to use their devices to tap high-performance computing power. This opens possibilities such as real-time audiovisual analysis: extracting useful information from images, videos and sound that can be used to rescue victims and instruct personnel.

Moreover, all mobile teams will be supplying information to and accessing information from the Grid, allowing diverse emergency resources and teams to share knowledge and improve collaboration and planning.

To fulfil this potential, however, a range of new research challenges must be addressed.



Grids assist in predicting the impact of floods in river basins

Image: CROSSGRID

Take the design of a new car. Although this is led by the car manufacturer, the project involves designers, engineers, computer experts and business managers from potentially hundreds of different suppliers, located around the world.

The different parts of the project, however, are highly interrelated — the engine has to fit under the bonnet. The different teams therefore have to work together closely, regularly integrating their data and models into the overall design and testing the overall result. Making these different models work together is complicated further by security — the project manager cannot give all team members access to the entire design.

A Grid can help by allowing data and models to be integrated together seamlessly without letting confidential information 'leak'. Data from full-vehicle crash tests carried out by one partner, for example, can be shared with every supplier, who can then use the Grid's computing power to analyse their various components' performance.

The result is improved, faster and less expensive design and manufacturing processes. This in turn translates into higher European competitiveness, more jobs and superior quality products.

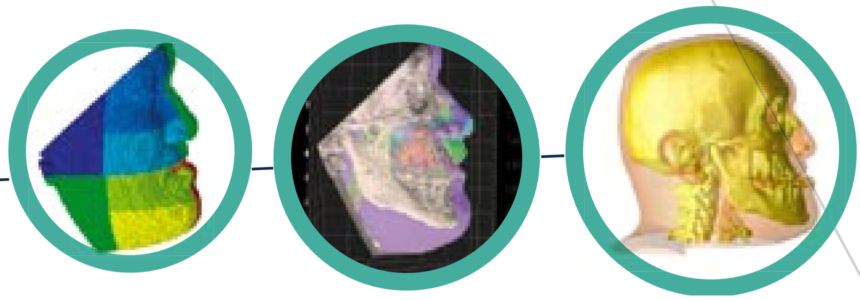
From finance to retail

The benefits of Grids, however, will not be limited to large manufacturers and their suppliers. Companies in sectors as diverse as finance, retail and media could use Grid-based 'virtual work spaces' to collaborate more closely with their partners, as well as profit from the Grids' ability to mine data and transform it into knowledge.

Archives of print and audiovisual media, for example, are currently being semantically indexed in massive databases located around the world. With Grid technology, publishers will be able to search these archives, extract knowledge and deliver new content services quickly and flexibly. The full richness of the world's cultural heritage, currently locked away in databases across the globe, will be opened to everyone.

Retailers, on the other hand, would be able to manage their supply chains and customer relationships better and mine their geographically dispersed databases for buying patterns, while the financial and insurance sectors could perform better analyses of statistics, demographics and more.

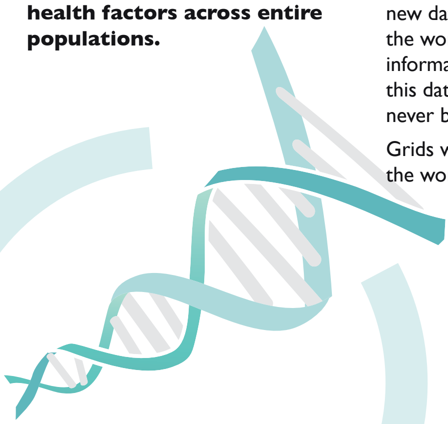
THE HEALTH GRID



Use of Grids in maxillo-facial surgery planning

Patient data courtesy of Dr T. Hierl, U. Clinic Leipzig, figures courtesy of the GEMSS Consortium

Grids will have an enormous impact on the healthcare sector, from accelerating the development of medicines to improving the analysis of health factors across entire populations.



Healthcare will be revolutionised in the 21st century by the mapping of the human genome, and proteomics, the analysis of protein functions. Both disciplines are creating massive new databases in laboratories across the world. Without the right bio-informatics tools to share and use this data, however, the promise may never be realised.

Grids will allow laboratories around the world, working together in virtual organisations, to search the data and create new molecules in silico with desired characteristics (multi-drug resistance, toxicity, etc.) for testing.

As another example in healthcare, Grids allow the federation of databases of mammograms from across Europe, along with software tools to improve breast cancer screening and diagnosis. ■

Building Grids for Europe

The challenge facing Europe today is to turn technologies developed for researchers into industrial strength business tools.

