Contract for:

SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

Annex I - "Description of Work"

Project acronym: **MANMADE**
Project full title: **Diagnosing vulnerability, emergent phenomena, and volatility in man-made networks**
Proposal/Contract no.:043363

Related to other Contract no.: (to be completed by Commission)

Date of preparation of Annex I: 17/11/06

Operative commencement date of contract: (to be completed by Commission)

Table of Contents

Diagnosing vulnerability, emergent phenomena, and volatility in man-made networks.

MANMADE
NEST-2005-Path-COM

1 Project Summary

The scope of the project concerns the mathematical methods required to understand the dynamics of the network of networks that comprise Europe's critical infrastructure; concentrating primarily on energy supply, emergency response systems and subsidiary key infrastructures (such as transport) that are either directly dependent on them, or are critically relied for in times of crises.

Man-made interdependent infrastructures are strategic assets and commodities, whose secure, reliable and affordable supply are essential to Europe's socio-economic development and stability. Europe is undergoing a radical conversion of the operability in many of its critical physical infrastructure systems (electricity, gas, water, sewage and transport). This is being driven by market deregulation and unbundling of the European energy and utilities sectors, promoted by a suite of policies and EU Directives.

In the energy sector, concerns regarding the vulnerabilities associated with the increasing dependency of the EU on imported hydrocarbons (particularly gas for power generation), the infrastructures for transportation, and, in view of major blackout events, the electricity grid systems, are the subject of serious attention by policy makers. Recently, the heightened sensitivities to the threat of terrorist attacks have raised additional major concerns regarding the security of these, so-called, critical infrastructures. However, even though serious, maliciously initiated, disruptions are and have been possible, records would seem to indicate that major regional, or nation-wide, blackouts and service disruptions are often the result of chance events perturbing systems that are highly congested, of low-redundancy, and at the limit of their operational limits.

The threats to these networks include: supply side geo-politics and market instability; malicious acts (terrorism, crime); natural processes and calamities (extreme weather, seismic activity, flooding) and impacts of climate change. Technological factors include ageing infrastructures (particularly outside of the EU), accidents and disasters on land and sea, and increasingly, electricity blackouts resulting from complex grid interconnections.

Such concerns transcend the interests of individual Member States. However, at present, there is lacking a knowledge and understanding of the macroscopic dynamic behaviour of interconnected transport infrastructures. Even though it is well understood how the individual systems that make them up operate, their interdependencies, key vulnerabilities, and the consequences of a major disruption at critical nodes of the infrastructures are still far from being well understood.

In addition to the day-to-day planning, both long-term and emergency planning strategies increasingly require an understanding of the underlying *dynamic* response of such complex systems to external stimuli. By dynamic response we mean the macroscopic changes in the topological and structural stability of the system at a macro-scale that arise in network interconnectivity as a result of a wide range of stimuli. These stimuli may be brought about by natural or man-made causes at both long and short time scales. For example, un-damped frequency oscillations in electricity grids, originate locally and may propagate very quickly over

thousands of kilometres; long-term planning strategies such as road network renewal or the proposals for numerous large offshore wind-farms are currently the subject of much fervent discussion between network utilities owners and users and society at large.

Arguments for and against the reliability and resilience of these complex systems, —as proposed by opposing group interests— are ricocheting through the halls of the corporate and political world. Often, the views are polarized, and the arguments —for and against— rely on postulations which, so far, have not been rigorously analysed using the mathematical methods which could best suit such a complex problem.

In tandem with these techno-economic concerns, certain governmental bodies —working alongside other national authorities— must cooperate closely with network owners so as to ensure minimum services of these networks in times of major disruptions. In order to manage the complexity overall and target the network elements most at risk, this too, requires a macroscopic vision of how these interconnected systems interact.

2 Project Objectives

The aim of this project is to analyse real-world infrastructure systems with a view to aiding day-to-day and emergency planning of critical —primarily energy— European infrastructures. Our strategy will be to apply the mathematical findings that constitute the body of, so-called, complexity theory to real-world networks. In order to do so we shall map specific networks (both physical and service) that make up the main elements of functional interconnected networks. The project partners will engage directly with infrastructure owners and governmental decision-making bodies; thus enabling access to knowledge sets that will form the basis of the project case studies.

In view of these goals, the project will assemble, develop and apply complementary mathematical methods to analyse large, man-made multi-element infrastructure systems that exhibit, so-called, complex behaviour.

The linking themes between these widely differing systems will be the common needs for both qualitative and quantitative prescriptions required to gain insight into the processes that generate complex behaviour. This will assist in the development of civil emergency preparedness strategies as well as in the general long-term planning of energy infrastructure programmes. In order to address such interdisciplinary topics, researchers working in a wide variety of fields will bring insights to problems that, in complex systems terms, have a common qualitative nature; thus enabling a macroscopic overview of the complex behaviour of key infrastructures.

The themes running across the individual subject areas will be vulnerability, volatility and emergent phenomena. In addition to tackling specific real-world problems, the project will provide a generalised view of how specific classes of topology, coupling laws, and interdependencies affect their vulnerabilities (or conversely robustness) to unexpected natural, economic or man-made perturbations.

To gain insight into the key qualitative dynamical features exhibited by such networks, the consortium will identify which types of non-linear phenomena are responsible for generic network behaviour such as:

- instabilities and collapse: both structural (catastrophic failure of network components), functional (electricity grid blackouts, supply chain),
- volatility and memory (spot electricity pricing),
- feedback (influence on congestion in networks)
- inter-network coupling (e.g. vulnerability of interconnected networks to unexpected failures)

Although the project will make ample use of standard mathematical concepts of complex systems theory, new methods based on the spectral representation of the weighted connectivity matrices will be introduced and tested on real-world networks to measure the vulnerability of agglomerate networks systems to widespread propagation of failures. We shall also study the role of feedback and scaling as drivers for emergent phenomena, and correlate volatility (or conversely persistence) from differing parametric time series in coupled systems

2.1 Vulnerability

The error (failure) tolerance of networks has been the subject of much recent study. Vulnerability of critical networks to failures is an aspect that will be studied across the gamut of network types dealt with in our proposal. The capacity of a network to sustain malfunctions and yet still maintain acceptable levels of operability has been linked to the topological metrics of the system. The first step in order to ascertain how a network deals with faults is to monitor the evolution of some of these measures as a function of the nodes eliminated in accordance with some failure scheme. The findings by Barabassi and co-workers have highlighted that although Scale Free networks are highly tolerant to random failures, their ability to deal with selective failure of critical nodes is often weak. For instance, they have shown that for a number of real-world networks whose topology approximates to Scale Free networks, the connectivity of the network breaks down quickly when critical nodes are eliminated; specifically, the diameter of the network and the formation of isolated large clusters grows geometrically compared to random attacks.

So far, network vulnerability has been studied from a topological point of view; i.e. its connectivity. We intend to examine network vulnerability in terms of the functional importance of its nodes and lines; to do this we shall combine both algebraic and topological properties in order to provide weighting functions to the networks topological features. We conjecture that, in order to examine the robustness of a certain classes of networks', it is not enough to know the connectivity of the nodes, but also the range of potential, unplanned, flows running through them.

Another aspect that has so far not been widely studied is the robustness of heterogeneous interconnected networks, by this we mean interconnected networks that are of different classes. For example let us assume that the synchronously connected power grid in Europe is of the scale-free type and that a certain percentage of its nodes (e.g. power generating plants) are gas-fired power stations fed by a gas pipeline network, which in turn is small-world. What would be the robustness of the whole and how does it depend on the percentage of gas-powered stations? This scenario can be compounded further if we consider that, in order to maintain gas pipeline pressure, pumping stations are run on electricity supply with only marginal back-up capacity.

Stochastic dynamical systems defined on graphs: In order to study the vulnerability of networks of networks we intend to model the failure rates of such interconnected systems at the macro-scale, whereby the vulnerability status of a whole network is represented at a node by Markov chains. The individual Markov chains will be designed to model the error tolerance consistent with the size and topology of the network it is representing. Implementing contextual and aggregation concepts from graph theory, and linking these to the macroscopic topological properties of large graphs condensed from the Markov chains will develop this approach. In principle this could provide us with a method to study the robustness of very large, heterogeneous interconnected networks.

2.2 The role of feedback, scaling and emergent behaviour in complex networks

Many network problems are increasingly looked at from the perspective of dynamical systems. The typical problem is modelled as a coupled set of nodal activities. The activity at each node is often described by a dynamical system and introducing coupling terms into the otherwise independent set of nodal equations usually facilitates the connections in the network. Such systems can exhibit complex behaviour when observables of the system are considered. In particular, many such systems tend to show aspects of self criticality.

The generation of dynamical systems in networks would motivate their study in terms of dynamical systems analysis. Ultimately the aim of this part of the project is to explain the generic behaviour of real-world systems in terms of their topological and non-linear properties, and thus arrive one step closer to explaining why simple non-linear laws in networks generate so-called, emergent, phenomena.

Feedback is believed to play a central role in the laws governing complex systems, even if these laws are deceptively simple. In principle, feedback has already been included in the formal prescriptions to describe the manner of growth of small-world and scale free systems. The aim of including feedback in our analysis of networked systems is to simulate the emergence of different dynamical systems for a given network structure, rather than the topological description of their growth. In this sense we are interested in how different types of feedback are responsible for the emergence of standard attractors in the broader, dynamical systems, meaning. For example, given a roadway grid map, a pseudo-variational approach (e.g. seeking paths that minimise distance between given points) will be used to develop a spectral decomposition of all possible paths based on the weighted connectivity matrices of the road network. The weighted connectivity matrix is then updated with feedback from the preceding modal participation factors projected onto the original network topology.

Scaling: Simple non-linear systems can generate a wide variety of dynamic behaviour, however, whereas in single-element systems attracting states 'emerge' from bifurcations resulting from variations in parameter and state space, they are not classified as emergent systems in the complex systems sense. What is meant by emergence, here, is the generation of a given pattern from the application of a non-linear rule to a system comprised of more than one component. So the question is: given a generic interaction law between any two adjacent elements in a multi-element system on a fixed network topology class (e.g. exponential, small-world or scale-free), how does emergent behaviour depend on the size of the network?

2.3 Volatility and persistence in time series of complex systems

We can define two types of networks in connection with the electricity markets. The first is the "physical" one connecting the participants of the electricity market; the other is a "logical" or "commercial" one defining the business relations and financial transactions between the participants or groups of participants. The participants try to optimize their behaviour mostly under the "financial" constraints, but the result has to satisfy the "physical" constraint as well. This raises the following questions: what difficulties can this link cause to the "physical" network management? How stable is the "commercial" network? Which network topologies can live together without any systemic risk? Are the results in accordance with deregulation? Extremely volatile markets —like the energy exchange— demand specially tailored risk measures for the characterization of their dynamics.

We shall consider how the volatility, in the time series of energy market spot prices affects congestion and its links to blackout trends in European synchronously connected grids.

A good example is electricity flowing through the interconnected synchronous grid systems in Europe. Electricity flows obey only Kirchoff's and Ohms laws. Planning flows in a trivial circuit is simple if one knows the supply and demand ratios, but if demand on certain transfer lines is linked to a premium governing the net benefits of the electricity spot market, the planning of exact flows between grid sectors, is, as yet, not feasible. The flows between discrete points on the grid are governed by the simple laws of physics; but the macroscopic behaviour is conditioned by the volatility of the market. Some power lines may be critically overloaded, so that if the system is perturbed, fluctuations of the load along busy corridors may result in cascading failures that can propagate over large areas of the grid. This is a phenomenological hypothesis for blackouts. Time series analysis of spot market and blackout series from real grid systems will be analysed to detect volatility (anti-correlation in tine) and persistence (correlation in time) with the aim of deducing the extent to which market forces affect the statistical distribution of blackouts.

3 Participant List

Participant no.	Participant organisation name	Participant org. short name
1 (coordinator)	Queen Mary University of London	QMUL
2 CR	JRC-IPSC	JRC
3 CR	Collegium Budapest	COLB
4 CR	Macedonian Academy of Sciences and Arts	MASA
5 CR	Universita Carlo Cattaneo, LIUC	LIUC

The MAMMADE consortium is comprised of four academic institutions (Queen Mary College, Collegium Budapest, University Carlo Cattaneo and the Macedonian Academy of Sciences and Arts) one international research institution (Joint Research Centre). In addition to the list of contractors, the consortium will also count on the direct collaboration of the National Emergency Supply Agency from Finland, who will also act as interlocutor with the Nordic Countries' (Scandinavia plus Iceland) electricity and emergency planning organisations. Other important links include the Union for the Co-ordination of Transmission of Electricity (UCTE) who has agreed to provide blackout data sets for the largest interconnected HV grid system in Europe, and the European Wind Energy Association.
A total of three Member States (UK, IT, and HU,) and EU-wide institution are represented. In addition the consortium has a representative from a target country (FYROM) benefiting from specific measures in support of International Co-operation as defined by the Work Programme for Integrating and strengthening the European Research Area.
.

4 Relevance to objectives of NEST

The research to be conducted is of a highly interdisciplinary nature, bringing together groups working in the fields of earthquake and electrical engineering, financial analysis, dynamical systems, graph theory and complex systems analysis.

The project will promote the development of techniques for tackling specific real-world networks by applying complex systems analysis —and related mathematical— theories to man-made networks considered to be part of Europe's critical infrastructure that are essential for conducting everyday life.

The prime motivating principle behind this approach is that, although the owners and managing authorities of such systems are aware of such concepts as interdependence in networks and 'complex' systems, mathematicians have, as yet, not fully bridged the gap, or proved the worth, of complex systems analysis (as a science) to the professionals who run the networks. For this reason the project strategy will conform to the NEST philosophy of applying a practical problem-solving approach grounded, not only on observation of experimental data, but dealing directly with the networks/complex systems involved in the analysis.

Concerning NEST's objective of encouraging transfer of techniques for tackling complexity problems from one area of science to another, we seek to encourage such transfer by assigning specific problems in the systems mentioned above to interdisciplinary teams. The project will bring together researchers alongside technologists from the networked utilities and the social entities responsible for maintaining/monitoring the systems being investigated.

The consortium will attempt to blend the riskier, blue-sky, research-based visions of the scientists with the needs of infrastructure owners and governmental authorities responsible for their management. The latter, will, in-turn, have to consider that although their trusted methods have served their industry well, they will have to engage, and take on board, seemingly alien mathematical concepts that will enable them to understand the evolution of a vast interconnected network over which, increasingly, they have a less tangible control.

5 Potential Impact

Network structures are pervasive throughout natural and engineered systems. Furthermore, complex information networks are vital to the operation of our society. There is no doubt that we are all highly dependent on them. However, as of today a rigorous theoretical framework for analyzing vulnerability, emergent phenomena, volatility, and the dynamical behavior of these systems is still missing and strong efforts are required to achieve this goal. The main difficulty in providing such a theory lays in the fact that the macroscopic behavior of a network is determined by both the highly non-linear dynamical rules governing the nodes, and the flows occurring along their links. It is our belief that the approach that we promote in this project can shed new light on these behaviours. This is essential for improved design, efficient protection, and robustness. Benefits will be visible not only within the engineering community, but will have a broader impact at all levels of society.

The strong theoretical component and the novel approach of the proposed research will lead to a long-term educational effort.
While being driven by application-type questions that arise in different man-made networks, we also want to put some emphasis on the independent intellectual merit of the techniques adopted. As we provide a set of key tools for a theory of networking which will be available in the future, we will need to develop new mathematical ideas of independent intellectual value. For these reasons the project leaders are engaged in international collaborations with scientists of a broad range of disciplines. It is potentially the case that the new mathematical techniques developed will lead to additional applications that we have not directly envisaged. Hence, not only the theory will serve to the application and benefit society in the short time scale, but also the motivating applications we start with can inspire new, strongly generic, mathematical ideas.

The research conducted in the MANMADE project will address specific real-world networks. Ideally we wish to apply our methods to working systems wherever possible. The level of verisimilitude will depend strongly on the level of data and knowledge accesses (other than public domain sources) that the MANMADE partners have to these systems. It is for this reason that the consortium includes network stakeholders. They will endeavor to provide to the consortium access to network infrastructure data whenever such access meets with the stringent security and market confidentiality conditions imposed by the network owners.

Irrespective of the actual networks analysed, the project will provide results for related networks that have similar characteristics. In this sense the MANMADE approach will analyze generic complex interconnected networks. The potential impact to these systems could be summarized below.

5.1 Contribution to standards

5.1.1 As regards electricity infrastructures

The Nordic countries, Finland, Sweden, Norway, and Denmark, were the first ones in the EU/EEA to deregulate their electric networks. Today, exactly these countries have insufficient electricity generation capacity in the EU/EEA. This was not the case when the electricity companies were regulated in the Nordic countries. One way to cure the problem would be to build more capacity. An alternative is to import electricity from neighbouring countries. This alternative has been used, and the imported amounts are growing steadily.
The questions that could be posed as follow-ups to the MANMADE project are:

- Where would it be useful to build new connections to neighbouring countries?
- Where would it be wiser to build new generation capacity?
- What would the effects of the above alternatives be for the stability and vulnerability of the electric grid in the Nordic countries?

The question of operational (including security of supply) standards are routinely handled by ETSO (European Transmission System Operators), however although such studies are carried out with sophisticated analytical models, in general they do not apply a complex systems approach. MANMADE will engage and disseminate its findings to European Transmission systems operators (TSO) such as UCTE (Union for Coordination of Transmission of Electricity) and, NORDEL (Association of electricity co-operation of European Nordic countries) with whom it has established preliminary contact within the context of its dealings with other Commission organisations such as DG TREN. Of particular interest is the need of DG TREN to liaise with operators of Translational European energy networks (TEN-E). A high potential impact is realistic if our work is properly disseminated to these organisations.

5.1.2 As regards the European railway network

A vital logistical and competitiveness problem in the EU is the non-compatibility of the railway systems. To transport goods from Finland to Spain by rail would need several engine changes.
In the EU there are 3 different rail gauges, 10 different electricity systems in the railways, and 7 different axle loads are used.
The follow up to any results from MANMADE regarding heterogeneous interconnected systems could be:

- Which are the points of vulnerability in the European rail system?

- Which changes to the existing situation would give the greatest positive effect to European rail transports?

The solution(s) to this problem would mean adopting standards at a EU-wide level. Given the European context, the obvious vehicle would be to disseminate MANMADE's findings on transport networks to organizations such as DG TREN.

There are also broader question on vulnerability of urban rail transport systems. The current hypotheses linking network vulnerability to its topology when studied at a European level, could provide policy and transport organizations such as the International Association of Public Transport who will coordinate the EU- DG TREN funded COUNTERACT (Consortium of User Networks in Transport and Energy Relating to Anti-Terrorist Activities) of which JRC-IPSC is charged with leading the activities of the energy cluster. MANMADE's results will therefore be disseminated to this activity directly.

5.1.3 Potential applications to other logistical systems

Yet another system is the container identification and follow-up system, which is now based on bar codes and the Internet. In the future, radio readable chips will be used as container identifiers. Within the Institute for the Protection of security of the Citizen at the JRC, the Institutional Action IMIA (JRC Action n°4312), deals with support to intelligence and analysis for the anti-Fraud and security practices. Specifically within the context of monitoring container traffic at a world-wide level, an on-line follow-up container traffic system would benefit from new analytical tools from complex network analysis. Profiting from these institutional links, MANMADE will endeavour to disseminate its finding to the research groups who could apply our developments in this specific area, which in turn, could provide a valuable service to authorities interested in monitoring container traffic flowing into Europe

5.2 Contribution to policy developments

5.2.1 As regards European air traffic control

Eurocontrol, *The European Organization for the safety of air navigation* has as its primary objective the development of a seamless, pan-European Air Traffic Management (ATM) system.
For safety reasons, there is a limit to the number of flight slots between the airports. If there is any unexpected rush situation at a critical air hub in Europe, much of traffic all over Europe will have to wait.
The following questions may find some parallels with the type of networks studied in the MANMADE project:

- which are the points of vulnerability in the European air traffic system?
- which changes to the existing situation would give the greatest positive effect to European air transports?

MANMADE will not study directly the European organization for the air safety navigation; however, as is the case for the electricity transmission system operators, we will endeavour to disseminate our findings on generic network systems to these organizations. Within the Institute for the Protection of security of the Citizen at the JRC, the Institutional Action ISARM-CA (JRC Action n°4312) is specifically addressing Council Directives and Commission documents, such as: the Directive 94/56 on accident investigation, the Communication on Community initiatives concerning civil aviation incidents and accidents (Document SEC (91) 1419 final), the Commission Proposal for a Directive on "Occurrence reporting in Civil Aviation", (Document COM(2000) 847 final 2000/0343), and in the Amended proposal for a Directive of the European

Parliament and of the Council on occurrence reporting in civil aviation, Official Journal of the EC, C 332 E/320, 27/11/2001.

MANMADE's activities in the field of analysis of non-linear time series (e.g. for European blackout sets) have many parallels with the statistical distributions of rates of occurrence of failures in power-law dominated systems. Our analysis methods could prove useful to study the volatility and correlation of accidents and near accidents in civil aviation.

Additionally the methods used to define the topology of networked systems could also be applied directly the airport network connections within Europe and link these to the accident rates reported. These JRC institutional activities offer the MANMADE project a vehicle to communicate its finding to other scientists that may wish to apply complex system network analysis techniques to aviation security problems.

5.2.2 Supply chain systems

MANMADE will count with the participation of NESA, the Finnish National Emergency Supply Agency. Their direct interest in our proposal will ensure that any systems developments or further understanding of the dynamics of supply chains (including energy, trading and transport systems) could be put to use in the emergency planning strategies of said EU Member State. NESA devotes considerable resources for emergency planning, which affects a large and varied number of utilities and services at both national level, and its interaction with neighbouring EU and non-EU states. Their direct insight into the aspects of supply chain will motivate the development of complex systems analysis techniques that are anchored to real-world systems with a direct impact on the lives of EU citizens, both in terms of practical applications and national standards. The direct involvement of NESA in the project opens up the possibility of using our findings in the emergency supply chain policy of an EU member state.

5.3 Risk assessment and related communication strategy

Although, in principle, there is no direct risk to individual or selected groups of citizens, there are some aspects relating to the sensitivity of vulnerability analysis of critical infrastructures that will have to be handled with care. Public dissemination that overtly identifies specific and clearly identified components of critical networks will have to be avoided, least this information be used for malicious purposes. In this sense, the research output should be publicly disseminated in such a way that the value of the methods developed is clearly set out in a generic manner, and that the examples for specific cases are presented in a scrambled or encrypted manner without loosing their intrinsic value as proofs of methods or theories.

6 Project management exploitation/dissemination plans

6.1 Project management

The project management will be centred at Queen Mary, University of London. The management committee will consist of one member from each of the institutions, with the chair taken by the principal member of the Queen Mary group. There will be three plenary meetings in the year 1, two meetings in year 2, and three meetings in the year 3. At least 50% of the project members must be present at the meeting to be a quorum. The Chair will be assisted in her/his role by a secretary who will be elected by simple majority of those present at the meetings. The secretary will prepare minutes from the meetings within two weeks of the date of the meeting, which will then by approved by the Chair before dissemination by the secretary to the members.

The minutes will be formally approved at the next meeting of the management committee. Should a decision on any aspect of the project be required, the decision will be made by a simple majority vote of the members present. In event of a tied vote, the Chair will have an additional vote to cast.

The key role of these meetings will be to assess activity for milestones and review the progress of the project. There will also be a workshop aspect to the meetings with a scientific presentation from each institution. We would extend an invitation to an EU representative to attend.

The management meeting would consider and be responsible for:

- The overall progress of the project against the agreed time scales.
- Action required correcting problems in the execution of the project.
- The overall financial state of the project.
- Dissemination of the results including organising workshops and noting publications put forward by members of the consortium.
- The composition of the Management Committee (discussed below) and for reviewing and implementing its recommendations.

The meetings will be empowered to review the proposed work packages at the beginning of the project and subsequently during the project. The representatives will be expected to assess new developments and situations and respond accordingly. The representative from each member will provide a task list for the project for the team of investigators at their institution in order to allow rapid delegation of responsibilities. The success of the project will depend on meeting the demands of the task list for each of the work programmes.

In addition, the Project Management Committee will meet at the beginning of the project and then twice-yearly to consider the technical progress and structure of the project.

Research assistants will be monitored using the in-house procedures of their own institutions. They will be expected to organize mini-workshops with co-investigators form other institutions taking part. Video- and audio- conferencing will be encouraged for short presentation meetings to help cement liaison and the development of common purpose within the projects and between the work-packages. Web cams will be used for more regular joining up of colleagues.

Given that the MANMADE project, itself, constitutes a network, it is appropriate that the management structure should consider the methods of network analysis as a useful tool for project management. Social networks play a key role in the success of any undertaking. It has been shown that, on a par with the quality and capacity of the network members, the social ties and information flow between the project's members must be built into the project management structure. The bottom line here is not to develop an unrealistic, unrealisable, network on paper, but rather to motivate consortium members to take some time to think about how they fit into the work programme. The project management team will provide a common tool (simple network analysis methods) to visualise the project network and how it can assist them in developing and communicating their scientific output.

The MANMADE project will pool the efforts of two highly interdisciplinary groups: one consisting of technologists and academic researchers, the other of Private Public Partnership (PPP) agencies and companies who coordinate the security of critical infrastructure and networks, and organise and manage transactions in energy markets. We refer to this group as 'network stakeholders'.

Because the project aims to tackle real-world networks and problems, the coordination should be able to bring together the analytical methods of mathematicians with the more pragmatic problem-solving approaches and in depth network knowledge afforded by the network stakeholders. In order to tackle complex problems in real-world networks, mathematicians should first have a proper insight into what the real issues are; this will set the background for the palette of analytical methods most suited to the problem and the available data sets, conversely the associated corporate partners need to understand if not the substance, at least the nature of the mathematical methods that are used to analyse complex network behaviour and the data types needed to do so.

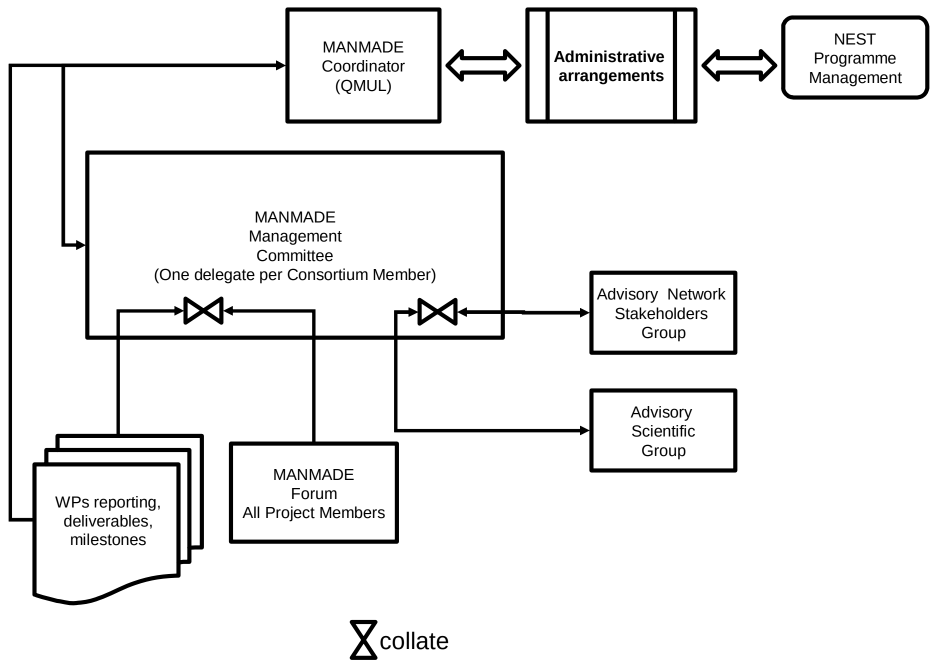

Figure 1 MANMADE management network

On the subject of data, the consortium will endeavour to formulate a secure data sourcing platform whereby sensitive data may be deposited in such a manner that satisfies the network stakeholders that its release into the public domain will not jeopardise security or commercial issues. This aspect is essential to build confidence between analysts and data owners.

The management of MANMADE is made of the clerical and administrative activities that comprise the tasks defined in WP1 and the various groups that compose the management network as shown in Figure 1. A clear distinction should be drawn between the management activities (the actual tasks in WP1) and the management network (the flow of WP1 tasks among the consortium members). The structure of the management network is as follows

6.1.1 The MANMADE Coordinator

The project coordinator is tasked with conducting all clerical and financial duties pertinent to the contractual obligations and administrative arrangements with the Commission, as well as coordinating the overall research and work package tasks. In addition to its own project team, the Coordinator will interact closely with the Management Committee to oversee the running of the project, check timelines for deliverables and milestones, review the evolution of the work-packages, and match the project results against the goals set at the outset. Update and monitor evolution of Pert chart processes. The coordinator will arrange all the plenary and work package meetings and act as secretary for all project meetings ensuring that all relevant information is disseminated to the relevant parties. The coordinator will oversee the scientific dissemination process: organising workshops and seminars when these span the whole breadth of the project and vetting the publications intentions of the contractors so that these may result in opportune disclosure of important results. Special attention will be given to promote the MANMADE project in outreach events to improve the impact of the research findings to a wider audience.

6.1.2 The MANMADE Management Committee

The designated project managers of each consortium contractors, plus the MANMADE Coordinator will make up the Management Committee. Its role is to assist the MANMADE coordinator in the overall running of the project. The major administrative and clerical duties (including the formal contact and distribution of project deliverables to the Commission) will be conducted by staff assigned, primarily, to the Coordinator supported by the administrative personnel of its own institution. However, the Management Committee will act as the single debating body whenever, primary decisions concerning, problem solving or communications with the Commission need to be taken, in the event that these were not comprehensively covered (or outside the scope) of the original contractual arrangements. The main tasks of the Management Committee are:

- Review the Work Package progress reports and deliverables
- Monitor input from MANMADE Forum
- Develop a gender action plan
- Control time-line of deliverables and milestones
- Collate, examine and respond to input from External Stakeholder and Scientific Group.
- Provide External Group with status of project with reference to their specific interest area.
- Identify promising or problematic areas that may imply a change to the work plan.

6.1.3 The MANMADE Forum

The Forum will constitute a major hub of MANMADE'S social-technical network project activity and will play a pivotal role in creating a concerted project effort in order to engage the project resources to best effect. Although face-to-face contacts, meetings and workshops constitute an essential part the information flow in any project, the handicaps induced by the geographic dispersal of the consortium members must be offset by a platform that enables frequent monitoring of the project's activities.

A cohesive project management scheme is not guaranteed by providing boundless communication links and deployment of wall-paper Pert and Gannt chart tables, but rather by ensuring that essential social network links are present and superfluous ones eliminated. Hence, although the MANMADE Forum's network and communication channels will rely on regular face-to-face, electronic communication channels and the project's web-page, it is the social network analysis of the Forum itself that will provide a measure of how the project contractors are interacting. This will allow the Coordinator and the Management Committee to modify the project structure as the network evolves and highlight promising, or problematic network interactions. Analysis reports of the Forum network dynamics will constitute a number of deliverables of WP1.

In order to do so the project web-site will act both as a data-base repository, message board and project chat-line and feedback questionnaire. Forum members will be able to provide input at differing levels of perceived importance to the project. This will allow them to differentiate between flagging important aspects or simply keep tabs on where and what members are doing. Statistics on the number and type of transactions between the contractors will constitute the data set for the analysis.

6.1.4 Advisory Groups

The MAMMADE advisory and evaluation will comprise scientific and network stakeholder groups. The participants to the stakeholder groups can be considered as external advisors their commitment to the MANMADE project will be formalised as associate contractors at zero cost. The meeting attendance costs (travel and allowance) costs incurred by these advisors will be borne by the respective organisations. Scientific evaluators from academia, will, wherever possible be budgeted consortium management committee as part of the outreach and dissemination activities.

Stakeholder Group: Will be composed of two entities, selected from the electricity market and national emergency planning agencies, will participate directly as zero cost partners members. They will report directly to the MANMADE Management Committee. Other potential contacts from the European Wind Energy Association and the European Construction Technology Platform have also been contacted and will be invited to participate in outreach and dissemination stages. Their task is to evaluate how the consortium is addressing the problems that are most pertinent to the managing networks pertinent to their expertise, but not exclusively to their affiliated company or authority; especially on those matters relating to vulnerability and security. They will endeavour to point the project into lines of research that will result in methods that have the potential to be implemented and have an impact in the running of real-world networks. Whereas they will have no direct vote in the managing of the work programme, the Management Committee will ensure that due notice is taken of their points of view, which will be included in the general reporting to the Commission.

External advisory group: The task of this group will consist of three persons two (from the fields of network analysis and physical sciences), and a third, female, scientist with expertise in gender action programmes at national or EU-wide level. Their role is to (a) oversee the technical excellence of the mathematical and technical methods devised and applied during the project duration, (b) monitor the Project Management Committee's efforts with regards to the gender action plan. This group will help to drive the technical excellence and balance of the project by ensuring that the ideas developed are proposed within a peer-reviewed context familiar to the technical/academic project members.

Both groups will be selected on the basis of proven expertise and impartiality and will be expected to adhere to confidentiality clauses where applicable. In order to stimulate vivid exchange of ideas, meetings between the Management Committee and the External Groups will be conducted under Chatham House Rules; thus allowing the members to highlight and report delicate subject matter anonymously.

6.2 Plan for using and disseminating knowledge

The dissemination plan intends to target both academic, R&D and policymaking audiences. Part of the dissemination activities will include specific actions that overlap with its gender action plan described below.

The expertise of the consortium in disseminating knowledge through the standard academic outputs and activities is well established, and it is to be expected that the members of the consortium will raise awareness of their own project through their own institutional outreach activities. However, the consortium intends to target important social groups that do not normally fall within the scope of dissemination activities usually encountered by practicing researchers. This will include Knowledge Transfer and popularization activities in events for local schools and colleges, and policy makers.

In addition to publishing in authoritative journals, an emphasis on publishing some articles as popular science will be part of the initiative, and every project workshop will be expected to develop their work in this way. They will also participate in any EU activities for widening participation in "Complexity Science". A regular audit of communication activities will be made by the management committee.