Existing Grids in academic environments are considered to deliver adequate performance by their users if they are operational only 80–90 % of the time. Furthermore, as universities using Grids are staffed with world-class computer scientists who intimately understand what they themselves have built, the problem of restarting after a crash can be overcome, even if — in difficult cases — up to 20 personnel are required to restart following a system failure.

However, in industry, performance levels of, for example, at least 99.5 % 'uptime' for IT systems are required and expected. This is especially the case for critical systems used to monitor global financial markets or nuclear power stations. Similarly for industry an IT system cannot be overly complex and require teams of computer scientists to be constantly 'on call' in case it suddenly crashes.

When talking about Grids what is required is that the Grid be 'virtualised': the complex resource brokering and management going on behind the scenes, hidden behind a user-friendly layer of standard, interoperable interfaces.

The research world also worries less about security — Grids were originally developed, after all, to help researchers share data and solve problems together. However, data and resource sharing taking place in industry needs to be controlled through reliable and trusted access and authentication systems.

Finally, most Grids today are built around an early set of de facto standards and toolkits. A new generation of industrial strength global standards are required to fully exploit the Grid's potential.

Towards 2010: Next generation Grids for industry and business

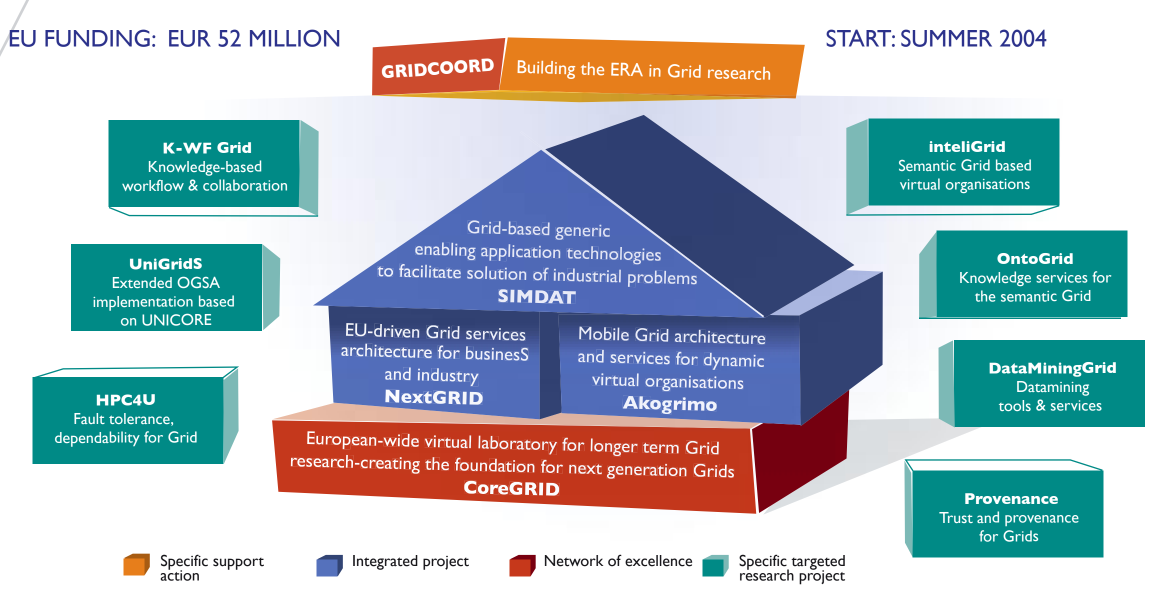
The European Commission has been financing Grid research since early 2000, when the first EU projects were launched under the fifth research framework programme (FP5). The Grid research projects under FP5 were focused on technology development and application pilots. Results of these Grid projects are now deployed, for example, in the Grid-enabled research infrastructures made available by FP6 projects EGEE and DEISA.

In FP6 (2002–06), a new two-fold approach for Grid research is being pursued from the outset:

- **technology push**: developing the underlying technologies and tackling generic issues such as integration, open standards and interoperability;
- **application pull:** developing the enabling technologies required for real world applications, such as modelling, simulation, data-mining and collaboration.

The budget for Grids in FP6 is more than double that in FP5, demonstrating the field's strategic importance. There will also be an increased emphasis on developing open standards, using open source and developing and testing Grids over GEANT, the world's most powerful research network which links over 3 000 research institutions across Europe.

NEW GRID RESEARCH PROJECTS IN FP6



Today's FP6 programme (2002–06) has a budget for Grids more than double that of the previous framework programme.