6.3 Raising public participation and awareness

Within the scope of disseminating basic science to future young researchers, QMUL, in conjunction with the Universities of Leeds, Coventry and Birmingham, is currently involved in a large three-year project awarded by the joint UK Higher Education Grant (HEFCE). The aim of the grant is to develop a UK NATIONAL awareness of taking degrees in the Mathematical Sciences and the outstanding variety of careers that are available to such students. The work will involve building local networks of Schools around the University hubs, but a key part of the deliverables will be national. Similar initiatives are already underway in the UK in Engineering and Physics. We would intend to use the knowledge developed within this grant to project "women in science" to both teachers and students. Our aim will be to develop a joint EU-HEFCE initiative for Women's careers in Science which would feed from the School Initiative (HEFCE) and the Research Initiative (EU).

At the opposite end of the audience range we intend to disseminate our findings to policy and decision makers. It is felt that a key challenge lies in promoting the importance of basic science to a broader (especially a more corporate) audience. In general, organizing such outreach conferences is usually beyond the scope, or budget, of dedicated basic science researchers working within the framework of a collaborative research project. Thus, it is often the case that important results rarely gain, either in form or substance, the attention of policy makers. To this effect, one of the consortium members (JRC) has suggested to a well-established conference-organising company the possibility of organising an event on the theme of complex infrastructure networks.

The research results will be disseminated to academic and industrial beneficiaries by means of:

- Standard academic output in academic, industrial and commercial publications and media; particular attention will be made for the interdisciplinary nature of the output;
- Attendance and presentations at types of EU knowledge transfer activities;
- Attendance at appropriate academic and industrial conferences;
- A sequence of workshops with a target audience from the power industry;
- Public access to project web-site supported;
- Inviting external industry and academic partners to attend strategy committee meetings.
- Policy making bodies at EU and Member State level with a stake in critical infrastructures (e.g. DGs TREN, JFS).

The members of the consortium will raise awareness of their own project but will also actively participate in the activities that will raise the profile of the NEST_PATHFINDER "**Tackling Complexity in Science**" initiative in general.

The contractors will ensure that the project works with and interacts with the other projects supported by this initiative. They will seek to collaborate and cooperate amongst each other, and participate in any "clustering" activities which may be organized in the future, e.g. workshops or joint review meetings.

In addition to the planned activities at project level, the partners of the consortium will contribute to common dissemination activities of the initiative (as e.g. organizing press conferences, inviting journalists to major events, spreading articles to specialised and non-specialised press, organizing events with industrial participation as part of the conferences, seminars or brokerage events, etc…).

The members of the consortium will ensure that appropriate resources from the project are devoted to the efforts outlined above. Decisions on how to spend the money put aside for the specified activities on clustering and dissemination will be made by the consortium in the consultation with the Commission.

7 Work plan for the whole duration of the project

7.1 Introduction

The structure of the MANMADE work plan (other than the management activities already described above) is divided into research-based activities, goal-specific network applications and dissemination activities.

In the first category, the project will concentrate on the riskier, blue-sky, mathematical methods associated with complex networks. In the second we shall try to adapt promising mathematical methods to examples from real-world networks, and, as part of the dissemination activities, we will target, not just on the standard academic readership and audiences, but also social groups not usually associated to basic research projects, specifically pre-university pupils and corporate and policy-making entities.

These three themes are, in general, spread over all the work-packages; however, the more basic research will be clustered around WP3 (Mathematical methods), whereas the fulcrum for the application-specific activities will take their cue from WP2 (Network Collation). The wider scope of dissemination will be handled in WP1 (Management Activities). The remaining, theme-oriented WPs will, to varying degrees, contain all these primary activities.

The overall content of the individual work-packages, tasks, deliverables, and the associated risks of conducting them successfully, are given in more detail in the following sections. The key milestones to monitor the evolution of the project are as follows.

In the area of network implementation, our main milestones are associated with those given in WP2. In essence these will be monitored by our success at contacting and engaging the confidence of potential network stakeholders. This is required in order to provide the various research groups with substantive data sets to motivate the basic research aspects conducted in WP3 and the other theme-oriented WPs (4, 5 and 6). With this view in mind, milestones M1.1 to M1.3 are marked for months 6 to 9 of the project; as we feel that it important to know as early as possible where the project stands with regards to accessing data sets regarding real or verisimilar network. The same milestone dates serve as the basis for WP3, as we feel that the trends for basic research in the mathematical methods to be developed must be conditioned by the availability of data sets (e.g. such as for time series analysis of blackouts and electricity markets in M5.2 at M12). Likewise in view of the importance of the milestones of WP2 for the analysis of interconnected networks in WP6, we have referred back to milestones M1.1 to M1.3 at the head of WP6 milestone M6.1.

As regards the milestones for the theme-oriented WPs (4, 5 and 6), we feel that the major milestones for the research-based activities will take shape within the first two years of the project; specifically, the wind field assessment methodologies (M4.1), development work on supply-chain dynamics (M5.1), and on the methods to calculate vulnerability and interoperability matrices (M6.1).

For the more operationally-oriented output from these WPs, these are expected to come on line after the first two years of the project. The major milestones in this set include M4.3 and M4.4 concerning the risk analysis of extreme weather on different network architectures, and the EU grid interconnection for the HV electricity grid, respectively. Likewise, for the supply-chain analysis in WP5, milestones M5.3 and M5.4 leading to the development of the coupled (blackout/market) model, and the early warning system for extreme events in HV grid systems are foreseen for the latter part of year three.

As regards the dissemination activities, there are no specific milestones regarding generic publicising of the project at conferences or workshops organised within the context of the NEST Complexity in Science Fora; however, there are a number of workshops organised within the context of MANMADE, specifically D1.6 (on careers in science for women on the themes of MANMADE), D.4.2 (on natural and man-made vulnerabilities of EU grid) and D6.2 (on the deregulated European energy market). Whereas the last two can be organised without any major external dependence, D1.6 must count on the collaboration of an inner London School Authority, and for this we have set a milestone M1.3 at M12 which will enable us to plan ahead in cooperation with the selected school board.

7.2 Work Planning and timetable

The Project aims are ambitious; the risks high, but commensurate with the benefits. A unified approach to map formal mathematical methods with key infrastructures such as electricity, gas and dependent networks, and to seek a method to assess their combined resilience to generic perturbations, has as far as we know, not been achieved at a EU level.

The main risk to the project arises from the dispersed nature of the data sets we seek to compile for later analysis: these concerns, essentially WP2.

Although some members of the consortium (JRC) have been in contact with network owners and corporate stakeholders for a number of years, there is a reticence for such organizations to provide network data to outsiders. Public domain data on some of these networks is usually in non-electronic format. This implies that if we do not manage to engage well with a wide variety of network owners we may be faced with the laborious task of compiling network data from standard paper maps. In some cases, such as the EU electricity grid network, the disruption to the timeline of the WPs that feed off WP2 could be considerable. However, considerable progress on WPs dependent on WP2 can still proceed in readiness for the completion of acceptable data sets.

To offset these risks the Project can count on the collaboration of two partners with access to either direct data sources, or corporate network links that will serve the purpose of bridges between the Project and the network owners.

The Gantt chart given in Figure 2 provides the general time line and the most critical dependencies. Although some lag has been built into WP2 and its dependents, it can be said that WP6 (interconnected systems) will bear the highest risk resulting from its dependence on WPs 4 and 5. Although WP3 feeds into WPs 4, 5 and 6 no major dependencies have been shown to these work packages as it is perceived that no major inherent risks are foreseen in its development.

7.2.1 Risk assessment

In terms of human resources the perceived risk is low. All the research partners can count on a wide range of expertise in most of the themes, and are capable of providing substitute personnel in the event of individual researchers leaving the Project.

In view of the role of providing the project with data derived from real-world network systems, the JRC has examined the proposal with its own staff who will be working on this key part of the project. Two of the JRC personnel have a broad experience in systems risk analysis, specifically in the area of developing vulnerability maps for critical infrastructure. Their analysis confirms the high risk involved in developing the approach proposed in this project. It is felt that proposing the research work outlined here would be too risky for a more operational project, but optimal within the context of the NEST programme.

As regards the data sets required, it was concluded that GIS-based (as well as other knowledge sets) data of complex systems —verisimilar or real-world critical-network-based— could be compiled for eventual dissemination to the academic partners. It is often the case that governmental authorities charged with developing scenario analyses for emergencies, often compile large inventories of critical infrastructure for which they have limited resources to develop macroscopic vulnerability analyses, such as that proposed for MANMADE. On the basis of the needs of such authorities to 'add value' to already existing GIS-based information, it was thought that the risk of not gaining access to such data was diminished by the need of said authorities to compile macroscopic, system-oriented analysis of interconnected networks, and hence motivate a closer collaboration with the MANMADE project. The JRC will exploit its already existing contacts with national and regional authorities to such an end.

For all cases, there remains the unavoidable risk of having at hand, incomplete, or inappropriate, data sets that could be usefully implemented using the mathematical analysis methods developed for MANMADE. On the basis of the data classes to which the project members have had access in the past (specifically with regards to the electricity grid system), such risks are not in-substantial. For example the data sets on EU-wide blackouts have only recently been compiled by a central authority (UCTE); this means that the length of some time series are rather short, making their analysis for volatility or emergence analyses prone to errors.

In general terms, one can say that the project members are aware of the major risks, especially of the qualitative nature of said risks, but that they have sufficient breadth of expertise to implement mitigation plans.

MANMADE

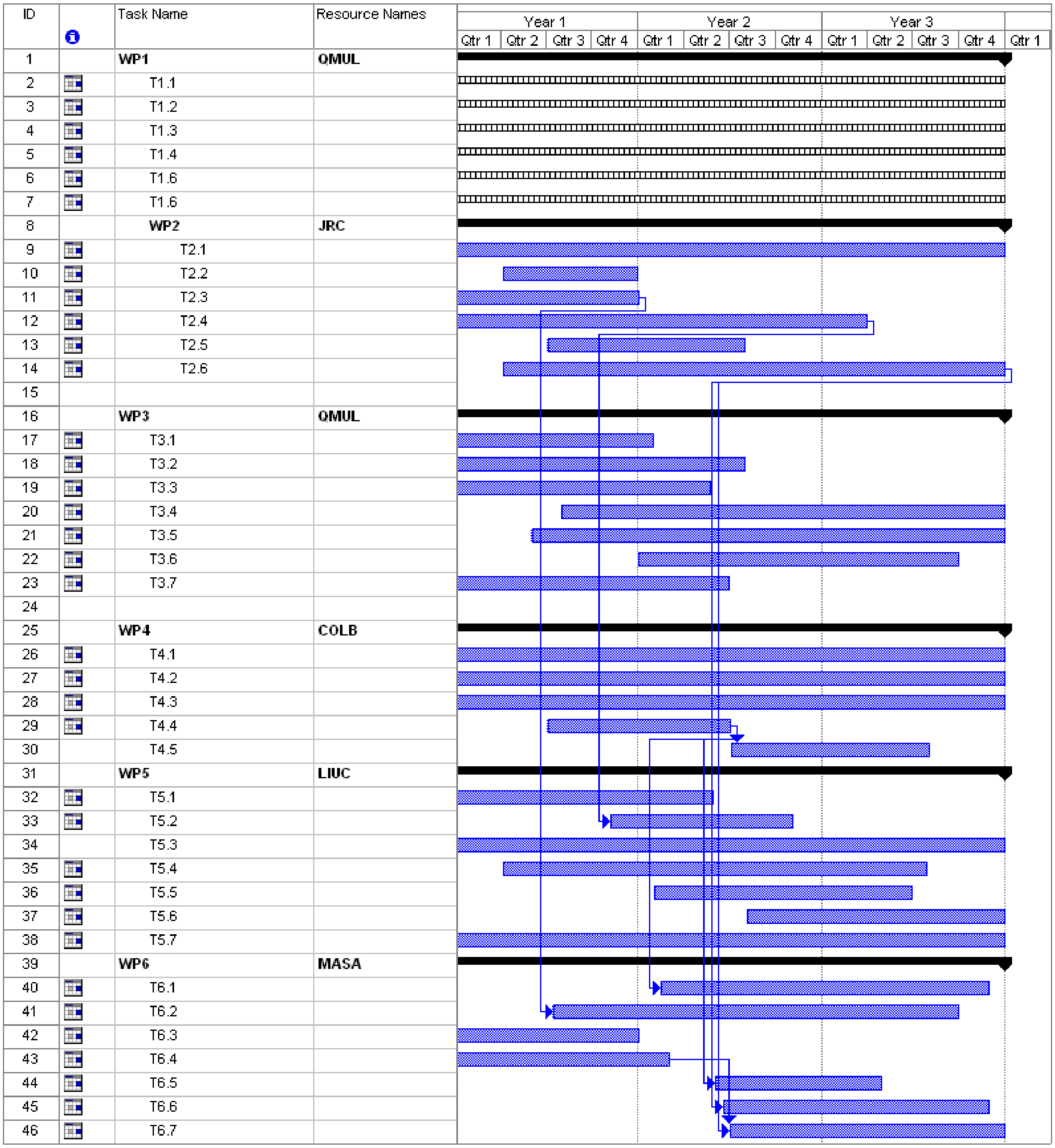

Figure 2 MANMADE Gantt chart

7.3 Graphical representation of Work Packages

The domains of the WPs are shown in Figure 3. The sketch provides a visual guide as to how the WPs overlap in scope; the timelines and critical paths are discussed in the chapters below. Horizontally-oriented WPs (1, 2, 3 and 6) are meant to indicate activities that run across, and generally provide backup, input or are the result of work done in the vertical, thematic, WPs (4 and 5). The project management activities in WP1 intersect and set the background with all the WPs and require the direct involvement of all the WP leaders within the context of the Project Management Committee.

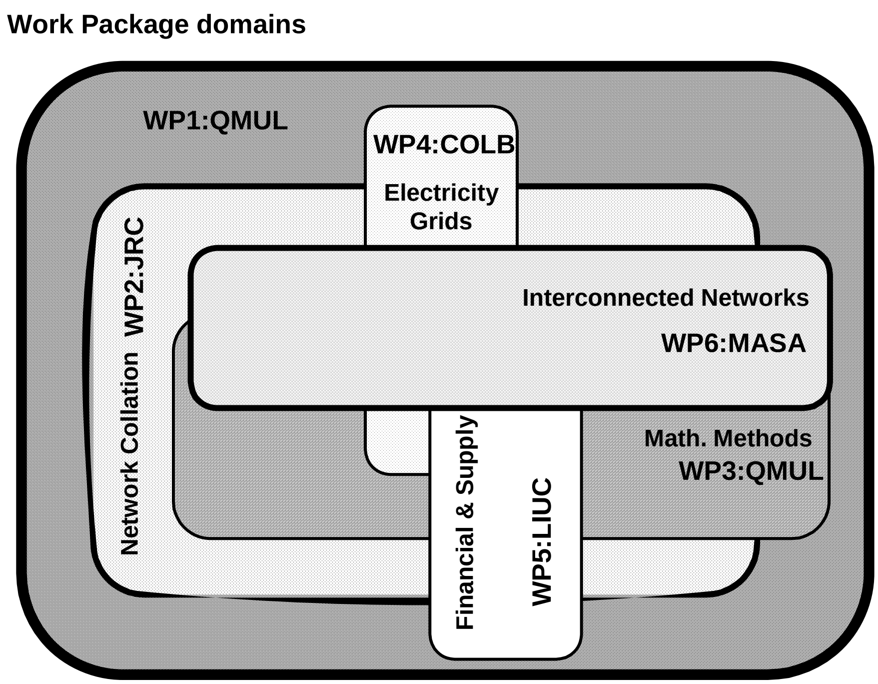

Figure 3 Interaction of Work Package domains

At the next level, the broadest domain of the technical WPs, corresponds to WP2, as it in this package that the data sets needed to feed into the thematic WPs 4 and 5. However, WP2 interacts with WP3 (math methods) as it is the nature of the available data that will drive, to some extent, the mathematical techniques that will be deployed in the thematic WPs. Likewise WP6 requires knowledge of the individual networks in order to build a picture of interconnection aspects.

The topology and vulnerability of supply chain, electricity and financial systems linked to networked systems are developed in WPs 4 and 5. Although their interactions will be studied in WP6, it is clear that the electricity WP4 will interact with WP5 (financial and supply chain).

In order to avoid fragmentation of the WPS into isolated clusters, each of them will involve at least 6 person months —and usually considerably more— from at least two other consortium partners. This evolution of the effort will be monitored both at management level, and, less informally, via the MANMADE forum, which will reflect the actual level of information flow between partners.

7.4 Work package list

Work-package No1	Work package title	Lead contractor No2	Person-months3	Start month4	End month5	Deliverable No6
WP1	Project Management	QMUL	26	1	36	D1.1-D1.6
WP2	Network Collation	JRC	29	1	36	D2.1-D2.4
WP3	Mathematical Methods	QMUL	97	1	36	D3.1-D3.4
WP4	Electricity Networks	COLB	49	1	36	D4.1-D4.3
WP5	Dynamics of supply-chain and market volatility of networks	LIUC	55	1	36	D5.1-D5.5
WP6	Vulnerability of interconnected networks	MASA	59	1	36	D6.1-D6.4
	TOTAL		315			

1 Workpackage number: WP 1 – WP n.
2 Number of the contractor leading the work in this workpackage.
3 The total number of person-months allocated to each workpackage.
4 Relative start date for the work in the specific workpackages, month 0 marking the start of the project, and all other start dates being relative to this start date.
5 Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
6 Deliverable number: Number for the deliverable(s)/result(s) mentioned in the workpackage: D1 - Dn.

The work content of the WPs should, by virtue of their inter-disciplinary nature, motivate collaboration that will often be required in order to meet the deliverables set out. Hence, given the central role played by the development of mathematical methods in WP3, it is expected that it carries, by far, the largest work-load. Moreover, the list of the tasks given for WP3 coincides with the main themes running through the other technical WPs; serving as it does as the repository and workhouse for the tools to be implemented in the thematic WPs described above.

7.5 Deliverable list

Deliverable No1	Deliverable title	Delivery date 2	Nature 3	Dissemination level 4
D1.1.	Report describing consortium groups and responsibilities, specifics of gender action plan.	M1	R	PU
D1.2	MANMADE web-page.	M1	O	PU/RE
D1.3, 1.4,1.5	Network analysis of interactions between consortium members and MANMADE Forum.	M12, M24, M35	R	RE
D 1.6	Workshop targeting careers in science for women, incorporating key themes of MANMADE Project. To be organized with local school authorities (Inner London area)	M35	O	PU
D2.1.	Data sets of major gas lines and exchange flows between and into Western Europe.	M9	O	RE
D2.2	Data sets of spot price electricity traded in selected European electricity markets.	M12	O	RE
D2.3.	Sets of spatial and topological maps of selected urban/transport networks (Italy, or other).	M12	O	RE
D2.4.	Data sets containing the grid connections for the NORDEL /UCTE synchronously connected high-voltage electricity grid system.	M18	O	RE
D3.1	Report on the use of the Hurst coefficient and correlation with power law decay for the project data	M12	R	PU
D3.2	Report on the applicability of growth mechanisms of evolving networks and growth strategies to guarantee desired topological features (e.g. scale free structure, degree correlation etc.).	M18	R	PU
D3.3	Scientific paper on the vulnerability of heterogeneous interconnected networks.	M24	R/O	PU
D3.4	Emergence simulator (neural network) in generic graphs to mimic long-range coupling in networks.	M36	O	PP

D.4.1.	Wind field construction assessment report and maps of potential wind energy production over Europe (M18).	M18	R	PU
D.4.2.	Workshop on natural and man-made vulnerabilities of EU grid.(M35)	M35	O	PU
D.4.3	Topological analysis of selected EU synchronous grid systems and report on risk and fragmentation analysis of EU grid networks (M36).	M36	R	RE
D5.1.	Report on supply-chain logical model by means of the Petri nets formalism	M12	R	PU
D5.2	Report on market dynamics model.	M12	R	PU
D5.3.	Report (paper) on Cross Recurrence Quantification Analysis between markets volatility and the dynamics of power systems dynamic.	M24	R	PU
D5.4.	Report (paper) on coupled market dynamics and power systems chains	M30	R	PU
D5.5.	Report on early warning detection algorithm and suggestions on how to implement it in real systems.	M36	O	RE
D6.1	A method to calculate interoperability matrices	M18	O	PU
D6.2	Workshop on the deregulated European energy market	M24	O	PU
D6.3.	A report on a GIS-based method to assess fragility curves for interconnected systems.	M30	R	C
D6.4	A report on simulation of the dynamics (resilience and fragmentation) resulting from graph erosion of a realistic interconnected system .	M36	R	RE

1 Deliverable numbers in order of delivery dates: D1 – Dn
2 Month in which the deliverables will be available. Month 0 marking the start of the project, and all delivery dates being relative to this start date.
3 Please indicate the nature of the deliverable using one of the following codes:
R = Report
P = Prototype
D = Demonstrator
O = Other
4 Please indicate the dissemination level using one of the following codes:

PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).

7.6 Work package descriptions

7.6.1 WP1 Project management

The rationale for this WP is given in Section 6 above.

Work package number	1	**Start date or starting event:**			**Month 0**
Work package title		Project Management			
Participant ID		QMUL	JRC	COLB	MASA	LIUC
Person-months per participant:		22	1	1	1	1

Objectives:
Ensure a cohesive work effort from the consortium members by establishing continuous monitoring and reporting over all aspects of scientific and administrative project tasks. Motivate cooperation and dialogue between project partners. Motivate the flow of ideas whilst ensuring that these serve to fulfil the overall aims of the project.

-

Description of work
Task 1.1 Establish the formal structure of the project management groups and advisory committees
Task 1.2 Conduct financial transactions.
Task 1.3 Compile and monitor project deliverables and reports.
Task.1.4 Compile and monitor calendar for project meetings.
Task.1.5 Compile dissemination and outreach activities.
Task 1.6 Brokerage on scientific, ethical, gender and administrative matters.
Total PM.26

Deliverables:
D1.1 Report describing consortium groups and responsibilities.(M1)
D1.2 MANMADE web-page (M1)
D1.3-1.5 Network analysis of interactions between consortium members. Identify, brokers, bridges, cohesive groups and weighted information groups based on data sets resulting from MANMADE Forum (M12, M24,M35)
D1.6 Workshop targeting careers in science for women, incorporating key themes of MANMADE Project. To be organized with local school authorities (Inner London area) (M35)

Milestones[1] and expected result:
M1.1 Constitution of Project Management groups as per Section 6 above (M0)
M1.2 Set up of MANMADE web-site with data collation (M3)
M1.3 Selection of a candidate School for implementation of D1.6 (M12)

[1] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

7.6.2 WP2 Network collation

As for any scientific endeavor purporting to tackle real-world problems, specimens are required for analysis. Our project will require certain types of data sets that will allow us to study the phenomena presented above on real-world networks. In order to study the range of issues proposed in this project, we require data sets regarding electricity, urban road networks and electricity stock market data. In the case of stock market data, it will be sufficient, in the first instance, to collect time series of the evolution of markets over time. In the case of urban road networks topological properties of the networks will be sufficient to define the specimen, to a first approximation. In the case of electricity grids both topological and physical (e.g. capacity of high-voltage lines) will be required.

There is a major difference between naturally occurring and man-made networks; whereas in the former the sufficient data sets are, in some sense, public domain, man-made networks, in general are not. By this we are not implying that natural network data is easy to extract, simply that, in principle there are no man-made barriers to do so: extracting network connections for protein-protein interactions may be highly time consuming and expensive. However there are no corporate barriers preventing one from trying to extract such information from experimental samples. Knowledge bases concerning man-made networks are subject to restrictions due to commercial, security reasons, or a combination of both.

New theories in network analysis have tended to be tested on networks that are easily accessible to data mining, and where it is possible to test network analysis concepts in a generic manner. Having validated useful analysis methods, these are subsequently applied to real-world systems.
In the class of networks to be studied in our project some types of data sets can be classed as open source (e.g. urban road networks or time series from electricity stock markets) those pertaining to critical infrastructures such as electricity or oil or gas distribution networks are subject to both commercial and security sensitive considerations.

In order to access the pertinent data sets for important man-made infrastructures, corporate entities directly involved in their functioning and emergency planning of critical networks will liaise with the scientific project partners in order to compile the data.
The data gathering will, in the first instance, be based on data sets that are known to be public domain.

Work package number	2	**Start date or starting event:**				**Month 0**
Work package title		Network Collation				
Participant ID		QMUL	<u>JRC</u>	COLB	MASA	LIUC
Person-months per participant:		6	14	3	4	2

Objectives:

1. To liaise with organizations that own or are responsible for the operation of the networks studied in the proposal.
2. To gather data and maps of critical networks (transport and energy).
3. To develop procedures that will allow the dissemination of certain sensitive network data without compromising security or commercial interest of network owners/operators.

Description of work

Task 2.1 Initiate, expand and maintain continuous contact with organizations responsible for electricity high-voltage, energy and urban networks in order to obtain the most up-to-date

topographical maps of grid systems.
Task 2.2 In the event of the unavailability of grid interconnection tables directly from network utilities generate interconnection tables directly by digitizing maps and parsing the interconnection date as topological connection graphs.
Task 2.3 Compile map of major gas trunk from North Sea and Russia and gross gas flow exchanges into W. Europe and transition countries. Assess for each country net dependence and reserves of gas supplied for electricity generation.
Task 2.4 Liaise with electricity market authorities from Nord Pool electricity markets in order to obtain, directly, time series of spot market prices.
Task 2.5 Generate topologies and graphs of urban transport systems of (Italian urban area)
Task 2.6 Prepare and maintain a data base (wherever applicable also GIS-based) containing assembled data sets in format suitable to be used within the context of WP3 (Math methods) and thematic WPs 4 5 6 (electricity, financial, gas and transport interconnections respectively)

Total PM. 29

Deliverables:
D2.1 Data sets of major gas lines and exchange flows between and into Western Europe (M9)
D2.2 Data sets of spot price electricity traded in selected European electricity markets (M12).
D2.3 Spatial and topological maps of the road network from selected urban areas (Italy, or other) (M12).
D2.4. A data set containing the grid connections for the NORDEL synchronously connected high-voltage electricity grid system (M18).

Milestones[2] and expected result:
M1.1 Selection of two urban networks viable to conversion into topological connection maps (M6).
M1.2. Agreement with the Nordic Countries Emergency Planning Association (NEF) and NESA for data sharing of electricity (+other) networks (M9)
M1.3 Agreement with NORDPOOL for access to time histories of share prices (M9).

7.6.3 WP3 Mathematical methods

A key part of the project is centred on the fact that nearly all modelling of dynamics on networks has been static modelling, i.e. the network has a fixed topology throughout a simulation. This is clearly a gross simplification, and there is a strong need to gain expertise in the modelling of dynamical systems on changing or evolving networks, [1 to 5]. The topology of power networks is continually changing in time as power stations have programmed or unexpected shut-downs and developing models to accommodate these changes and finding measures that detect their stability and viability is badly needed. The current preferred network type for such situations has the *scale-free* property where the expectancy of a node of a given connectivity decreases as a power law of the connectivity, [6], [14], but there is no growth approach to the network dynamics in any of these studies. In [11], a first attempt was made to characterise such intricate interdependence by using capacity generation models to describe the end-to-end performance as the network topology was changed from regular to random.

[2] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Another approach, see [13], which may be useful for modelling evolving networks is the use of variable weights on the channels. An investigation we are considering is one where the weights are used to effect or grow transmission capacity in response to various parametric indicators of a `neural nature'. Neural network algorithms provide a paradigm for growth mechanisms in networks which respond to the output needs, [8] and highly correlated centres of activity.

We have already made a preliminary study on the effects on flow dynamics on the scale-fee networks. In this project we will further develop techniques for analysis of the relations between the dynamics of the network and their topologies, especially for heterogeneous interconnected networks which relates to WP6.

To achieve our objectives we plan to start piecewise linear chaotic maps recently presented in [7] as digital traffic generators and investigate further their statistical properties. The correlation decay or memory in the network traffic is intimately related with congestion and breakdown through unexpected over-demand relative to capacity in networks, [9, 10 and 12]. This aspect of the modelling relates strongly to the statistical data mining which forms part of WP2. The aim would be to construct modelling devices which reflect some of the characteristics of the statistical behaviour found there.

On the basis of the data collated in WP2 we will investigate how existing observables characterise the features of growing networks. This part of the project relates directly to WP4 which is looking at other approaches to network performance. This is an essential stage of the proposed research as we envisage it will allow the development of adaptive mechanisms to improve the overall network performance.

We also plan to use neural network algorithms to provide a paradigm for growth mechanisms in networks which respond to the output needs [8] using Hebb's Law, which allows for strengthening links between highly correlated centres of activity.

The expertise in our team in the field of distributed coupled systems will be used to develop simple models for man-made networks based on phase coupled oscillators, coupled map lattices, or probabilistic cellular automata; specifically, understanding the interplay between the type of local dynamics (regular periodic vs. chaotic) and the topology of the network. This will also allow us to consider the influence of finite, or more importantly restricted, transmission speed on the performance of networks. The feedback modelling ideas of WP6 have direct relevance to some of our modelling techniques.

Currently, at QMUL mathematical tools borrowed from probability theory, stochastic processes and convex analysis are used to study systems of particles that interact strongly with each other. These long-range systems, as they are called, have interesting physical properties that set them apart from short-range systems composed of particles interacting weakly with each other (e.g., the particles of a gas). Among other things, long-range systems give rise to sudden phase transitions which are different in nature from those arising in short-range systems. These differences and their relevance to power supply over networks will be studied

Work package number	3	**Start date or starting event:**				**Month 0**
Work package title		Mathematical Methods				
Participant ID		<u>QMUL</u>	JRC	COLB	MASA	LIUC
Person-months per participant:		20	3	24	36	14

Objectives:

- To develop methods for the analysis of the dynamics of a network on its topology and vice versa.
- To develop methods to study how the vulnerability of the network depends on different topological structures and different dynamical behaviours that the network supports.
- To develop novel dynamic models on evolving networks;
- To investigate the growth mechanisms of evolving networks and study growth strategies to guarantee desired topological features (e.g. scale free structure, degree correlation etc.)

Description of work

Task 3.1 Assessment of statistical analysis of methods of non-linear time series and applicability to selected network phenomena (European grid Black outs)
Task 3.2 Assessment of graph-theoretic methods for a-periodic networks.
Task 3.3 Review and development of network growth laws for irregular networks and comparison to real-world electricity and urban infrastructure networks.
Task 3.4 Risk measures for extremely volatile markets will be developed and their robustness against estimation error analyzed.
Task3.5 Development of vulnerability indicators for heterogeneous interconnected networks
Task 3.6 Analysis of feedback mechanisms in networked systems. Develop phenomenological laws reminiscent of physically-driven networks.
Task 3.7 Study on the effects on flow dynamics on the scale-fee networks.

Total PM.97

Deliverables:
D3.1 Report on the use of the Hurst coefficient and correlation with power law decay for the project data (M12)
D3.2 Report on the applicability of growth mechanisms of evolving networks and growth strategies to guarantee desired topological features (e.g. scale free structure, degree correlation etc.)(M18)
D3.3 Scientific paper on the vulnerability and heterogeneous interconnected networks(M24)
D3.4 Emergence simulator (neural network) in generic graphs to mimic long-range coupling in networks (M36)

Milestones[3] and expected result:
M3.1 Data sets and time-line as per WP2

7.6.4 WP4 Electricity grid Networks

The problem of electricity grid network analysis can be split into two approaches: on the one hand there is the analysis of the physical laws describing the interaction between discrete network elements; on the other we have spatial connectivity between the elements that provides a path through which the flows travel from one node to another. The dynamics of the whole depends on both aspects and each part tells us something about the behaviour, but from very different

[3] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

perspectives. The topological structure of the network provides information on the overall functionality with which it is possible to answer structural questions, which the physical state equations alone cannot.

One such question is the vulnerability of networks to different types of threats. In the case of electricity grids we require information as to which parts of the system are vulnerable to disruptions and whether there is any difference in response of the system to different types of threats. For example, is there a difference in the vulnerability of the electricity grid to concerted attacks as opposed to random failures, and what about environmental threats such as earthquakes or snow storms? How does the system react to each of these? Modelling the whole network, component by component using causal relationships is, at present, not tractable for all loading scenarios.

In this Work Package we will analyse the vulnerability of the European electricity High Voltage (HV) grid by comparing the fragmentation evolutions and changes in network topology when it is subjected to random and selective failure strategies. In addition to the standard methods usually used to measure the size and connectivity of a network, we will apply a modal decomposition method that, we conjecture, is capable of identifying the busiest paths over a wide complex network without explicit reference to the actual flows. The measures of fragmentation resulting from random and selective failures will provide sufficient evidence to suggest whether the EU's synchronous grid sectors are of the *scale free* type. This is important because it is known that such network types are resilient to random failures but are *highly susceptible to strategy-based failures* affecting the most connected nodes, or busy/congested nodes and lines that, although not highly connected may attract parallel flows from all over the network.

We will consider the threats that are most likely to affect such important classes of nodes — noting their geographical distribution—, and investigate if there is any correlation between these and the historical (publicly reported) blackouts and failures in European HV systems. We conjecture that the methods we will apply are capable of differentiating between secondary, low traffic, lines and those that, by virtue of their disposition within the network as a whole, are liable to receive high flows from all over the network. This will allow us to devise a node ranking scheme which is complementary to the more usual one based on the number of lines a node receives.

Whereas the risks to the system associated with malicious attacks, as a whole, is to be seriously regarded, the risk of network fragmentation arising from concatenated natural events, and/or malicious causes, on a congested EU grid system (e.g. as a result of large de-regulated flows and an increased use of trans-national lines for cross border commerce between TSO) poses a continuing and increasing threat to the resilience of the overall system.
A comprehensive risk analysis is outside the scope of this proposal. However, we conjecture a comprehensive scenario analysis of these threats has yet to be quantified at a European level. In this respect much work has yet to be carried out.

A second theme we will explore in this Work Package concerns the challenge of meeting EU's targets in electricity generation from renewable energy sources.

The capacity of European power systems to absorb significant amount of renewable power is determined more by economics and regulatory rules than by technical or practical constraints. For example, it has been suggested that a penetration of 20% of power from wind is feasible without posing any serious technical or practical problems.

Electricity systems – supply and demand – are inherently highly variable, and are influenced by a large number of planned and unplanned factors. Power stations, equipment and transmission lines break down on an irregular basis, or are affected by extremes of weather such as drought, which particularly impacts hydro and nuclear energy. The major issues of electric renewable power integration are related to changed approaches in operation of the power system, connection requirements (and their effect on the grid topology) needed to maintain a stable and reliable supply, extension and modification of the transmission infrastructure.