Among the first 12 FP6 IST Grid research projects launched in summer 2004 (see figure on the previous page) are four major projects each receiving an average of EUR 9.3 million in EU funding. These will create a 'critical mass' of expertise and resources from across Europe in essential areas, as described below.

- The **CoreGRID** network of excellence addresses longer term Grid research, creating the foundations for next generation Grids towards 2010 and beyond. The project brings together existing Grid research communities by creating virtual 'centres of excellence'.
- The **NextGRID** integrated project is focusing on the underlying technologies of the Next Generation Grid, aiming to deliver a new Grid architecture by the end of the decade. *Inter alia* work addresses security and business models, taking into account requirements from sectors such as finance and media.
- The **Akogrimo** integrated project is developing mobile Grid architectures and services. Building on Europe's strengths in mobile communications, the project will demonstrate a vision of 'dynamic virtual organisations' in pilot applications in e-health and e-learning.
- The **SIMDAT** integrated project will develop generic Grid technologies for industry in the areas of data integration, collaboration and knowledge discovery. The focus is on the use of Grids to solve complex problems in important sectors such as aerospace, automotive, pharmacology and meteorology.

Seven smaller 'specific targeted research projects' focus on issues such as knowledge extraction, workflows, datamining, collaboration, trust and security.

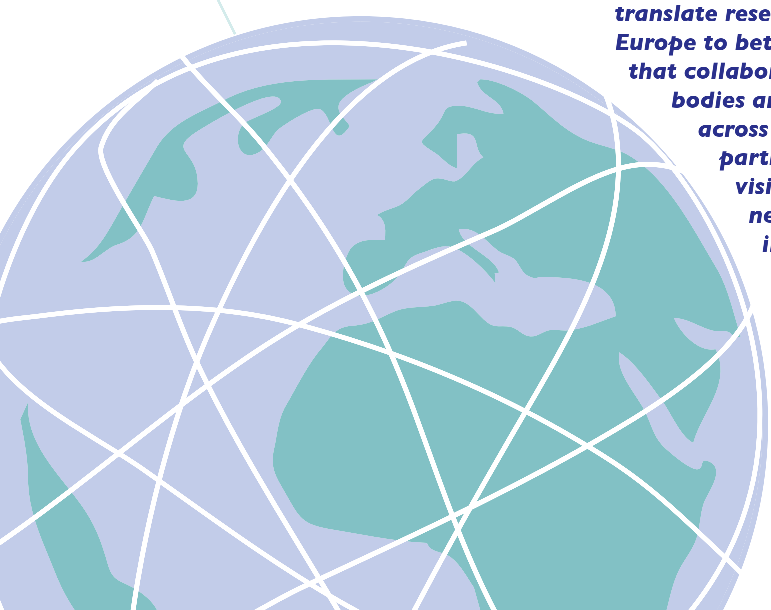
TOWARDS A 'EUROPEAN RESEARCH AREA' FOR GRIDS

Apart from the EU's 'Information society technologies' (IST) programme, several EU Member States fund Grid research at national and regional levels. Coordinating these activities across Europe would help pool Europe's resources, creating a 'critical mass' of expertise which will strengthen European competitiveness in Grid research.

While EU funding for Grid research doubled to around EUR 125 million during FP6 (2002–06), national research funding will reach several hundred million euro during a similar period.

It is imperative that coordination of these programmes takes place to ensure that research teams in different countries pursuing similar goals do not run the risk of 'reinventing the wheel'. Europe needs a 'European Research Area' (ERA) in Grids to ensure it gets the most out of the world-class resources spread across its 25 Member States.

Hence **Gridcoord**, an FP6 project, has been established to support coordination of national Grid programmes and, therefore, to help create a European Research Area in Grids research. ■



CAPITALISING ON EU GRID RESEARCH

Considering the significant and sustained European investment in Grid research, Europe's strengths in this area are well established. Now the time has come to create more effective routes for industrial exploitation in order to successfully translate research results into economic benefits. In order for Europe to better capitalise on its strengths, it is indispensable that collaboration between research organisations, funding bodies and industry at all levels of the value chain and across national borders is reinforced (e.g. public–private partnerships). More integrated, long-term research visions and effective plans for their implementation need to be established, taking into account industrial needs and commercial ambitions. High-level industrial commitment from large companies and SMEs (technology and service providers as well as users) will be essential for reaping benefits from the promising area of Grid research, paving the way towards the provision of Grid and knowledge services as a utility.

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