In this Work Package we will address the following areas related to wind energy grid integration: (i) developing improved forecast methods based on dynamical system theory; (ii) modeling dynamic interaction of wind farms and power system; (iii) transmission network studies on transnational level; (iv) investigation of solutions to increase power system flexibility and security; (v) optimization of trade and market regulation in order to minimize energy distribution vulnerability.

Work package number	4	**Start date or starting event:**				**Month 0**
Work package title		Electricity grid networks				
Participant ID		QMUL	JRC	COLB	MASA	LIUC
Person-months per participant:		6	5	24	9	5

Objectives: Spatial and temporal characterization of the intermittent nature of small scale (especially wind generated) electricity production.

Description of work: **Task 4.1** Based on girded meteorological, construct wind fields covering Europe with a temporal resolution of 6 hours. **Task 4.2** Based on this wind field, estimate wind power generation on different spatial scales. **Task 4.3** Quantify the statistical properties of this highly intermittent power generation dataset. Concentrating on the spatial scale where the amplitude of fluctuations is optimized with respect to the demand of European electrical power line interconnections. **Task 4.4** Topological analysis of EU synchronously connected electricity grids. **Task 4.5** Modal analysis of selected of EU electricity grid sectors. **Task 4.6** Network fragmentation studies of EU grid. *Total PM.49*

Deliverables: **D.4.1**. Wind field construction assessment report and maps of potential wind energy production over Europe (M18) **D.4.2** Workshop on natural and man-made vulnerabilities of EU grid.(M35) **D.4.3**.Topological analysis of selected EU synchronous grid systems and report on risk and fragmentation analysis of EU grid networks (M36).

Milestones[4] and expected result:

M.4.1. Assessment and comparative analysis of wind field construction methodology (M12).
M.4.2. Lower and upper bound estimates of energy production at different meteorological scenarios over Europe (M24).
M.4.3. Analysis of risk related to weather extremes on different network architectures (M24)
M.4.4 Data set of EU grid interconnection available (24).

7.6.5 Dynamics of supply chain and market volatility of networks

The potential benefits of near real time competitive markets to determine production in the electric power industry has long been discussed [1]. Studies of the stability of interconnected power system and market dynamics have some recent tradition as a consequence of black-outs in industrial countries. For example [2], examined the question of stability in such coupled systems through numeric tests using various market update models in the New England transmission network, whereas [3] analyzed the welfare properties of two-settlement systems for electricity in the presence of network uncertainty and market power and find that by the imposition of a delivery requirement on the forward contract the problems associated with zonal aggregation could be alleviated.

In this WP we are interested in studying how the volatility of the energy markets affects the frequencies and length of blackouts. From one side we will develop a model for the grid of power system as a Petri Net. Petri nets are useful tools for modelling supply-chain dynamics [4]. Then we will couple this model with market dynamics in a system with a certain number of power producers and power consumers in a market-driven environment assuming that the price of power reflects the degree of energy imbalance in the system, and then there is a delayed feedback in the power price. We will study the stability of the integrated system as well as the bifurcation points.
Using time series data we plant to adapting typical financial models (GARCH models) to the energy market behavior, and also on the basis of a comparison among a set of different non linear approaches like Markov switching models with changing regimes, Bayesian probability models, neural networks models [5].

In addition, the simulated time series provided by this integrated model will be analyzed using techniques from nonlinear time series analysis such as Recurrence Quantification analysis (RQA) [6], which is based on the quantification of recurrence plots (RP) [7] and which has already been applied to study of non stationary time series as those found in financial time series [8].

Finally, with simulated and real time series the state space reconstruction of the divergence of the system will be analyzed to develop an early warning detection algorithm able to detect in advance the preliminary stages of a black out. This approach has been used with success in the operation of chemical reactors to avoid dangerous states that may lead to an eventual explosion (runaway) [9] as well as to analyze sudden changes in financial time series [10]

[4] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Work package number	5	Start date or starting event:			Month 0
Work package title		Dynamics of supply-chain and market volatility of networks			
Participant ID		QMUL	JRC	COLB	MASA	LIUC
Person-months per participant:		10	2	15	4	24

Objectives:

- To understand and measure how the volatility, in the time series of energy market spot prices affects congestion and its links to frequencies and length of blackouts trends in European synchronously connected grids.
- To develop and implement a prototype for early warning detection of blackouts.

Description of work

Task 5.1. Definition of the supply-chain logical model by means of the Petri nets formalism; development of the corresponding simulation model; identification and evaluation of the risky events concerning the supply chain. Development and implementation of model of market dynamics. Stability and sensitivity analysis. Generation of simulated time series for Task 6.3

Task 5.2. Temporal time series analysis: Simulated and experimental data sets from energy market spot prices and loadings in electricity power transmission systems will be analyzed using Cross Recurrence Quantification Analysis to find possible correlations between both data sets.

Task 5.3. Assessment of blackouts events: non-linear time series analysis of volatility in energy market spot prices will be used to correlate spot prices with blackouts. The analysis would be made both adapting typical financial models (GARCH models) to the energy market behavior, and also on the basis of a comparison among a set of different non linear approaches like Markov switching models with changing regimes, Bayesian probability models, neural networks models.

Task 5.4. Early warning detection of blackouts using time series of loadings in power transmission systems: state-space divergence reconstruction approach will be used to monitor and measure the time series with the objective to set-up a n early warning detection system.

Task 5.5. Development of a simulation model considering the supply chain operational risks previously defined, the blackouts occurrence and the market dynamics.

Task 5.6 The systemic risk aspects of the interaction between the physical network and the commercial network on the electricity market will be analyzed.

Task 5.7 Volatility analysis of the energy option markets and pricing of energy options in Europe.

*Total PM.*55

Deliverables:
D5.1. Report on supply-chain logical model by means of the Petri nets formalism (M12)
D5.2. Report on market dynamics model (M12)
D5.3. Report (paper) on Cross Recurrence Quantification Analysis between markets volatility and the dynamics of power systems dynamic (M24)

D5.4. Report (paper) on coupled market dynamics and power systems chains (M30)
D5.5. Report on early warning detection algorithm and suggestions on how implement it in real systems (M36)

Milestones[5] and expected result:
M5.1. Supply-chain and market dynamics models ready and tested (M12)
M5.2. Time series data provided (M12)
M5.3. Coupled model ready and tested (M30)
M5.4. Early warning detection prototype ready (M36)

7.6.6 WP6 Vulnerability of interconnected Networks

In essence most real-world networks are not closed sets; this motivates the concept of conceiving complex man-made networks as assemblages of coupled sub-networks each of which performs a specific function. However, the ensemble of modern man-made networks serves one function only, and that is of delivering a combination of services without which we would not be able to conduct our everyday lives. Such an all-encompassing supra-network was neither designed —nor is it run— by a single individual or organization: it has evolved to its present sate in a self-organised manner providing essential functions adequately at a world-wide scale.

In this work package we intend to understand how certain network ensembles (electricity, gas transportation and emergency response structures) can cope with disruptions (natural or intentional) to one or more of its sub-networks.

In order to perform this analysis we shall couple the adjacency (weighted) matrices of the individual sub-network topologies and condense the generic vulnerability and fragility properties of sub-networks as Markov Chains.

We shall introduce feedback into the dynamics of potential flows in networked systems in order to mimic the evolution of congestion; especially within the context of urban transport and electricity networks. We shall consider how this mechanism is responsible for concentrating the vulnerability of the whole system by generating flux corridors that may generate cascading failures.

We shall also study how deregulation of certain utilities (especially electricity) has resulted in a self-organized system that operates in conditions near to equilibrium. To do so we shall compare the NORDEL and UCTE markets: in the NORDEL region liberalization of the markets was introduced earlier than in the UCTE area. Some analysts have reported that this has generated a situation in the Nordic countries whereby substantial imports of electricity from surrounding areas has to take effect in order to satisfy the demand on a purely loss and profit basis. This has generated a complex interconnected energy supply network that did not exist before liberalization: this phenomenon is an example of emergence caused by simple rules of demand and supply.

The underlying processes will be developed with the assistance of emergency management agencies from EU Member States.

[5] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

Work package number	6	**Start date or starting event:**				**Month 0**
Work package title		Vulnerability of interconnected networks				
Participant ID		QMUL	JRC	COLB	MASA	LIUC
Person-months per participant:		6	5	3	36	9

Objectives:
1. Develop and test methods to assess the interoperability matrices of interconnected network graphs.
2. Develop individual network fragility curves for selected realistic cases of natural and man-made threats for the Finish National Emergency Supply Agency.
3. Simulate the vulnerability of interdependent networks that possess differing topological structures.

Description of work

Task 6.1 Apply spectral analysis of grid networks and graph erosion to detect the most vulnerable node and line elements of electricity and gas transport networks.
Task 6.2 Compile macroscopic (at national level) of interdependency matrices for electricity and gas networks.
Task 6.3 Theoretical analysis of vulnerability of interconnected grids of differing topologies.
Task 6.4 Analysis of the effect of scaling (number of nodes and lines) on the vulnerability for given grid topology types.
Task 6.5 Verify or otherwise the scale invariance network topology of real European electricity and gas grids.
Task 6.6 Vulnerability scenario analysis on the overall grid topology resulting from connection of large wind energy farms (data to be obtained from European Wind energy Association) onto present grid topology.
Task 6.7 Develop fragility curves for electricity, gas and urban transport networks for man-made and natural threat scenarios. Case studies will be Finish grid system subjected to snow/ice storm. Gas network in E. Europe subjected to seismic and landslide, urban transport network subjected to major industrial or malicious attack.
Total PM.59

Deliverables:
D6.1 A method to calculate interoperability matrices (M18)
D6.2 Workshop on the deregulated European energy market (M21)
D6.3 A report on a GIS-based method to assess fragility curves for interconnected systems (M30)
D6.4. A report on simulation of the dynamics (resilience and fragmentation)
resulting from graph erosion of a realistic interconnected system (M36)

Milestones[6] and expected result:
M6.1 Network data available as per WP2 (up to M9)
M6.2. GIS tool for interconnected systems set up by (M24)
M6.3 Availability of real-case electricity and urban networks of selected urban area (M20)

---

[6] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

8 Project Effort

8.1 STREP Project Effort Form

Project acronym - **MANMADE**

	QMUL	JRC	COLB	MASA	LIUC	TOTAL PARTICIPANTS
Research/Innovation activities						
WP2	6	14	3	4	2	29
WP3	20	3	24	36	14	97
WP4	6	5	24	9	5	49
WP5	10	2	15	4	24	55
WP6	6	5	3	36	9	59
Total research/innovation	**48**	**29**	**69**	**89**	**54**	**289**
Management activities						
Management WP1	22	1	1	1	1	**26**
TOTAL ACTIVITIES	**70**	**30**	**70**	**90**	**55**	**315**

8.2 Overall budget for the project(Forms A3.1 &A3.2)

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	043363	Proposal Acronym	MANMADE

Financial information - whole duration of the project

Participant n	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD or innovation related activities (1)	Demonstration activities (2)	Consortium Management activities (3)	Total (4)=(1)+(2)+(3)	Total receipts
1	QMUL	AC	Eligible costs	*Direct Costs (a)*	272,100.00	.00	49,234.00	321,334.00	.00
				of which subcontracting	.00	.00	.00	.00	
				Indirect costs (b)	54,420.00	.00	9,846.00	64,266.00	
				Total eligible costs (a)+(b)	326,520.00	.00	59,080.00	385,600.00	
			Requested EC contribution		326,520.00	.00	59,080.00	385,600.00	
2	EC-DG JRC	FCF	Eligible costs	*Direct Costs (a)*	211,666.66	.00	8,333.34	220,000.00	.00
				of which subcontracting	.00	.00	.00	.00	
				Indirect costs (b)	42,333.34	.00	1,666.66	44,000.00	
				Total eligible costs (a)+(b)	254,000.00	.00	10,000.00	264,000.00	
			Requested EC contribution		127,000.00	.00	5,000.00	132,000.00	
3	COLB	AC	Eligible costs	*Direct Costs (a)*	192,200.00	.00	2,800.00	195,000.00	.00
				of which subcontracting	.00	.00	.00	.00	
				Indirect costs (b)	38,440.00	.00	560.00	39,000.00	
				Total eligible costs (a)+(b)	230,640.00	.00	3,360.00	234,000.00	
			Requested EC contribution		230,640.00	.00	3,360.00	234,000.00	
4	MASA	FC	Eligible costs	*Direct Costs (a)*	167,000.00	.00	4,500.00	171,500.00	.00
				of which subcontracting	.00	.00	.00	.00	
				Indirect costs (b)	133,600.00	.00	1,200.00	134,800.00	
				Total eligible costs (a)+(b)	300,600.00	.00	5,700.00	306,300.00	
			Requested EC contribution		150,300.00	.00	5,700.00	156,000.00	
5	LIUC	AC	Eligible costs	*Direct Costs (a)*	157,567.00	.00	2,766.00	160,333.00	.00
				of which subcontracting	.00	.00	.00	.00	
				Indirect costs (b)	31,513.40	.00	553.20	32,066.60	
				Total eligible costs (a)+(b)	189,080.40	.00	3,319.20	192,399.60	
			Requested EC contribution		189,080.00	.00	3,319.00	192,399.00	
TOTAL			Eligible costs		**1,300,840.40**	**.00**	**81,459.20**	**1,382,299.60**	**.00**
			Requested EC contribution		**1,023,540.00**	**.00**	**76,459.00**	**1,099,999.00**	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.2

Proposal Number	043363	Proposal Acronym	MANMADE

Estimated breakdown of the EC contribution per reporting period

Reporting Periods	Start month	End month	Estimated Grant to the Budget	
			Total	In which first six months
Reporting Period 1	1	18	550,000.00	.00
Reporting Period 2	19	36	549,999.00	183,333.00
Reporting Period 3	25	36	.00	.00
Reporting Period 4	37	48	.00	.00
Reporting Period 5	49	60	.00	.00
Reporting Period 6	61	72	.00	.00
Reporting Period 7	73	84	.00	.00

8.3 Management level description of resources and budget

The expertise breakdown and fields of involvement are given in section **10.2 B**. The four academic institutions will provide the sufficient expertise in pure and applied mathematics. In addition to the contractual partners additional 'stakeholder' associate partners will participate in the projects advisory committee, and will oversee and guide the project towards ensuring that real-world complex network problems will be tackled. The JRC will act as broker and bridge between academics and 'end users' participating in both academic and the project's outreach activities.

Partner	**Function or specialised field**						
	WP Leader	**Math Methods**	**Data Series Analysis**	**Network Stakeholder**	**Network Analysis**	**Network Knowledge Access**	**Background**
QMUL	●	●			●		**Academic Maths**
JRC	●		●		●	●	**Enegry & Transport System Dynamics**
COLB	●	●			●		**Academic Theoretical Physics**
MASA	●	●			●		**Electrical Engineering**
LIUC	●	●	●				**Academic Financial**

Table 1 Make up of Consortium

QMUL will act as Project Coordinator and oversee the management, dissemination and outreach goals set up by the consortium. QMUL will engage four permanent investigators from the College teaching staff (at various levels of participation). In addition, the grant will allow for as one post-doctoral research staff (full-time). In order to assist in the managerial and clerical duties, a project manager will be appointed (0.5 full-time) to assist the project coordinator, Prof. D.K. Arrowsmith. The External Grants Department will be responsible for the financial processing of the grant.

The Collegium Budapest (COLB) will concentrate primarily on the tasks related to high-voltage electricity networks, participate in the development of mathematical methods and, where appropriate, provide input to the work packages which deal with electricity networks from the risk and financial side, or their interconnections top other networks. The COLB team will be lead by Dr.G. Vattay

The Macedonian Academy of Sciences and Arts (MASA) will be in charge of the research related to interconnected networks and will also participate in the development of mathematical methods. MASA will play a key role in understanding how certain network ensembles (electricity, gas transportation and emergency response structures) can cope with disruptions to one or more of its sub-networks. MASA will engage three permanent investigators from the Department of Electrical Engineering as well as two doctoral students and one postdoctoral research assistant. The MASA team will be lead by Dr. Kocarev.

Although FYROM is not a member state, the Project will benefit greatly from the expertise of this group in both dynamical systems and electrical engineering. MASA has good academic links with some of the partners in the consortium (COLB). Their participation in this project would further help the integration of FYROM into the broader context of EU-funded research. The EU needs to strengthen both links with EU neighbourhood countries at all levels, MASA's participation fits in with these broader aims.

The Universittà Carlo Cattaneo (LIUC) will concentrate primarily on the analysis of volatility and dynamics of supply networks. They will also contribute to the work package dealing with mathematical methods. Their main area of expertise is in financial analysis and decision support simulation methods. The LIUC team will be lead by Dr. F. Strozzi

The Joint Research Centre (JRC) will be in charge of liaising with network stakeholders and mining the knowledge data sets applicable to complex network infrastructure. The JRC will provide a GIS-data repository onto which network analysis data can be mapped in a format that will enable outreach of MANMADE's results to organisations who have a stake in geographically dispersed networked systems. The JRC will play a key role in disseminating MANMADE's output to policy or regulatory bodies: an important process if MANMADE is to fulfil its mission of tackling real-world network problems and ensuring that MAMMADE's impact is not solely academic. In order to fulfil this role the JRC will also play a major part in thematic and basic research work packages dealing with 'complexity science' and will act as a broker between academic partners and end users. The JRC will dedicate (at various levels of participation) four permanent research staff (one of which will deal with GIS and data collation), one permanent technical assistant and one post-doctoral research assistant. JRC's administrative and clerical duties will be supported by its own Management Support Unit. The JRC team will be lead by E. Gutièrrez.

A more extensive description of the research partners their institutions and how their context background for the Project is given below in Section 10: Consortium Description.

<u>Associate stakeholder companies</u>
The group of 'stakeholder' agencies and associations will participate as nil cost project partners. Although will not dedicate any resources to management or research activities they will play a fundamental role in guiding the consortium to those problems that are most important to the operational aspects of their core business. Their commitment to the project will be an integral part of the outreach and dissemination process, and will motivate the other project members to tackle real-world problems in networked infrastructures. The individual agencies, although under no obligation to do so, will be encouraged to attend plenary meetings and liaise with the Project Management Committee. They will be encouraged to follow the project at all levels, including the evolution of the individual Work Packages. As they will not perceive any funds from the Commission their attendance and participation will be on an *ad hoc* basis; however the project coordinator will ensure that their input and participation is dully noted and their views reported in any documents between the Commission and the Project Consortium.

The <u>National Emergency Supply Agency of Finland</u> (**NESA**) is a fund working under the auspices of the Ministry of Trade and Industry. Its task is to plan and finance the maintenance and development of Finland's security of supply. The objective is to safeguard economic activities necessary to the population's livelihood, the national economy, and national defence during emergency situations and serious disturbances to normal life.

Security of supply shall be safeguarded in the following sectors:

- energy supply
- ICT, financial services, and mass communication
- transport, warehousing, and distribution systems
- food supply
- social welfare and health care
- production for national defence purposes and system maintenance.

NESA's core activity is safeguarding the functioning of technical systems. An important task is to act as secretariat for a national Public Private Partnership organisation, the National Board of Economic Defence. This gives NESA excellent contacts with all major businesses in Finland. Besides practical measures meant to secure supply, NESA also finances research in this area.
In this project, the NESA team consists of two experts in the electricity and energy sector and two experts in the transport logistics sector as well as of the contact person, Mr. H. Sivonen who is a mathematician and systems expert

9 Ethical Issues

The project will not involve any research on humans or animals. Ethical issues within the context of transparent dealings between MANMADE's project partners will be dealt with by the Project Management Committee.
Although not strictly of ethical nature, the sensitivity (commercial or security related) of some data sets compiled during the Project's lifetime will have to be handled with reserve. Some publications may therefore be restricted to consortium members and EU Commission services only, with special provisions on confidentiality. These will be dealt with on an ad hoc basis by the Project Management Committee.

Table A.

Does your proposed research raise sensitive ethical questions related to:	**YES**	**NO**
Human beings		X
Human biological samples		X
Personal data (whether identified by name or not)		X
Genetic information		X
Animals		X

Table B

	YES	**NO**
Confirmation : the proposed research involves none of the issues listed in Table A	X	

10 Other Issues

10.1 Gender action plan

The specific policies regarding gender balance, and, more specifically, women in science, vary considerably between the participant's organisations and their originary member states. The most appropriate solution, given the European-wide involvement of this project, is to adopt the principles given by the document '*Gender action plans: A compendium of good practices*' published by the European Commission DG RTD Directorate C Science and Society. We shall take our queue on the basis of recommendations as given in the section 'Good practices in designing a Gender Action Plan'. The broad lines are as follows:

1. Within the context of academic institutions: inform female undergraduate and research students of the Project's research activities and actively request them to participate in both scientific and management activities.
2. Steer project workshops and seminars with the aim of maximising the population of female scientists from the consortium.
3. Collecting gender statistics on the workforce employed by the Consortium and monitor the progress made in terms of gender balance. Within the context of the MANMADE Forum, data compilation on gender balance (or lack of it) will be highlighted.
4. Establishing a Gender Awareness Group or equivalent structure to encourage networking and mentoring amongst women researchers.
5. Organising outreach activities to future women scientists: the consortium will contact local educational authorities and draw up an action plan geared to motivate female high-school students into international research programmes.
6. Special provisions for female researchers with young children. In particular, the Project partners will endeavour to:
    - Provide (or subsidise the costs) of daytime childe care services.
    - Encourage flexible working hours to allow female researchers to attend to young children when circumstances require.
    - Ensure tenure of post during pregnancy or maternity leave.
    - Encourage maternity leave planning by WP and Task leaders by making provisions to cover female researchers' posts during their absence.

To oversee the agenda we intend to seek advice to the Project Management Committee from Dr. D. Al-Khudhairy. She has been involved in a number of initiatives relating to promoting gender balance in EU and other international scientific research projects, and was the Chair of the JRC Women in Science Network. She is currently the Unit Head of the External Security Unit of the JRC-IPSC.

10.2 Policy

A number of EC-related poly issues have been discussed in Section 5: Potential Impact .

A. References relevant to research-driven Work Packages

WP3

1. R. Albert, A-L. Barabasi, Statistical Mechanics of Complex Networks, *Rev. Mod. Phys.*, **74**, 2002, p47.
2. P. Holme, Edge overload breakdown in evolving networks, *arXiv: cond- mat/ 0207466 v1* **18**, 2002.
3. P. Holme, B.J. Kim, Vertex overload breakdown in evolving networks, *preprint*, Department of Theoretical Physics, Umeå University, 901 87 Umea, Sweden 2.
4. J-W. Kim, B. Hunt, E. Ott, Evolving networks with multispecies nodes and spread in the number of initial links, *Physical Reviews E*, **66**, 046115, 2002.
5. S.N. Dorogovtsev, J.F.F. Mendes, Evolution of networks with ageing of sites.*Phys. Rev. E* **62**,2000, 1842, *Europhys. Lett.*, **52** (33), 2000.
6. H. Fuks, A.T. Lawniczak, Performance of data networks with random links, *Math and Computers in Simulation*, **51** 1999, 101-17.
7. A. Giovanardi, G. Mazzini, R. Rovatti, G. Setti, Features of chaotic maps with self-similar trajectories, *Proceedings NOLTA'98*, Crans-Montana, Switzerland, 1998, 203-206.
8. S.Haykin, *Neural Networks: A Comprehensive Foundation*, Prentice Hall, 1998.
9. W.E. Leland, M.S. Taqqu, W. Willinger, D.V. Wilson, On the Self-Similar Nature of Ethernet Traffic. *Proc. ACM SIGCOMM* 93, 1993.
10. R.V. Sole, S. Valverde, Information transfer and phase transitions in a model of internet traffic, *Physica A*, **289**, 2001, 595-605.
11. D.K. Arrowsmith, M.di Bernardo, F. Sorrentino, Effects of variations of load distribution on network performance, *Proc. IEEE Conf. Systems and Circuits*, Kobe, May, 2005.
12. D.K. Arrowsmith, R.J. Mondragon, M. Woolf, Data Traffic, Topology and Networks, *Complex Dynamics in Communication Networks (eds Vattay and Kocarev), Springer Verlag, 2006*.
13. S.H. Yook, H. Jeong, A-L. Barab\'asi, Y. Tu, Weighted Evolving Networks, *Physical Review Letters*, **86** (25), 2001, 5835.
14. S. Zhou, R.J. Mondragon, `Towards modelling the Internet topology: the Interactive Growth model,' *Proceedings of the 18th International Teletraffic Congress, Berlin, Germany, 2003 (Elsevier Science, Amsterdam, 2003)*}(cs.NI/0308029), 121.

WP4

15. P. Bak, C. Tang, K. Wisenfeld, Self-organised criticality, Phys. Rev. A, 1988, 38 , 364-374.
16. G. Boffeta et al., Power laws in solar flares: self-organised criticality or turbulance?, Phys. Rev. Letters, vol. 83, 22, 1999, 4662-4665.
17. M. J. Cannon et al., Evaluating scaled windowed variance methods for estimating the Hurst coefficient of time series, Physica A: Statistical and theoretical physics, vol.241, 1997, 606-626.
18. B. A. Carreras. D. E. Newman, I. Dobson, I. B. Poole, Evidence for self-organized criticality in a time-series of electric power system blackouts, to appear in IEEE Transactions on Systems and Circuits Part 1.

19. P. Devynck, G. Wang, G. Antar, G. Bonhomme, The Husrt esponent and long-time-correlation, 27th EPS Conf. On Cotr. Fusion Plasma Phys. Budapest, ECA Vol. 24B ,2000, 632-635.
20. Energy Infrastructure and security of supply, COM(2003)743 final, European Commission, Brussels, 2003.
21. Concerning common rules for the internal market in electricity, Directive 2003/54/EC, European Commission, Brussels, 2003.
22. P. Hähner and Y. Drossinos, Scale invariance and intermittency in a creep-slip model of earthquakes, Phys. Rev. E, vol 59, 6, 1999, 6231-6233.
23. H. E. Hurst, Long-term storage capacity of reservoirs, Trans. Am. Soc.Civil Eng., vol. 116, 770, 1951.
24. Union for the Co-ordination of Transmission of Electricity, http://www.ucte.org/
25. I.Simonsen, Measuring anti-correlations in the Nordic electricity spot market by wavelets, Physica A: Statistical Mechanics and its applications, vol. 322, 2003, 597-606.

WP5

1. Hung-Po Chao and Stephen Peck, 1996."A market Mechanism for Electric Power Transmission", Journal of Regulatory Economics, 10, 10-25,
2. F.L. Alvarado, J. Meng, C.L. DeMarco, 2001, Stability analysis of interconnected power systems coupled with market dynamics, IEEE Trans. on Power Systems, 16, no. 4, pp. 605-701.
3. Ranish Kamat and Shmuel S. Oren, 2002.Two settlement systems for electricity markets: zonal aggregation under network uncertainty and market power. POWER program of the University of California,. http://www.ucei.berkeley.edu/PDF/pwp091.pdf
4. Rossi T., Noé C., Dallari F., 2005. A formal method for analyzing and assessing operational risk in supply chains, 23rd International Conference of the System Dynamics Society, Boston (MA).
5. Amisano G., Serati M. (1999) "Forecasting Cointegrated Series with BVAR models", Journal of Forecasting, 18, 7, 463-476.
6. Zbilut, JP, Webber, CL, Jr.,1992. Embeddings and delays as derived from quantification of recurrence plots. Phys. Lett . A 171: 199-203
7. P. Eckmann, SO Kamphorst, and D. Ruelle.,1987. Recurrence plots of dynamical systems.J. of Europhysics Letters, 4:973—977.
8. Strozzi, F., Zaldivar, J. M. and Zbilut, J. P., 2002. Application of nonlinear time series analysis techniques to high-frequency currency exchange data. Physica A 312, 520-538.
9. Zaldívar, J.M., Strozzi, F. and Bosch, J., 2005.The divergence as a goal function for control and on-line optimization. AIChE Journal 51(2), 678-681
10. Strozzi, F. and Zaldívar, J. M., 2006. Non-linear trading strategy for financial time series. Chaos, Solitons and Fractals, vol 28, 601-615.

WP6

1. L. Dueñas, J. Craig, B. Goodno, 2004, Rapid regional response simulation of three-dimensional prototype structures for fragility characterization, 13th World Cof. In Earthquake Engineering, Vancouver, Canada, paper 1499.
2. Y. Haines and P. Jiang, 2001, Leontief-Based Model of Risk in Complex Interconnected Infrastructures, ASCE Journal of Infrastructures, Vol. 7, No1, 1-12
3. S.M. Rinaldi, J.P. Peerenboom and T.K. Kelly, 2001, Critical infrastructure interdependencies, IEEE Control Systems Magazine, December, Vol. 21, issue 6, 11-25
4. R. Kinney, P. Crucitti, R. Albert, and V. Latora Modeling Cascading Failures in the North American Power Grid Eur. Phys. J. B 46 , 101-107 (2005)

5. R. Albert, I. Albert, and G. L. Nakarado Structural Vulnerability of the North American Power Grid Phys. Rev. E 69, 025103(R) (2004)
6. H. P. Thadakamalla, U. N. Raghavan, S. Kumara, and R. Albert Survivability of Multiagent-Based Supply Networks: A Topological Perspective IEEE Intelligent Systems, Volume 19, issue 5, pp 24-31 (2004)

B. Consortium Description

QMUL

School of Mathematical Sciences, Queen Mary, University of London

The Queen Mary School of Mathematical Sciences has some 50 permanent academic staff with a very strong research group in Dynamical Systems consisting of 8 staff. There is a strong research culture of weekly seminars, and workshop activity, in all the major areas of interest within the School. There is also an interdisciplinary Networks Group in the Department of Electronics with which we have strong links and which has collaborated on three major joint EPSRC research assistant grants since 1996.

The main members of the group are as follows.

David Arrowsmith is a Professor and also Head of the School of Mathematical Sciences at Queen Mary. He has wide experience of dynamical systems having published authoritative texts on the area, as well as many papers. He also has current research interests in walker configurations on lattice graphs and the associated percolation problems. He has had an extensive collaboration including two EPSRC awards with Professor J.M. Pitts and Dr R.J. Mondragón of the Electronic Engineering group on packet traffic modelling. He has spoken regularly at international conferences over the last few years on modelling of networks. He is scheduled to be a member of the International Organizing Committee for an IMA conference in 2006 on the Mathematics of Networks and is currently supported by EPSRC for a research assistantship. He has successfully supervised all of his 6 PhD students. A former and current student have been part-supported by British Telecom grants. The current BT sponsored student is researching the behaviour of ad-hoc networks using percolation theory.

Wolfram Just is a reader in the School of Mathematical Sciences. His research covers topics from theoretical physics and applied mathematics with a special focus on nonlinear dynamics and statistical physics far from equilibrium . Results have been published in about 60 publications in international journals (6 contributions to Phys. Rev. Lett., others in Phys. Rev. E, Physica D, J. Stat. Phys. and others) and two textbooks. Some of the articles have been cited more than 100 times.
My two major research branches are concerned with fundamental aspects as well as applications in solid state physics. From the point of view of fundamental research investigations of space-time chaos, nonlinear stochastic systems, and various techniques for the derivation of effective equations of motion are at the centre of my interest. Concerning applications the focus is on time-delay dynamics and in particular control problems. Both parts of this research strategy benefit from intense collaboration with several research groups, experimental as well as theoretical, on the continent.

Raul J. Mondragon was the catalyst for the interdisciplinary collaboration at Queen Mary between the Dynamical Systems Group (Maths Research Centre) and the Communications Research Group (Department of Electronic Engineering), and has been involved in all of its funded projects. In the last three years he has been working in the characterisation, modelling and visualisation of large networks. He joined the QM Electronic Engineering academic staff as a Lecturer in 2000. In 1997 he worked full time in the ARMAN project (GR/K44152), from 1998 until March 2000 in the project Chaotic Control for Fast Resource Management of ATM Networks (EPSRC grant GR/L78659) and he is the principal investigator of the project Small-world Modelling of Internet Behaviour (EPSRC grant GR/R30136).

Hugo Touchette is a recently appointed lecturer in Applied Mathematics and an Interdisciplinary Academic Fellow at Queen Mary, University of London. His research centers on applying mathematical ideas and methods, old and new, for studying problems of statistical physics – basically, random systems composed of many particles.

Prof. Jonathan Pitts leads the Network and Service Assurance Laboratory at Queen Mary. His doctoral research pioneered the concept of rate-based simulation for ATM networks, quantifying the nature of the speed-up, and the accuracy limitations of the modeling approach. He co-authored, with John Schormans, the definitive student text on IP/ATM performance modelling (Wiley 1996, 2000: ISBN 0-471-49187-X), and in 1998 was seconded to Cable & Wireless Comms., and supported by the Royal Academy of Engineering's Industrial Secondment Scheme. He joined the Queen Mary academic staff in 1994 and is currently Professor of Communication Engineering (since 2001).

Relevant publications:

1. M. Barenco and D.K. Arrowsmith, The autocorrelation of double intermittency maps and the simulation of computer packet traffic , *Dynamical Systems*, **19**(1) 2004, 61-74.
2. D.K. Arrowsmith, M. di Bernardo and F. Sorrentino, Effects of variations of load distribution on network performance, *Circuits and Systems, 2005. ISCAS 2005. IEEE International Symposium* on 2005, 3773 - 3776.
3. D.K. Arrowsmith, R.J. Mondragon and M. Woolf, Data Traffic, Topology and Congestion, in: *Complex Dynamics in Communication Networks (Eds L. Kocarev and G. Vattay),* 127-158 (Springer) 2005.
4. H.G. Schuster and W. Just, *Deterministic Chaos*, (Wiley-VCH, 2005).
5. W. Just and F. Schmüser, On phase transitions in coupled map lattices, in Dynamics of Coupled Map Lattices and of Related Spatially Extended Systems, Eds. J.-R. Chazottes and B. Fernandez, *Lecture Notes in Physics* **671** (Springer, 2005), 33-64.
6. S. Zhou and R.J. Mondragón, Topological Discrepancies Among Internet Measurements Using Different Sampling Methodologies, *Lecture Notes in Computer Science, Springer-Verlag, 2005 http://www.springerlink.com/index/GNAUNEE1H5RFJB5M*.
7. S. Zhou and R. J. Mondragón, Redundancy and robustness of the AS-level Internet topology and its models, IEE Electronic Letters, **40**, No 2, 151-152, 2004.
8. H. Touchette, C. Beck, Asymptotics of superstatistics, *Phys. Rev. E* **71**, 016131, 2005.
9. H. Touchette, R.S. Ellis, Nonequivalent ensembles and metastability, *in Complexity, Metastability and Nonextensivity*, C. Beck, G. Benedek, A. Rapisarda, C. Tsallis (eds), World Scientific, 2005.

MANMADE

JRC-IPSC

The JRC Joint Research Centre (JRC) is a European scientific and technical research Centre established by the European Commission, which comprises several sites and Institutes. Within the Institute for the Protection and Security of the Citizen a number of Units are currently dealing with vulnerability of transport and energy networks. The scientific approaches range from statistical to structural analysis with a strong emphasis on the operational knowledge of such systems.

The European Laboratory for Structural Assessment (ELSA) is an analysis and experimental facility of the Joint Research Centre of the European Commission. Its mission is to provide research and contribute to European Standards for risk mitigation in construction, transport, and industrial installations. An emerging area of research activity in the Unit has been the development of numerical methods to study the behaviour of non-linear systems within an interdisciplinary context especially in the field of seismic vulnerability of transport infrastructures.

Within the context of FP5 and FP6, ELSA has been participating in more than 20 research projects together with other European research teams and industries. Their aims are to contribute to the set-up and validation of design codes and norms for the open common market, to promote high-level scientific and technical developments and to increase the competitiveness of the European industry through the assessment of new innovative techniques for construction and transport.

The role of the JRC, in addition to networks data collation and analysis in the various research work packages, is to develop the interface between researchers and network users.

Eugenio Gutiérrez: - is a Mechanical Engineer with post-graduate studies in Applied Mechanics and Dynamical Systems Theory. He is currently involved in applying dynamical systems theory to generic non-linear problems in structural engineering and networked infrastructures. He has worked in number of interdisciplinary projects related to complex systems, such as multivariate GIS-based analysis of earthquake mortality, the analysis and control of discontinuous mechanical systems and, more recently, the application of non-liner time series analysis to electricity grid blackouts and network vulnerability indicators.

He has extensive experience in EU funded projects and contractual research work which has motivated his interest in applying an interdisciplinary approach to solving real-world technical problems grounded in analytical dynamical systems methods. His research approach to complex systems analysis is to synthesise the qualitative phenomena that generate complex behaviour in networked systems and transform these into simple but tractable mathematical problems. His role in the project will be to act as a bridge between the scientific specialists and the network stakeholders.

Relevant publications:

1. E. Gutiérrez, F. Taucer, T. De Groeve, D. Al-Khudhairy, J.M. Zaldivar ‘Analysis of Worldwide earthquake mortality using multivariate demographic and seismic data’, American Journal of Epidemiology, Vol. 161, No12, 1151-1158, 2005.
2. E, Gutiérrez, D. K. Arrowsmith, ‘The equivalence between feedback and dissipation in impact oscillators’ International Journal of Bifurcations and Chaos, (accepted for publication).
3. E. Gutiérrez, P. Caperan. S. Morris ‘A case study in vulnerability analysis of high-voltage electricity transmission systems from a sector of the European grid. JRC Technical Report I.05.59 (Restricted circulation), 2005
4. E. Gutiérrez ‘Time series analysis of European Blackouts’ EUR report 21570 EN, 2005.

MANMADE

Carmelo Di Mauro: is an environmental engineer with twelve years international experience in risk analysis and system modelling, with practical knowledge of decision-making supporting techniques (e.g. multi-criteria analysis, geographical information system, environmental modelling).
In the last two years at JRC, his research activities have been steered substantially towards vulnerability assessment of complex critical systems. This move was made as a response to strong interest in this field expressed by the Commission with its Communication on "Critical Infrastructure Protection in the Fight against Terrorism" and the forthcoming European Programme on Critical Infrastructure Protection (EPCIP).
To this end, he further developed the concept of vulnerability and resilience to support the activities of Civil Protection Authorities in managing natural and technological risks at local, regional and national levels. In particular, I lead two competitive projects that aim at the development of vulnerability and multi-risk maps with contribution of the most relevant stakeholders, for the Civil Protection Authorities of Piemonte Region and Varese Province, respectively. Validation of methods and maps had been the subject of a workshop held on April 11, 2006, with participation of more than fifty institutional stakeholders.

Relevant Publications

1. C. Di Mauro, S.Bouchon, A.Carpignano, E. Golia, S. Peressin**;** 2006; *"Definition of MultiRisk maps at Regional level as management tool: experience gained by Civil Protection Authorities of Piemonte Region"*. Submitted to VGR 2006 – V Edizione Convegno sulla Valutazione e Gestione del Rischio negli Insediamenti Civili ed Industriali, 17-19 October 2006 – Pisa, Italy

2. M. Atkinson, C. Di Mauro, J.P. Nordvik G. Antonioni, G. Spadoni; 2006 "Towards risk assessment of critical infrastructures: experiences gained from quasi real-time vulnerability assessment of the transportation of dangerous substances by road". Submitted to VGR 2006 – V Edizione Convegno sulla Valutazione e Gestione del Rischio negli Insediamenti Civili ed Industriali, 17-19 October 2006 – Pisa, Italy

3. M. Atkinson, C. Di Mauro, J.P. Nordvik; 2006 *"Monitoring the transport by road of hazardous substances and risk reduction: results from an Italian case-study"***;** Submitted to ESREL 2006 Safety and Reliability ConferenceSurface Transportation Industrial Sector, 18-22 September 2006 – Estoril, Portugal

4. C. Di Mauro; S. Bouchon; 2006, "Les cartes régionales de vulnérabilité, outils de réflexion et supports d'aide à la décision : le cas de la Région Piémont et de la Province de Varèse". Responsabilité Environnement, Issue : Catastrophes et Territoires: les vulnérabilités, Série Trimestrielle des Annales des Mines, Juillet 2006, No 43, pp. 26-31, Editions Eska, Paris, ISSN 1268-4783.

5. Christiaan Logmeijer, Carmelo Di Mauro, Jean-Pierre Nordvik; 2005, "Regional vulnerability for energy disruption"; EUR Report EC JRC Report, Ispra (I), 2005.

6. M. Atkinson, C. Di Mauro, J. P. Nordvik, G. Antonioni, G. Spadoni, 2005, "Terms of reference for a traceability and vulnerability assessment demonstrator for the transport of dangerous substances - An activity report in the context of the COMPASS institutional action", EUR Report EC JRC Report, Ispra (I) , 2005.

7. C. Di Mauro, 2005, "*Regional vulnerability map for supporting policy definitions and implementations*", ARMONIA Conference "Multi-Hazards: Challenges for Risk Assessment, Mapping and Management", 5-6 December, 2005, Barcelona (E)

8. M. Atkinson, C. Di Mauro, J. P. Nordvik**;** 2005, *"Traceability and risk assessment for the transport of dangerous substances: results from an Italian case-study*, Conference Proceeding of Systems Analysis for More Secure World **-** Application of System Analysis and RAMS to Security of Complex Systems, 29th ESReDA – European Safety, Reliability & Data Association, Ispra (I),October 25-26, 2005

9. E. Mazzucco, M. Pozzoni, C. Di Mauro, J. P. Nordvik; 2005, "*Studio per la definizione degli standard di acquisizione delle informazioni a supporto delle attività di Protezione Civile della Regione Piemonte"*, EUR Report EC JRC Report, Ispra (I) , 2005.

10. J.M. Ham, M. Struckl, A.-M. Heikkilä, E. Krausmann, C. Di Mauro, M. Christou, J.-P. Nordvik, *2005 "Comparison of risk analysis methods and development of a template for risk characterisation",* EUR Report EC JRC Report, Ispra (I) , 2005

11. C. Di Mauro; A.L.Vetere Arellano; B.Ranguelov; J.Hervas; R. Peckham; C. Michalis; S.J.Duffield; M. Wood; J.P. Nordvik; A.C. Lucia, 2004**,** *"Questionnaire – Risk Mapping – Natural and Technological Risks and Contaminated Land",* The Institute for the Protection and Security of the Citizen (IPSC), European Commission – Joint Research Centre, January 2004 **-** Ispra, Italy.

Dr. José-Manuel Zaldívar is a chemical engineer working on the application and development of nonlinear dynamical systems to engineering and environmental problems. He has researched in dynamical systems and non-linear time series analysis.He has recently patented a device for early detection of runway initiation in chemical reactors based on chaos theory. This device has been industrially developed in the FP5 project AWARD and now it has been installed at several chemical plants. He has been working in the DITTY project concerning the management of coastal lagoons using advanced models and the IP project on Thresholds of Sustainability in coastal systems where nonlinear techniques are applied to analyze environmental data sets. During 2005 he has been Guest Editor of Ecological Modelling, Chemistry and Ecology and Hydrobiologia.

Relevant publications:

1. Zaldívar, J. M., Bosch, J., Strozzi, F., and Zbilut, J. P., 2005, Early warning detection of runaway initiation using non-linear approaches. *Communications in Nonlinear Science and Numerical Simulation* **10**(3), 299-311.
2. Strozzi, F. and Zaldívar, J. M., 2006. Non-linear trading strategy for financial time series. *Chaos*, *Solitons and Fractals* **28** (3), 601-615.
3. Zaldívar, J.M., Strozzi, F. and Bosch, J., 2005.The divergence as a goal function for control and on-line optimization. *AIChE Journal* **51**(2), 678-681.
4. Marinov, D., Norro, A. and Zaldívar, J. M., 2006. Application of COHERENS model for hydrodynamic investigation of Sacca di Goro coastal lagoon (Italian Adriatic Sea shore). *Ecol. Model.* 193, 69-89.

5. Zaldívar, J. M., Austoni, M., Plus, M., De Leo G. A., Giordani, G. and Viaroli, P., 2005. Ecosystem health assessment and bioeconomic analysis in coastal lagoons. *Handbook of Ecological Indicators for Assessment of Ecosystem Health* edited by Sven E. Jorgensen, Fu-Liu Xu and Robert Costanza. CRC Press, ISBN: 1566706653. pp 448.

Russ Pride is a physicist with over 40 years research experience in the energy industry, the first 20 in the electricity sector and the last 20 in the gas sector. He is currently working for the European Joint Research Centre, ISPRA, Italy, on gas pipeline infrastructures. Prior to this he worked for Advantica Ltd in the UK, (previously the British Gas Research Centre) where he worked on gas appliances, heat pumps, flueing systems and sensor technologies. In recent years he specialized in pipeline monitoring systems. He has managed many multi-national projects including EU and ESA funded projects, and has presented and published widely on gas technologies. He has several patents to his name. He was a founder member of the Gas Analysis and Sensing Group –"GASG" in the UK with a focus on gas detection technologies. Two of the most recent successful multi-million euro projects he has managed were the 17 partner EU consortium on remote satellite surveillance "Presense", focussed on third party interference to pipeline structures, and the 10 partner consortium "Vogue", on visualisation of gas leaks using laser pointers and scanners.

Christiaan Logtmeijer is en economist with three years experience in damage assessment and consequence modelling. His expertise lies in the use of GIS and socio-economic modelling with the focus on providing input in decision making processes.

In his work his activities have included the vulnerability assessment of complex critical systems as well as socio-economic impact assessment. His most recent work has shifted towards network vulnerability. His research in this field stretches from assessment of vulnerability of critical systems like energy systems to the use of road networks in emergency management.

Relevant publications:

1. van der Veen, A., N. S. Groenendijk, N. Mol, A.J. Wesselink, C.J.J. Logtmeijer "*Kosten-Baten analyse en evaluatie van maatregelen tegen overstromingen*." (cost benefit analysis and evaluation of flood-evaluation schemes) in: Vrouwenvelder, A., A. van der Veen, et al. (2003). "Wat als we nat gaan? Een beschouwing van de stand van zaken". Delft, Delftlcuster workshop, oktober 2001.

2. van der Veen, A., A. E. Steenge, M. Bockarjova and C. J. J. Logtmeijer (2003). *Structural economic effects of large-scale inundation: A simulation of the Krimpen dike breakage*. Proceedings: Joint NEDIES and University of Twente Workshop – In search of a common methodology for damage estimation. Report EUR XXXXX EN (2003), Office for Official Publications of the European Communities. A. van der Veen, A. L. Vetere Arellano and J. P. Nordvik. Bruxelles, European Union.

3. van der Veen, A., and C. J. J. Logtmeijer (2003). *Economic Hot Spots: visualisation of vulnerability to flooding in GIS*. Proceedings: Joint NEDIES and University of Twente Workshop – In search of a common methodology for damage estimation. Report EUR XXXXX EN (2003), Office for Official

Publications of the European Communities. A. van der Veen, A. L. Vetere Arellano and J. P. Nordvik. Bruxelles, European Union.

4. van der Veen, A., A. E. Steenge, M. Bockarjova and C. J. J. Logtmeijer (2003).

5. *Structural economic effects of large-scale inundation: A simulation of the Krimpen dike breakage*. DC1-233-12. Delft, Delft Cluster: 46.

6. van der Veen, A. and Logtmeijer, C. J. J.:2004. "Economic hotspots: visualizing vulnerability to flooding." *Natural Hazard* (to appear)

7. Logtmeijer, C. Vetere Arellano A. Nordvik, J.P. *Using CommonGIS to Analyze and Visualize Lessons Learn from Disasters as Input to a Risk Communication Methodology,* EUR Technical Note No. I.05.33, Office for Official Publications of the European Communities, May 2005.

8. Logtmeijer, C. di Mauro, C. Nordvik, J.P. *Regional Vulnerability for Energy Disruptions*, EUR Technical report, Ispra (I), 2005.

COLB

Collegium Budapest – Institute for Advanced Study (CB) was founded in 1992 as an international research institute by a consortium of six European states and some private foundations. It is a multidisciplinary institute with a program comprising the humanities and the social sciences, as well as the theoretical natural sciences. With a small number of permanent fellows and some 35 outstanding scholars visiting each year, CB has established itself as a Centre of Excellence, and has been recognized as such by the European Commission in 2000. Recently it has become involved in two large scale FP6 Integrated Projects: EVERGROW (structure, stability and future of the internet) and ECAGENTS (possible evolution of communication between artificial agents – robots), and has built up a powerful information technology infrastructure. Last year CB won a major grant from the Hungarian National Office of Research and Technology and established a Centre of Complex Systems within the institute, with the mission of carrying out research in network data analysis including structural, stability and traffic studies in the global financial network, risk and risk governance, the power grid, and emergence, reliability and vulnerability of biological organizations. In order to carry out these programs, CB has developed close links with a number of Hungarian and foreign university groups, and has a team of about 30 additional researchers working on the projects.

Imre M. Janosi, born in 1963, MSc (physics, 1987), PhD (statistical physics,1992), MA (European studies, 2000), associate professor at the Department of Physics of Complex Systems at Eötvös University. Author of 76 papers (44 in refereed journals). Guest research experience in Germany (3 years), Denmark (6 months), Brasil (2 months), and USA (1 months), several short visits and conference participations (over 30 occasions). Research interest:
nonlinear time series analysis, geophysical fluid dynamics, statistical climatology, modeling biological systems and ecological networks, chaotic systems. Education: general physics, environmental fluid flows, nonlinear time series analysis, statistics.

Relevant publications:

1. I. Bartos, and I.M. Janosi, Atmospheric response function over land: Strong asymmetries in daily temperature fluctuations. Geophysical Research Letters, 32, L23820 (2005). doi: 10.1029/2005GL024559.
2. R. Muller, and I.M. Janosi, Empirical mode decomposition and correlation properties of long daily ozone records. Physical Review E, 71, 056126 (2005). doi: 10.1103/PhysRevE.71.056126.
3. A. Kiraly, and I.M. Janosi, Detrended fluctuation analysis of daily temperature records: Geographic dependence over Australia. Meteorology and Atmospheric Physics, 88, 119-128 (2005). doi: 10.1007/s00703-004-0078-7
4. M. Pattantyus-Abraham, and I.M. Janosi, What Determines the Nocturnal Cooling Timescale at 2 m? Geophysical Research Letters, 31, L05109 (2004). doi: 10.1029/2003GL019137
5. M. Pattantyus-Abraham, A. Kiraly, and I.M. Janosi, Nonuniversal atmospheric persistence: Different scaling of daily minimum and maximum temperatures. Physical Review E, 69, 021110 (2004). doi: 10.1103/PhysRevE.69.021110

Gábor Vattay, born 1965, PhD (statistical physics, 1994), full professor and head of the Department of Physics of Complex Systems at Eötvös University. He is the coordinator of the Large International Project “Cooperative Center for Communication Network Data Analysis” which includes the Complex Networks Research Center at Collegium Budapest – Institute for Advanced Study. He is board member of EXYSTENCE, a network of excellence in complex systems and subproject manager of the IST FET Complex Systems Integrated Project EVERGROW. His research interest includes modeling of dynamical systems, interdisciplinary application of statistical physics. In 2000 he funded the Communication Networks Laboratory at Eötvös University with the support of ERICSSON Research Sweden and his research interest shifted towards computer and communication networks. He published one book and about 50 per reviewed publications.

Relevant publications:

1. Complex Dynamics in Communication Networks Eds.: L. Kocarev and G. Vattay in Understanding Complex Systems Series Springer Verlag (2005)
2. G. Németh and G. Vattay “Giant Clusters in Random Ad-Hoc Networks” Phys. Rev. E67, 036110 (2003)
3. A. Veres, Zs. Kenesi, S. Molnar, and G. Vattay, "On the Propagation of Long-Range Dependence in the Internet," SIGCOMM (2000), also appeared in Computer Communication Review 30, No 4, 243-254 (2000)

Professor **Imre Kondor** is Rector of *Collegium Budapest – Institute for Advanced Study*, professor of physics at the *Department of the Physics of Complex Systems, Eötvös University, Budapest*, and titular professor of finance *at Corvinus University, Budapest*. In 1992 he founded *Bolyai College*, a school of excellence, in 1998 the *Department of Market Risk Research at Raiffeisen Bank,* where he held the office of director of risk management until 2002. He holds a PhD and DSc, three academic and two government prizes. He has published over 70 publications, including 65 research papers in international journals, 2 books and one e-volume. He is coeditor of *Fractals, JSTAT*, and review editor of *Journal of Banking and Finance*. His research experience includes the theory of condensed Bose systems, critical phenomena, random systems and spin glasses, and, presently, the application of statistical physics methods to problems in economics and finance (especially the theory of portfolios, risk management and risk regulation). Professor Kondor organized about 20 international conferences, the last one on *Systemic Risk in* *the Financial Sector* held in Budapest, 28-29 September 2005, has served as chairman or member on various grant committees and science policymaking bodies, including his present membership of the Technology and Research Policy Advisory Board to the Prime Minister of Hungary.

MASA

The Macedonian Academy of Sciences and Arts is the highest scientific, scholarly and artistic institution in the Republic of Macedonia. As an independent scientific and artistic institution the Academy achieves its objectives by basic, developmental and applied research, comprehensive and inter-disciplinary research projects, by organising scientific and scholarly conferences and symposia, publishing the results of the same and of other scientific research and organising events in the field of the arts. The Academy collaborates with the universities, other scientific, scholarly and cultural institutions, scientific and artistic societies and other comparable organisations in the Republic of Macedonia. It also co-operates with other academies of sciences and arts, and with scientific, scholarly and artistic institutions abroad. The Department of mathematical and technical sciences at MASA has 15 members.

Ljupco Kocarev is a member of MASA, Professor at the Graduate School of Electrical Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia, and Research Professor at University of California San Diego, USA. He has coauthored more than 100 journal papers in 18 different international journals, ranging from mathematics to physics, and from electrical engineering to computer sciences. According to Science Citation Index his work has been cited more than 2500 times. He is a fellow of IEEE. His scientific interests include networks, nonlinear systems and circuits; coding and information theory; networks on chip; and cryptography.

Relevant publications:

1. A. Fekete, G. Vattay, and L. Kocarev, Distribution of edge load in scale-free trees, Phys Rev E, in press, 2006.
2. A. Fekete, G. Vattay, and L. Kocarev, Traffic dynamics in scale-free networks, Journal of Complexity, ComPlexUs, in press, 2006.
3. L. Kocarev, F. Lehmann, G.M. Maggio, B. Scanavino, Z. Tasev, and A. Vardy, "Nonlinear Dynamics of Iterative Decoding Systems: Analysis and Applications," IEEE Transactions on Information Theory, in press, 2006.
4. N. Masuda, G. Jakimoski, K. Aihara, and L. Kocarev, "Chaotic Block Ciphers: from theory to practical algorithms," IEEE Transactions on Circuits and Systems, in press, 2006.
5. L. Kocarev, J. Szczepanski, J. M. Amigo, and I. Tomovski, "Discrete Chaos: part I – Theory," IEEE Transactions on Circuits and Systems, in press, 2006.

Danco Davcev is a Professor at the Faculty of Electrical Engineering, Ss. Cyril and Methodius University, Skopje, Macedonia. D. Davcev is a Coordinator of the TEMPUS JEP Project UM_JEP – 17045-2002, Wireless Campus for Strengthening of student services, with partners from Politecnico di Torino (Prof. Francesco Profumo), London S.B. University (Prof. Dilip Patel), Institute National de Telecommunication, Paris (Prof. Pierre Vincent). In 2001/2002 Dr. Davcev was a Visiting Fulbright Research Professor at several Universities in USA working on Distance Education projects, cross-cultural educational programs, Augmented Reality systems and Multi-agent systems. Dr. Davcev is a senior member of IEEE and voting member of ACM. His fields of interest include computer science, distributed systems, databases, networks and sensors and wireless networks.

Relevant publications:

1. A. Kulakov, D. Davcev, and G. Stojanov, Learning patterns in wireless sensor networks based on wavelet neural networks. ICPADS (2) 2005: 373-377
2. A. Kulakov, D. Davcev, and G. Trajkovski, Application of Wavelet Neural-Networks in Wireless Sensor Networks. SNPD 2005: 262-267
3. I. Jovanovski, D. Davcev, Distributed Energy Fading in Sensor Networks - Energy Aware Distributed Constraint Satisfaction Model, 1st IEEE Int. Conf. on Mobile Ad hoc and Sensor Systems, MASS-2004
4. G. Kimovski, D. Davcev, Sensor network for flow control- the advantage of wireless over wired solution, 1st IEEE Int. Conf. on Mobile Ad hoc and Sensor Systems, MASS-2004.
5. Danco Davcev: A Dynamic Voting Scheme in Distributed Systems. IEEE Trans. Software Eng. 15(1): 93-97 (1989).

Zoran Hadzi-Velkov received his B.Sc. (1996), M.Sc. (2000) and Ph.D. (2003) degrees in electrical engineering from the Ss. Cyril and Methodius University in Skopje, Macedonia. He is with the Faculty of Electrical Engineering at the Ss. Cyril and Methodius University, where he currently holds the position of Assistant Professor. Dr. Zoran Hadzi-Velkov realized multiple stays at the University of Torino, the University of Lille, the INT research center in Paris, the University of Modena, and the IBM TJ Watson Research Center in New York. He has appeared as a reviewer in IEEE Comsoc journals (TCOM, TWireless and Comm. Letters). His current research interests include networks in general, communication networks, wireless local area networks, digital communications over fading channels and diversity systems.

Relevant publications:

1. Z. Hadzi-Velkov, B. Spasenovski, Z. Nikolic, “Capture Effect in Wireless LANs with RAKE Reception of DSSS/DPSK Signals”, AEU Int. Journal ofElectronics and Communications, Vol. 60, No. 3, To appear in March 2006
2. Z. Hadzi-Velkov and B. Spasenovski, “Saturation Throughput–Delay Analysis of IEEE 802.11 DCF in Fading Channel”, Proc. IEEE International Conference on Communications 2003 (ICC 2003), 11–15 May, 2003, Anchorage, Alaska, USA, pp. 121 – 126
3. Z. Hadzi-Velkov and B. Spasenovski, “An Analysis of CSMA/CA Protocol with Capture in Wireless LANs”, Proc. IEEE Wireless Communication and Networking Conference 2003 (WCNC 2003), 16–29 March, 2003, New Orleans, Louisiana, USA., pp. 1303–1307
4. Z. Hadzi-Velkov and B. Spasenovski, “Capture Effect in IEEE 802.11 Basic Service Area under Influence of Rayleigh Fading and Near/Far Effect”, Proc. IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2002), 15–18 September, 2002, Lisboa, Portugal, pp. 172–176
5. Z. Hadzi-Velkov and B. Spasenovski, “On the Capacity of IEEE 802.11 DCF with Capture in Multipath-faded Channels”, International Journal of Wireless Information Networks, Kluwer Academic Publishers, Vol. 9, No. 3, pp. 191–199, July 2002

Università Cattaneo-LIUC

The Università Carlo Cattaneo (LIUC) is one of the youngest Universities in Italy. Set up by the Industrial Association of the Province of Varese, it was officially founded by decree of the Ministry of Universities and Technological and Scientific Research on 31st October 1991.LIUC has three faculties, Law, Economics and Engineering; since 1991 it has run a degree course in Business Administration, and since 1994 a diploma course (the so-called short degree) in Logistics and Production Engineering. The teaching program is interdisciplinary with courses linking economic and technological areas of study to give a global vision of the company, its functions and problems. This means that in the degree course in Business Administration, attention is paid to the economic, organizational and strategic significance of technological change and the university diploma course in Engineering looks at management methods and business administration. This represents an innovative approach within the Italian academic tradition.

Short CV of Dr. Strozzi Fernanda

Dr. Fernanda Strozzi graduated in Mathematics from Pavia University (Italy). PhD in Mathematics and Chemical Engineering from Twente University, Enschede (The Netherlands) in 1997. PhD title: Runaway prevention in chemical reactors using chaos theory techniques. She has worked for LIUC as contract Professor, teaching Numerical Analysis and Dynamical Systems theory since 1997. In parallel she researches on Nonlinear Economic dynamics and on Logistics. She was a work package leader in a EU founded project: AWARD (Advance Warning and Runaway Disposal) on the safety of chemical reactor .

Relevant publications:

1. Strozzi, F. and Zaldívar, J. M., 2006. Non-linear trading strategy for financial time series. Chaos, Solitons and Fractals 28, 601-615.
2. Strozzi, F., Bosch, J. and Zaldivar J. M., 2006. Beer Game Order Policy Optimization under Changing Customer Demand. Decision Support Systems (in press)
3. Strozzi, F. and Zaldívar, J. M., 2005.Non-linear forecasting in high-frequency financial time series. Physica A 353, 463-479.
4. Zbilut, J. P., Zaldívar, J. M., and Strozzi, F., 2002, Recurrence quantification based-Liapunov exponents for monitoring divergence in experimental data. Physics Letters A 297, 173-181
5. Strozzi, F., Zaldívar, J. M., and Zbilut, J. P., 2002, Application of nonlinear time series analysis techniques to high frequency currency exchange data, Physica A 312, 520-538.

Short CV of Prof. Carlo Noè

Prof. Carlo Noè graduated in Mechanical Engineering from Politecnico of Milan (Italy). Full professor in Industrial Plants since 1998 at LIUC where he is teaching Quality Management and Logistics. Before joining LIUC he has worked for Politecnico of Milan as researcher and, then, assistant professor, teaching Design and Management of Production Systems since 1984. His present research fields of interest are Simulation of Production Systems, Risk Management, Facility Management. In 2004 he was a work package leader in an Italian University Ministry founded project on Facility Management and Outsourcing.

Relevant publications:

1. Bettanti, A., Noè, C., Preda, U., Rossi, T., (2005). Methodological Approach to Risk Assessment in the Utilities, 1° International Conference on Maintenance Management, Venezia
2. Rossi, T., Noè, C., Dallari, F., (2005). Supply Chains Risk Management: a formal Approach, 18° International Conference on Production Research, Salerno
3. Noè, C., Rossi, T., (2004). The Use of ACD Model in Hybrid Production Systems Simulation, International IMS Forum, Varenna

4. Noè, C., Rossi, T., Sorrenti, D., (2004). Survey on facilities management. Valuation of Extended Global Service (EGS) applicability, LIUC Papers n. 152

Short CV of Dr. Tommaso Rossi

Dr. Tommaso Rossi graduated in Production and Management Engineering from Politecnico di Milano in 2000. PhD on Industrial Engineering from the Politecnico di Milano. PhD title: Modeling and analysis of hybrid production systems. A case study belonging to the fiber-glass industry (developed at the Massachusetts Institute of Technology, Boston, MA). He is Researcher at the Department of Industrial Engineering of Università Cattaneo – LIUC (Castellanza) where he holds the courses of Operations Management and Supply Chain Design. His research interests concern with production planning, logistic network design, simulation, hybrid production systems and risk assessment.

Relevant publications :

1. Cigolini R., Rossi T., 2006. A note on supply risk and inventory outsourcing. Production Planning and Control (in press).
2. Rossi T., Noé C., Dallari F., 2005. A formal method for analyzing and assessing operational risk in supply chains, 23rd International Conference of the System Dynamics Society, Boston (MA).
3. Rossi T., 2004. Hybrid production systems: logical modeling and simulation. Guerini Scientifica, Milano.

Short CV of Prof. Massimiliano Serati

Education

1998: Ph-D in Economics, University of Pavia (Ph-D title: Forecasting macroeconomic variables in BVAR models: methodology and empirical applications to quarterly and monthly models for the italian case)

1993: Degree in Economics, Bocconi University, Milan, with honours (1110/110 cum laude)

Current Position

Associate Professor of Economic Policy, Carlo Cattaneo University – LIUC

Fields of interest

Econometrics, Economic Policy, Regional Economics

Research areas

Business cycle, Forecasting models (theory and practice), Monetary policies and disinflation, labour markets and unemployment, Regional Policies

Professional and research duties

2002-2005: Academic expert in study groups on local economies within Formez, Regione Basilicata and Regione Lombardia

1998-1999: Member of various Research teams on forecasting macro-models within different Private Banks

1998-1999: Member of a Research team on forecasting macro-models within Bank of Italy

Relevant publications:

MANMADE

Amisano G., Serati M. (2003), “What goes up sometimes stays up: shocks and institutions as determinants of unemployment persistence”, Scottish Journal of Political Economy, (Glasgow,UK), Vol. 50, No 4, September, 440-470

1. Amisano G., Serati M. (2003) “Effetti aggregati della tassazione sul mercato del lavoro: un’analisi econometrica”, in "Temi di fiscalità internazionale", E. Bonzani, R. Levaggi e P. Panteghini Eds, Franco Angeli.
2. Amisano G., Serati M. (2002) “BVAR models and forecasting: a quarterly model for the EMU-11”, Statistica, year LXII, n.1, 51-70.
3. Amisano G., Serati M. (1999) “Forecasting Cointegrated Series with BVAR models”, Journal of Forecasting, 18, 7, 463-476.
4. Amisano G., Giannini C. and Serati M. (1997) “Tecniche BVAR per la costruzione di modelli previsivi mensili e trimestrali”, Discussion Paper n. 302, Bank of Italy.

Queen Mary, University of London				
Full Project Costs				
Salary (Keuros)	Year 1	Year 2	Year 3	Total
Res Assistant	51.2	79.3	85.6	216.1
Management/Audit	14.4	17.2	18	49.6
Travel	8	8	8	24
Equipment	20	0	0	20
Consumables	4	4	4	12
Indirect costs at 20%	23.2	20	20.7	64.3
Total	120.8	128.5	136.3	385.6

Collegium Budapest				
Project Costs				
Salary (Keuros)	Year 1	Year 2	Year 3	Total
Res Assistant	56.0	56.0	56.0	168.0
Management/Audit	1.0	0.9	0.9	2.8
Travel	7.0	7.0	7.0	21.0
Equipment	0.0	0.0	0.0	0.0
Consumables	1.0	1.1	1.1	3.2
Indirect costs at 20%	13.0	13.0	13.0	39.0
Total	78.0	78.0	78.0	234.0

ICEIM-MASA				
Full Project Costs				
Salary (Keuros)	Year 1	Year 2	Year 3	Total
Res Assistant	45	45	43.5	133.5
Management/Audit	1.5	1.5	1.5	4.5
Travel	7	7	6	20
Equipment	1.5	0	0	1.5
Consumables	4	4	4	12
Indirect costs at 80%	46	45	43.8	134.8
Total	105	102.5	98.8	306.3

Università Cattaneo-LIUC				
Project Costs				
Salary (Keuros)	Year 1	Year 2	Year 3	Total
Res Assistant	52.8	42.2	42.2	137.2
Management/Audit	1.0	0.9	0.9	2.8
Travel	5.0	4.0	5.0	14.0
Equipment	10.4	0.0	0.0	10.4
Consumables	0.0	0.0	0.0	0.0
Indirect costs at 20%	10.8	8.6	8.6	28.0
Total	80.0	55.7	56.7	192.4

MANMADE

IFMWTP03R v7.7 16.11.2006

Page 1 of 4

Cost evaluations form

Contract nr	Annex nr	Amendment nr 0

Unit	: European Laboratory for Structural Asses	**Amount incl. MF**	: 264.000
Institute	: Inst. for Protection and Sec. of Citizen	**Reimbursable amount**	: 132.000
Scientific responsible	: GUTIERREZ TENREIRO	**% paid by customer**	: 50,00
Customer	: 6999999008 RTD DG RECHERCHE RESEARCH DG*	**Currency**	: EUR
Subject	: MANMADE	**Exchange rate**	: 1,00
Contract type	: A2CP	**Total manmonth**	: 29,70
Calculation model	: FULL COST FLAT RATE	**% FCF overhead**	: 20,00
Tariff / version	: 2005 / 1	**Start date**	: 01.01.2007
		End date	: 31.12.2009

Summary of costs (EURO)

	2007	2008	2009	Total
Staff	63.703	66.876	70.858	201.437
Mission	3.363	3.500	3.500	10.363
Audit Certificates			1.200	1.200
Specific Credits	4.000	3.000		7.000
Optional Costs				
Overhead FCF	14.213	14.675	15.112	44.000
Total	85.279	88.051	90.670	264.000

Summary ABAC Financial Information

	Amounts including MF	Reimbursable amounts
Staff credits (including missions and audit certificates)	238.519	119.260
Means of execution (optional costs excluded)	18.481	9.240
Specific Credits	7.000	3.500
Optional costs		
Total Forecast	264.000	132.000